WOOL SCIENCE, TECHNOLOGY AND DESIGN EDUCATION PROGRAM

FACILITATOR GUIDE
WOOL FABRIC FINISHING

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THE WOOLMARK COMPANY | AUSTRALIAN WOOL INNOVATION

The Woolmark Company (TWC) is a subsidiary of Australian Wool Innovation (AWI) and is the global authority on Merino wool. With a network that spans the entire global wool supply chain, The Woolmark Company builds awareness and promotes the unique traits of nature's finest fibre.

Australian Wool Innovation (AWI) is the research, development and marketing body for the Australian wool industry. More than 60,000 Australian woolgrowers co-invest with the Australian government to support the activities carried out by AWI and TWC along the global wool supply chain.

The Woolmark Company supports and connects global supply chain participants through initiatives such as The Wool Lab and Wool Lab Sport. These internationally renowned wool-sourcing tools provide designers, retailers and brands with the latest trends in wool yarns, fabrics and technologies, while promoting Australian Merino wool as the ultimate fibre of choice for apparel.

Marketing activities focus on education and awareness raising to ensure consumers, manufacturers and designers are aware of Australian wool's benefits and qualities, can capitalise on wool's inherent properties, and can successfully integrate wool into their product lines.

THE WOOL SCIENCE, TECHNOLOGY AND DESIGN EDUCATION PROGRAM OVERVIEW

The Wool Science, Technology and Design Education Program combines a series of introductory and advanced courses of study developed to meet the needs of tertiary-level participants studying within the fields of: textile science and engineering, fashion and textile design and/or textile manufacturing. Individual courses within the series may also be of interest to participants studying sheep and wool science, and those working in the wool production, raw wool processing, textile manufacturing and textile sales and marketing industries.

Introductory level courses are suitable for participants studying at first or second-year tertiary levels, while the advanced courses are aimed at participants in their more senior years of study. The extension courses can be used for specific course requirements.

INTRODUCTORY COURSES

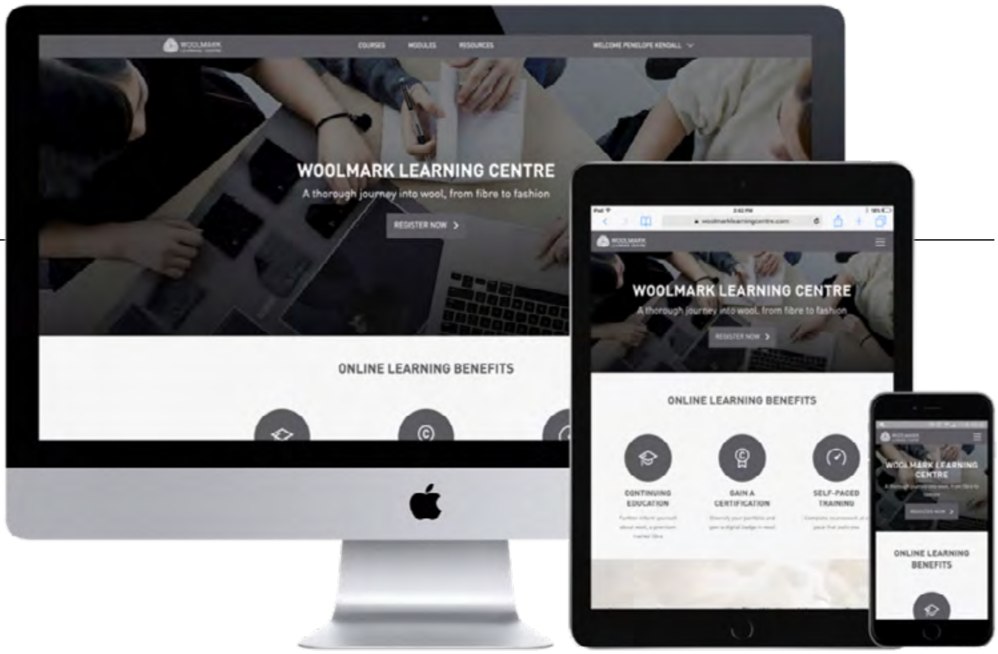
- Wool fibre science
- Introduction to wool processing

ADVANCED COURSES

- Raw wool scouring
- Worsted top-making
- Worsted and woollen spinning
- The dyeing of wool
- **Wool fabric finishing**

EXTENSION COURSES (IN DEVELOPMENT)

- Finishing of wool knitwear
- Wastewater management
- Wool product quality
- Methods of wool fabric formation



THE WOOLMARK LEARNING CENTRE

The *Woolmark Learning Centre* is a freely accessible, online learning platform, which supports The Woolmark Company's commitment to education and awareness raising with regard to wool, wool processing and product innovation.

Make sure you have completed the *Wool Appreciation Course* online before delivering any courses of the *Wool Science, Technology and Design Education Program* to familiarise yourself with The Woolmark Company's approach and core messages about wool production and the wool supply chain.

It is also important to encourage all participants to explore the online *Woolmark Learning Centre* to reinforce and build on the knowledge they have gained by attending this advanced level course.

The W*oolmark Learning Centre* can be accessed at:
https://www.woolmarklearningcentre.com/

INTRODUCTION TO THIS FACILITATOR GUIDE

This Facilitator Guide covers the *Wool fabric finishing* course of the *Wool Science, Technology and Design Education Program*.

The information in this Guide will support you to:

- deliver the technical content across a series of face-to-face lectures in an engaging and easy-to-follow way
- carry out a range of practical demonstrations and interactive discussions to support participant learning.

This Facilitator Guide provides:

- an overview of the *Wool Science, Technology and Design Education Program* courses
- the target audience for the *Wool fabric finishing* course
- the pre-requisites for the course
- an overview and learning objectives for *Wool fabric finishing*
- a suggested agenda for delivering *Wool fabric finishing*
- an overview and the learning objectives for each module within *Wool fabric finishing*
- course materials and resources required to deliver *Wool fabric finishing*
- administrative requirements and institutional responsibilities when delivering *Wool fabric finishing*
- guidelines and processes regarding participant recognition upon completing *Wool fabric finishing*
- links to participant and facilitator feedback and evaluation questionnaires
- a facilitator checklist to enable successful planning and preparation leading up to, during and following delivery
- recommended room layout for small venues or groups
- a guideline for the effective and engaging delivery of the course content.

INTRODUCTION TO THIS COURSE

Wool fabric finishing is an advanced-level course, which provides participants with an understanding of why the finishing of wool fabrics is important, how fabrics are finished and how finishing operations are evaluated.

The course structure and module plan contained in this Facilitator Guide indicate the technical content to be addressed, however it's important to adapt the focus of your training in line with participants' existing understanding and specific target audience requirements.

TARGET AUDIENCE

The *Wool fabric finishing* course is primarily aimed at senior-level tertiary participants studying textile science and engineering, and staff and managers from wool processing companies.

The course is designed to be delivered face to face, in groups of 6 – 50 people, although the ideal number of participants who can attend course lectures depends on the resources available to support the delivery.

COURSE PREREQUISITES

As an advanced course, *Wool fabric finishing* is suitable for participants with sound knowledge of wool or the wool industry, or participants who have undertaken the introductory courses of the *Wool Science, Technology and Design Education Program* (e.g. *Wool fibre science* and *Introduction to wool processing*).

If this is the first *Wool Science, Technology and Design Education Program* course being delivered to these participants, start the initial lecture with an *Introduction to The Woolmark Company*.

This presentation is included in the *Wool fabric finishing* facilitator slides as an optional introductory module.

COURSE LEARNING OBJECTIVES

By the end of the *Wool fabric finishing* course, participants are expected to be able to evaluate finished wool fabrics produced within a weaving or knitting mill and assess whether the material meets the aims of the finishing operation.

COURSE AGENDA

The Wool fabric finishing course consists of 13 lectures, of approximately one hour each, supported by a set of PowerPoint slides, videos and recommended demonstrations, as outlined in the table below. **Note:** it is recommended to break Modules 3 and 4 into two one-hour lectures, as indicated in the table below.

NOTE: Indicated slide numbers for Module 1 take account of the introductory Woolmark Company slides as outlined in the following facilitator notes.

MODULE | SLIDE NUMBER	VIDEOS AND PRACTICAL DEMONSTRATIONS
Module 1: The aims of fabric finishing | 17 slides	Slide 10: Finished and unfinished fabrics (handout)
Module 2: Review of setting and felting | 13 slides	Slide 1: Setting using plasticine (demonstration)
Module 3: Wet finishing operations | 88 slides	Slide 5: Inspection and mending (video) Slide 15: Wet batch decatising (demonstration) Slide 28: Open-width scouring operation (video) Slide 29: Rope formation (demonstration) Slide 30: Bagging (demonstration) Slide 33: Rope scouring (video) Slide 36: Open-width continuous scouring process (video) **NOTE:** Recommended Break Slide 42: Before and after development fabric samples (handout) Slide 43: High speed rope scouring machine (demonstration) Slide 45: Milling comparison (handout) Slide 48: Rotary milling for batch (rope) milling (video) Slide 54: Combined scouring and milling (video) Slide 62: Hygral expansion (demonstration) Slide 65: Rope opening (video) Slide 72: Weft straightener (video) Slide 73: Multi-layer stentering (video) Slide 74: Stenter-single layer (video)

MODULE | SLIDE NUMBER	VIDEOS AND PRACTICAL DEMONSTRATIONS
Module 4: Dry finishing operations | 70 slides	Slide 6: Shearing/cropping (video) Slide 10: Singeing (video) Slide 14: Festoon formation (activity) Slide 18: Raised and unraised fabric comparison (handout) Slide 20: Teazel raising, single drum (video) Slide 21: Teazel raising, two drums (video) Slide 22: Wet teasel raising (video) Slide 25: Wire raising (video) Slide 26: Emerising (demonstration) Slide 31: Belt pressing (video) **NOTE:** Recommended Break Slide 33: Wet batch decatising (demonstration) Slide 40: Pressure decatising (video) Slide 51: Continuous decatising (video) Slide 66: Steam framing (video)
Module 5: Typical worsted finishing routes | 12 slides	No videos or practical demonstrations
Module 6: Chemical finishing | 22 slides	Slide 3: Vegetable matter identification (handout) Slide 7: Optically brightened fabric in UV light comparison (handout and demonstration) Slide 8: Softened and unsoftened towelling fabric comparison (handout) Slide 12: Treated and untreated fabric comparison (handout)
Module 7: Assessment of fabric finishing | 43 slides	Slide 5: Fabric properties (demonstration) Slide 10: Cantilever bending (demonstration) Slide 33: Handle measurement (demonstration) Slide 36: Coarse and fine wool comparison (handout)
Module 8: Fabric mechanics | 16 slides	No videos or practical demonstrations
Module 9: Faults in finishing | 17 slides	No videos or practical demonstrations
Module 10: Performance standards | 15 slides	Slide 9: Woolmark specifications (video)
Module 11: Environmental issues | 10 slides	No videos or practical demonstrations

MODULE OVERVIEW AND LEARNING OBJECTIVES

Module 1 — The aims of fabric finishing starts off this 11-module course by explaining aims of fabric finishing, the types of fabric that require finishing, the requirements of a finished fabric and the potential unwanted effects of finishing.

By the end of this module participants are expected to be able to:

- describe the aims of fabric finishing
- differentiate between the functional properties and aesthetic characteristics of wool
- describe the requirements of a finished fabric
- identify some of the potential unwanted effects that can occur from finishing processes.

Module 2 — The *Review of setting and felting* module provides a quick review of the chemistry and physics of setting and felting. Both processes play a prominent role in fabric finishing.

By the end of *Review of setting and felting* module participants are expected to be able to recall the mechanisms of setting of wool, the mechanism of felting of wool and the methods for treating wool to prevent felting.

Module 3 — Wet finishing operations will cover the following components of wool fabric finishing:

- pre-finishing operations
- wet finishing (namely pre-setting, scouring, milling, rope opening, wet raising, hydroextraction, stenter drying)
- quality of water used in finishing
- the unwanted effects of each process.

At the end of this module participants are expected to be able to:

- describe the finishing processes commonly used to wet finish wool and their aims.
- outline the machinery used to conduct each process
- explain the importance of the quality of water used in finishing
- summarise the advantages and disadvantages associated with different alternative wet finishing processes
- describe some of the unwanted effects that can occur with each process.

Module 4 — Dry finishing operations explores dry finishing operations, the aims and unwanted effects of each process and how aims and unwanted effects are measured.

At the end of this module participants are expected to be able to:

- describe the finishing processes commonly used to dry finish wool and their aims
- describe the machinery used to carry out each process
- describe the advantages and disadvantages associated with different alternative dry finishing processes
- describe some of the unwanted effects that can occur with each process
- describe the process variables associated with decatising and how these impact the properties of the treated fabric.

Module 5 — Typical worsted finishing routes covers the worsted finishing routes, including:

- all-wool colour-woven plain weave
- all-wool colour-woven flannel
- all-wool colour-woven gabardine
- all-wool piece-dyed gabardine
- wool/polyester colour-woven gabardine
- wool/polyester piece-dyed plain-weave
- wool/mohair colour-woven suiting
- a route for all-wool knitted fabric.

It also explores the idea that not all finishers use the same routine or conditions for a single cloth. The route used depends on:

- the finish sought,
- the requirements of the customer
- the experience of the finisher.

At the end of this module, participants are expected to be able to describe the typical steps taken to finish both common worsted and all-wool knitted fabrics and explain the relevance and importance of each step in the finishing process.

Module 6 — Chemical finishing covers some of the chemical finishes that can be applied to wool to impart certain functional attributes (e.g. felt resistance).

At the end of this module, participants should be able to describe the chemical finishes used to:

- remove residual vegetable matter from the fabric (e.g. carbonising)
- improve the appearance and handle of the fabric (e.g. bleaching and softening)
- impart functional finishes (e.g. felt-resist finishes, oil and water-repellent finishes).
- describe the benefits associated with chemical finishing, as well as the potential problems
- describe some of the unwanted effects that can occur as a result of chemical finishing and how to reduce these
- discuss the environmental concerns associated with chemical finishing and how these are currently being addressed.

Module 7 — Assessment of fabric finishing provides an overview of the key properties of fabrics modified during finishing that affect quality and the options for instruments to measure these properties.

At the end of this module, participants should be able to:

- describe the functional properties and aesthetic characteristics that are modified during finishing and affect quality
- list the instruments commonly used to assess the key fabric properties affected by finishing
- identify what each instrument measures and how it measures the specific fabric properties.
- calculate properties from the measurements taken by the SiroFAST instrument (e.g. bending rigidity, shear rigidity, formability, finish stability)
- explain the methods used to interpret the results from SiroFAST, KES-F, Phabrometer and Wool handle meter.

Module 8 — Fabric mechanics provides a simple description of the mechanics of fabrics.

By the end of this module participants will be able to describe:

- a simple model for the description of a fabric to explain its dimensional stability and extensibility
- the application of the simple model to describe the engineering of the dimensions of a fabric and the impact on fabric properties.

Module 9 — The *Faults in finishing* module reviews some typical faults in finishing and outlines the corrective procedures for each.

At the end of this module, participants should be able to:

- describe some of the faults that can occur due to errors in finishing
- list some of the faults that are immediately visible and those which are on visible in the final product (latent faults)
- recognise how latent faults can be detected using objective measurements, such as SiroFAST
- describe how faults can be prevented
- describe how to correct the named faults, if correction is possible.

Module 10 — The *Performance standards* module covers the functional tests used for determining whether the fabric meets the required performance standard and the different types of performance standard fabrics have to meet. It also covers the functional properties of wool represented by the Woolmark Standard and the performance standards required for Woolmark's sub-brands.

At the end of this module, participants should be able to:

- briefly describe the different standards of performance all wool fabrics have to meet
- explain the difference between test methods and specifications
- list the different properties of wool that are covered by the Woolmark Standards, for both woven and knitted fabrics
- describe additional claims that are associated with the Woolmark Standard
- identify key differences between Woolmark sub-brands.
- describe some of the functional tests used.

Module 11 — The image of wool and wool products and the issues of environmental responsibility are important to all sectors of the processing chain from woolgrowers to retailers of wool products. The *Environmental issues* module looks at the environmental impacts associated with wool finishing.

At the end of this module, participants should be able to:

- describe how the 'environmentally friendly' image of wool products can be challenged
- describe the positive and negative environmental aspects of wool products
- describe how the limits for indirect discharge of chemicals in wool finishing are changing
- describe some of the common environmental issues related to wool finishing processes and how these can be effectively managed
- recognise the benefits associated with pro-actively changing finishing processes to more environmentally responsible options.

COURSE MATERIALS AND RESOURCES

To deliver the *Wool fabric finishing* series of lectures, you will need the following materials:

Provided in each course Facilitator Pack

- Facilitator Guide (PDF provided via DropBox link)
- Facilitator slides (PowerPoint files for each module provided via DropBox link)
- participant sign-on sheet (Word template provided via DropBox link)
- Participant Guide (PDF provided via DropBox link)
- Demonstration kit (see details below)
- Certificates of Participation (supplied by the regional Woolmark Company office on confirmation of student numbers).

To be sourced by facilitators

- speakers (for listening to the videos)
- laptop, data projector and overhead screen
- participant name tags (e.g. sticky labels or equivalent and a black marker to write participant names)
- flipchart and paper or access to a whiteboard
- markers for the flipchart or whiteboard where available

NOTE: The WST&DEP materials are designed to be delivered on a Microsoft 365 platform, on a 64bit hard drive. Please contact the regional Woolmark office if you do not have access to adequate technology.

WOOL FABRIC FINISHING DEMONSTRATION KIT

A range of practical demonstrations, group activities, handouts and samples is recommended to be used throughout this course to support participant learning and complement the content delivered in the lectures.

Recommended resources are listed at the start of each module in the *Wool fabric finishing* Facilitator Guide.

The following samples and resources for demonstrations are provided in the *Wool fabric finishing* Demonstration kit (resources not supplied in the kit will need to be supplied by the facilitator):

Module 1:
- sample of woollen fabric (unfinished)
- sample of woollen fabric (finished)
- sample of plain weave worsted fabric (unfinished)
- sample of plain weave worsted fabric (finished)
- sample of circular knitted fabric (unfinished)
- sample of circular knitted fabric (finished)

Module 2:
- No resources required

Module 3:
- cotton fabric
- wool fabric
- length of woven fabric (1m)
- 'bone dry' length of fabric (stored in plastic bag)
- woven wool fabric after development and control
- woven wool fabric after milling and control

Module 4:
- sample of raised fabric
- sample of unraised fabric
- length of woven wool fabric

Module 5:
- No resources required

Module 6:
- woollen fabric containing vegetable matter
- sample of optically brightened white cotton
- sample of non-optically brightened white cotton
- sample of optically brightened wool fabric (half-yellowed by sunlight)
- softened cotton towelling
- unsoftened cotton towelling
- cotton with water-repellent finish
- cotton without water-repellent finish

Module 7:
- sample of woven wool fabric cut in warp and weft
- sample of woven wool fabric cut in bias
- dimensional stability sample
- sample of knitted wool fabric
- broad-wool fabric sample
- fine-wool fabric sample

Module 8:
- No resources required

ADMINISTRATIVE DETAILS

ORGANISATIONAL RESPONSIBILITIES

Institutions delivering the *Wool Science, Technology and Design Education Program* course *Wool fabric finishing* will be responsible for:

- ensuring all facilitators have completed the online *Wool Appreciation Course* prior to delivering their first course
- providing the venue and equipment required to support the program (i.e. lecture theatre, data projector, data screen, flip chart, whiteboard and markers)
- enrolling the participants in the course
- ensuring all participants have undertaken the prerequisite courses of study or have sufficient industry knowledge to complete this advanced course of study
- administrative paperwork (i.e. participant sign-in sheets, name tags etc.)
- providing administrative support for communication between the facilitator and the participants
- ensuring both the participants and the facilitator have the required access to external sites required to support participant learning
- providing supporting services, as required. (e.g. interpreter, transport to or from external sites)
- providing The Woolmark Company with participant numbers, and participant and facilitator feedback and course evaluation post delivery.

The Woolmark Company will be responsible for providing:

- Facilitator Guide (PDF provided on USB)
- Facilitator slides (PowerPoint files for each module provided on USB)
- Participant sign-on sheet (Word template provided on USB)
- Participant Guide (PDF provided on USB)
- Demonstration kit
- Certificates of Participation (printed copies will be provided by the local TWC office upon request).

NOTE: Course materials are provided in English. If translation to the local language is required, this is the responsibility of the delivering institution.

PARTICIPANT RECOGNITION

At the conclusion of the *12 Wool fabric finishing* lectures, each participant who has attended all lectures is eligible to receive a Woolmark Company-endorsed Certificate of Participation.

PROGRAM EVALUATION

Feedback from those attending the *Wool fabric finishing* course must be collected by way of an online survey link. This feedback will be used to adapt the course on an annual basis, if and where necessary, to ensure it achieves the desired objectives in the most effective way.

Feedback from those delivering the *Wool fabric finishing* course also must be submitted at the completion of the course. This feedback can be submitted via the online survey.

Facilitator survey:
www.woolmarklearningcentre.com/wstd-surveyfacilitator

Participant survey:
www.woolmarklearningcentre.com/wstd-surveyparticipant

FACILITATOR CHECKLIST

The following list outlines the actions required before, during and after delivery of the *Wool fabric finishing* course.

One month before:

- ☐ Fully familiarise yourself with the course materials.
- ☐ Check you have all the materials required to deliver the course (including the facilitator materials and the demonstration kit).
- ☐ If you are an external facilitator, obtain contact details for your key point of contact at the host institution. Make contact, introduce yourself and arrange regular meetings leading up to the delivery dates.
- ☐ Confirm the number of participants attending, along with the year level and any previous studies relevant to the course.
- ☐ Confirm any specific needs for the target audience in consultation with the institution.
- ☐ Familiarise yourself with the venue and facilities that will be available for the lectures including room size and potential room layout options (see following notes regarding room layout). This may be via site maps or discussions with your key contact.
- ☐ Confirm equipment available at the venue (e.g. data projector, screen, speakers, laboratory equipment).
- ☐ Adapt the program (if required) to meet the needs of the participants and venue facilities.
- ☐ Check the availability of participant materials in sufficient quantity.
- ☐ Ensure you have reviewed the delivery material and have checked any videos for the upcoming lectures work on the available equipment.

One week before:

- ☐ Confirm shipping details of the course materials and equipment (if required)
- ☐ Confirm transport between the institution and any external site visits. (if required).
- ☐ Confirm names of the participants attending the course.
- ☐ Ensure you have ordered a sufficient number of the 'Certificate of Participation' to be distributed to the appropriate participants following the completion of the final lecture.
- ☐ Ensure your wardrobe contains various wool garments. In order to demonstrate the benefits and versatility of wool and wool products, facilitators are encouraged to wear as much wool as possible, across a range of garment types. For example:
  - wool trousers or skirt
  - wool t-shirt or undershirt, long-sleeved shirt, sweater or jacket
  - wool socks.

One day before:

- ☐ Arrange to meet your key institution contacts face to face and any key contacts at external sites (if required).
- ☐ Familiarise yourself with the venue's emergency procedures.
- ☐ Tour the facility. Visit the rooms you will be using.
- ☐ Check the equipment you need is available in working order and you know how to use it (including lighting, heating and cooling).
- ☐ Ensure you have reviewed the delivery material and have checked any videos for the upcoming lectures will work on the available equipment (e.g. speakers).
- ☐ Familiarise yourself with the rest rooms available at the venue.
- ☐ Take note of any challenges associated with each room (e.g. noise, heat, lighting). Identify strategies to minimise these challenges.
- ☐ Prepare the student materials you will need to distribute at the first lecture (e.g. participant name tags and sign-in sheets).
- ☐ Check you have all the materials you need to deliver the course (including the Participant Guides).
- ☐ Distribute the PDF (soft copy) of the Participant Guide to participants prior to the first lecture if possible, to allow them to become familiar with the course materials and content.

Prior to each lecture:

- ☐ Ensure you are wearing a variety of wool garments that reflect the benefits and versatility of wool and wool products.
- ☐ Arrive 30 minutes before each lecture to check the equipment is available and working.

At commencement of the first lecture:

- ☐ Distribute the hard copy of the Participant Guide to each participant.
- ☐ Distribute name tags to each participant.
- ☐ Record those who are present.

After each lecture:

- ☐ Stay to answer any questions the participants may have about the course content.

Prior to the final lecture:

- ☐ Ensure you have received a sufficient number of the 'Certificates of Participation' to be distributed to the appropriate students following the completion of the final lecture.

At the completion of the course:

- ☐ Provide participants with the online feedback and evaluation survey link.
- ☐ Complete and submit your own online evaluation survey.
- ☐ Provide feedback to the institution regarding the successful completion of the course.
- ☐ Explore future delivery opportunities and liaise with The Woolmark Company regional office.

Post-course survey links:

Facilitator survey:
www.woolmarklearningcentre.com/wstd-surveyfacilitator

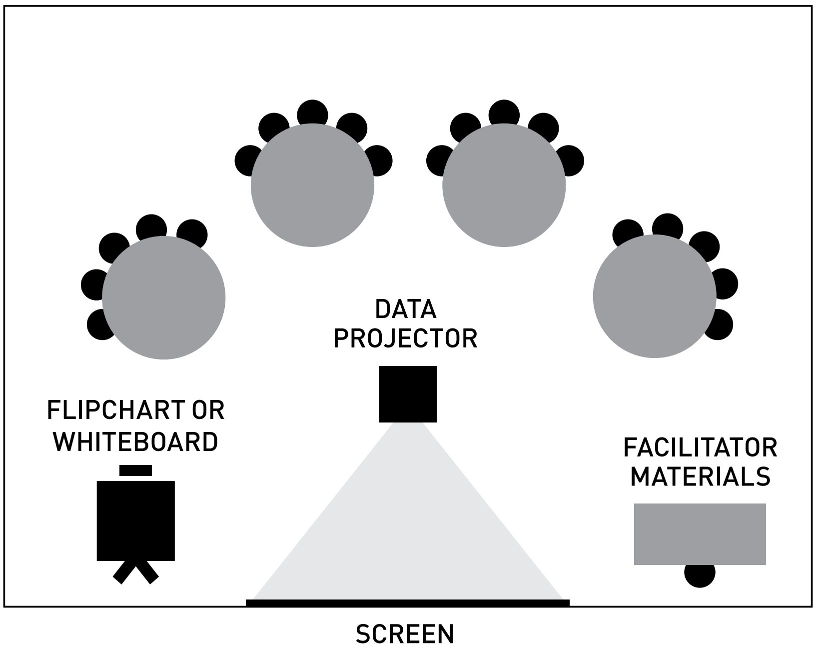
Participant survey:
www.woolmarklearningcentre.com/wstd-surveyparticipant

ROOM LAYOUT

The *Wool fabric finishing* course is designed to be delivered face-to-face, in groups of 6 – 50 people. In many cases this will mean delivery occurs in a large lecture theatre and there will not be an opportunity to influence the physical learning environment.

In smaller groups and settings where the learning environment can be influenced:

- arrange tables in a cabaret style (see diagram below) facing a flipchart or whiteboard and a data projector/screen
- allow for small group discussion in groups of three or four.



A GUIDELINE FOR THE EFFECTIVE AND ENGAGING DELIVERY OF THE COURSE CONTENT.

The course materials are designed to achieve a Gunning Fog Index of 8–10, with the exclusion of technical terms specific to the course.

The Gunning Fog Index formula implies short sentences written in plain English achieve a better score than long sentences written in complicated language.

Materials with a Gunning Fog Index of 8 have a readability equivalent to a Grade 8 reading level for English speaking students. It is considered the ideal score for readability. Anything above 12 is too hard for most people to read[1].

Information is provided in Appendix A for facilitators who wish to enhance their skills in facilitation by acknowledging the different learning styles of participants.

Research has shown each person has a preferred way of learning[2]. As adults, we tend to adopt the learning style with which we are most comfortable and ignore learning styles with which we are unfamiliar or uncomfortable. This means learning is most effective when a student can process information and solve problems in a way that is meets their preferred learning style.

When you know a person's learning style, you can present information to them so they can grasp it quickly and easily. If information is presented in a way that is at odds with their preferred learning style, the student will find it more difficult to learn. Sometimes this means, as a facilitator, you may have to present information to a student in a way that will engage them, although that may not be your preferred method. If you do not accommodate the student's preferred learning style, you make it harder to get the message across, which may lead to frustration on your part, as well as a lack of commitment from the student.

Honey & Mumford have developed a questionnaire, included in Appendix A, which helps you identify your students' preferred learning styles.

1 http://www.usingenglish.com/glossary/fog-index.html, http://juicystudio.com/services/readability.php
2 Kolb D. A. (1984). Experiential Learning experience as a source of learning and development, New Jersey: Prentice Hall.

APPENDIX A:
LEARNING STYLES QUESTIONNAIRE

NAME: ______________________________

This questionnaire is designed to find out your preferred learning style(s). Over the years you have probably developed learning "habits" that help you benefit more from some experiences than from others. Since you are probably unaware of this, this questionnaire will help you pinpoint your learning preferences so that you are in a better position to select learning experiences that suit your style and having a greater understanding of those that suit the style of others.

This is an internationally proven tool designed by Peter Honey and Alan Mumford.

There is no time limit to this questionnaire. It will probably take you 10-15 minutes. The accuracy of the results depends on how honest you can be. There are no right or wrong answers.

If you agree more than you disagree with a statement put a tick by it.

If you disagree more than you agree put a cross by it.

Be sure to mark each item with either a tick or cross.

- ☐ 1. I have strong beliefs about what is right and wrong, good and bad
- ☐ 2. I often act without considering the possible consequences
- ☐ 3. I tend to solve problems using a step-by-step approach
- ☐ 4. I believe that formal procedures and policies restrict people
- ☐ 5. I have a reputation for saying what I think, simply and directly
- ☐ 6. I often find that actions based on feelings are as sound as those based on careful thought and analysis
- ☐ 7. I like the sort of work where I have time for thorough preparation and implementation
- ☐ 8. I regularly question people about their basic assumptions
- ☐ 9. What matters most is whether something works in practice
- ☐ 10. I actively seek out new experiences
- ☐ 11. When I hear about a new idea or approach I immediately start working out how to apply it in practice
- ☐ 12. I am keen on self discipline such as watching my diet, taking regular exercise, sticking to a fixed routine, etc
- ☐ 13. I take pride in doing a thorough job
- ☐ 14. I get on best with logical, analytical people and less well with spontaneous, 'irrational' people
- ☐ 15. I take care over the interpretation of data available to me and avoid jumping to conclusions
- ☐ 16. I like to reach a decision carefully after weighing up many alternatives
- ☐ 17. I'm attracted more to novel, unusual ideas than to practical ones
- ☐ 18. I don't like disorganised things and prefer to fit things into a coherent pattern
- ☐ 19. I accept and stick to laid down procedures and policies so long as I regard them as an efficient way of getting the job done
- ☐ 20. I like to relate my actions to a general principle
- ☐ 21. In discussions I like to get straight to the point
- ☐ 22. I tend to have distant, rather formal relationships with people at work
- ☐ 23. I thrive on the challenge of tackling something new and different
- ☐ 24. I enjoy fun-loving, spontaneous people
- ☐ 25. I pay meticulous attention to detail before coming to a conclusion
- ☐ 26. I find it difficult to produce ideas on impulse
- ☐ 27. I believe in coming to the point immediately
- ☐ 28. I am careful not to jump to conclusions too quickly
- ☐ 29. I prefer to have as many resources of information as possible – the more data to think over the better
- ☐ 30. Flippant people who don't take things seriously enough usually irritate me
- ☐ 31. I listen to other people's points of view before putting my own forward
- ☐ 32. I tend to be open about how I'm feeling
- ☐ 33. In discussions I enjoy watching the manoeuvrings of the other participants
- ☐ 34. I prefer to respond to events on a spontaneous, flexible basis rather than plan things out in advance

- ☐ 35. I tend to be attracted to techniques such as network analysis, flow charts, branching programs, contingency planning, etc
- ☐ 36. It worries me if I have to rush out a piece of work to meet a tight deadline
- ☐ 37. I tend to judge people's ideas on their practical merits
- ☐ 38. Quiet, thoughtful people tend to make me feel uneasy
- ☐ 39. I often get irritated by people who want to rush things
- ☐ 40. It is more important to enjoy the present moment than to think about the past or future
- ☐ 41. I think that decisions based on a thorough analysis of all the information are sounder than those based on intuition
- ☐ 42. I tend to be a perfectionist
- ☐ 43. In discussions I usually produce lots of spontaneous ideas
- ☐ 44. In meetings I put forward practical realistic ideas
- ☐ 45. More often than not, rules are there to be broken
- ☐ 46. I prefer to stand back from a situation
- ☐ 47. I can often see inconsistencies and weaknesses in other people's arguments
- ☐ 48. On balance I talk more than I listen
- ☐ 49. I can often see better, more practical ways to get things done
- ☐ 50. I think written reports should be short and to the point
- ☐ 51. I believe that rational, logical thinking should win the day
- ☐ 52. I tend to discuss specific things with people rather than engaging in social discussion
- ☐ 53. I like people who approach things realistically rather than theoretically
- ☐ 54. In discussions I get impatient with irrelevancies and digressions
- ☐ 55. If I have a report to write I tend to produce lots of drafts before settling on the final version
- ☐ 56. I am keen to try things out to see if they work in practice
- ☐ 57. I am keen to reach answers via a logical approach
- ☐ 58. I enjoy being the one that talks a lot
- ☐ 59. In discussions I often find I am the realist, keeping people to the point and avoiding wild speculations
- ☐ 60. I like to ponder many alternatives before making up my mind
- ☐ 61. In discussions with people I often find I am the most dispassionate and objective
- ☐ 62. In discussions I'm more likely to adopt a "low profile" than to take the lead and do most of the talking
- ☐ 63. I like to be able to relate current actions to a longer term bigger picture
- ☐ 64. When things go wrong I am happy to shrug it off and "put it down to experience"
- ☐ 65. I tend to reject wild, spontaneous ideas as being impractical
- ☐ 66. It's best to think carefully before taking action
- ☐ 67. On balance I do the listening rather than the talking
- ☐ 68. I tend to be tough on people who find it difficult to adopt a logical approach
- ☐ 69. Most times I believe the end justifies the means
- ☐ 70. I don't mind hurting people's feelings so long as the job gets done
- ☐ 71. I find the formality of having specific objectives and plans stifling
- ☐ 72. I'm usually one of the people who puts life into a party
- ☐ 73. I do whatever is expedient to get the job done
- ☐ 74. I quickly get bored with methodical, detailed work
- ☐ 75. I am keen on exploring the basic assumptions, principles and theories underpinning things and events
- ☐ 76. I'm always interested to find out what people think
- ☐ 77. I like meetings to be run on methodical lines, sticking to laid down agenda, etc.
- ☐ 78. I steer clear of subjective or ambiguous topics
- ☐ 79. I enjoy the drama and excitement of a crisis situation
- ☐ 80. People often find me insensitive to their feelings

SCORING AND INTERPRETING THE LEARNING STYLES QUESTIONNAIRE

The Questionnaire is scored by awarding one point for each ticked item. There are no points for crossed items. Simply indicate on the lists below which items were ticked by circling the appropriate question number.

	2	7	1	5
	4	13	3	9
	6	15	8	11
	10	16	12	19
	17	25	14	21
	23	28	18	27
	24	29	20	35
	32	31	22	37
	34	33	26	44
	38	36	30	49
	40	39	42	50
	43	41	47	53
	45	46	51	54
	48	52	57	56
	58	55	61	59
	64	60	63	65
	71	62	68	69
	72	66	75	70
	74	67	77	73
	79	76	78	80
TOTALS	________	________	________	________
	Activist	**Reflector**	**Theorist**	**Pragmatist**

LEARNING STYLES QUESTIONNAIRE PROFILE BASED ON GENERAL NORMS FOR 1302 PEOPLE

ACTIVIST	REFLECTOR	THEORIST	PRAGMATIST	
20	20	20	20	Very strong preference
19				
18		19	19	
17				
16		18		
15		17	18	
14				
13	18	16	17	
12	17	15	16	Strong preference
	16			
11	15	14	15	
10	14	13	14	Moderate
9	13	12	13	
8				
7	12	11	12	
6	11	10	11	Low preference
5	10	9	10	
4	9	8	9	
3	8	7	8	Very low preference
	7	6	7	
	6	5	6	
2	5	4	4	
	4	3	3	
	3			
1	2	2	2	
	1	1	1	
0	0	0	0	

LEARNING STYLES – GENERAL DESCRIPTIONS

Activists

Activists involve themselves fully and without bias in new experiences. They enjoy the here and now and are happy to be dominated by immediate experiences. They are open-minded, not sceptical, and this tends to make them enthusiastic about anything new. Their philosophy is: "I'll try anything once". They tend to act first and consider the consequences afterwards. Their days are filled with activity. They tackle problems by brainstorming. As soon as the excitement from one activity has died down they are busy looking for the next. They tend to thrive on the challenge of new experiences but are bored with implementation and longer-term consolidation. They are gregarious people constantly involving themselves with others but in doing so they seek to centre all activities on themselves.

Reflectors

Reflectors like to stand back to ponder experiences and observe them from many different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to any conclusion. The thorough collection and analysis of data about experiences and events is what counts so they tend to postpone reaching definitive conclusions for as long as possible. Their philosophy is to be cautious. They are thoughtful people who like to consider all possible angles and implications before making a move. They prefer to take a back seat in meetings and discussions. They enjoy observing other people in action. They listen to others and get the drift of the discussion before making their own points. They tend to adopt a low profile and have a slightly distant, tolerant unruffled air about them. When they act it is part of a wide picture which includes the past as well as the present and others' observations as well as their own.

Theorists

Theorists adapt and integrate observations into complex but logically sound theories. They think problems through in a vertical, step-by-step logical way. They assimilate disparate facts into coherent theories. They tend to be perfectionists who won't rest easy until things are tidy and fit into a rational scheme. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories models and systems thinking. Their philosophy prizes rationality and logic. "If it's logical it's good". Questions they frequently ask are: "Does it make sense?" "How does this fit with that?" "What are the basic assumptions?" They tend to be detached, analytical and dedicated to rational objectivity rather than anything subjective or ambiguous. Their approach to problems is consistently logical. This is their "mental set" and they rigidly reject anything that doesn't fit with it. They prefer to maximise certainty and feel uncomfortable with subjective judgments, lateral thinking and anything flippant.

Pragmatists

Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications. They are the sorts of people who return from management courses brimming with new ideas that they want to try out in practice. They like to get on with things and act quickly and confidently on ideas that attract them. They tend to be impatient with ruminating and open-ended discussions. They are essentially practical, down to earth people who like making practical decisions and solving problems. They respond to problems and opportunities "as a challenge". Their philosophy is: "There is always a better way" and "if it works it's good".

In descending order of likelihood, the most common combinations are:

1st Reflector/Theorist
2nd Theorist/Pragmatist
3rd Reflector/Pragmatist
4th Activist/Pragmatist

LEARNING STYLES – A FURTHER PERSPECTIVE

ACTIVISTS:

Activists *learn best from activities where:*

- There are new experiences/problems/opportunities from which to learn.
- They can engross themselves in short "here and now" activities such as business games, competitive teamwork tasks, role-playing exercises.
- There is excitement/drama/crisis and things chop and change with a range of diverse activities to tackle
- They have a lot of the limelight/high visibility, i.e. they can "chair" meetings, lead discussions, and give presentations.
- They are allowed to generate ideas without constraints of policy or structure or feasibility.
- They are thrown in at the deep end with a task they think is difficult, i.e. when set a challenge with inadequate resources and adverse conditions.
- They are involved with other people, i.e. bouncing ideas off them, solving problems as part of a team.
- It is appropriate to "have a go".

Activists *learn least from, and may react against, activities where:*

- Learning involves a passive role, i.e. listening to lectures, monologues, explanations, statements of how things should be done, reading, watching.
- They are asked to stand back and not be involved.
- They are required to assimilate, analyse and interpret lots of "messy" data.
- They are required to engage in solitary work, i.e. reading, writing, thinking on their own.
- They are asked to assess beforehand what they will learn, and to appraise afterwards what they have learned.
- They are offered statements they see as "theoretical", i.e. explanation of cause or background
- They are asked to repeat essentially the same activity over and over again, i.e. when practicing.
- They have precise instructions to follow with little room for manoeuvre.
- They are asked to do a thorough job, i.e. attend to detail, tie up loose ends, dot the i's, cross t's.

Summary of strengths

- Flexible and open minded.
- Happy to have a go.
- Happy to be exposed to new situations.
- Optimistic about anything new and therefore unlikely to resist change.

Summary of weaknesses:

- Tendency to take the immediately obvious action without thinking.
- Often take unnecessary risks.
- Tendency to do too much themselves and hog the limelight.
- Rush into action without sufficient preparation.
- Get bored with implementation/consolidation.
- Key questions for activists:
- Shall I learn something new, i.e. that I didn't know/ couldn't do before?
- Will there be a wide variety of different activities? (I don't want to sit and listen for more than an hour at a stretch!)
- Will it be OK to have a go/let my hair down/make mistakes/have fun?
- Shall I encounter some tough problems and challenges?
- Will there be other like-minded people to mix with?

REFLECTORS:

Reflectors *learn best from activities where:*

- They are allowed or encouraged to watch/think/chew over activities.
- They are able to stand back from events and listen/ observe, i.e. observing a group at work, taking a back seat in a meeting, watching a film or video.
- They are allowed to think before acting, to assimilate before commencing, i.e. time to prepare, a chance to read in advance a brief giving background data.
- They can carry out some painstaking research, i.e. investigate, assemble information, and probe to get to the bottom of things.
- They have the opportunity to review what has happened, what they have learned.
- They are asked to produce carefully considered analyses and reports.

– They are helped to exchange views with other people without danger, i.e. by prior agreement, within a structured learning experience.
– They can reach a decision in their own time without pressure and tight deadlines.

Reflectors *learn least from, and may react against, activities where:*

– They are "forced" into the limelight, i.e. to act as leader/chairman, to role-play in front of on-lookers.
– They are involved in situations which require action without planning.
– They are pitched into doing something without warning, i.e. to produce an instant reaction, to produce an off-the-top-of-the-head idea.
– They are given insufficient data on which to base a conclusion.
– They are given cut and dried instructions of how things should be done.
– They are worried by time pressures or rushed from one activity to another.
– In the interests of expediency they have to make short cuts or do a superficial job.

Summary of strengths:

– Careful.
– Thorough and methodical
– Thoughtful
– Good at listening to others and assimilating information.
– Rarely jump to conclusions.

Summary of weaknesses:

– Tendency to hold back from direct participation.
– Slow to make up their minds and reach a decision.
– Tendency to be too cautious and not take enough risks.
– Not assertive - they aren't particularly forthcoming and have no "small talk".

Key questions for reflectors:

– Shall I be given adequate time to consider, assimilate and prepare?
– Will there be opportunities/facilities to assemble relevant information?
– Will there be opportunities to listen to other people's points of view – preferably a wide cross section of people with a variety of views?
– Shall I be under pressure to be slapdash or to extemporise?

THEORISTS:

Theorists *learn best from activities where:*

– What is being offered is part of a system, model, concept, or theory.
– The have time to explore methodically the associations and inter-relationships between ideas, events and situations.
– They have the chance to question and probe the basic methodology, assumptions or logic behind something, i.e. by taking part in a question and answer session, by checking a paper for inconsistencies.
– They are intellectually stretched, i.e. by analysing a complex situation, being tested in a tutorial session, by teaching high calibre people who ask searching questions.
– They are in structured situations with a clear purpose.
– They can listen to or read about ideas and concepts that emphasise rationality or logic and are well argued/elegant/watertight.
– They can analyse and then generalise the reasons for success or failure.
– They are offered interesting ideas and concepts even though they are not immediately relevant.
– They are required to understand and participate in complex situations.

Theorists *learn least from, and may react against, activities where:*

- They are pitch-forked into doing something without a context or apparent purpose.
- They have to participate in situations emphasising emotions and feelings.
- They are involved in unstructured activities where ambiguity and uncertainty are high, i.e. with open¬ended problems, on sensitivity training.
- They are asked to act or decide without a basis in policy, principle or concept.
- They are faced with a hotchpotch of alternative/contradictory techniques/methods without exploring any in depth, i.e. as on a "once over lightly" course.
- They find the subject matter platitudinous, shallow or gimmicky.
- They feel themselves out of tune with other participants, i.e. when with lots of Activists or people of lower intellectual calibre.

Summary of strengths:

- Logical "vertical" thinkers.
- Rational and objective.
- Good at asking probing questions.
- Disciplined approach.

Summary of weaknesses:

- Restricted in lateral thinking.
- low tolerance for uncertainty, disorder and ambiguity
- Intolerant of anything subjective or intuitive.
- Full of "shoulds, oughts and musts".

Key questions for theorists:

- Will there be lots of opportunities to question?
- Do the objectives and program of events indicate a clear structure and purpose?
- Shall I encounter complex ideas and concepts that are likely to stretch me?
- Are the approaches to be used and concepts to be explored "respectable", i.e. sound and valid?
- Shall I be with people of similar calibre to myself?

PRAGMATIST:

Pragmatists *learn best from activities where:*

- There is an obvious link between the subject matter and a problem or opportunity on the job.
- They are shown techniques for doing things with obvious practical advantages, i.e. how to save time, how to make a good first impression, how to deal with awkward people.
- They have the chance to try out and practice techniques with coaching/feedback from a credible expert, i.e. someone who is successful and can do the techniques themselves.
- They are exposed to a model they can emulate, i.e. a respected boss, a demonstration from someone with a proven track record, lots of examples/anecdotes, and a film showing how it's done.
- They are given techniques currently applicable to their own job.
- They are given immediate opportunities to implement what they have learned.
- There is a high face validity in the learning activity, i.e. a good simulation, "real" problems.
- They can concentrate on practical issues, i.e. drawing up action plans with an obvious end product, suggesting short cuts, giving tips.

Pragmatists *learn least from, and may react against, activities where:*

- The learning is not related to an immediate need they recognise/they cannot see, an immediate relevance/practical benefit.
- Organisers of the learning, or the event itself, seems distant from reality, i.e. "ivory towered", all theory and general principles, pure "chalk and talk".
- There is no practice or clear guidelines on how to do it.
- They feel that people are going round in circles and not getting anywhere fast enough.
- There are political, managerial or personal obstacles to implementation.
- There is no apparent reward from the learning activity, i.e. more sales, shorter meetings, higher bonus, promotion.

Summary of strengths:

- Keen to test things out in practice.
- Practical, down to earth, realistic.
- Businesslike – gets straight to the point.
- Technique oriented.

Summary of weaknesses:

- Tendency to reject anything without an obvious application.
- Not very interested in theory or basic principles.
- Tendency to seize on the first expedient solution to a problem.
- Impatient with waffle.
- On balance, task oriented not people oriented.

Key questions for pragmatists:

- Will there be ample opportunities to practice and experiment?
- Will there be lots of practical tips and techniques?
- Shall we be addressing real problems and will it result in action plans to tackle some of my current problems?
- Shall we be exposed to experts who know how to/can do it themselves?

GLOSSARY

ACRONYMS, ABBREVIATIONS AND UNITS OF MEASUREMENT

%OWW	Percentage on weight of wool
ASTM	American Society for Testing and Materials
AWTOMEC	Australian Wool Textile Objective Measurement Executive Committee
BL	Bending length
BR	Bending rigidity
CEN	European Committee for Standardisation
DCCA	Dichloroisocyanuric acid
DCF	Dimensional change factor (%)
DCR	Dimensional change — relaxation
DFE	Directional friction effect
GB (China)	National Standards (Guobiao) of China
HE	hygral expansion (%)
KES-F	Kawabata Evaluation System for Fabrics
MEAS	Monoethanolamine sesquisulfite
OBA	Optical brightening agents
PMS	permonosulphate salts, also permonosulphuric acid
TWC	The Woolmark Company
UV	ultra-violet

GLOSSARY

Term	Definition
actual dimensions	The dimensions of the fabric as presented in the absence of relaxation.
aesthetic	Refers to the appearance of the fabric, its performance during garment manufacture and how it maintains its appearance during wear.
bagging	A process in which the selvedges of a fabric are sewn together to prevent the formation of running marks or permanent creases in the fabric during rope processing.
batch (rope) scouring	A process in which the required amount fabric in rope form is placed in the machine, alternately immersed in the scouring liquor and squeezed through the rollers, and then removed when clean.
batch processing	A technique in which the fabric undergoes a single operation in a machine and is then removed (manually).
beaming	A wet pre-setting operation, similar to potting but the roll is immersed in warm (approximately 40°C) water (as opposed to hot water).
bruising	Milling faults evident as scuff marks, formed when the fabric slips in the rollers of the milling machine.
brushing	A form of raising that lifts fibre on the fabric surface before shearing, or lays pile already on the surface of the fabric using rotating brushes.
cohesive set	Set released when wool is wet out in water at 20oC or heated in steam. Responsible for relaxation shrinkage.
conditioning	A process designed to increase the moisture content of wool fabrics, where: • the fabric is sprayed with water • the fabric is sprayed with water • steam is passed through the fabric.
continuous processing	Processes where the fabric continuously enters the front of the machine and exits at the end of the process, so fabric is continuously entering and exiting the process without interruption.
continuous scouring	A process in which the fabric is treated in a continuous machine and repeatedly immersed in the bath, or the scouring bath is sprayed onto the fabric. The liquid is repeatedly squeezed from the fabrics as the direction is reversed around rollers.
couple	The force used to bend the fabric in the KES-F2 bending meter (µN).
cover factor	A measure of the density of threads in a woven fabric; the ratio of the yarn diameter (mm) to the thread spacing (mm).

Term	Definition
crabbing	A batch open-width pre-setting process that can be used to permanently flat set the fabric.
crimp interchange	The reduction of the crimp in the yarns of fabric in the direction of extension and associated increase increasing the crimp in the cross-threads.
curvature	The extent to which the fabric bends (m-1).
decatising	A setting process in which the fabric is wrapped with a interleaving cloth onto a drum, steamed, cooled then unrolled. The process can be batch or continuous.
dimensional change relaxation	The difference between actual dimensions (held by cohesive set) and relaxed dimensions of the wool fabric.
ends	Warp threads.
fabric development	A process in which the wet fabric is subjected to mild mechanical action, also called light milling or 'bursting' the yarns to soften the handle.
felting shrinkage	Fabric shrinkage that occurs when fibres lock together when subjected to mechanical action and become increasingly entangled.
festoon	Loops of fabric hung from bars.
float	This term describes the average number of threads crossed between interlacings.
formability	A measurement derived from bending rigidity and extensibility that predicts the appearance of seams in tailored garments, especially for overfed seams.
functionality	Refers to how a fabric performs in wear and laundering (e.g. abrasion resistance).
glass transition temperature	The temperature at which macromolecules in a polymer rapidly become more mobile and the polymer is more easily deformed.
loom-state condition	Unfinished fabric as it comes off the loom, generally unusable. Sometimes also referred to as 'greasy' .
mangle	A mechanical drying process where the fabric is squeezed between two rollers to remove excess water.
Merino Extrafine	Woolmark sub-brand used on a product where the wool fibre has a mean fibre diameter of less than 19.75μm.
milling	A process to impart control felting of fabric (called 'fulling' in the US), where the fabric becomes thicker and stiffer due to increased fibre entanglement.

Term	Definition
nap	The raised fuzzy surface, which is required on certain fabrics.
permanent set	Set stable to release in water at 70°C for 30 minutes
picks	Weft threads.
potting	A wet pre-setting operation in which the fabric is wet out, wrapped on a cloth-covered (often canvas-covered) roller and held at ~60oC for an extended time.
pressing	A process where fabrics are flattened, smoothed and thickness reduced by pressing them between flat surfaces and/or rollers at high pressure and temperature.
Pure Merino Wool	A Woolmark sub-brand used on products from 100% wool with a mean fibre diameter of less than 22.5μm.
raising	A process used to draw fibres to the surface of a fabric (called a pile), also called teazelling, gigging or napping.
recovery from extension	A measure of the ratio of the work to extend the fabric to the energy recovered on recovery.
recovery from shear	The residual strain in the fabric when the shear load is zero.
regain	A measure of moisture content.
relaxation shrinkage	The dimensional change that can occur when a yarn or fabric is allowed to relax by immersing it in water, or exposing it to steam.
relaxed dimensions	The dimensions adopted by the fabric when the fibres are relaxed by steaming or by immersion in water and reconditioning the fabric.
rub fastness	The ability of the dye to be permanent and not rub off onto adjacent fabrics.

Term	Definition
saponify	The process of converting a fat into soap, by treating with an alkali.
seam slippage	The inability of the fabric to form a stable seam when sewn due the mobility of the yarns under lateral load.
sett	The number of threads per unit length of fabric: • warp sett: sett of warp threads across the fabric • weft sett: sett of weft threads along the fabric.
setting	A process in which the shape of a wool product is changed by deforming it under conditions where it will not return to its original shape.
shearing	A process in which fibres protruding from the fabric surface are cut off (also called cropping).
singeing	A process to burn fibres protruding from the surface of the fabric to create a .clean surface.
skew	An unwanted effect of finishing, occurs when weft yarns are straight from one end to another end, but not at right angles to the warp threads
specifications	The criteria that define the limits of performance (maximum or minimum), which must be met to satisfy the customer requirements.
spin hydroextraction	A mechanical drying process where fabric is spun centrifugally to remove excess water.
sponging	A damping and steaming process designed to relax fabric, thereby removing any residual relaxation shrinkage also known as 'London shrinking'.
spotting	White spots on the fabric, caused by small particles of cured polymer lying on the surface of the fabric, a challenge associated with the use of silicone softeners.

WOOL FABRIC FINISHING

WELCOME participants as they arrive, ensuring they collect their pre-prepared name tags or ask them to write their name on a tag as they arrive.

ENSURE each participant takes a copy of the Participant Guide and records their attendance.

INTRODUCE yourself and provide a brief (maximum three-minute) overview of your role, experience and broad objectives in delivering this series of lectures.

After introducing yourself, if you have a group of 20 participants or less, ask each participant to provide a brief introduction (name, role and organisation, or area of study) and share three things they wish to achieve by attending this series of lectures.

NOTE: If you have 20 participants and they each take about 30 seconds to introduce themselves and their objectives, this exercise will require 10 minutes.

Keep it brief. You may need to modify your approach, based on the number of participants in the room. For example, in a large group (20+ participants select a small sample of participants to introduce themselves and share their expectations).

RECORD AND group participants' responses regarding their own learning objectives on the flipchart or whiteboard.

This introduction will expand upon your understanding of each participant's needs and attitude towards their participation in the program and will give them the opportunity to build rapport with you as the facilitator and other participants in the group.

EXPLAIN TO participants you will revisit these objectives throughout the course to ensure each objective has been covered or participants are directed to additional resources that will help them meet their own learning objectives.

Endeavour to draw on these participant objectives as you progress through the course.

SET UP guidelines for participant interaction by stating that if you ask a question of the audience, the correct answer is acceptable, the incorrect answer also is acceptable, however silence is unacceptable.

ENCOURAGE participants to ask questions by reassuring them that all questions are valuable.

SPEND a few moments exploring participants current understanding of wool. Establishing how much individuals, or the group as a whole, already know about wool will allow you to acknowledge and leverage the experience of those in the room and tailor the content and delivery of the course appropriately to either dispel misperceptions or build on current understanding.

ALLOW about 5–10 minutes for a group discussion prompted by a questioning approach outlined below.

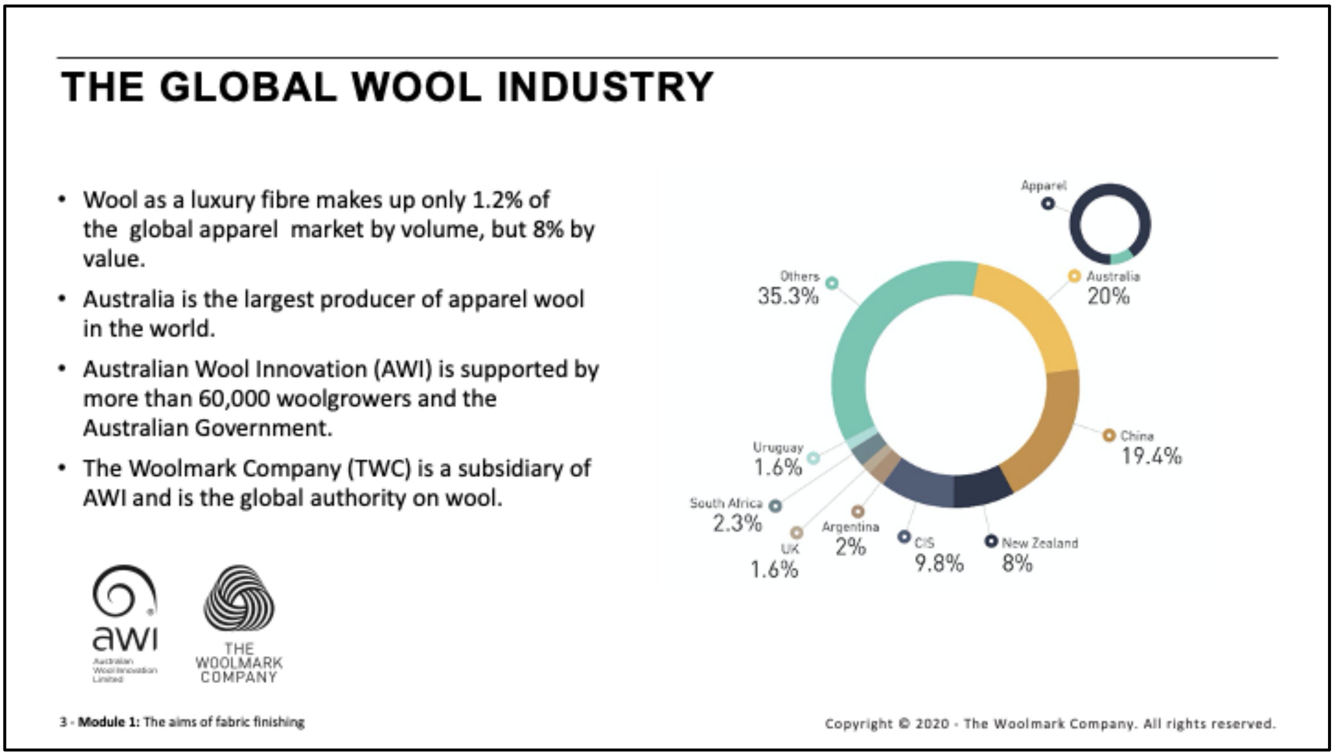
ASK *participants to share what they already know about wool.*

Examples of questions you might ask to encourage participation include:

- *What does 'fabric finishing' mean?*
- *Why do we need to finish fabrics?*
- *Is finishing one operation or many?*
- *Is finishing always done the same way?*

RECORD *responses to the above questions on a flipchart or whiteboard and explain that you will re-visit the responses at the end of this module and the course to reflect upon what participants may have learnt during the course.*

NOTE: *If participants have not already been introduced to Australian Wool Innovation (AWI) and The Woolmark Company (TWC) insert this short presentation here, before continuing with Module 1—The aims of fabric finishing.*



REFER TO the slide as you indicate that Australian woolgrowers produce 90% of the world's fine apparel wool as part of Australia's $2.5 billion wool export industry*.

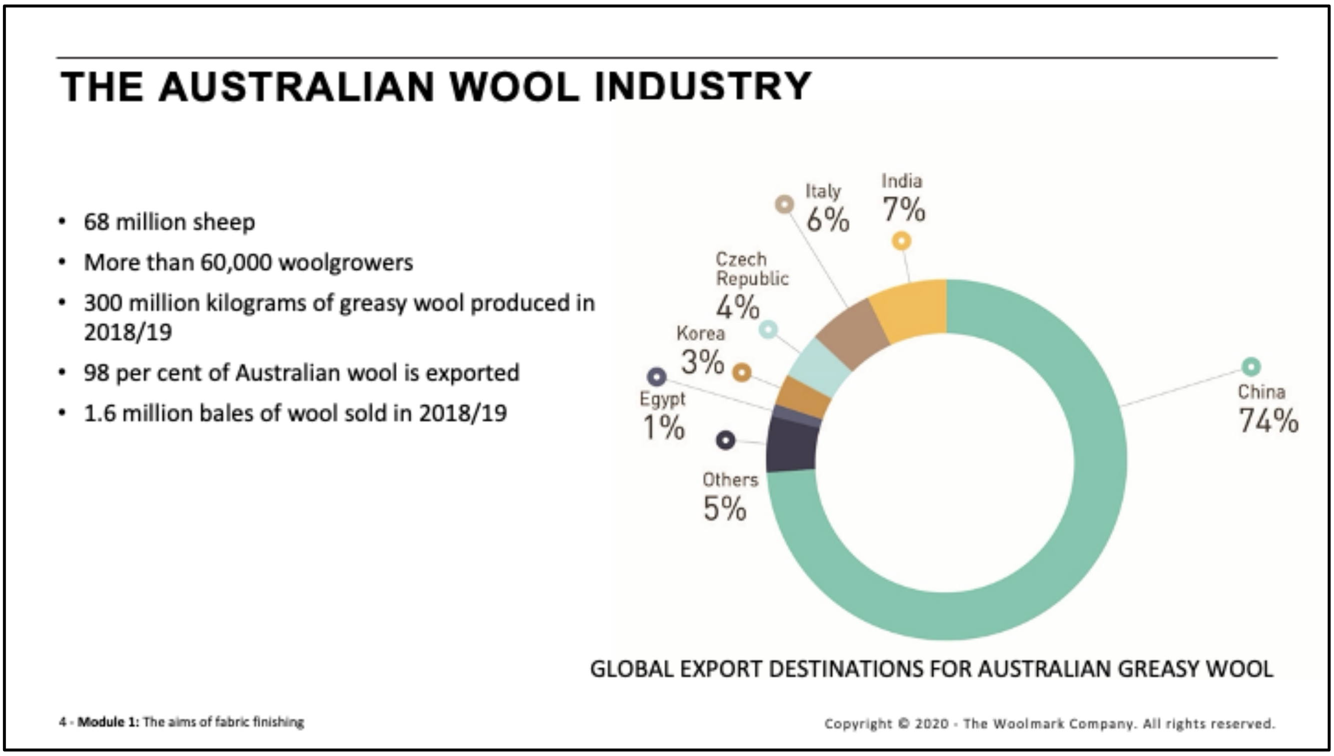
**Source ABARES Agricultural Commodities, March 2020 quarter.*

EXPLAIN THAT Australian Wool Innovation (AWI) is the research, development and marketing body for the Australian wool industry, supported by more than 60,000 Australian woolgrowers, who co-invest with the Australian government to support the activities carried out by AWI and TWC along the global wool supply chain.

EXPLAIN THAT The Woolmark Company is a subsidiary of Australian Wool Innovation and is a global authority on Merino wool. With a network that spans the entire global wool supply chain The Woolmark Company builds awareness and promotes the unique traits of nature's finest fibre.

REINFORCE THAT The Woolmark Company collaborates with global experts on all aspects of wool science, technology and design to develop and deliver educational materials, such as the course you are about to deliver.

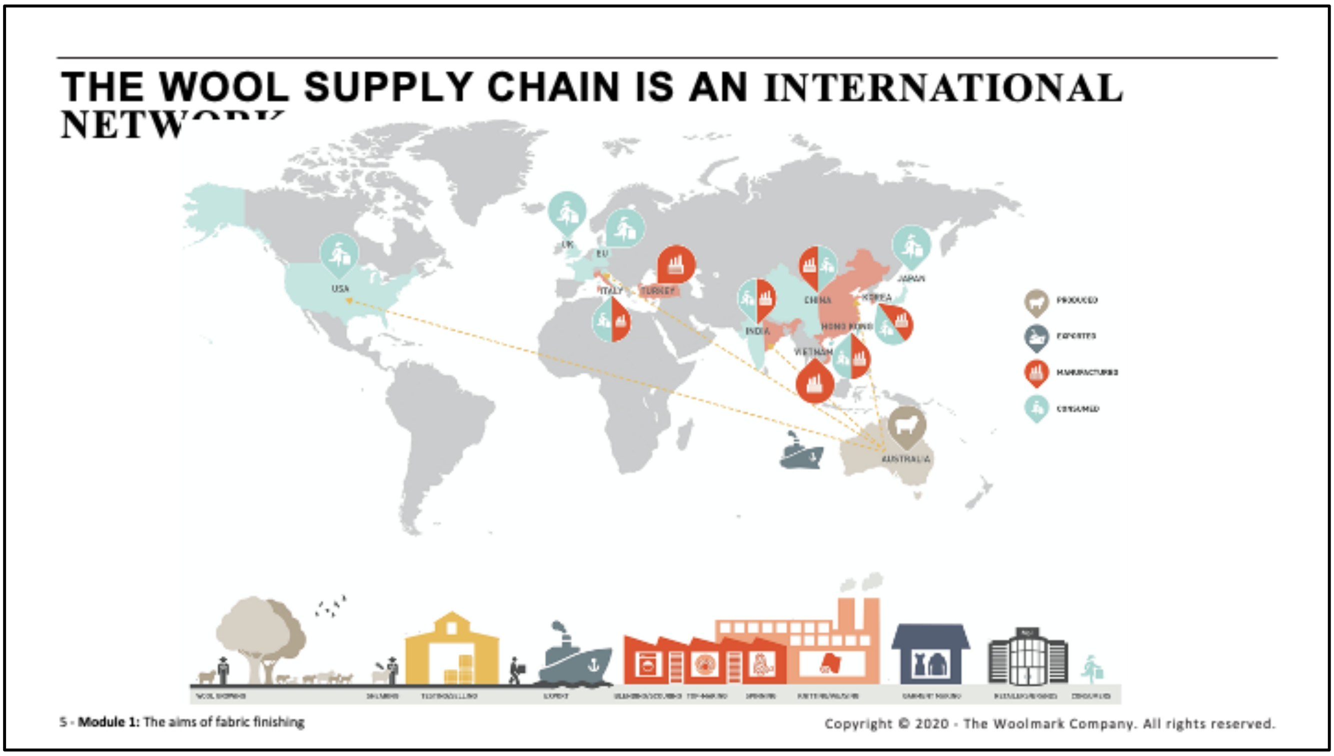
NOTE THAT you will provide a brief overview of the Australian wool industry and global supply chain, and elaborate on the role of The Woolmark Company in the global context before commencing the technical components of the course



EXPLAIN THAT there are more than 68 million sheep in Australia, carefully managed by more than 60,000 woolgrowers.

INDICATE THAT in 2018/19 Australia's woolgrowers produced 300 million kilograms of greasy wool and sold 1.6 million bales of wool.

POINT OUT that 98 per cent of Australia's wool is exported to other countries for further processing into a diverse range of products.



REFER TO the slide as you explain that it offers a snapshot of the global dynamics of the Australian wool industry, illustrating where the key export markets are for Australian wool, where most wool is processed from its raw state into yarn and fabrics and where the fashion and trend influencers and wool consumers are located.

NOTE THAT countries such as China, India and Italy are major manufacturers and consumers of wool products.

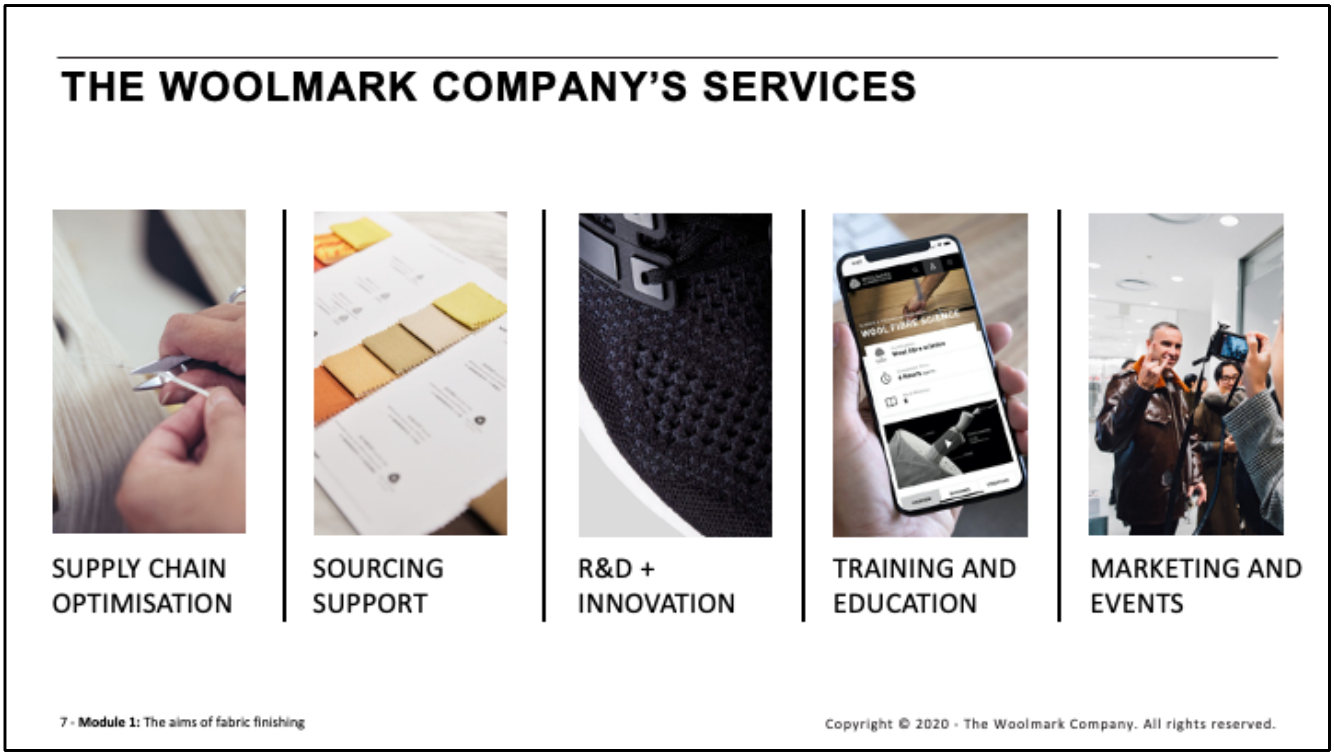
EXPLAIN THAT in line with these global dynamics, The Woolmark Company head office in Sydney, Australia is supported by a growing number of regional offices globally. Through this support The Woolmark Company invests in innovation along the global wool supply chain.

REINFORCE THAT The Woolmark Company works on behalf of Australia's 60,000+ woolgrowers, who are responsible for producing 90 per cent of the world's fine apparel wool.

EXPLAIN THAT The Woolmark Company's parent body — Australian Wool Innovation — invests in on-farm research and development to deliver new knowledge to woolgrowers to increase the profitability and sustainability of the growing wool business.

NOTE THAT The Woolmark Company strives to deliver tangible solutions across the global wool textile industry through process and product research and development.

EXPLAIN THAT the Woolmark Company builds industry confidence through communication, collaboration and a range of educational programs across the industry.



EXPLAIN THAT The Woolmark Company partners with designers, brands and retailers worldwide, offering support with quality assurance, product innovation and supply chain assistance.

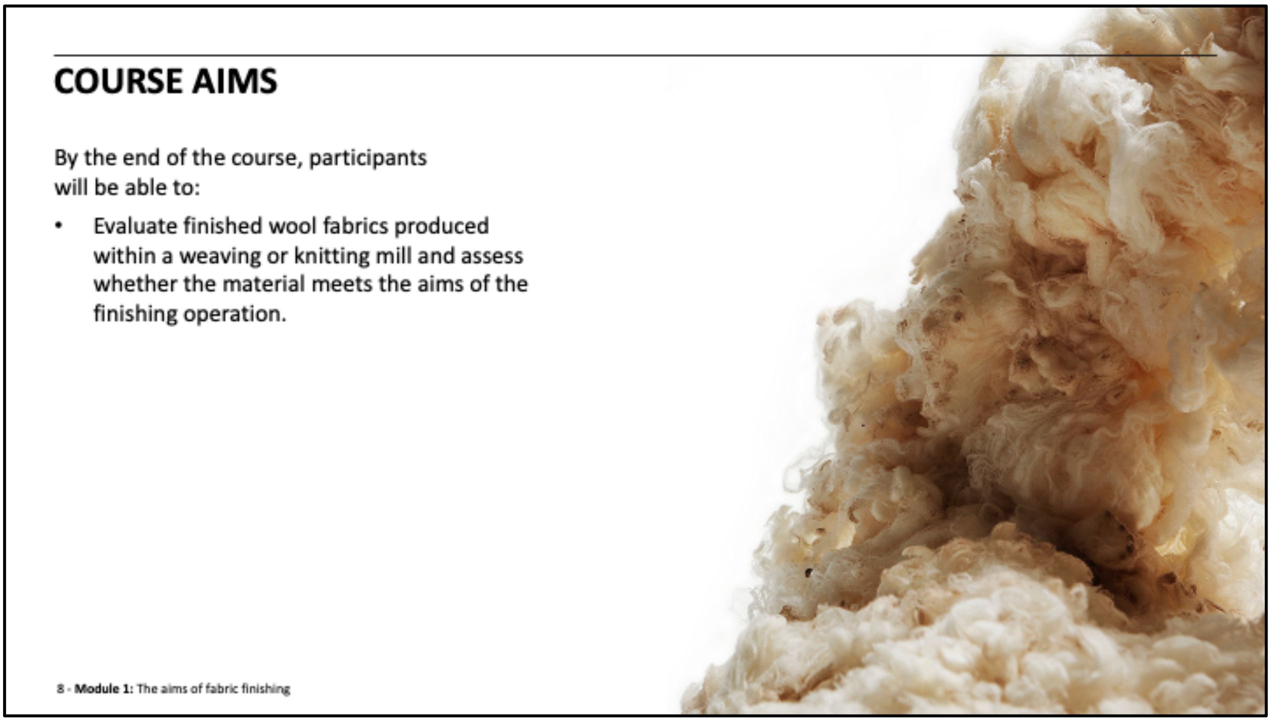
INDICATE THAT The Woolmark Company provides sourcing support through direct access to the global wool manufacturing industry through The Wool Lab. A seasonal guide to the latest innovations in wool, fabrics are sourced from the world's best spinners and weavers in the global supply network.

REINFORCE THAT The Woolmark Company takes secures funding and delivers research to improve wool production and processing through fibre science, traceability and fibre advocacy.

EXPLAIN THAT The Woolmark Company offers a range of online and face-to-face training programs to educate the industry. During 2019, The Woolmark Company launched the Woolmark Learning Centre, an online educational hub for industry professionals.

POINT OUT that The Woolmark Company markets the performance and environmental benefits of the fibre to ensure industry and consumers are informed and inspired to make better purchasing choices.

ASK PARTICIPANTS if they have any questions about the Woolmark Company before you proceed with the course aims.

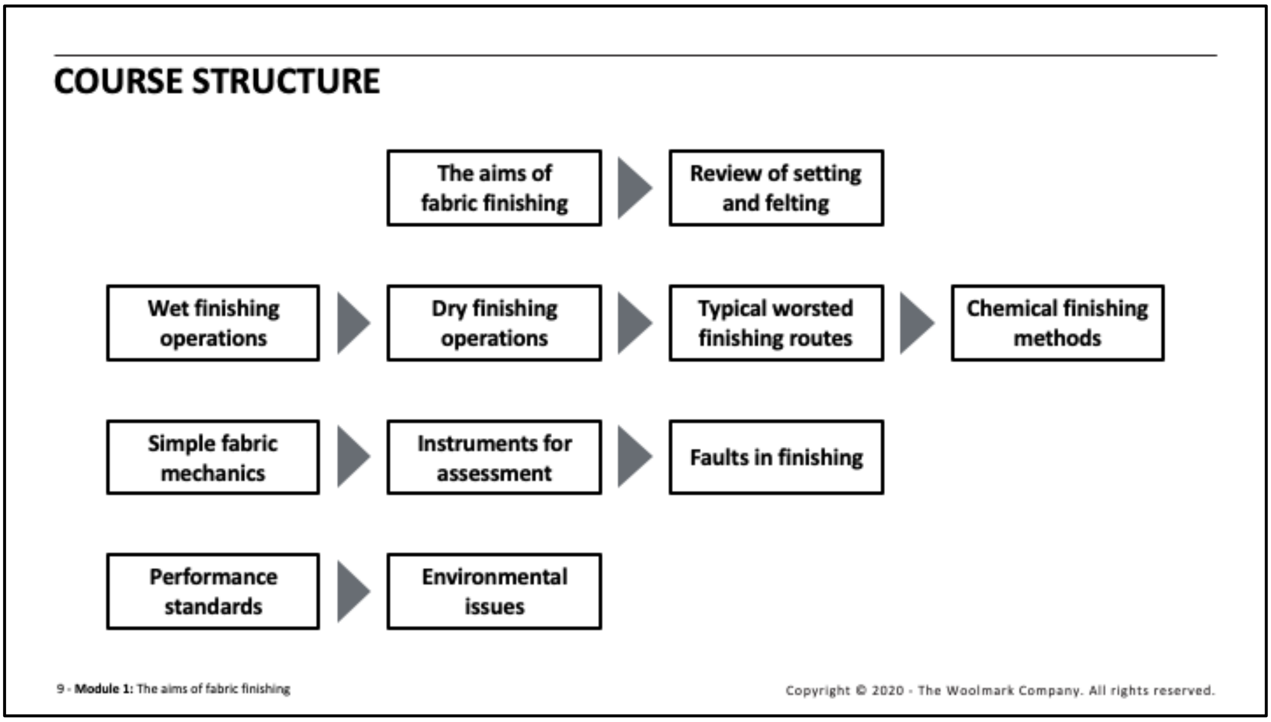


EXPLAIN THAT the aim of the *Wool fabric finishing* course is to provide participants with an understanding of:

- why the finishing of wool fabrics is important
- how fabrics are finished
- how finishing operations are evaluated.

INFORM participants that by the end of the course, they will be able to

- evaluate finished wool fabrics produced within a weaving or knitting mill and assess whether the material meets the aims of the finishing operation.



NOTE: The sequence of the following information may differ from the actual presentation to allow for differences in venue and participant prior knowledge and experience.

EXPLAIN THAT this course takes an in-depth look at the finishing processes applied to wool fabrics, the purpose and operations carried out under each procedure and the factors affecting the final quality of the finished product.

INDICATE THAT in particular this course explores:

- the purpose of each fabric finishing operation
- how each finishing operation is performed
- some specific finishing routines for individual fabrics.
- how the success of each finishing operation can be assessed
- the side effects of each operation.

NOTE TO FACILITATOR: *The first two modules, The aims of fabric finishing and Review of setting and felting, are short in nature and can be combined into a single lecture, particular where students are already familiar with the concepts of setting and felting.*

THE AIMS OF FABRIC FINISHING

RESOURCES — MODULE 1: THE AIMS OF FABRIC FINISHING

Contained in the *Wool fabric finishing* Demonstration kit you will find the following resources for use as you deliver **Module 1: The aims of fabric finishing**:

- sample of woollen fabric (unfinished)
- sample of woollen fabric (finished)
- sample of plain weave worsted fabric (unfinished)
- sample of plain weave worsted fabric (finished)
- sample of circular knitted fabric (unfinished)
- sample of circular knitted fabric (finished)

Additional resources to be sourced by the facilitator include:

- textile dictionary

EXPLAIN THAT this module covers the following issues:

- aims of fabric finishing
- types of fabric that require finishing
- requirements of a finished fabric
- potential unwanted effects of finishing.

INFORM participants that by the end of this module they will be able to:

- describe the aims of fabric finishing
- differentiate between the functional properties and aesthetic characteristics of wool
- describe the requirements of a finished fabric
- identify some of the potential unwanted effects that can occur from finishing processes.

RESOURCES REQUIRED FOR THIS MODULE

- *sample of woollen fabric (unfinished)*
- *sample of woollen fabric (finished)*
- *sample of plain weave worsted fabric (unfinished)*
- *sample of plain weave worsted fabric (finished)*
- *sample of circular knitted fabric (unfinished)*
- *sample of circular knitted fabric (finished)*
- *textile dictionary (facilitator to supply)*

***HAND OUT** the finished and unfinished fabric samples to participants.*

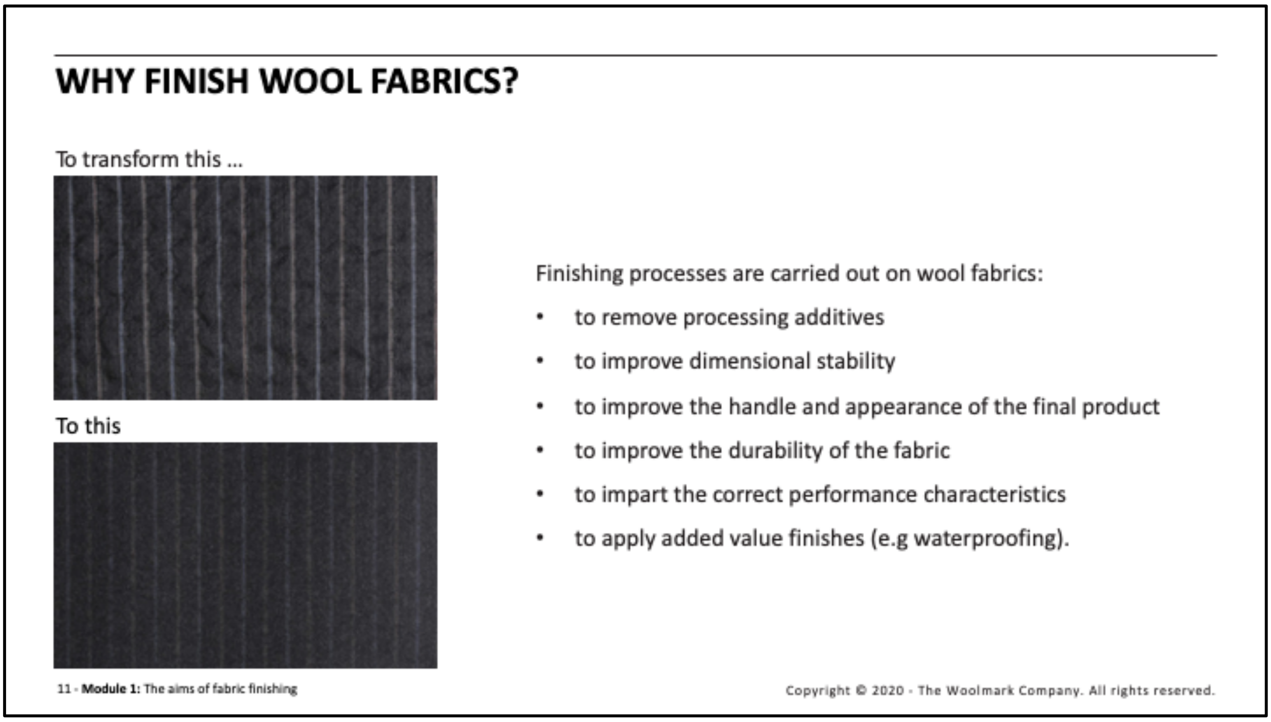
***ASK** participants to note differences in handle and appearance of the samples.*

***TAKE** two or three responses from across the room.*

***ASK** participants why it is necessary to finish fabric?*

***ALLOW** participants time to respond.*

***PROCEED** to the next slide to continue the discussion.*



INDICATE THAT a fabric is finished to convert it from a 'loom-state condition' (i.e. unfinished fabric as it comes off the loom) into a fabric that is fit for purpose.

EXPLAIN THAT a number of processes are used to finish fabric. Their aims are:

- to clean the fabrics removing any remaining processing aids added in yarn and fabric manufacture
- to improve dimensional stability
- to impart the correct 'handle' to the fabric:
    - extensibility
    - flexibility
    - smoothness
- to impart the appropriate appearance to the fabric
    - stable flat appearance
    - correct lustre
    - clarity of weave
- to improve fabric durability
- to impart required functional characteristics
    - crease recovery
    - felt resistance
- to apply value-added finishes
    - water-resist or water-proof finish
    - oil-repellent characteristics.

THE REQUIREMENTS OF A FINISHED FABRIC

Fit-for-purpose:

- meets consumer expectations
- matches legal requirements for:
  - aesthetic properties
  - functional performance.

Quality optimised:

- consistent in handle and appearance
- contain no more than an agreed number of faults.

12 - **Module 1:** The aims of fabric finishing

EXPLAIN THAT the requirements of a finished fabric can be covered by two major classifications: fitness for purpose and quality optimisation.

1. Fit for purpose
The fabric must match the consumer's expectations and (where appropriate) legal requirements for a particular end use in terms of:

- aesthetic properties
- functional performance

2. Quality optimised
The quality of a fabric will vary according to the quality of the wool or blend used and details of the yarn and fabric manufacture. Within the constraints imposed by the raw materials, a finished fabric :

- must be consistent in handle and appearance
- must not have more than an agreed maximum number of faults.

THE AIMS OF FABRIC FINISHING

To develop and control:

- **aesthetic characteristics —** how the fabric and garment look and feel
- **functional characteristics —** how the fabric performs.

13 - **Module 1:** The aims of fabric finishing

EXPLAIN THAT there are two types of fabric characteristic that ensure the finished fabric meets the fit-for-purpose and quality-optimised requirements.

Aesthetics

Aesthetic characteristics describe

- how the fabric looks and feels
- how the fabric performs during garment manufacture
- how the fabric maintains its appearance in some aspects of wear.

Functional

Functional characteristics describe how the fabric performs during subsequent finishing or wear.

NOTE: The lines dividing the aesthetic and functional aims of finishing processes are sometimes indistinct and some finishing processes can have both functional and aesthetic aims.

THE AIMS OF FABRIC FINISHING OPERATIONS

Aims of finishing	Key operations
1. To clean the fabric	1. Scouring
2. To dry or add moisture to the wool fibres	2. Hydroextraction, stenter drying, dewing and moisturising
3. To change the dimensions of the fabric	3. Stenter drying, steam framing, pressing and decatising
4. To change the geometry of the fabric surface	4. Milling, cropping and raising
5. To colour the fabric	5. Piece dyeing
6. To set or stabilise the fabric	6. Crabbing, potting and decatising
7. To assist handling the fabric in subsequent operations	7. Bagging, rope-opening and milling
8. To confer a particular functional property, such as oil repellence or shrink-resistance, to the fabric	8. Pad-dry application
9. Impart dimensional stability	9. Pre-setting, piece dyeing, decatising, sponging and felt-resist treatment
10. Impart the required appearance and handle	10. Milling, raising, setting and cropping

NOTE: The sequence of the operations is often changed to suit the fabric requirements (e.g. woollen or worsted, clear finish or matt finish)

14 - **Module 1:** The aims of fabric finishing

INDICATE THAT the table above outlines the operations that will be discussed during this course and their relationship to the aims of fabric finishing operations.

To understand the impact of a series of finishing operations it is necessary to know what the finisher is trying to achieve and what the potential side effects are.

NOTE THAT even with individual operations it is important to be sure why the operation is being done.

EXPLAIN THAT individual finishing operations can have more than one aim. For example, milling is used to change both the geometry of the fabric surface and to consolidate and strengthen the fabric.

POINT OUT that the sequence of the operations in finishing is often changed to suit the fabric requirements, for example:

- woollen or worsted
- clear finish or matt finish.

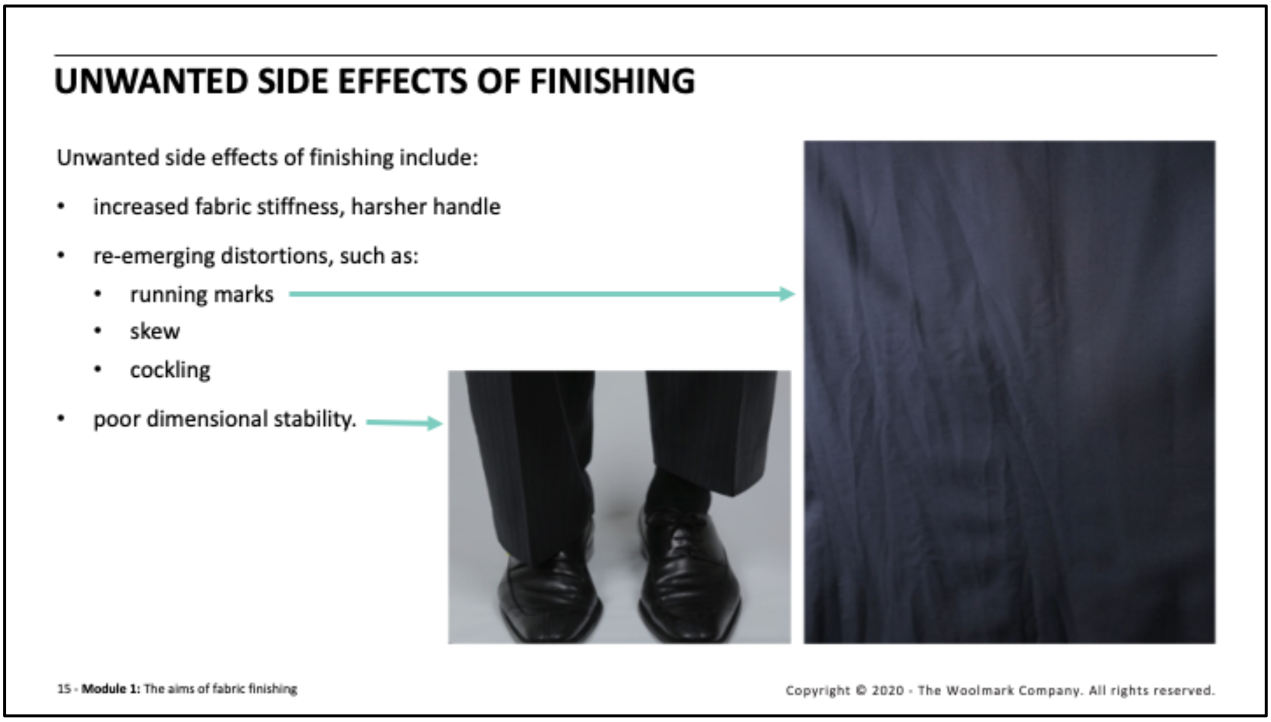
NOTE THAT the aims described in the table above are:

- to clean the fabric removing residual oils and additives
- to change the dimensions of the fabric
- to change the surface of the fabric to confer required performance
- to colour the fabric
- to set or stabilise the fabric in a flat form
- to prepare the fabric for subsequent operations
- to confer a particular functional property, such as oil repellence or shrink-resistance, to the fabric
- to impart dimensional stability
- to impart the required appearance and handle.

Each aim may be accomplished in a single operation of in a series of operations.

EXPLAIN THAT in addition to operations which modify the aesthetic and functional properties of fabric, there are finishing operations that have a purely practical role and are designed to assist handling the fabric during the subsequent finishing process.

- to open out the fabric for processing in open width.
- to strengthen the fabric for later operations
- to dry or add moisture to the wool fibres.

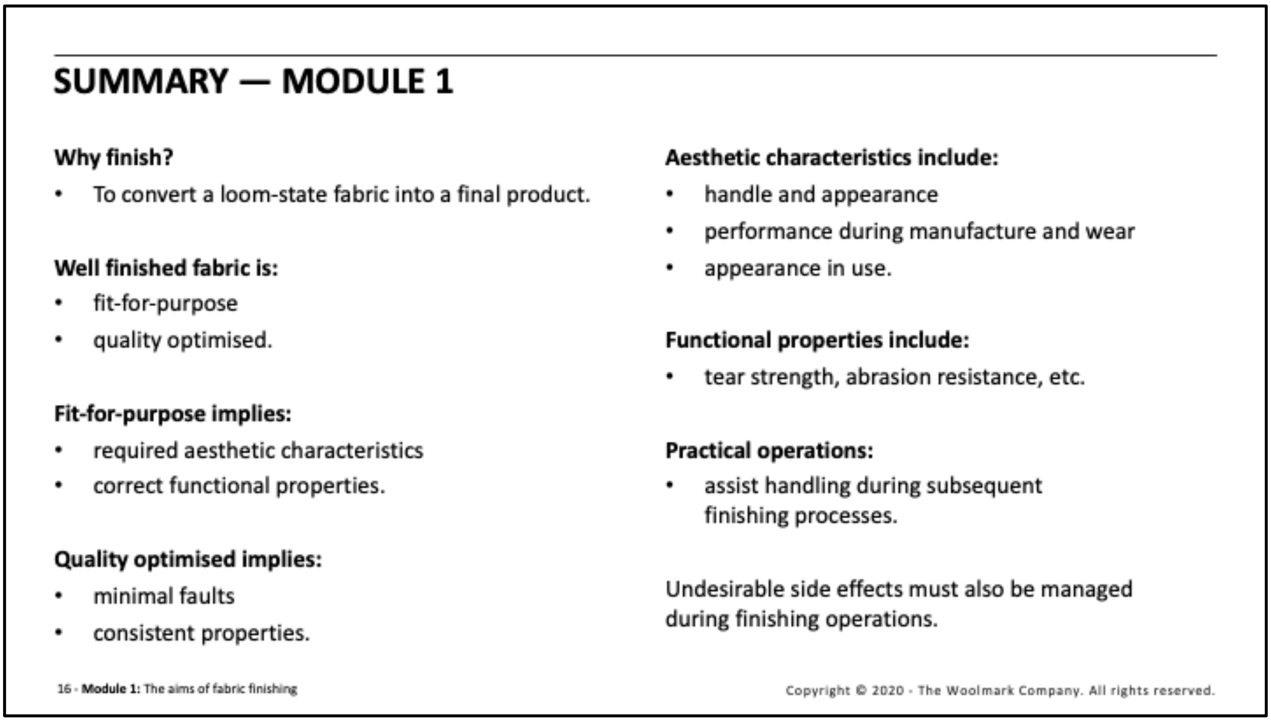


EXPLAIN THAT there can be some unwanted effects of finishing, which must be avoided or at least controlled.

These unwanted effects include:

- increased fabric stiffness, giving a harsher handle than required
- re-emerging distortions, including:
    - running marks (crease marks normally running in the warp direction in finished goods)
    - skew (occurs when weft yarns are straight from one end to another end, but angled across the width of the fabric)
    - cockling (wrinkling or puckering of the fabric)
- poor dimensional stability.

NOTE THAT finishing processes must be managed to maximise the benefits and minimise the unwanted side effects.



REITERATE THAT fabric is finished in order to convert a loom-state fabric (which is unusable) into a final product that is suitable for use.

REMIND participants that well finished fabric is both:

- fit-for-purpose, which implies it has:
    - the required aesthetic characteristics
    - the correct functional properties.
- quality optimised, which implies it has:
    - minimal faults
    - consistent properties.

REMIND participants that aesthetic characteristics refer to those characteristics which impact how the fabric looks and feels, for example:

- how the fabric handles
- the fabric's appearance.
- how the fabric performs during garment manufacture
- how the fabric performs during some aspects of wear.

Functional properties refer to those that impact how the fabric performs, for example the fabric's

- tear strength
- abrasion resistance.

SUMMARISE the module by explaining that in addition to aims associated with the aesthetics and functionality of the final product, finishing includes practical operations designed to assist handling the fabric during the subsequent finishing process.

REVIEW that fact that finishing operations must be managed to maximise the benefits and minimise the side effects.

EXPLAIN THAT this module will introduce participants to a number of new terms that are important in finishing.

To aid in familiarisation of these terms, each participant guide has a glossary or dictionary for all processes and terms used in fabric finishing.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 2 Review of setting and felting*— and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

MODULE 2

REVIEW OF SETTING AND FELTING

RESOURCES — MODULE 2: REVIEW OF SETTING AND FELTING

Additional resources to be sourced by the facilitator include:

- plasticine
- rubber ball

WELCOME participants to Module 2 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Review of setting and felting*.

EXPLAIN THAT this module provides a quick review of:

- the chemistry and physics of setting
- the chemistry and physics of felting.

Both processes play a prominent role in fabric finishing.

INFORM participants that by the end of this module they will have recalled:

- the mechanisms of setting of wool
- the mechanism of felting of wool
- the methods for treating wool to prevent felting.

RESOURCES REQUIRED FOR THIS MODULE:

- *plasticine (facilitator to supply)*
- *rubber ball (facilitator to supply)*

ASK *participants if they can explain the concept of setting.*

ALLOW *time for participants to respond.*

ANSWER: *Setting is a process in which the shape of a wool product is changed by deforming it under conditions where it will not return to its original shape.*

DEMONSTRATION — DEFORMATION AND SET

Resources required:

- *plasticine*
- *rubber ball (e.g. tennis ball).*

PLUNGE *your thumb into the plasticine and remove, noting the permanent depression (i.e. deformation) left by your thumb.*
Press your thumb into the rubber ball and remove, noting the immediate return to the original from.

REINFORCE *that the tennis ball cannot be permanently 'set' (i.e. it immediately recovers to its original shape after the pressure is removed), while the plasticine remains in the new, 'deformed' shape.*

THE SETTING OF WOOL

Setting operations:

- require stress relaxation of the deformed fibres
- require re-arrangement of protein molecules within the fibre
- are critical in conventional finishing
- are conducted on both wet and dry wool

Wool fabrics are set:

- in loom state
- after wet finishing
- during dry finishing
- during garment manufacture
- during garment aftercare.

2 - **Module 2:** Review of setting and felting

EXPLAIN THAT setting is a process that changes the shape of a wool product by deforming it under conditions where it will not return to its original shape.

NOTE THAT setting requires stress relaxation in the fibres so there is no significant force trying to return them to their original shape. Stress relaxation is the decay in the force required to hold a material in a fixed deformation.

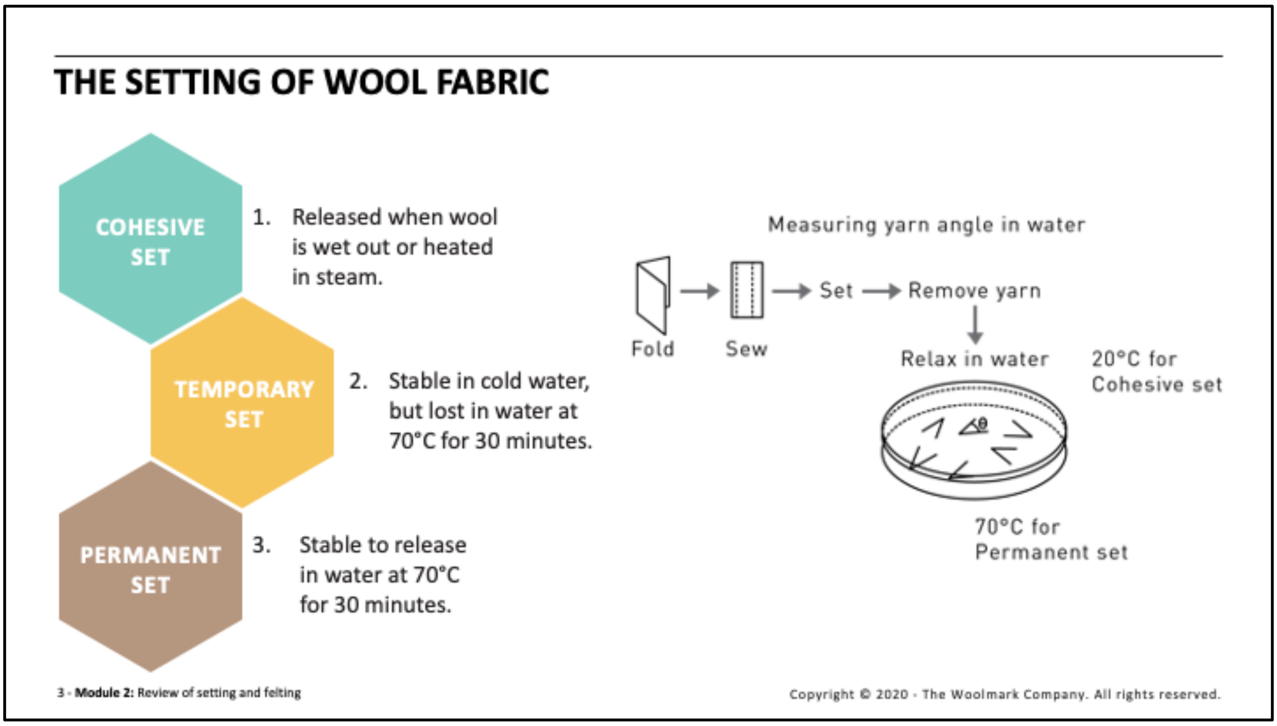
To achieve set, the forces trying to return the material to its original state must decay to a low level.

INDICATE THAT both setting and the release of setting require movement of the protein molecules within the wool fibre. This, in turn, requires re-arrangement of some of the bonds between the protein molecules.

Setting operations are among the most critical in conventional finishing of wool fabric.

POINT OUT that setting operations can be carried out on either wet or dry wool, and normally on both. Wool fabrics are set in one or more of the following ways:

- in loom state (i.e. before wet finishing)
- after wet finishing
- during dry finishing
- during garment manufacture
- during garment aftercare.



EXPLAIN THAT there are three different forms of set normally recognised in wool fibres:

- cohesive set is released when wool is wet out or heated in steam
- temporary set is stable in cold water but lost in water at 70°C (30 minutes)
- permanent set is stable to release in water at 70°C for 30 minutes.

POINT OUT that the test to distinguish between cohesive, temporary and permanent set involves measurement of yarn angle in water is illustrated on the slide.

- A fold is placed in the yarn or fabric.
- The substrate is then set under the required conditions.
- A snippet of yarn with the fold is extracted.
- The snippet is placed in water at 70ºC for 30 minutes.
- The angle formed by the yarn is measured.

If the crease is cohesively set, the yarns open up in water.

If the crease is permanently set, the yarns remain substantially closed.

NOTE THAT some finishing operations require cohesive or temporary set. Some finishing operations require permanent set. In some operations, finishers try to avoid permanent set. Some operations require all forms of set.

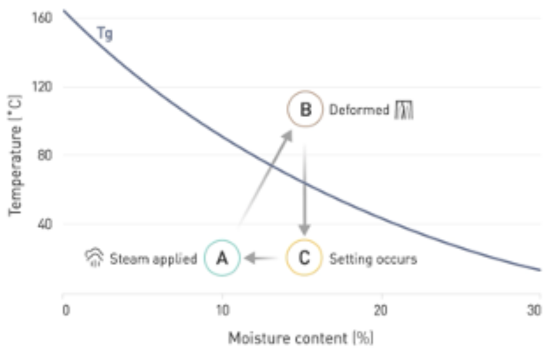
INDICATE THAT being able to distinguish between the various forms of set and the type of set imparted in the various operations is critical to correct finishing and to the evaluation of setting techniques in fabric.

Additional notes:

- Permanent set was formerly assessed after immersion in boiling water for 1hr. Some of the early literature on the setting of wool fibres may refer to these conditions.
- Some text books do not distinguish between cohesive and temporary set. The difference is thought to be merely a distinction between the rate of release in water at 20ºC and 70ºC

COHESIVE SETTING

- Associated with glass transition temperature (Tg)
- Formed when:
  - wool fibres are deformed above their Tg
  - cooled below their Tg
  - then released
- Set is released when the wool is taken back above its Tg
- Cohesive set cannot form in wet wool
- Cohesive set can be imparted below the Tg if the time or conditions of setting greatly exceeds the time or conditions of release.



Cohesive setting using steaming

4 - **Module 2:** Review of setting and felting

EXPLAIN THAT cohesive setting using steam is associated with the glass transition temperature (Tg) of the fibre.

PLAY THE ANIMATION, *which shows the relationship between the temperature of the fabric and the moisture content (or regain) of the wool fabric during steam setting.*

The solid blue line shows the glass transition temperature of wool.

At point A, the fabric is put into a steamer. This causes the temperature of the fabric to rise above the glass transition temperature.

At Point B the fabric is deformed into a new shape, before being cooled,

When the fabric cools it moves to Point C. Because Point C is below the glass transition temperature the fabric will stay in the new shape.

REINFORCE THAT *this is 'cohesive set'.*

NOTE: Set is released when the fibre is taken above the glass transition temperature again.

POINT OUT that cohesive set cannot form in wet wool (>30%) as it is already above its glass transition temperature, but can be imparted below the glass transition temperature if the time or conditions of setting greatly exceed the time or conditions of release.

TO RECAP — the glass transition temperature (Tg) is the temperature at which protein molecules in the fibre rapidly become more mobile and the fibre is most easily deformed. At the glass transition temperature the inter-molecular bonds restricting the relative movement of protein molecules become significantly weaker.

NOTE: This DOES NOT include the strong disulphide bonds.

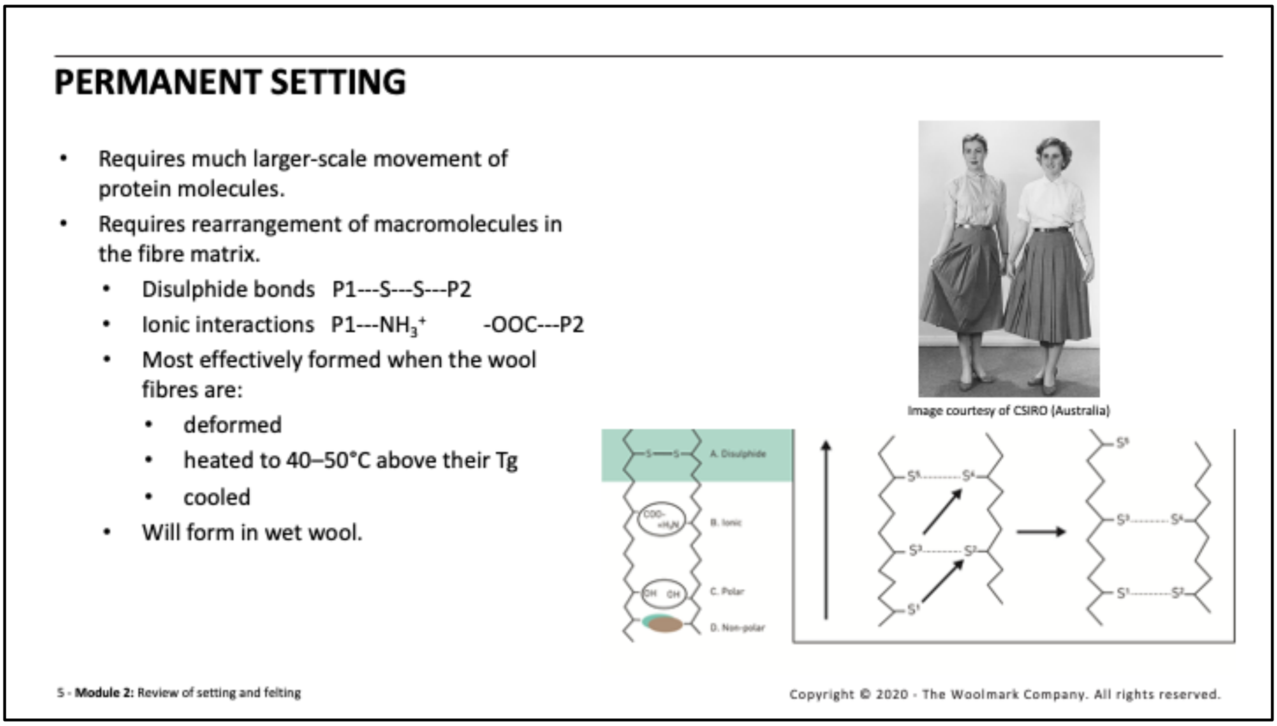
INDICATE THAT the subject of the glass transition behaviour of wool is discussed at length in The Wool Science, Technology and Design Education Program course *Wool Fibre Science*.

As illustrated on the slide, the glass transition temperature of wool is affected by its moisture content.

- The glass transition temperature of dry wool is above 160ºC
- The glass transition temperature of wet wool is below room temperature (i.e. <20ºC).

INDICATE THAT cohesive set is most effectively formed when the wool fibres are deformed above their glass transition temperature and then cooled below the glass transition before release.

Wool may be cohesively set in steam or by wetting and drying the wool.



INDICATE THAT permanent setting requires much larger-scale movement of protein molecules in the matrix regions of the fibre than cohesive set.

EXPLAIN THAT permanent set requires rearrangement of the covalent crosslinks (disulphide bonds) and ionic interactions between the macromolecules in the matrix regions of the fibre.

- Disulphide bonds P1—S—S—P2
- Ionic interactions P1—NH_3^+ –OOC—P2

Disulphide interchange:

- requires high temperatures
- is catalysed by thiol anions (S- or free H_2S/HS^-)

NOTE THAT permanent set is most effectively formed when the wool fibres are deformed and heated to temperatures 40–50ºC above their glass transition temperature and then cooled.

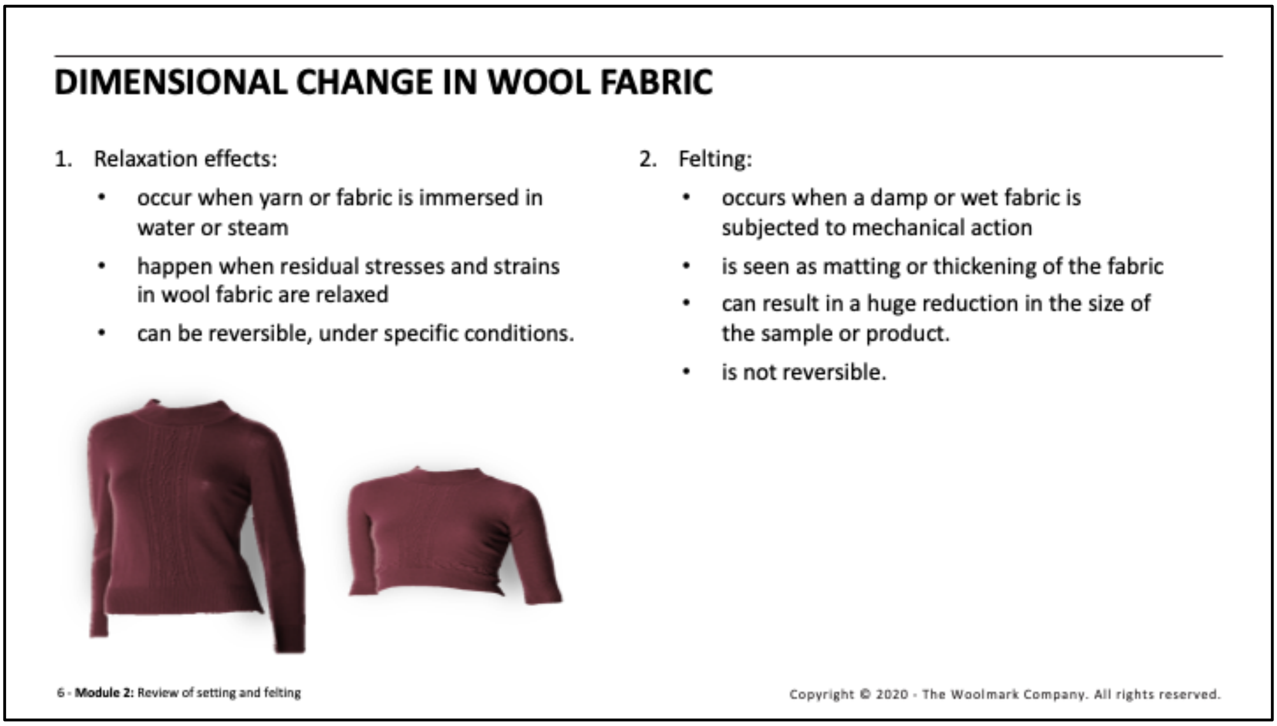
Permanent set is stable to release in water so will form in wet wool.

EXPLAIN THAT it is possible to increase the rate of permanent setting by:

- increasing the concentration of free ionised thiol groups, which can occur either at
  - a higher pH
  - in the presence of reducing agents (e.g. Siroset, MEAS)
- including water soluble alcohols in the setting bath (e.g. propanol or t-butanol etc.), which disrupt hydrophobic interactions.

POINT OUT that the widely used Siroset process (shown on the slide) uses a reducing agent to facilitate permanent setting of creases and pleats in woven apparel.

Permanent set is stable to wetting out. It is equivalent to having 'a perm' in hair.



EXPLAIN THAT dimensional change in wool fabrics occurs during many finishing operations. It is an important part of finishing some types of wool fabric.

POINT OUT that it is important to distinguish between the two different mechanisms involved in dimensional change — relaxation effects and felting shrinkage.

Relaxation effects (called relaxation shrinkage) These are the dimensional changes that can occur when a yarn or fabric is allowed to relax by immersing it in water, or exposing it to steam

The shrinkage occurs when residual stresses and strains in wool are allowed to relax.

NOTE THAT relaxation shrinkage can be reversible under specific conditions. The wool product can be stretched to a new shape although that shape will also not be permanent to immersion in water.

ASK *participants if they can explain the concept of felting.*

ALLOW *participants sufficient time to respond before consolidating participant understanding with the following notes.*

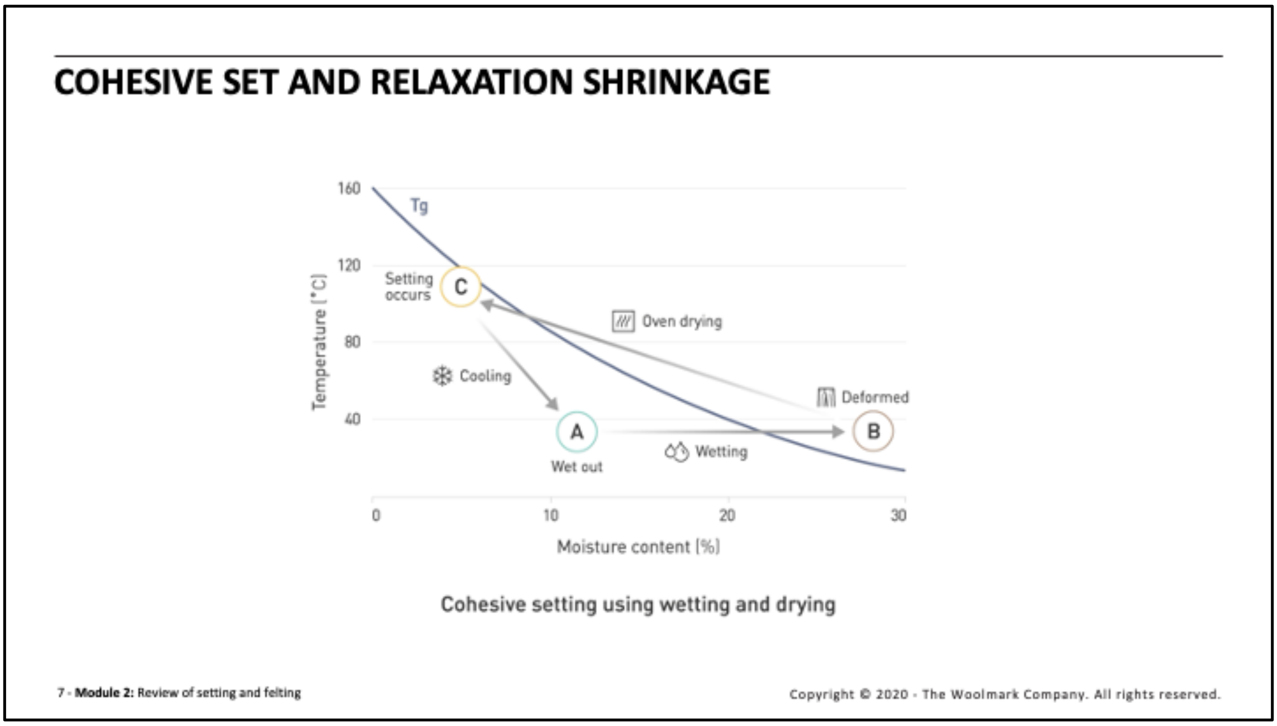
REINFORCE THAT felting shrinkage is a process in which fibres lock together when subjected to mechanical action and fibres become increasingly entangled.

MENTION THAT felting can be seen as shrinkage that occurs when a damp or wet fabric is washed and is also seen as matting or thickening of the fabric.

The reduction in dimensions of the fabric due to felting is often called ‘felting shrinkage’.

With extended mechanical action, felting can result in a huge reduction in the size of the sample or product.

NOTE THAT felting shrinkage is not reversible.



Cohesive setting is responsible for relaxation shrinkage.

EXPLAIN THAT fabric is often stretched during finishing or other handling operations and cohesively set. If fabric is held in stretched form by 'cohesive set', when the fabric is then relaxed in water or steam, the cohesive set is lost and the fabric returns to its original dimensions.

PLAY THE ANIMATION, *which illustrates the relationship between the temperature of the fabric and the moisture content (or regain) of the wool fabric.*

The solid blue line shows the glass transition temperature (Tg) of wool, which decreases as the moisture content of the fibres increases.

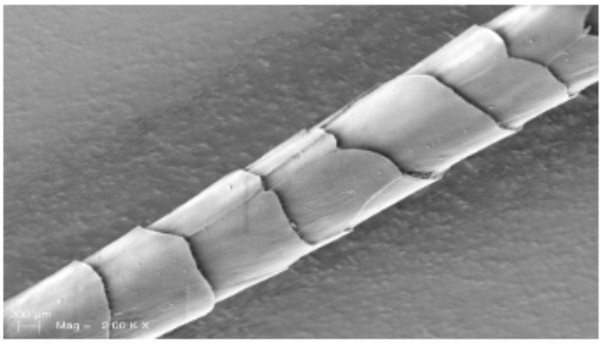
INDICATE THAT during finishing operations, fabric or garments are often deformed (e.g. stretched). Garments can also be stretched and distorted during wear.

NOTE THAT if the stretch or distortion is held (stabilised) by 'cohesive set', then when the fabric is subsequently relaxed in either water or steam:

- the cohesive set is lost
- the fabric shrinks back to its original (undeformed) state.

This is **relaxation shrinkage**.

FELTING SHRINKAGE



Individual wool fibres move more easily against each other in one direction than the other due to the overlapping arrangement of the cuticle cells (scales).

8 - **Module 2:** Review of setting and felting

EXPLAIN THAT felting shrinkage is caused by the fact that in a fibre assembly, individual wool fibres can move more easily in one direction than in the other relative to adjacent fibres when agitated in water.

NOTE THAT this directional friction effect (DFE), discussed in The Wool Science, Technology and Design Education Program course *Wool fibre science* is the cause of felting shrinkage in wool.

POINT OUT that the directional friction effect (DFE) is a result of the ridges formed by the cuticle cells on surface of the wool fibre (illustrated on the slide). The ratchet mechanism of felting shrinkage is a simple explanation of the directional friction effect.

THE FELTING OF WOOL

Wool fabrics are deliberately felted in a controlled manner in a 'milling' operation.

Milling requires:

- moisture — normally fabric is wet
- mechanical action, which moves the fibres relative to adjacent fibres.

9 - **Module 2:** Review of setting and felting

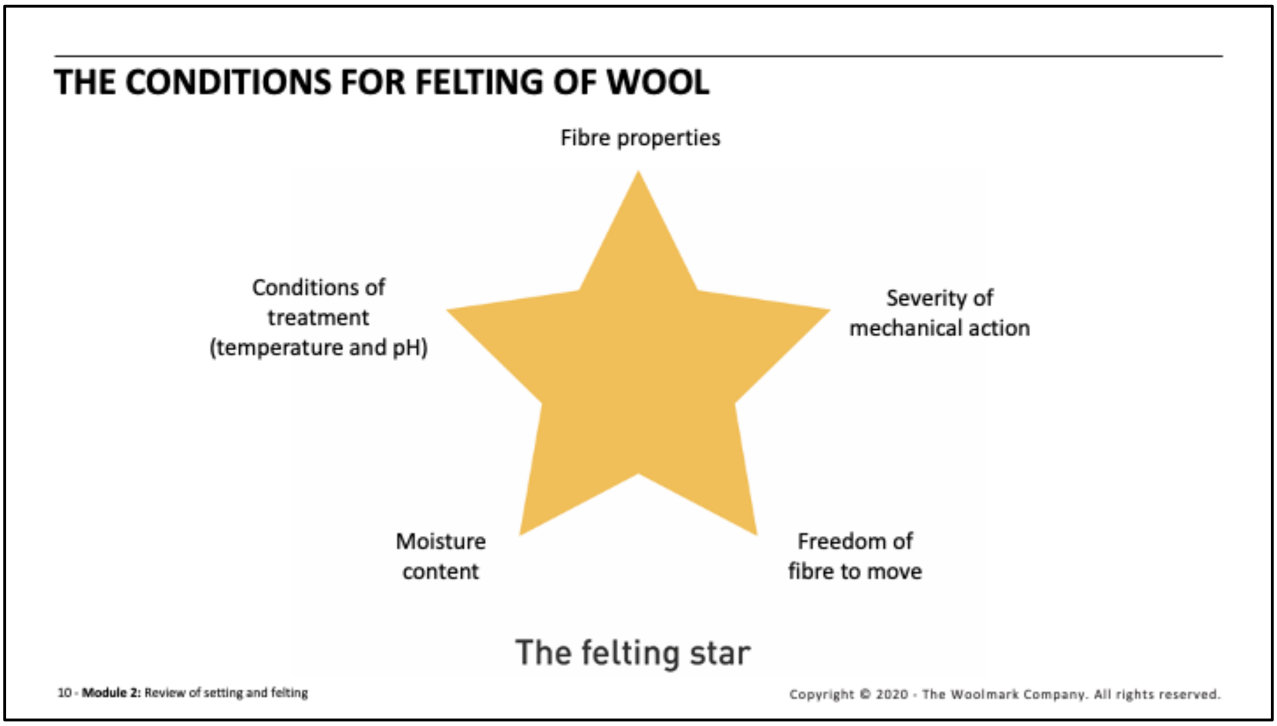
NOTE THAT the felting operation is also among the most critical in conventional finishing of wool fabric.

INDICATE THAT the most common operation for deliberate controlled felting of wool is called 'milling'.

POINT OUT that milling requires:

- moisture — normally fabric is wet
- mechanical action — moves the fibres relative to adjacent fibres.

MENTION THAT in former times this was achieved by treading the fabric in a bucket containing a mixture of urine and water. Today modern machines are used and this operation will be discussed in later modules.



EXPLAIN THAT the following factors affect the rate of felting and form the five corners of the ‘felting star’:

- fibre properties (frictional properties and stiffness of the wool fibre)
- severity of mechanical action
- freedom of fibre to move (yarn and fabric structure)
- moisture content
- conditions of treatment (temperature and pH).

***ASK** participants to explain each of these five factors to ensure participant understanding and clarity of each concept.*

***ALLOW** sufficient time for participants to respond.*

***ACKNOWLEDGE** responses.*

NOTE THAT fibre frictional properties can be modified to prevent felting by applying treatments that damage the surface scales (cuticle cells).

SUMMARY — MODULE 2

Setting requires relative movement of the protein molecules within the wool fibre.

There are three types of set in wool:
1. cohesive
2. permanent
3. Temporary.

Types of set can be distinguished by wetting out yarn snippets at 20°C or 70°C for 30 minutes.

Cohesive set is associated with the glass transition temperature of the wool fibre and can be formed:
- in steam
- by wetting and re-drying the fibre.

Permanent set requires disulphide interchange and is formed at high temperatures.

11 - **Module 2:** Review of setting and felting

SUMMARISE the module by reviewing the following points:

Setting requires relative movement of the protein molecules within the wool fibre.

There are three types of set in wool :
1. cohesive,
2. temporary
3. permanent.

The types of set can be distinguished by wetting out yarn snippets at 20ºC or 70ºC for 30 minutes.

Cohesive set is associated with the glass transition temperature of the wool fibre and can be formed
- in steam
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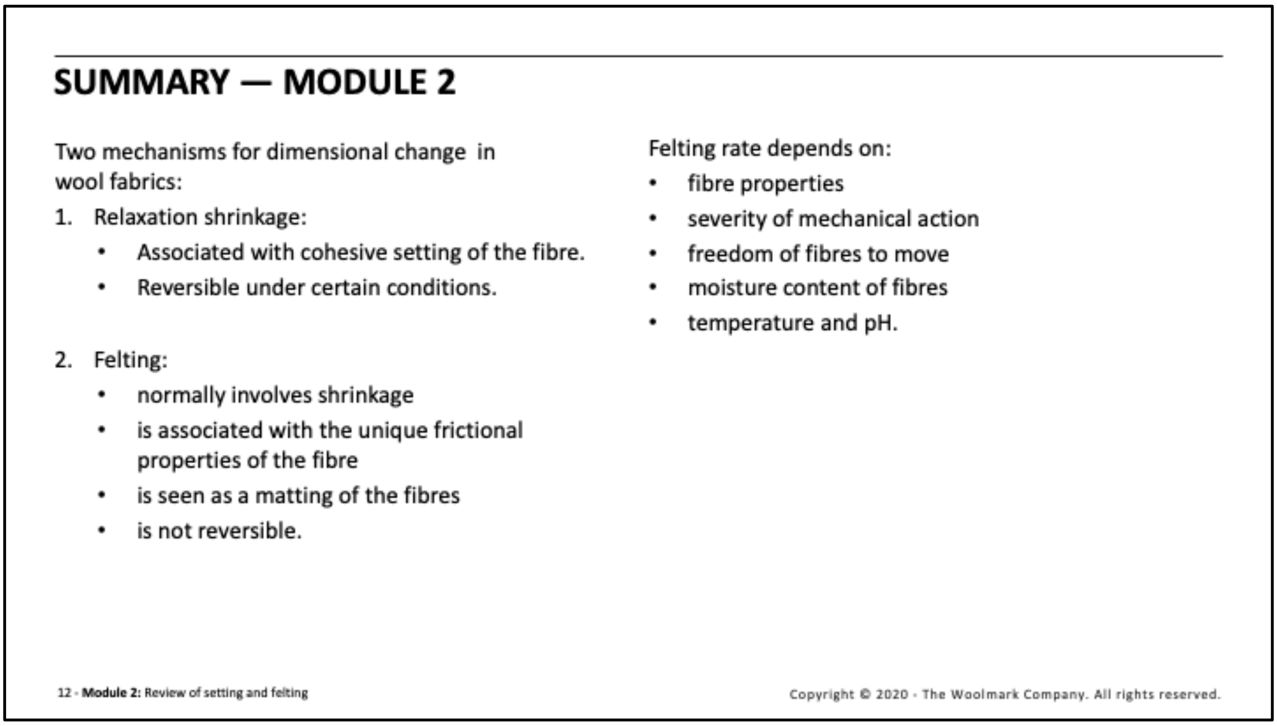

SUMMARY — MODULE 2

Two mechanisms for dimensional change in wool fabrics:

1. Relaxation shrinkage:
   - Associated with cohesive setting of the fibre.
   - Reversible under certain conditions.

2. Felting:
   - normally involves shrinkage
   - is associated with the unique frictional properties of the fibre
   - is seen as a matting of the fibres
   - is not reversible.

Felting rate depends on:
- fibre properties
- severity of mechanical action
- freedom of fibres to move
- moisture content of fibres
- temperature and pH.

12 - **Module 2:** Review of setting and felting

REMIND participants that there are two mechanisms for dimensional change in wool fabrics:

- Relaxation shrinkage is associated with cohesive setting of the fibre and can be reversed under certain conditions.
- Felting shrinkage is associated with the directional frictional effect (DFE) in wool fibres and is not reversible.

REITERATE THAT felting is seen as a matting of the fibres and requires:

- mechanical action on the fibres
- adequate moisture in the fibres (normally wet).

REVIEW the factors affecting the rate of felting are:

- fibre properties (frictional properties and pH of the wool fibre)
- severity of mechanical action
- freedom of fibre to move (yarn and fabric structure)
- moisture content
- conditions of treatment (temperature and pH).

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 3 Wet finishing operations* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

THE WOOLMARK COMPANY

WET FINISHING OPERATIONS

RESOURCES — MODULE 3: WET FINISHING OPERATIONS

Contained in the *Wool fabric finishing* Demonstration kit you will find the following resources for use as you deliver **Module 3: Wet finishing** operations:

- sample of cotton fabric
- sample of wool fabric
- length of woven fabric (1m)
- 'bone dry' length of fabric (stored in plastic bag)
- woven fabric after development and control
- woven fabric after milling and control

Additional resources to be sourced by the facilitator include:

- cardboard tube
- whiteboard and marker pens
- spray bottle with water

WELCOME participants to Module 3 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing —Wet finishing operations*.

***NOTE TO FACILITATOR**: This topic is large and is designed to be spread across two lectures. It is advisable to break the topic into separate lectures at the following points:*

- *Slide 41 Continuous rope washing (end lecture one)*
- *Slide 42 Fabric development (start lecture two)*

EXPLAIN THAT this module will cover the following components of wool fabric finishing:

- pre-finishing operations
- wet finishing (namely pre-setting, scouring, milling, rope opening, wet raising, hydroextraction, stenter drying)
- quality of water used in finishing
- the unwanted effects of each process.

INFORM participants that by the end of this module, they will be able to:

- describe the finishing processes commonly used to wet finish wool and their aims.
- outline the machinery used to conduct each process
- explain the importance of the quality of water used in finishing
- summarise the advantages and disadvantages associated with different alternative wet finishing processes
- describe some of the unwanted effects that can occur during wet finishing.

RESOURCES REQUIRED FOR THIS MODULE:

- *cardboard tube (facilitator to supply)*
- *sample of cotton fabric*
- *sample of wool fabric*
- *length of woven wool fabric (1m)*
- *'bone dry' sample of woven wool fabric (stored in plastic bag)*
- *whiteboard and marker pens (facilitator to supply)*
- *spray bottle with water (facilitator to supply)*
- *woven wool fabric after development and control*
- *woven wool fabric after milling and control*

THE AIMS OF FABRIC FINISHING

Aims of finishing	Key operations
1. To clean the fabric	1. Scouring
2. To dry or add moisture to the wool fibres	2. Hydroextraction, Stenter drying, dewing and moisturising
3. To change the dimensions of the fabric	3. Stenter drying, steam framing, pressing and decatising
4. To change the geometry of the fabric surface	4. Milling, cropping and raising
5. To colour the fabric	5. Piece dyeing
6. To set or stabilise the fabric	6. Crabbing, potting and decatising
7. To assist handling the fabric in subsequent operations	7. Bagging, rope-opening and milling
8. To confer a particular functional property, such as oil repellence or shrink-resistance, to the fabric	8. Pad-dry application
9. Impart dimensional stability	9. Pre-setting, piece dyeing, decatising, sponging and felt-resist treatment
10. Impart the required appearance and handle	10. Key operations are milling, raising, setting and cropping

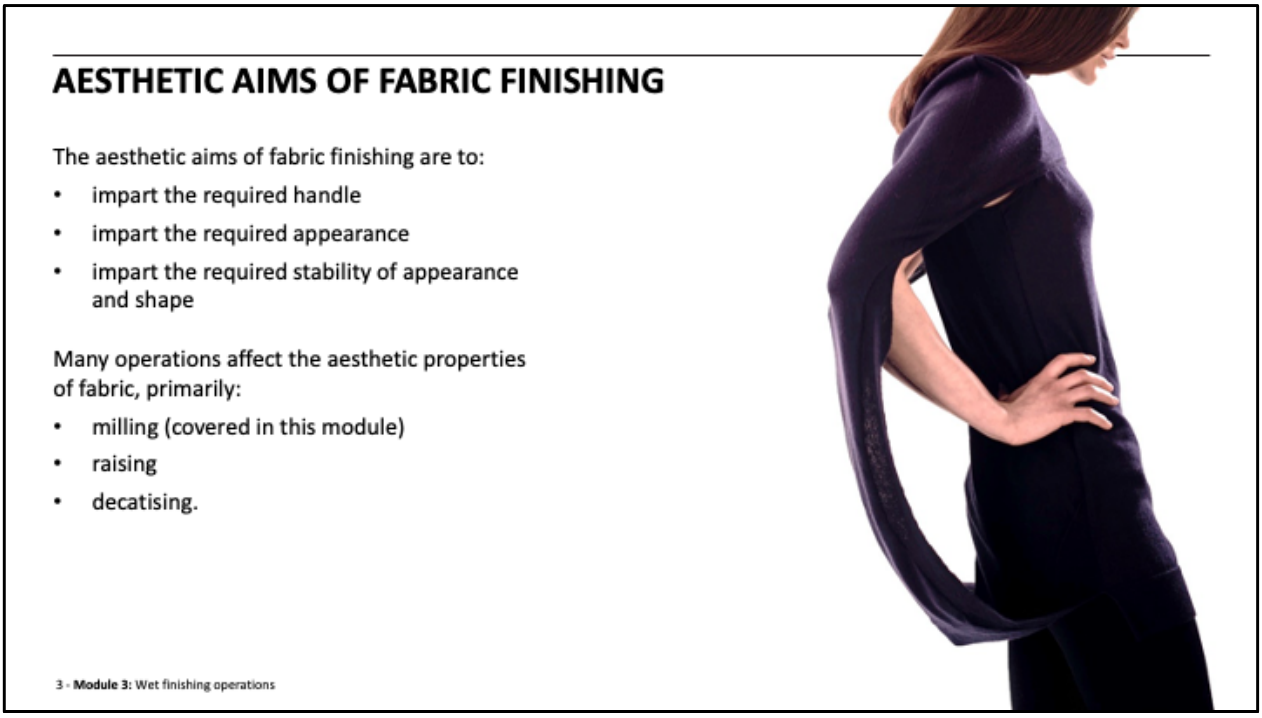
NOTE: The sequence of the operations is often changed to suit the fabric requirements (e.g. woollen or worsted, clear finish or matt finish)

2 - **Module 3:** Wet finishing operations

REFER participants to the list of operations shown on the slide, which will be discussed along with their relationship to the aims of finishing.

INDICATE THAT to understand a finishing operation you have to know what you are trying to achieve, what the potential side effects are and how to manage any unwanted effects.

NOTE THAT the operations outlined on the right-hand column of the table will be discussed in the next series of modules.



EXPLAIN THAT as outlined in *Module 1 The aims of fabric finishing*, imparting the appropriate aesthetic properties to fabrics is the primary aim of the finishing process. If the fabric does not have the appropriate look and feel, it is not well finished, irrespective of its functional properties.

ASK *participants to nominate the key aesthetic properties of wool fabrics.*

ALLOW *participants time to respond before confirming the answer below.*

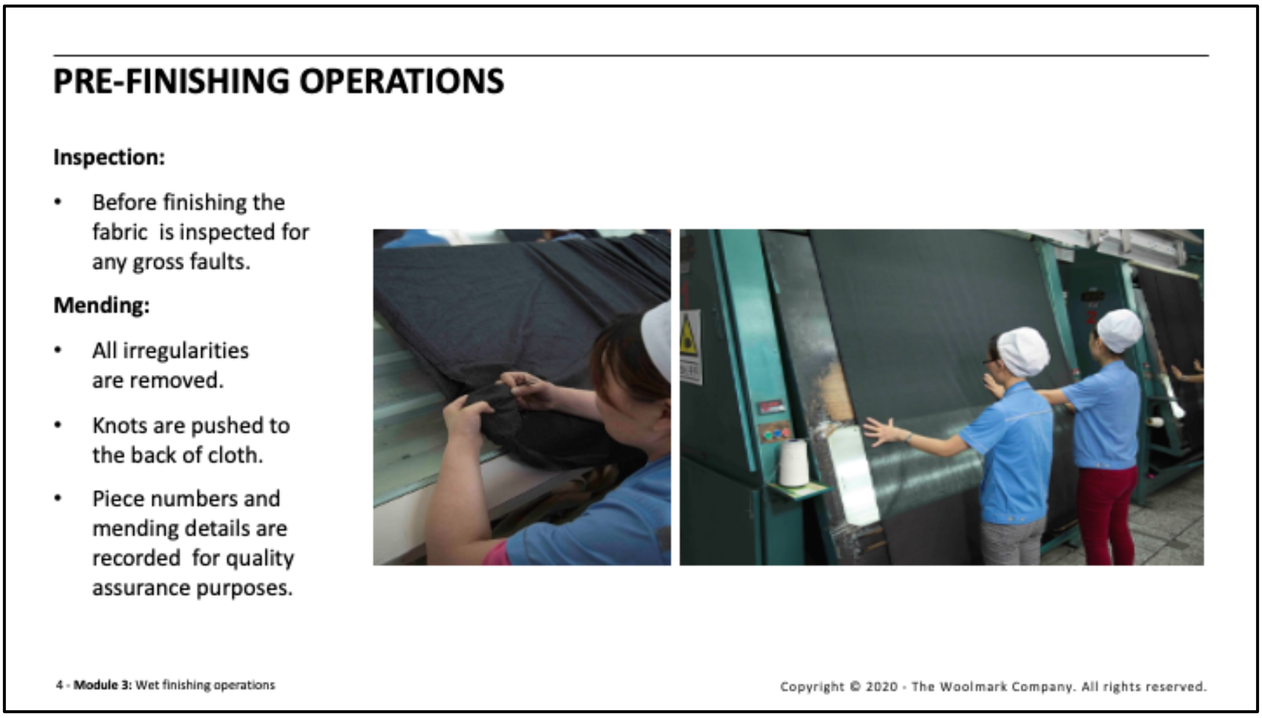
The key aesthetic requirements of wool fabrics are:

- handle
- appearance
- stability of shape (dimensional stability).

NOTE THAT many finishing processes — indeed most — affect the aesthetic properties of fabrics in some way.

INDICATE THAT the most important finishing operations are milling, raising and final decatising.

- The first operation (milling) will be discussed in this module.
- The other operations (raising and final decatising) will be covered in the next module.



EXPLAIN THAT before finishing starts the fabric must be inspected for any gross faults and mended.

All irregularities are removed.

Knots are pushed to the back of the cloth.

Piece numbers and mending details are recorded for quality assurance purposes.

PRE-FINISHING OPERATIONS
INSPECTION AND MENDING

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the inspection and mending processes.

PLAY *video (41 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

PRE-FINISHING OPERATIONS

Batching:

- Single-quality fabric, without wide variations in colour.
- Piece numbers are recorded and checked.
- Batch size to match machinery capacity.

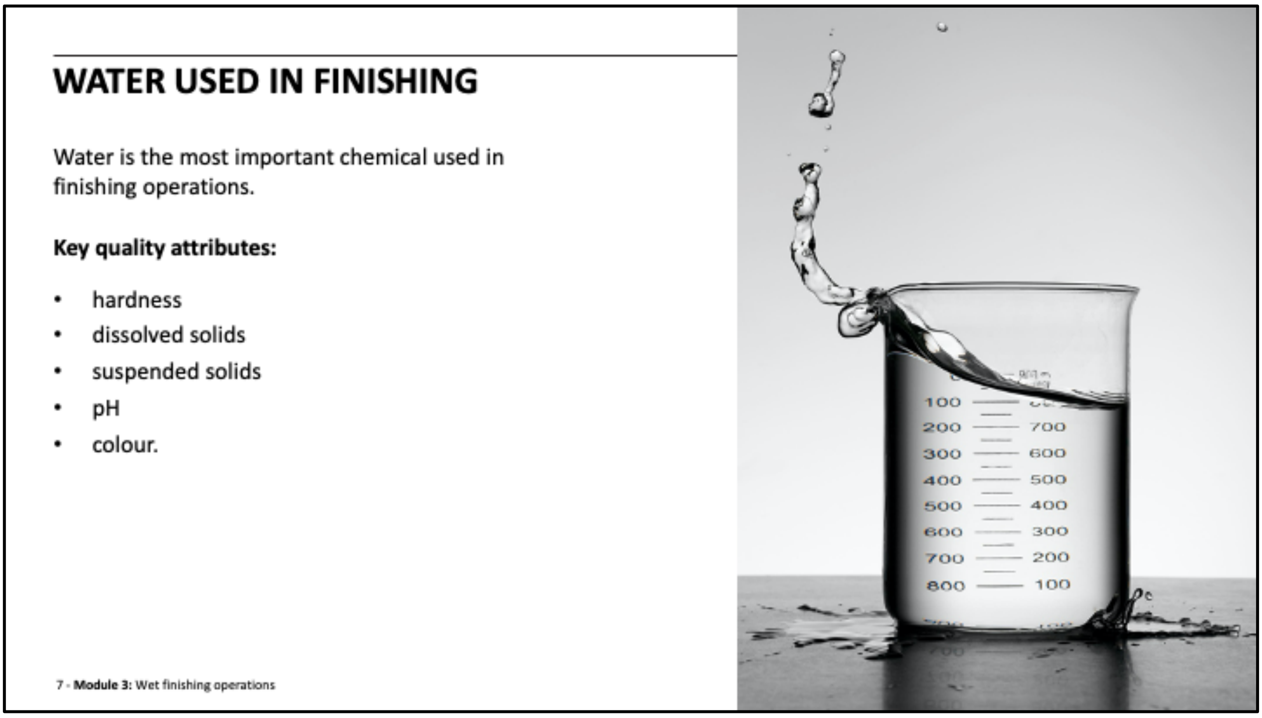
6 - **Module 3:** Wet finishing operations

NOTE THAT before finishing begins, fabrics must be formed into batches of the right size for processing.

The fabric should be a single quality, without wide variations in colour.

Piece numbers are recorded and checked.

INDICATE THAT the batch size needs to match the machinery capacity. For milled finishes or piece-dyed cloths, regular batch sizes (within 2%) are required.



EXPLAIN THAT water is an important chemical used during finishing and plays a key role in every wet finishing operation and a number of dry finishing operations. It modifies the properties of the fibre and acts as the medium used to remove contaminants from the fibre.

NOTE THAT the quality of the water used in finishing is important to get the desired result.

INDICATE THAT the key quality attributes of water that determine its suitability for finishing, are: hardness, dissolved solids, suspended solids, pH and colour.

Hardness
Hardness, caused by dissolved calcium and magnesium salts:
- renders natural soaps insoluble and ineffective
- leaves insoluble soap 'scum' deposits in machinery (requiring cleaning) and on fabric (affecting handle) so the finisher is forced to use synthetic detergent
- impacts on fibre lubrication during milling, affecting milling rate.

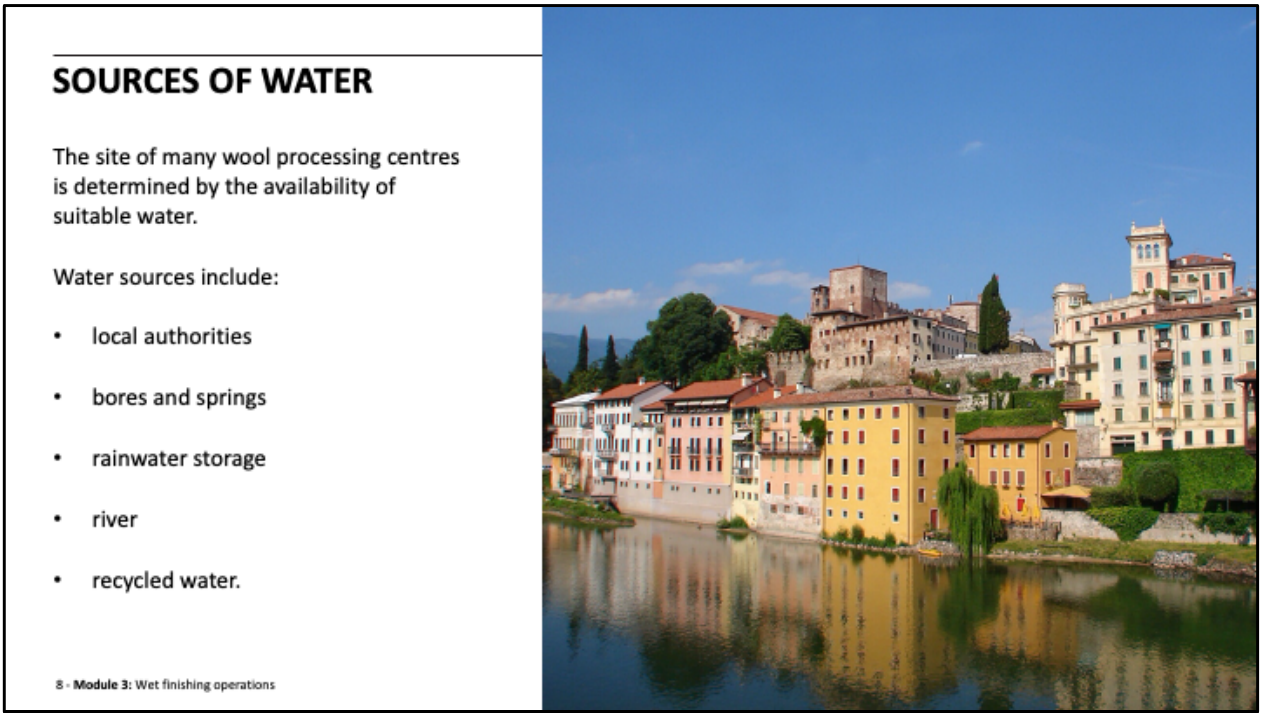
Water hardness of less than 100 ppm (as calcium carbonate — $CaCo_3$) and ideally less than 60 ppm is suitable for use during fabric finishing.

Dissolved solids
Water can contain other dissolved salts and organic materials that do not contribute to hardness, but can, nevertheless, modify the finishing process. Such materials should be controlled to acceptable levels.

Suspended solids
Water used in finishing must be free of suspended solids.

pH
The pH of water used in finishing can affect many wet operations. The pH of water used in finishing should be controlled.

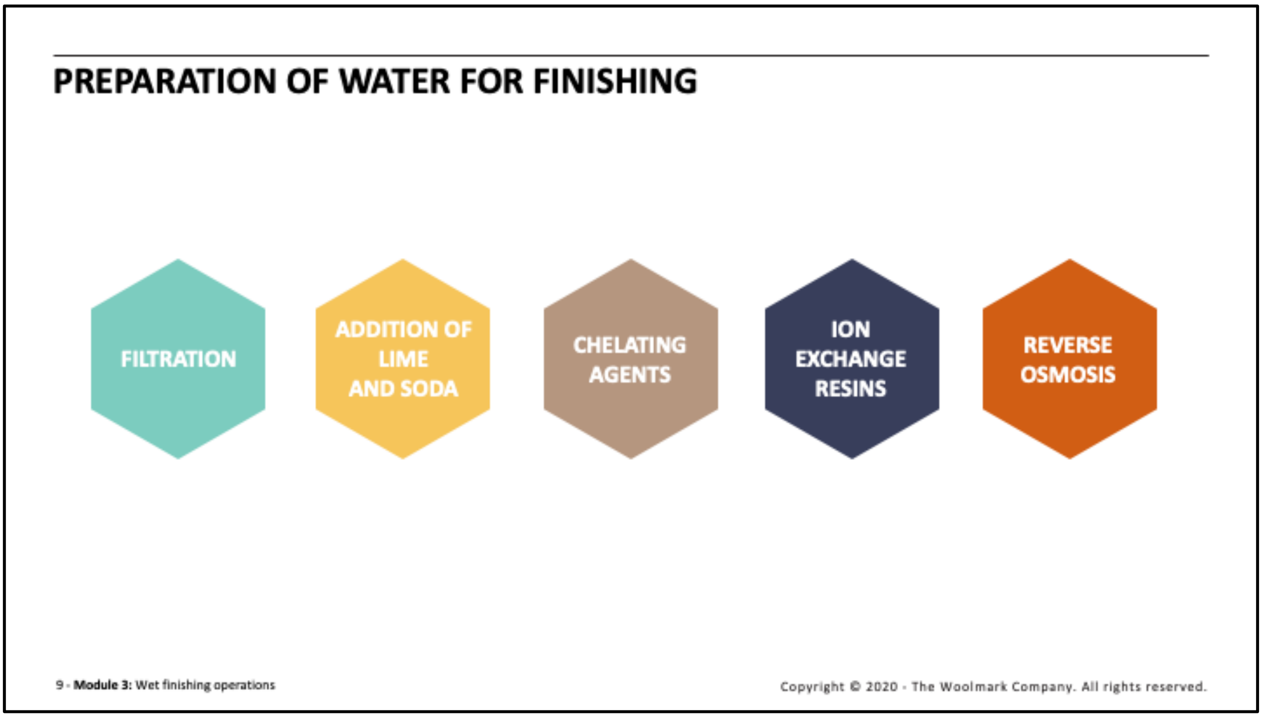
Colour
Water used in finishing must be free of soluble-coloured materials.



INDICATE THAT the quality of water depends on its source. As such, the site of many wool processing centres is determined by the availability of suitable water (e.g. Biella Italy, renowned for its woollen mills, is located at the foot of the Italian Alps and surrounded by small alpine rivers and lakes containing soft, high-quality water).

EXPLAIN THAT water for finishing operations can be sourced from:

- local authorities — quality depends on purification techniques used
- bores and springs — hardness depends on the region
- rainwater storage — collected rainwater is soft
- rivers or lakes — hardness depends on region and extent of local industry
- recycled water — depends on source, previous use and purification treatments used.



INDICATE THAT the methods used to improve water quality include:

Filtration
Filtration removes suspended solids. All ground or recycled water should be filtered to remove suspended solids.

Addition of lime and soda
The use of lime to remove hardness dates back to the early 19th century (1841). It is effective at reducing both hardness and total dissolved solids. Lime precipitates calcium and magnesium salts and reduces total solids.

Chelating (complexing) agents
Chelating agents can be used to 'complex' the calcium and magnesium ions and are commonly used in domestic laundries. However, these agents can interfere with metal-containing dyestuffs used on wool. A formerly popular product, called EDTA, is now banned because of its environmental impact.

Ion exchange resins
Ion exchange resins, which capture calcium and magnesium ions and replace them with sodium ions, are widely used to 'condition' water.

Reverse osmosis
Reverse osmosis technology uses a semipermeable membrane to remove dissolved solids. It is a relatively expensive process, but is used where a reduction in total dissolved solids is also required.

The method chosen to treat water used for finishing depends on the source of the water, its existing quality and the equipment available.

PRE-SETTING

Aims of pre-setting:

- flat set the fabric
- prevent the emergence of distortions from fabric forming (e.g. cockling)
- prevent formation of distortions in wet finishing (e.g. running marks).

The pre-setting process:

- removes residual strains
- prevents uncontrolled relaxation and formation of distortions
- imparts 'flat stability
- inhibits crease formation during rope processes.

Two types of pre-setting process:

- batch
- continuous.

Measuring set:

- crease angle test.

Unwanted effects:

- stretching the fabric in the warp
- reduction in width.

Measuring unwanted effects:

- warp and weft dimensions.

10 - **Module 3:** Wet finishing operations

EXPLAIN THAT pre-setting is a key operation aimed at preventing:

- the emergence of distortions in the fabric from the fabric-forming process (cockling)
- the formation of distortions in wet finishing (running marks).

NOTE THAT pre-setting involves:

- removing, in a controlled manner, any residual strains in the fabric, thereby preventing any uncontrolled relaxation, as well as the formation of distortions in wet processing
- permanently 'flat setting' the fabric to impart 'flat stability' and inhibit crease formation in rope processes.

INDICATE THAT there are two types of pre-setting methods: batch and continuous processing.

Batch processing
Batch processing is a technique in which the fabric undergoes a single operation in a machine and is then removed (manually).

No new fabric can be placed in the machine until the current 'batch' has been removed. An example is domestic machine washing and tumble drying.

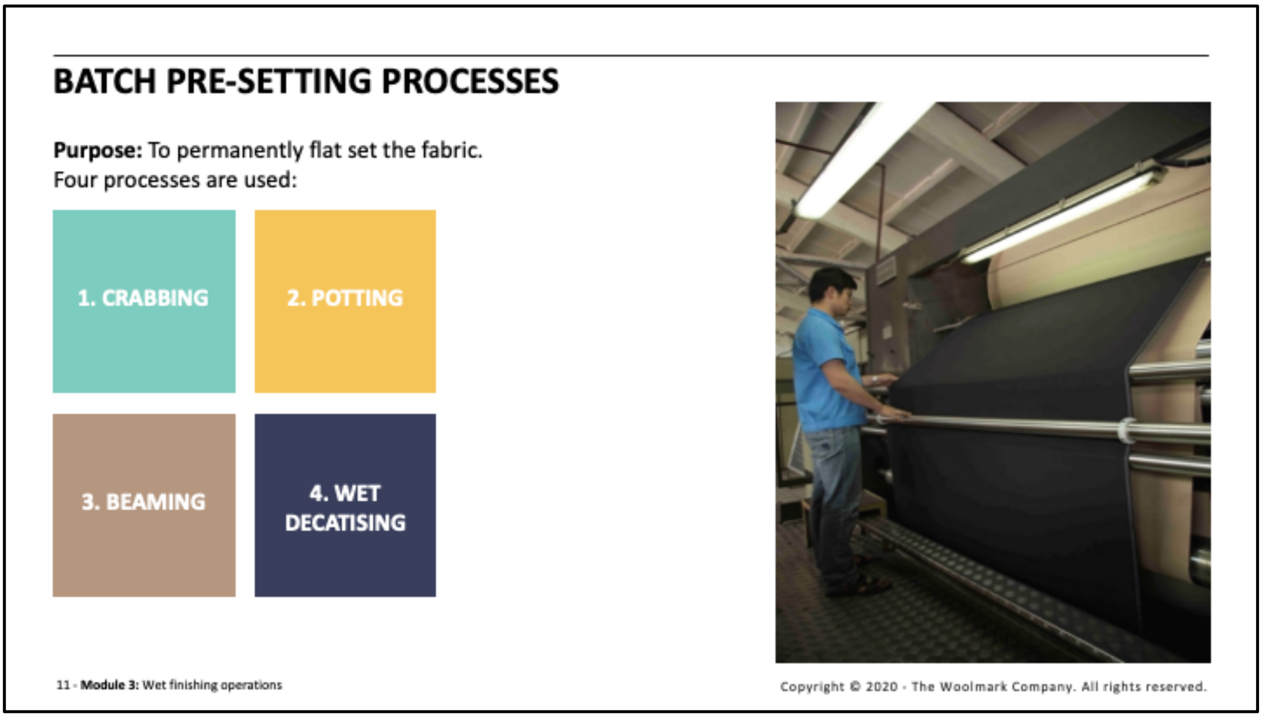
Continuous processing
Continuous processing occurs where the fabric continuously enters the front of the machine and exits at the end of the process, so fabric is continuously entering and exiting the process without interruption.

Testing to measure set
The appropriate test for measuring setting is the crease angle test discussed in Module 2. A crease is sewn into fabric before the pre-setting operation and removed after the process for testing.

Unwanted effects
The unwanted effects associated with pre-setting include:

- stretching of the fabric (especially in the warp direction)
- shrinking of the fabric in the weft direction, resulting in a reduction in width.

Testing to measure unwanted effects
The appropriate tests for measuring unwanted effects involve assessing the warp and weft dimensions of the fabric.

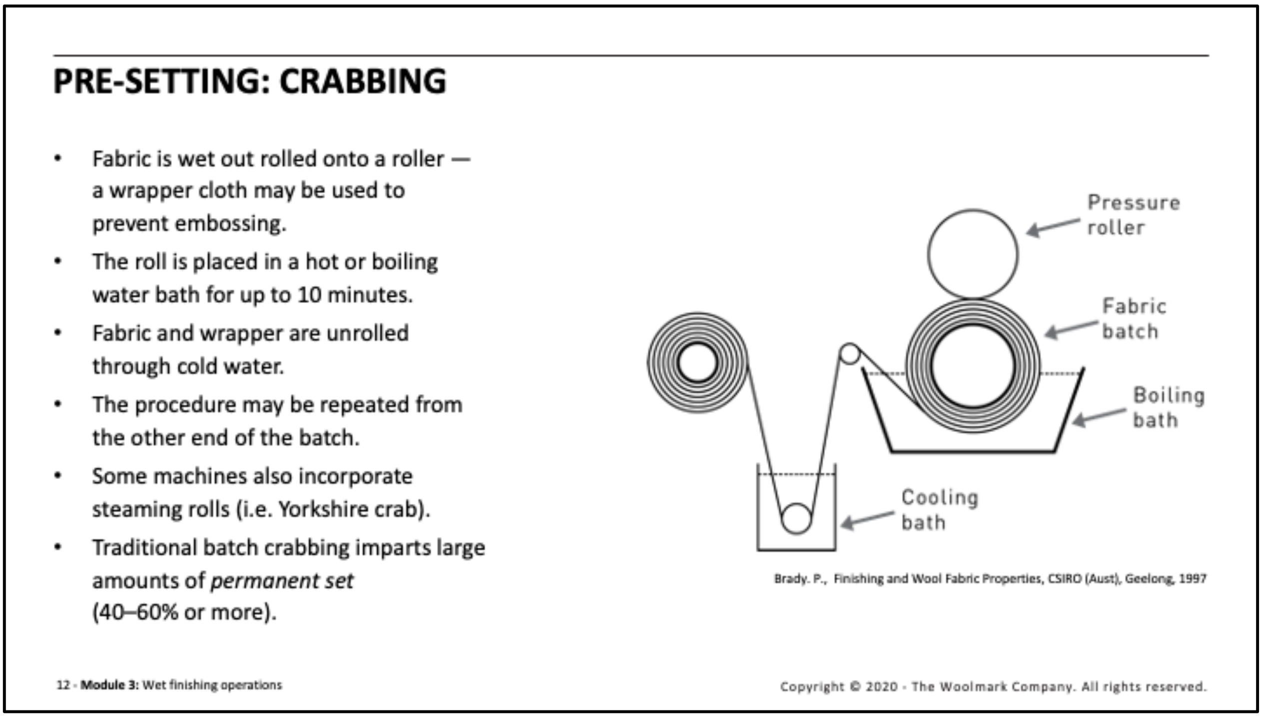


INDICATE THAT there are four different batch pre-setting processes that can be used to permanently flat set the fabric:

- crabbing
- potting
- beaming
- wet decatising.

Crabbing is most commonly used to pre-set wool fabrics.

EXPLAIN THAT potting, beaming and wet decatising are rarely used, because they are labour intensive and therefore expensive.



INDICATE THAT for the batch crabbing process the fabric is wet out and rolled onto a roller.

A wrapper cloth is normally rolled up with the fabric to prevent embossing.

The roll is placed in a hot, or boiling, water bath for up to 10 minutes. Alternatively hot water can be pumped through the roll from a perforated cylinder.

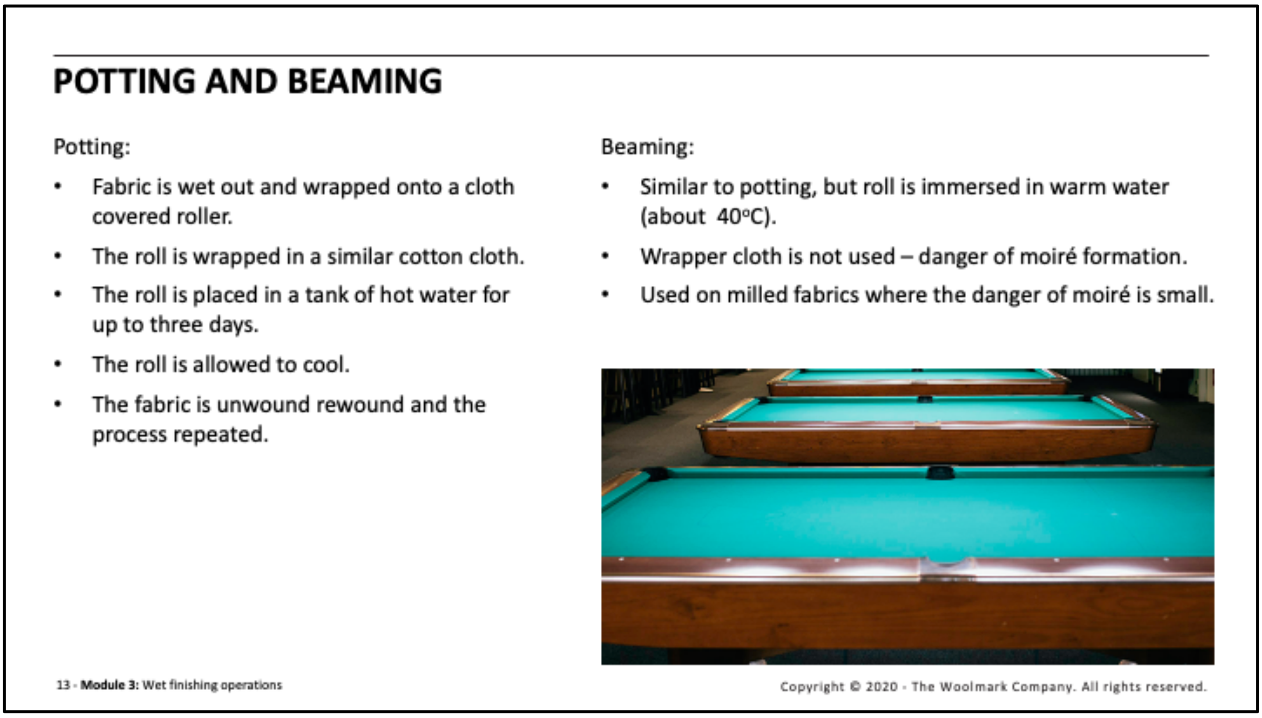
The fabric and wrapper are unrolled through cold water to stop the permanent setting action, so permanent setting does not continue if the fabric is distorted.

NOTE THAT the procedure may be repeated, rolling from the other end of the batch to prevent end-to-end variations.

MENTION THAT some machines also incorporate 'steaming rolls', which force steam through the wet roll (i.e. Yorkshire crab).

Traditional batch crabbing imparts large amounts of permanent set (often in excess of 60% using crease angle tests) to wool fabric.

NOTE THAT the diagram on the slide is schematic only.



Potting

EXPLAIN THAT potting is a wet pre-setting operation in which the fabric is wet out and then wrapped on a cloth-covered (often canvas-covered) roller.

The entire roll is then itself wrapped in a similar cotton cloth.

The roll is then placed in a tank of hot (60–100°C) water for up to three days, then allowed to cool.

The fabric is unwound and rewound from the other end and the process is repeated.

The process imparts large amounts of permanent set to the fabric. The process is labour-intensive and time-consuming, so it is rarely used.

Beaming

INDICATE THAT beaming is a wet pre-setting operation similar to potting, but the roll is immersed in warm (approximately 40°C) water (as opposed to hot water).

As a wrapper cloth is not used in this operation, there is a danger of moiré formation (which will be discussed shortly).

EXPLAIN THAT beaming tends to be used on milled fabrics, where the danger of moiré is small.

Beaming is rarely used because, like potting, it is time-consuming and labour intensive, making it expensive.

NOTE THAT potting and beaming were favoured methods used in the production of cloths for billiard tables.

MOIRÉ

- Wavy pattern, similar to a watermark or interference pattern, on the surface of the fabric.
- Caused by interference between the weaves of the two fabrics.
- Can be difficult to remove, if permanently set.

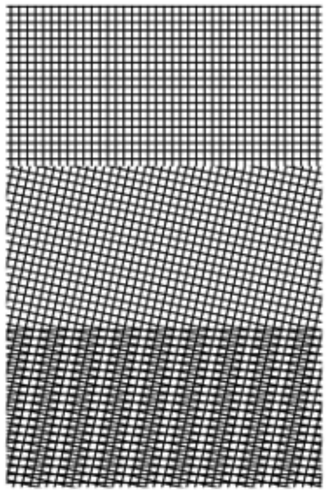


Image courtesy of Biella Shrunk Processes s.a.s. (www.madersrl.it)

14 - **Module 3:** Wet finishing operations

INDICATE THAT moiré is a wavy pattern, similar to that of a watermark or an interference pattern, produced on the surface of a fabric during finishing.

NOTE THAT it is the perception of a distinctly different third pattern, which is caused by the inexact alignment of two similar patterns as illustrated on the slide.

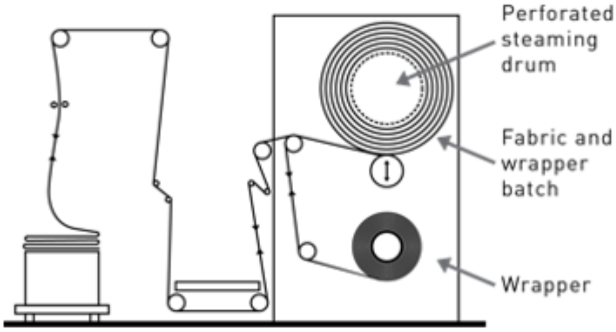
EXPLAIN THAT moiré patterns occur when there is some registration between the weaves of the normally dry (but also wet) sections of the same fabrics in contact.

If the process imparts permanent set, the moiré can be difficult to remove.

PRE-SETTING: WET BATCH DECATISING

- Fabric is wet out then squeezed using a pad mangle.
- Wet fabric is rolled onto a perforated drum with a cotton wrapper cloth.
- Saturated steam is forced through the roll.
- Vacuum pump draws air to cool the fabric.
- Fabric is unrolled.
- Fabric is rewound from the other end, and re-treated.

Wet decatising can impart large amounts of permanent set.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

15 - **Module 3:** Wet finishing operations

EXPLAIN THAT wet batch decatising is the process in which:

- wool fabric is wet out and squeezed to a water content of around 80%, often using a pad mangle
- the wet fabric is rolled into a batch decatiser interleaved with a cotton wrapper cloth, which is permeable to steam and air, onto a perforated drum. The wrapper cloth is a high-quality closely-woven cotton fabric (occasionally cotton-polyester), which ensures there is no embossing of faults on the surface of the wool fabric
- Saturated steam is forced through the roll to heat the wool (and wrapper) to temperatures around 100°C for up to five minutes
- A vacuum pump is used to draw air through the roll to cool the fabric
- The fabric is unrolled, with the wrapper being rolled onto a separate roller for use with the next batch.

INDICATE THAT often the fabric is rewound and re-treated to avoid end-to-end differences in the fabric.

NOTE THAT the wet decatising process can impart large amounts of permanent set.

DEMONSTRATION: WET BATCH DECATISING

Resources required:

- *cardboard tube*
- *cotton fabric*
- *wool fabric*

LAY *the wool and cotton fabrics on top of each other and roll the combined fabrics onto cardboard tube so the wool is sandwiched between layers of cotton.*

REINFORCE THAT *the purpose of the cotton wrapper fabric is to ensure no embossing of the surface of the wool fabric.*

DESCRIBE *how steam is forced through the cardboard to heat the fabric.*

DESCRIBE *how, at the same time, air is sucked back through the roll to cool the fabric.*

PRE-SETTING: DRY BATCH DECATISING

Loom-state fabric can be pre-set by decatising dry fabric:

- Sometimes called 'greasy blowing'.
- Dry batch decatising is carried out on wool with normal moisture content.
- Used to avoid drying, where the next process is carried out on dry fabric.
- Rarely used in modern mills.

Advantages:

- Easier handling of the fabric.

Disadvantages:

- Level of permanent set low.
- Removal of dirt and oil more difficult.
- May affect dyeing properties.
- Wrappers become soiled and require frequent cleaning.

16 - **Module 3:** Wet finishing operations

INDICATE THAT loom-state fabric can be pre-set by decatising dry fabric. This process is sometimes called 'greasy blowing'.

EXPLAIN THAT this technique can be used to avoid a drying operation where the subsequent process is to be carried out on the dry fabric (saving both time and money), however the process is rarely used in modern mills.

NOTE THAT fabric is decatised as described previously, except the fabric is not wet out before the process so the pre-setting is carried out on wool with normal moisture content (8–15%).

An advantage of dry batch decatising is that it allows easier handling of the fabric.

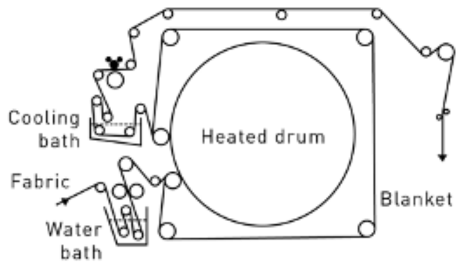
EXPLAIN THAT the disadvantages of dry batch decatising are:

- the level of permanent set is generally low.
- dry setting can make dirt and oil removal more difficult during scouring.
- dry setting can affect dyeing properties (this will be discussed later in piece dyeing).
- the level of permanent set is small.
- wrappers become soiled and required frequent cleaning.

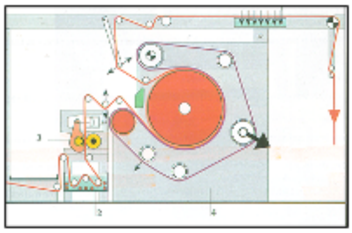
NOTE THAT decatising will be discussed again in more detail in the module on dry finishing.

PRE-SETTING: CONTINUOUS CRABBING

- Fabric is wet out in a trough.
- Fabric is squeezed to give consistent moisture content.
- Fabric is held against a hot rotating drum by an impervious endless blanket.
- Drum temperature up to 140-180°C.
- When the fabric emerges it is:
  - immersed in cold water, or
  - cooled by air.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997



EXPLAIN THAT in the continuous crabbing operation:

- the fabric is first passed through a trough where it is wet out
- the fabric is squeezed to give it consistent moisture content
- the fabric is held against a heated rotating drum by an impervious endless blanket, which is usually silicone coated
- the drum is steam or oil heated to a temperature of up to 140–180°C
- when the fabric emerges from the belt or roller seal it is either:
  - immersed in cold water, or
  - cooled by air.

ASK *participants why an effective seal by the belt or roller seal is important.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that an effective seal is required to increase the pressure in the region of the fabric so the temperature can exceed 100°C.*

ASK *participants to explain why it is important the fabric temperature exceeds 100°C.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that the higher the temperature, the more permanent the set.*

ASK *participants to explain why the amount of permanent set imparted by continuous crabbing is considerably lower than that achieved during batch crabbing.*

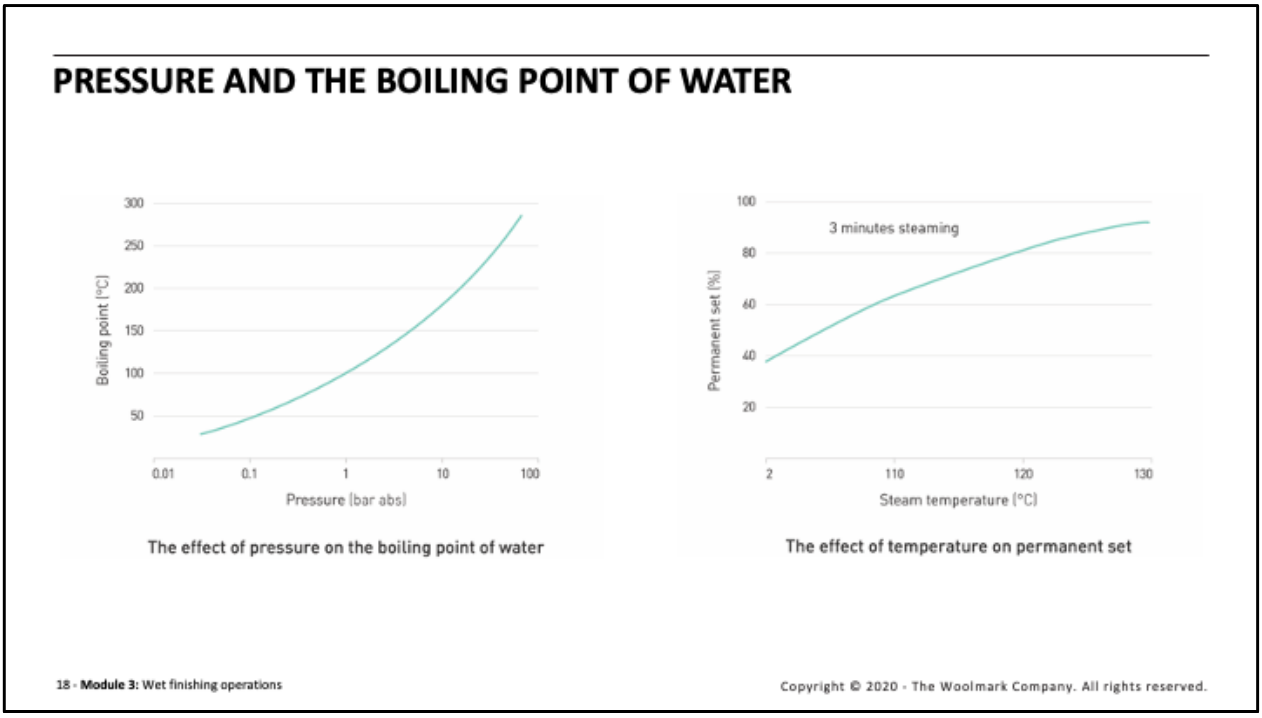
ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that because although the temperature may be higher, the time is very short.*

ASK *participants whether cohesive set is imparted during the continuous crabbing process.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that cohesive set is NOT imparted during continuous crabbing because the wet fabric because it is already above the glass transition temperature.*



EXPLAIN THAT in the continuous crabbing operation the belt is designed to form a pressure seal, so the temperature of the water on the fabric can exceed 100°C.

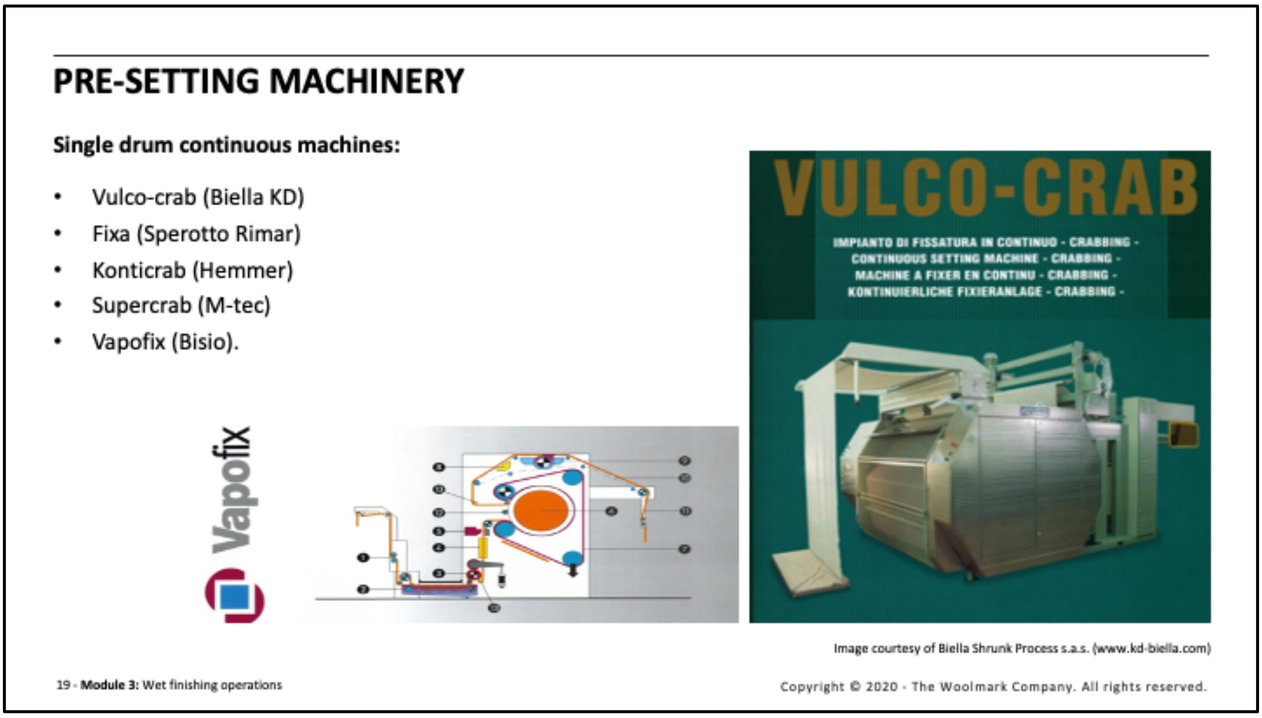
NOTE THAT if the belt does not form an effective seal the efficacy of the machine is reduced.

INDICATE THAT this slide shows:
- the effect of pressure on the boiling point of water
- the effect of temperature on the amount of permanent set in wool.

EXPLAIN THAT the wet fabric is held against the hot (160°C) drum of the crabbing machine. However, the temperature of the wet fabric only reaches that required to boil the water.

REINFORCE THAT the better the seal between belt and drum, the higher the pressure that can be maintained and the higher the boiling point of water.

NOTE THAT the higher the temperature the greater the amount of permanent set that can be imparted.



INDICATE THERE are several continuous pre-setting machines on the market.

Single drum machines include:

- Vulco-crab (Biella KD)
- Fixa (Sperotto Rimar)
- Conticrab (Hemmer)
- Supercrab (M-tec)
- Vapofix (Bisio).

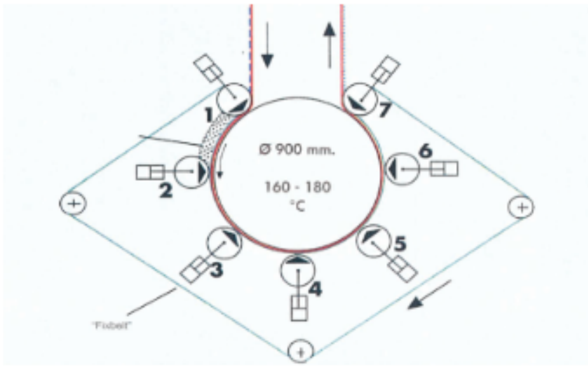
NOTE THAT more information is given about the first three machines on the following slides.

MENTION THAT the speed of the continuous crabbing process is typically 10–20 metres of fabric per minute, given a setting time of 10 to 15 seconds.

EXPLAIN THAT the amount of permanent set achieved can be relatively low, depending on the seal achieved by the belt. The amount of permanent set imparted by a continuous crab is much lower than that achieved in batch crabbing.

PRE-SETTING MACHINERY
VULCO CRAB (BIELLA KD)

- Vulco-Crab is a new combined crabbing and pressing machine using a particular patented technique based on a 'fabric direct pressure concept'.
- Seven pressure rollers maintain the pressure seal.



Drum diameter – 900 mm
Maximum drum temperature – 180 °C
Working speed – 0–35 m/min

Image courtesy of Biella Shrunk Process s.a.s. (www.kd-biella.com)

20 - **Module 3:** Wet finishing operations

EXPLAIN THAT this machine is a combined crabbing and pressing machine suitable for wool and wool blends, using a particular patented technique based on a 'fabric direct pressure concept'.

INDICATE THAT the novelty of the Vulco-Crab is the presence of seven pressure rollers in contact with the central steam-heated drum, around which the fabric to be treated and a special waterproof belt are wound.

NOTE THAT the Vulco Crab has:
- a drum diameter equal to 900 mm
- a maximum drum temperature of 180 °C
- a working speed of between 0–35 metres per minute.

PRE-SETTING MACHINERY FIXA (SPEROTTO RIMAR)

- Pressurised chamber with special seals at the entry and exit.
- Wet fabric passes around a heated drum within the pressurised chamber allowing treatment at temperatures > 100ºC.

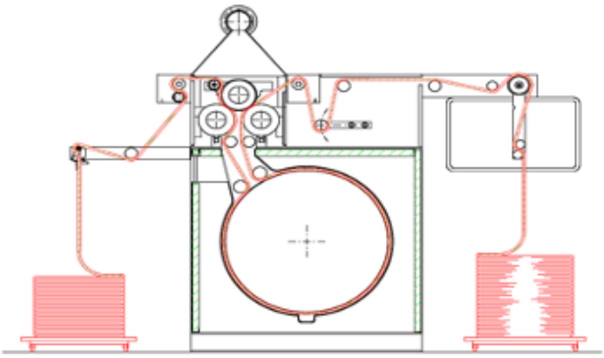


Image Courtesy of Santex Group

21 - **Module 3:** Wet finishing operations

INDICATE THAT this machine is a continuous pressurised crabbing machine.

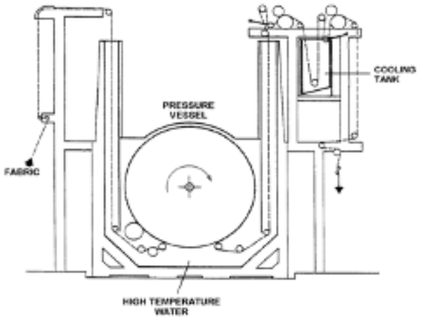
EXPLAIN THAT special seals at the entry and exit of the setting chamber allow for the wet fabric to pass through high-pressure water and around a drum.

The high-pressure water has a temperature above 100°C and this increases the rate of permanent setting.

NOTE THAT the sealed chamber is essential to exert the necessary pressure.

PRE-SETTING MACHINERY
HIGH-PRESSURE CONTINUOUS CRAB

- Hydrostatic head raises the temperature of the water to >100°C to increase level of permanent set.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

(MAT) high-pressure crab

22 - **Module 3:** Wet finishing operations

EXPLAIN THAT the Conticrab by MAT incorporates a hydrostatic head, which helps to raise the temperature of the water on the fabric to >100°C.

The higher temperature increases the level of permanent set.

CHEMICALLY-ASSISTED WET SETTING

A setting agent can be used to increase the level of permanent set. Examples include:

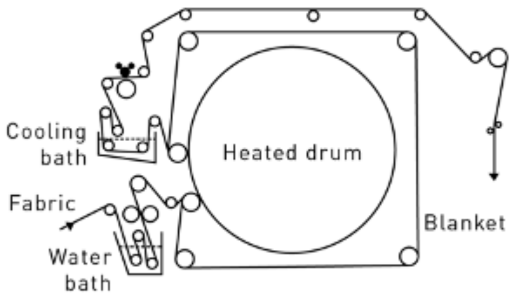
- monoethanolamine sulphite
- sodium bisulphite
- Ang-Ra (Rotta)
- Siroset (Boehme).

Advantages:

- Increases level of permanent set .

Disadvantages:

- Can affect dye colour.
- Modifies piece dyeing behaviour.



The setting agent is placed in the wetting trough (water bath).

Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

INDICATE THAT a setting agent can be used in continuous crabbing to increase the level of permanent set. The setting agent is placed in the wetting trough.

ASK *participants to explain why do the setting agents help to improve wet setting.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that **s**etting agents help improve wet setting by reducing some disulphide to thiol groups which catalyse disulphide interchange.*

EXPLAIN THAT an oxidising agent may be placed in the cooling bath to remove residual setting agent and stop the setting process.

Commercial setting agents include:

- Monoethanolamine sulphite
- Sodium bisulphite
- Ang-Ra (Rotta)
- Siroset (Boehme).

NOTE THAT the main advantage of chemically-assisted wet setting is that it increases the level of permanent set.

MENTION THAT the disadvantages of chemically-assisted wet setting are that it:

- can affect the colour of some dyes
- modifies piece dyeing behaviour, causing problems if the setting effect is uneven.

SCOURING

Scouring during finishing:

- Aims to clean the fabric
- Soaps can be used
- Anionic and nonionic detergents most commonly used.

Unwanted effects:

- Uncontrolled relaxation leading to puckering
- Stretching in warp direction
- Running marks
- Felting, if mechanical action is too severe.

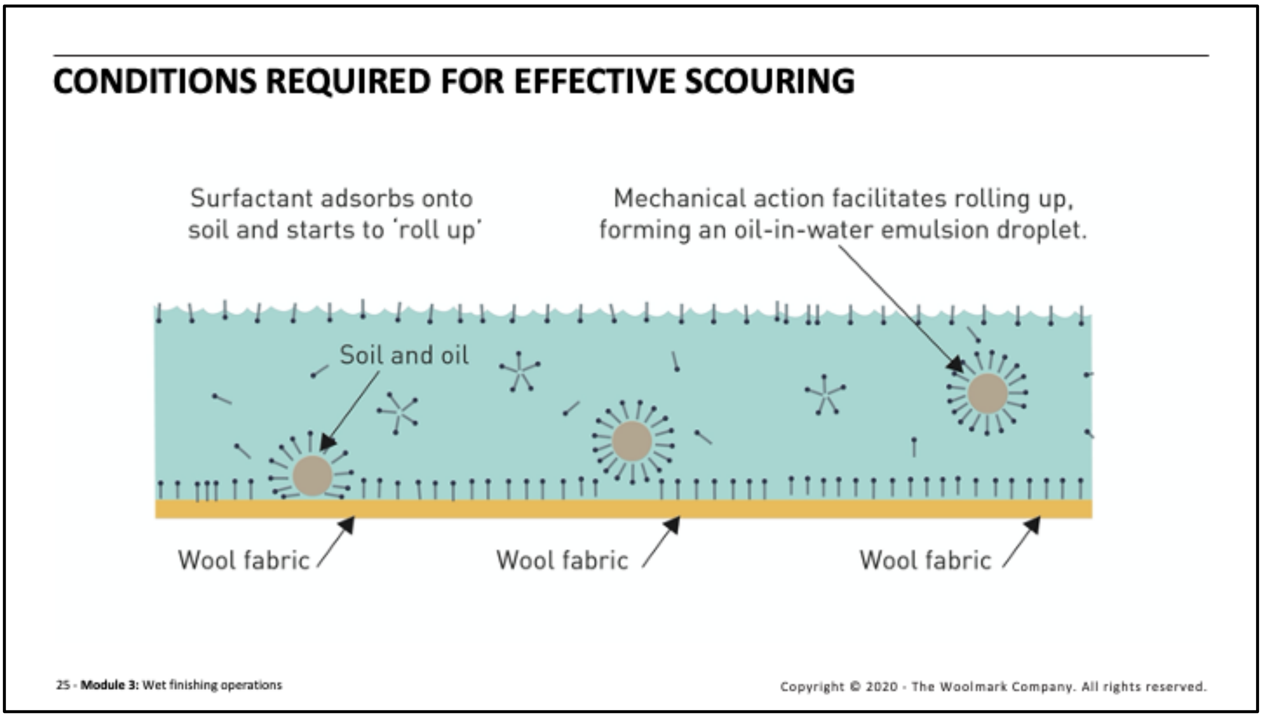
24 - **Module 3:** Wet finishing operations

INDICATE THAT scouring is a washing process designed to clean the fabric, removing residual oils, dirt and other contaminants.

EXPLAIN THAT soaps can be used, provided the water is soft and the washing liquor is alkaline. Anionic and non-ionic detergents are most commonly used for scouring operations at this stage of processing, as they are less affected by water hardness.

POINT OUT that the unwanted effects associated with scouring are:

- uncontrolled relaxation, leading to puckering
- stretching in the warp direction (i.e. longitudinally)
- running marks (explained later)
- felting, if the mechanical action is too severe.



EXPLAIN THAT effective scouring of fabrics requires:

- an effective surface active agent (surfactant) with good detergency properties, which prevents re-deposition on the fibres
- a builder to help with soil removal and control of pH
- adequate exchange between the liquor on the fabric and that in the scouring bath
- some mechanical action on the fabric to loosen the dirt — excessive mechanical action can cause felting
- a slightly elevated temperature to reduce the viscosity of the oils on the fabric.

INDICATE THAT the stages in the removal of contaminants are:

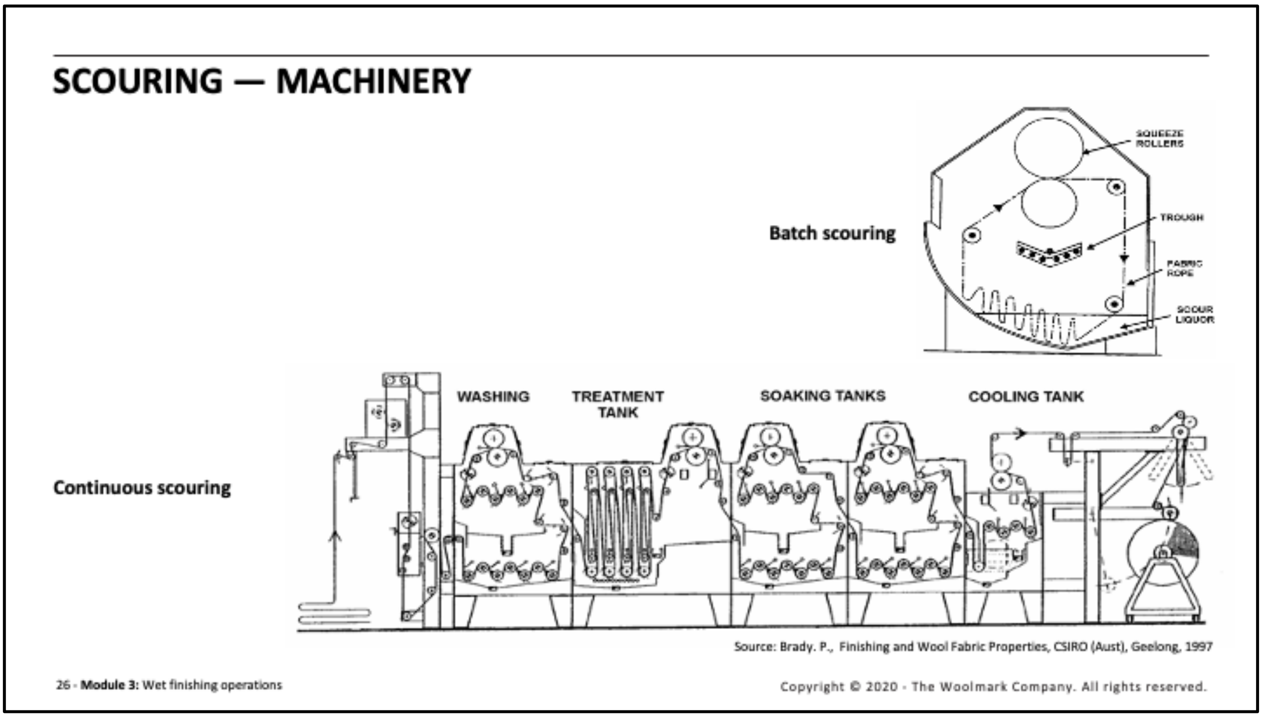
- the emulsification of the contaminants by the detergent
- the exchange of liquor between fabric and bath.

NOTE THAT the detergent coats the water insoluble particles, waxes and oils allowing them to lift off the fibres to be removed in the liquor interchange.

Liquor interchange is the interchange between the scouring liquor on the fabric and that in the scouring bath.

EXPLAIN THAT this interchange is promoted by

- frequent squeezing of the excess liquor from the fabric using squeeze roller
- a suction slot, which draws water from the fabric
- water sprays
- directional changes around rollers, which throw off excess water.



INDICATE THAT there are two types of scouring machinery used in wet finishing operations, both of which are illustrated on the slide:

Continuous scouring
In the continuous scouring machine shown on the slide, the fabric passes through the machine in the following sequence:

- washing chamber
- treatment chamber
- soaking chamber
- cooling chamber.

The number of chambers may vary with different machines and the nomenclature may also change (washing, rinsing etc)

EXPLAIN THAT in a continuous machine, the fabric is repeatedly immersed in the bath, or the scouring bath is sprayed onto the fabric. The liquid is repeatedly squeezed from the fabrics as the direction is reversed around rollers.

Batch (rope) scouring
As illustrated on the slide, the fabric rope is alternately immersed in the scouring liquor and squeezed through the rollers.

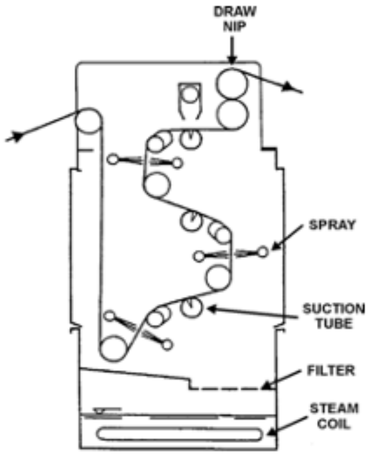
NOTE THAT in both types of machine, the removal of dirt is achieved by:

- the emulsification of the contaminants by the detergent

BATCH OPEN-WIDTH SCOURING MACHINERY

- The fabric is fed into the machine.
- The ends are sewn together to make continuous loop.
- Fabric remains in open width during scouring.
- Water sprays and rollers remove the contaminants.

This method is rarely used, but can be an option found in a few specialised machines.



JetVac – Farmer Norton

Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

27 - **Module 3:** Wet finishing operations

NOTE THAT there are two types of batch scouring machines:

- batch open-width machines
- batch rope machines.

Batch open-width scouring
This form of machinery is used less than other machine types.

EXPLAIN THAT the process is as follows:

- The fabric is fed into the machine.
- The ends are sewn together to make a continuous loop.
- The fabric remains in open width during the scouring process.
- Water sprays and rollers remove the contaminants before the fabric is rinsed in the same machine.

INDICATE THAT this technique for fabric scouring can be found in a relatively few specialised machines and is used for simple scouring operations.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of a batch open-width scouring operation.

PLAY *video (1.09 minutes)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

BATCH (ROPE) SCOURING — RUNNING MARKS

- Visible creases or folds in the fabric formed during rope processing.
- Are difficult to remove.
- Can be formed by:
  - setting
  - felting.

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EXPLAIN THAT in contrast to open-width scouring, rope scouring involves the fabric being scoured while it is in rope form. In rope form the fabric is randomly folded in the weft direction, while being fully open in the warp direction.

DEMONSTRATION: ROPE FORMATION

Resource required

- *length of woven wool fabric*

TAKE *the length of fabric and hold it at one end allowing the length to fall towards the floor.*

SQUEEZE *the fabric in at the sides with your free hand, while retaining the length, to form a rope.*

ENSURE *all participants can observe demonstration clearly.*

NOTE THAT the scouring action in rope scouring is derived from the liquor interchange caused by mechanical action imposed by squeeze rollers.

INDICATE THAT the advantages of rope scouring are:

- highly effective scouring
- the mechanical action on the fabric normally has a softening effect
- it can also be used for fabric development.

MENTION THAT the disadvantages of rope scouring are:

- potential for the formation of running marks and other distortions
- some fabrics must be bagged before rope scouring to prevent running marks
- some machines require air turbines to reduce running marks
- loading of the rollers is critical to prevent slipping, which will mark the fabric
- in some machines the process uses a lot of water (goods to liquor ratio >1:50)

POINT OUT that running marks are visible creases or folds in the fabric formed during rope processing, which can be removed temporarily, but can re-emerge during garment making or use. They are difficult to remove permanently because they are formed by the setting or felting actions of the scouring process. Running marks formed by localised felting around the edge of the fold are particularly difficult to remove.

BAGGING

- Fabric selvedges, and the ends of the fabric, are sewn together to form a tube.
- Air is trapped in the tube causing the fabric to balloon.
- This 'ballooning' redistributes the folds in the fabric.

INDICATE THAT bagging is a process which aims to prevent running marks or permanent creases in the fabric.

EXPLAIN THAT the process of bagging is as follows:

- The fabric selvedges are sewn together then when the fabric is placed in the machine.
- The ends of the fabric are sewn together to form a tube.
- Air is trapped in the tube causing the fabric to balloon when it enters the squeeze rollers.
- This 'ballooning' redistributes the folds in the fabric so successive squeezes do not reinforce the folds.

DEMONSTRATION: BAGGING

Resource required

- *length of woven wool fabric*

TAKE *the length of fabric and staple the selvedges together to form a tube of fabric.*

INDICATE *to the participants that this tube is formed face-in for bagging.*

ASK *participants to explain why it is formed in this way.*

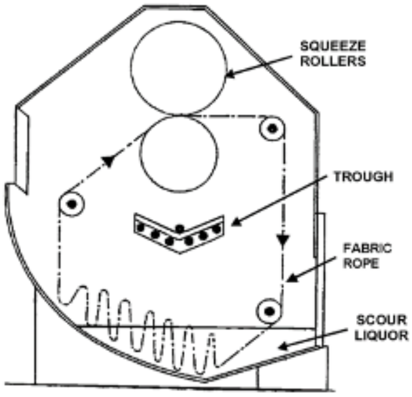
ALLOW *participants sufficient time t o respond.*

IF NECESSARY *confirm that this avoids damage to the face of the cloth.*

BATCH (ROPE) SCOURING MACHINERY

- The fabric is fed into the machine.
- Fabric ends are sewn together to make a continuous loop.
- Fabric rope makes multiple passes through the squeeze rollers.
- Rinsed in the same machine.

- Washes and rinses with a fairly gentle action.
- Widely used for worsted and woollen fabric.
- Often called a scouring 'dolly'.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

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POINT OUT that batch rope scouring is the most common form of scouring for worsted and woollen fabric.

EXPLAIN THAT the batch rope scouring process is as follows:

- The fabric is fed into the machine.
- The ends are sewn together to make a continuous loop.
- The fabric rope makes multiple passes through the squeeze roller.
- After washing the fabric is rinsed in the same machine.

INDICATE THAT early machines were often called a scouring 'dolly' and washed and rinsed the fabric with a fairly gentle action designed to avoid felting.

EXPLAIN THAT in practice, modern machinery used is more complex than a simple dolly scour, so more than one process can be undertaken in the one machine.

ROPE SCOURING MACHINERY

NOTE THAT the typical conditions for rope scouring machinery are as follows:

- Water should be softened to <120ppm (as $CaCO_3$)
- Anionic detergent
- pH=7–9 with sodium carbonate
- 20 minute scour then 2 × 15 minute rinses
- Temperature
    - scour 40–50°C
    - rinse 30–40°C and cold
- Speed up to 150m/min depending on fabric.

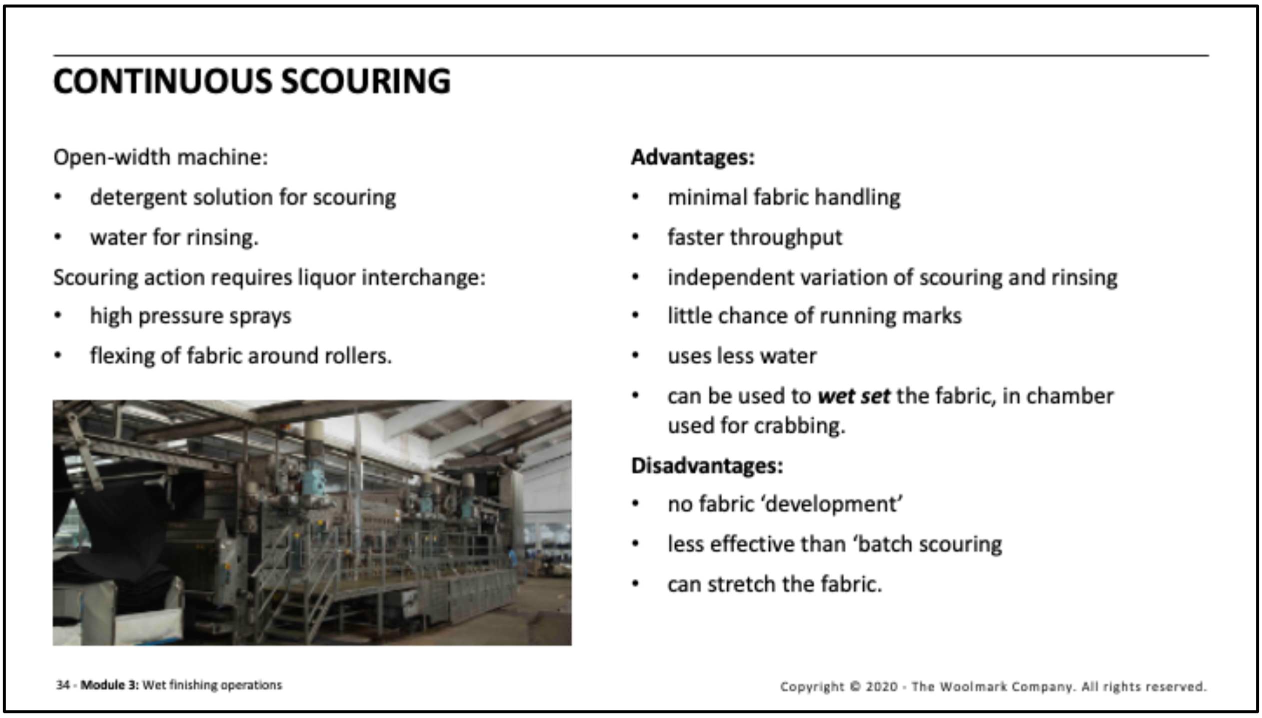
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the rope scouring operation.

***PLAY** video (58 seconds)*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond.*

***NOTE TO FACILITATOR** This slide indicates the mid-point of this module where a break can be taken before the second half of the module is presented.*



EXPLAIN THAT in a continuous scouring operation the fabric is run open width through a machine containing detergent solution for scouring and water for rinsing.

The scouring action results from liquor interchange derived from high-pressure sprays and flexing of fabric around rollers.

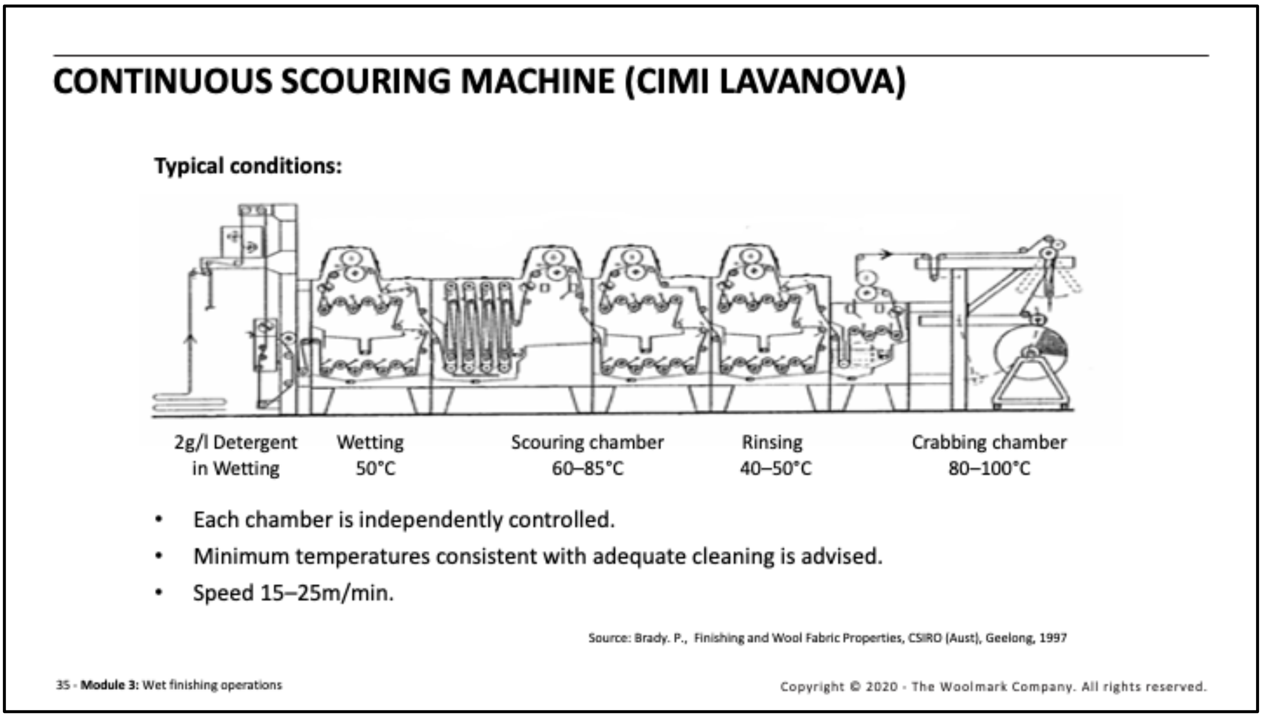
INDICATE THAT the advantages of continuous scouring are:

- minimal fabric handling and faster throughput
- separate sections allow for variation in scouring and rinsing conditions
- little chance of running marks
- lower water usage (goods to liquor ratio~1:5) than batch machines.

NOTE THAT a continuous scour can be used to wet set the fabric if a section or chamber of the machine is used for crabbing (80–100°C).

POINT OUT that the disadvantages of continuous scouring are:

- no fabric 'development'. Development is a process in which the wet fabric is subjected to mild mechanical action to soften the handle of the fabric.
- less effective stain and dirt removal than batch machines
- the process can stretch the fabric, reducing warp extensibility.



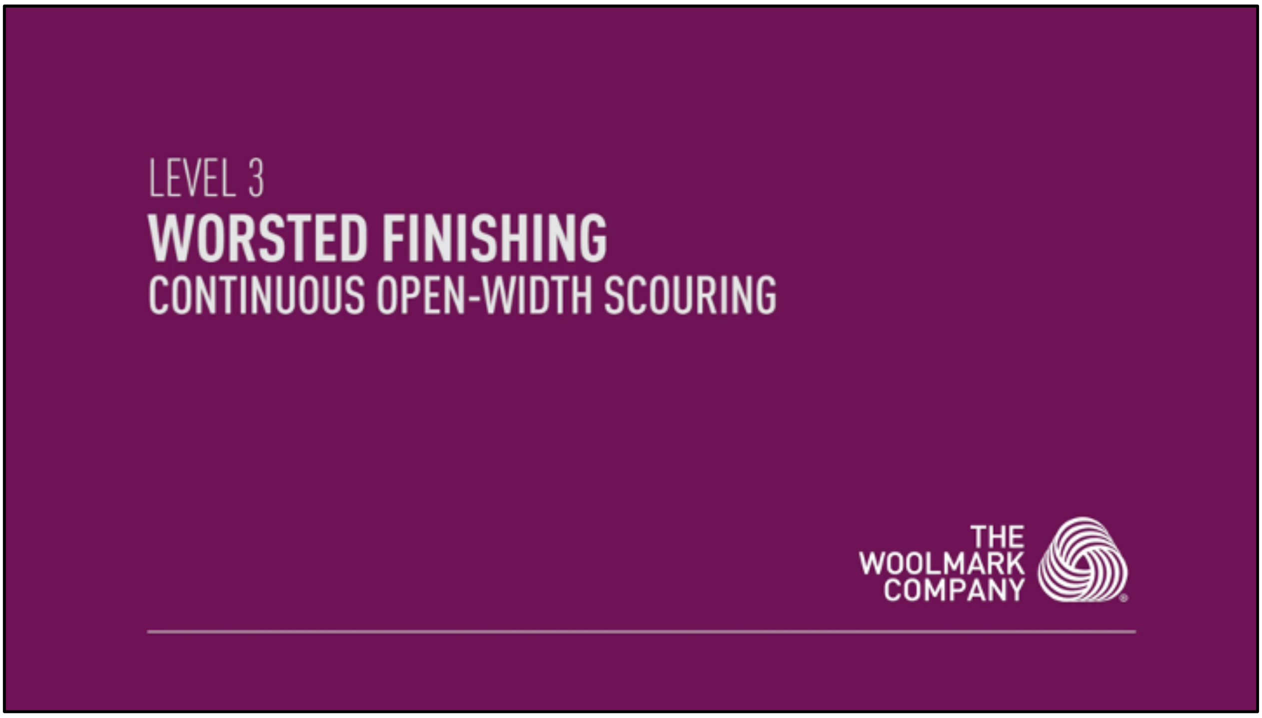
INDICATE THAT each chamber of the continuous scouring machine shown on the slide (made by CIMI Lavanova) is independently controlled:

- The first chamber will typically be at 50°C
- The scouring chamber at 60–85°C
- The rinsing chambers at 50°C.

NOTE THAT it is advisable to use minimum temperatures consistent with adequate cleaning.

EXPLAIN THAT the typical conditions for scouring are:

- 2g/l detergent in wetting and scouring sections.
- crabbing section at 80–100°C.
- speed of the machine from 15–25 metres per minute (m/min).

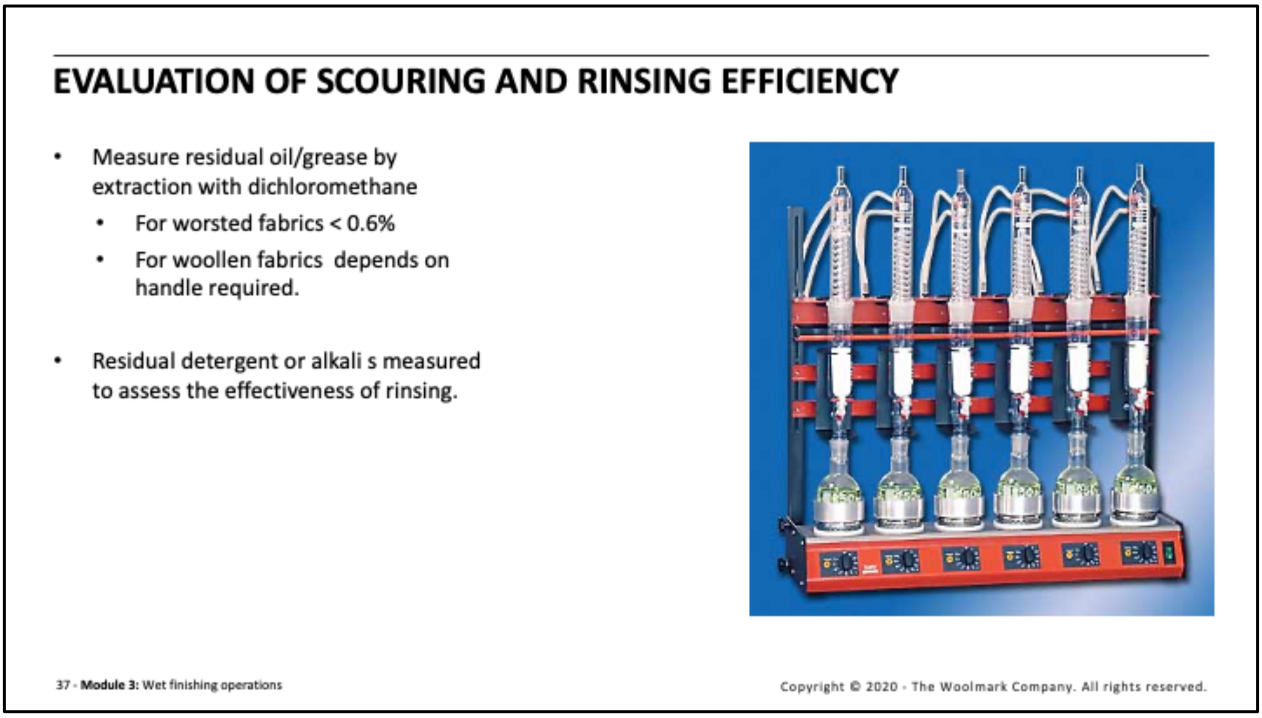


EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the open-width continuous scouring process.

PLAY *video (31 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*



EXPLAIN THAT scouring efficiency is evaluated by measuring residual oil and grease by extraction with dichloromethane:

- For worsted fabrics < 0.6%
- For woollen fabrics depends on handle required.

NOTE THAT the effectiveness of rinsing is assessed by measuring the residual detergent or alkali on the fabric.

SOLVENT SCOURING

Continuous open-width machines.

Use a chlorinated hydrocarbon solvent, such as perchlorethylene.

Advantages:

- Efficient for removing oily materials (processing lubricants)
- Does not use water.

Disadvantages:

- Does not remove water-soluble materials
  - Normally aqueous scouring must also be used
- No 'development' of the fabric
- Environmental concerns
- Health and safety concerns.

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EXPLAIN THAT solvent scouring is conducted in continuous open-width machines using a chlorinated hydrocarbon solvent, such as perchlorethylene. This solvent is used instead of water to clean the wool fabric.

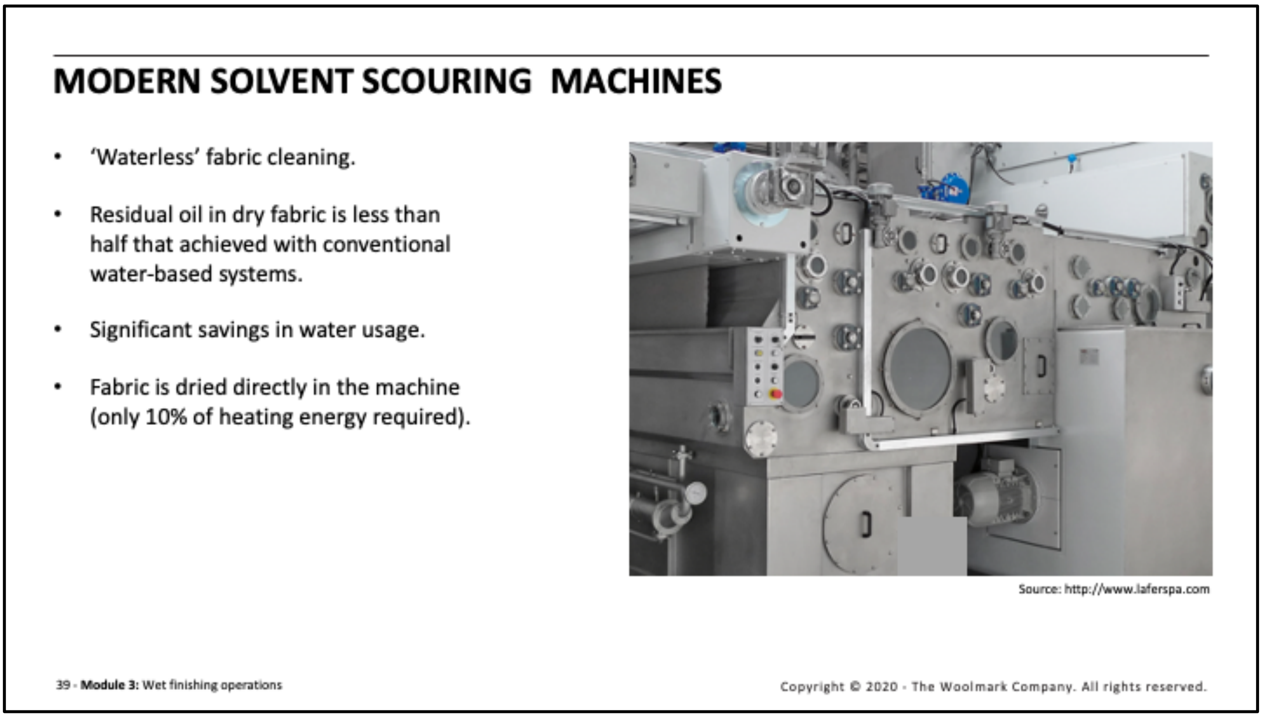
INDICATE THAT the advantages of solvent scouring are:

- efficient for removing oily substances (processing lubricants)
- does not use water.

NOTE THAT the disadvantages of solvent scouring are:

- does not remove water-soluble materials (e.g. sizes)
- normally aqueous scouring must be used after solvent scouring
- there is no 'development' of the fabric
- there are environmental concerns and health and safety concerns with chlorinated hydrocarbons.

POINT OUT that the last two disadvantages (environmental and health and safety) are significant issues.

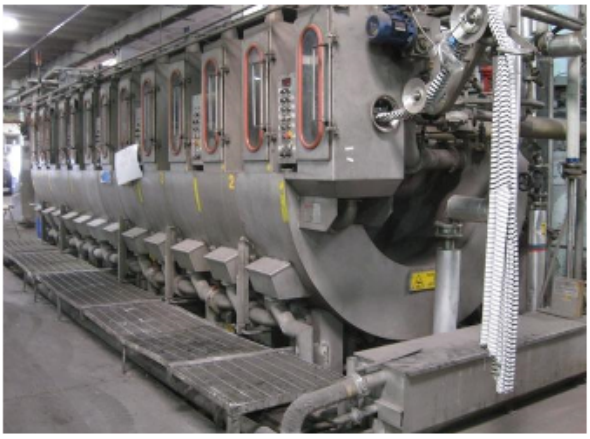


MENTION THAT both Santex and Lafer market solvent scouring machines. Both are examples of the leading technology for machinery of its type.

EXPLAIN THAT the machines offer:
- 'waterless' fabric cleaning – using solvent
- residual oil in dry fabric less than half that achieved with conventional water-based systems.
- significant water use savings
- fabric is dried directly in the machine — only 10% of heating energy required.

CONTINUOUS ROPE WASHING

- A small number of machines.
- More time-efficient than batch machines.
- The operating principals are the same as batch machines.
- Largely replaced by continuous open width washing.



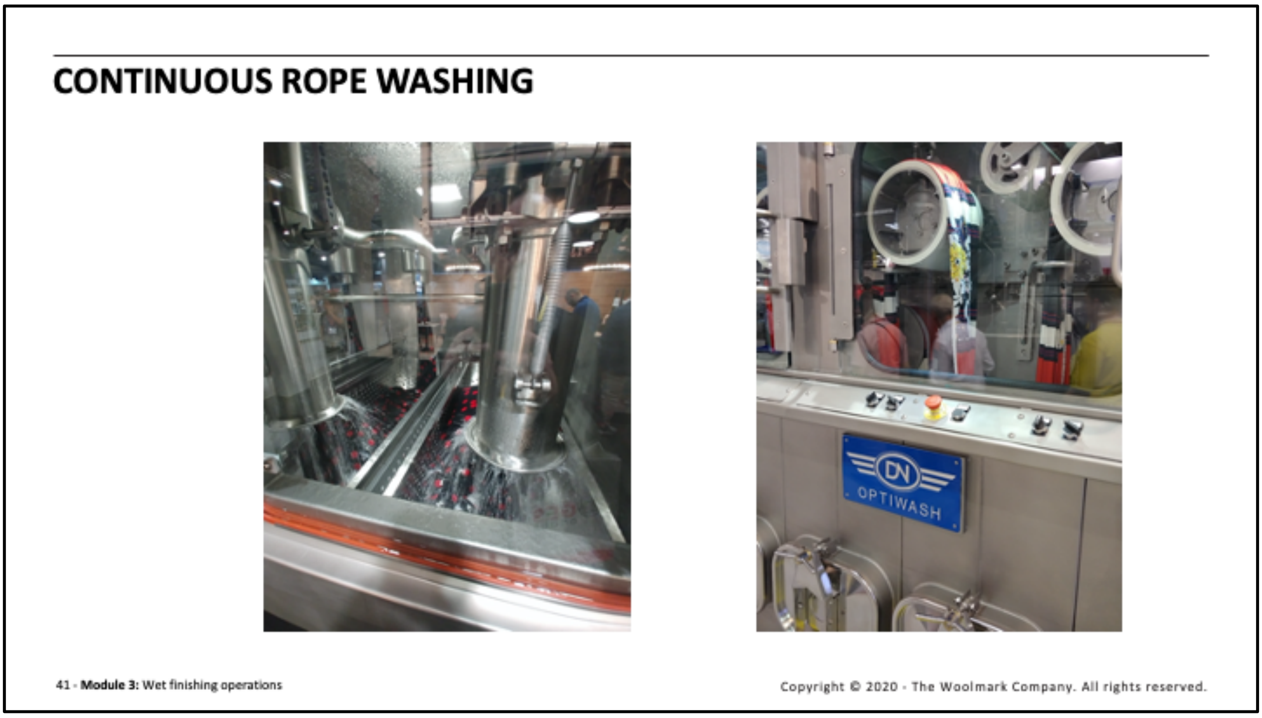
Source: http://www.wotol.com/1-arioli-continuous-rope-washer-for-knits/second-hand-machinery/prod_id/458024

40 - **Module 3:** Wet finishing operations

EXPLAIN THAT a small number of machines have been developed to continuously wash wool fabric in rope form. These are more time-efficient than batch machines.

NOTE THAT the operating principles for continuous rope washing are the same as continuous batch machines, with a number of squeeze rollers being used to achieve liquor interchange.

INDICATE THAT these machines have been largely replaced by continuous open-width washing.



INDICATE THAT these images are of new continuous rope scouring machines (e.g. the Optiwash by Danitech), which are being promoted for washing-off after digital printing of knitted (and some woven) fabrics. The machines were exhibited at ITMA 2019 (Barcelona).

NOTE TO FACILTATOR: *This is an appropriate point to break the module and end the first lecture.*

ASK *participants if they have any questions about the content covered in this module so far.*

FABRIC DEVELOPMENT

Fabric development (light milling or 'bursting' the yarns):

- Wet fabric is subjected to mild mechanical action to soften the handle.
- The surface of the fabric may become hairier, but the amount of shrinkage is small.

Used on many worsted fabrics:

- More mechanical action than scouring dolly.
- Less mechanical action than a milling machine.
- A high-speed scouring machine is often used.

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WELCOME participants to the second part of the module — *Wet finishing operations.*

EXPLAIN THAT the term 'fabric development' (also called light milling or 'bursting' the yarns) is a process in which the wet fabric is subjected to mild mechanical action. It is carried out to soften the handle of the fabric.

NOTE THAT the mechanical action causes some movement of the fibres in the yarn. The surface of the fabric may become hairier, but the amount of shrinkage is small.

EMPHASISE THAT many worsted fabrics undergo development to impart a softer handle.

More mechanical action is required than can be achieved in a scouring dolly in a reasonable time.

INDICATE THAT less mechanical action is required than can be adequately controlled in a milling machine (discussed later).

NOTE THAT a high-speed scouring machine is often used for such operations.

HAND OUT *fabric samples before and after development to the participants.*

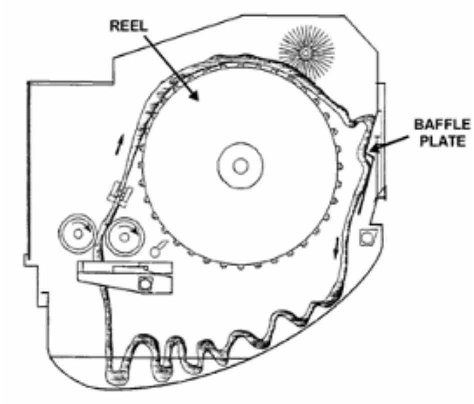
EMPHASISE *the effect of development on the fabric handle.*

ENCOURAGE *participants to comment on the differences observed.*

HIGH-SPEED BATCH (ROPE) SCOURING MACHINES

Widely used for scouring and development.

- The machines run up to 600m/min.
- Fabric is thrown against the back of the machine.
- Many different designs of machines.
- There can be several side effects.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

43 - **Module 3:** Wet finishing operations

NOTE THAT high-speed batch (rope) scouring machines are widely used for scouring and development of fabrics.

EXPLAIN THAT the machines can run at up to 600m/min 'throwing' the fabric against the back of the machine or a baffle plate to give the required mechanical action for development.

DEMONSTRATION: HIGH SPEED ROPE SCOURING MACHINE

Resource required

- *length of woven wool fabric*

ILLUSTRATE *the action of the machine by throwing the fabric against a wall.*

POINT OUT that there are many different designs of high-speed batch (rope) scouring machines.

MENTION THAT the potential side effects of the development process are:

- excessive felting of the fabric
- excessive surface modification (facing up)
- formation of felted running marks.

HIGH-SPEED ROPE SCOURING MACHINES (CONTINUED)

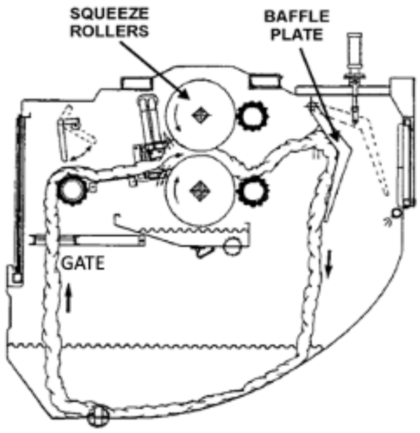
Scouring and development in the same machine

The scouring at relatively low speed (~120m/min).

The speed then increased (~220m/min) to impart the required mechanical action.

- induces bursting of the yarns and some felting
- softens the handle of the fabric.

For some fabrics (wool-polyester), blends scouring and development conducted simultaneously.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

44 - **Module 3:** Wet finishing operations

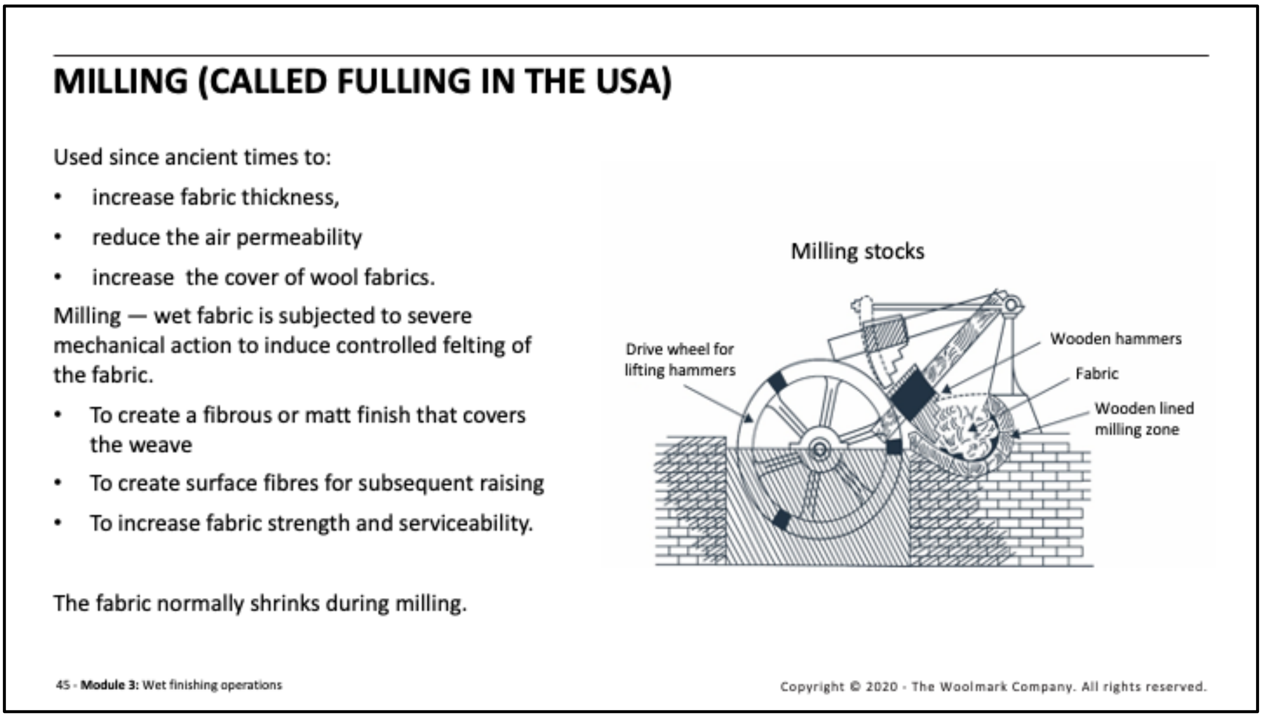
EXPLAIN THAT the conditions for scouring and development in high-speed rope scouring machines are as follows:

- For pure wool or delicate fabrics, the scouring process is carried out at relatively low speeds (~120m/min).
- The speed may then be increased (~220m/min) to impart the required mechanical action to the fabric for development. This induces 'bursting' of the yarns and fibre movement, the combined effects of which are to soften the handle of the fabric.

EMPHASISE THAT for some fabrics, such as wool/polyester blends, both scouring and development may be carried out simultaneously.

NOTE THAT there are many different types of high-speed rope scouring machines. The diagram on the slide illustrates the action of this type of high-speed rope scouring machine.

- gate
- squeeze/drive rollers
- baffle plate.



INDICATE THAT milling (known as fulling in the USA) is a process used to control felting of fabric.

EXPLAIN THAT in this process the wet fabric is subjected to more severe mechanical action to induce controlled felting of the fabric. The process is designed to increase the thickness and cover and to reduce the air permeability of wool fabrics.

HAND OUT *fabric samples before and after milling.*

ENCOURAGE *participants to note differences between the fabric samples.*

NOTE: *Milled fabric samples will appear thicker, hairier and have a lower air permeability.*

POINT OUT that milling has been used since ancient times. In Roman times milling was conducted by slaves, who worked the wet fabric by treading to induce felting of the fibres. The fabric was trodden in tubs of human urine. Stale urine, known as ‘wash’, assisted in cleansing and whitening the cloth. Urine was so important to the milling business that in England, merchants purchased and collected urine from homes every day to supply the local mills. In some countries urine used in milling was subject to tax.

Milling stocks

NOTE THAT the first mechanical machines were ‘milling stocks’ shown on the slide.

The rotary milling machine was developed in the early 19th century.

EXPLAIN THAT milling is also conducted to:

- create a fibrous or matt finish on the fabric that covers the weave
- create surface fibres for subsequent raising
- increase fabric strength and serviceability.

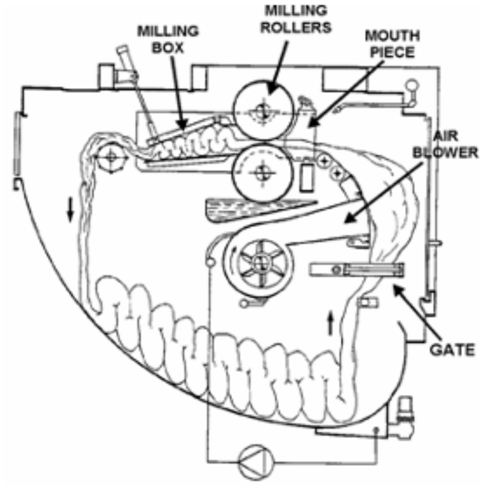
MENTION THAT the fabric normally shrinks during milling. Shrinkage is often used to measure the amount of milling achieved.

ROTARY MILLING MACHINES

The major components of the rotary milling machine are:

- The mouth piece or throat: controls felting in weft direction.
- The milling rollers: control felting in weft direction.
- The milling box or trap: controls felting in warp direction.

The fabric makes multiple passes around the machine.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

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INDICATE THAT the rotary milling machine is widely used. The major components of the machine are:

- The mouth piece or throat, which squeezes the fabric and induces felting in the weft direction
- Rollers, which grip the fabric, pull it through the throat and force it through the trap. These rollers are traditionally made of wood and contribute to felting of weft threads.
- The milling box (or trap), which inhibits the movement of the fabric and imparts mechanical action that causes felting in the warp direction. This component is also traditionally made of wood.

NOTE THAT the fabric makes multiple passes around the rotary milling machine.

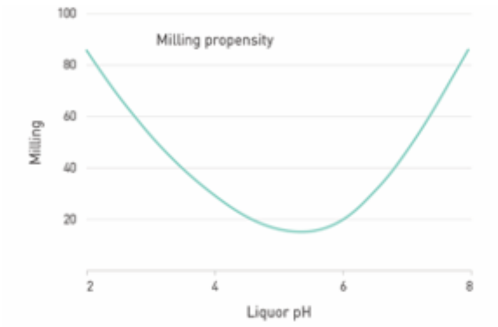
ROTARY MILLING MACHINES

Settings required for milling:

- throat setting
- load on rollers
- load on milling box (trap)
- speed (~180m/min)
- moisture content of fabric ~ 80%
- pH (acid or alkaline)
- milling aid is normally sprayed onto the fabric while it is in motion
- time – cycles.

pH during milling

- Fabrics mill most rapidly under acid or alkaline conditions.



The effect of ph on milling

INDICATE THE settings that need to be managed on rotary milling machines are as follows:

- throat setting
- load on rollers
- load on milling box (trap)
- speed (~180m/min)
- moisture content of fabric normally ~ 80%
- pH (acid or alkaline)
- milling aid (normally sprayed on while the fabric is in motion)
- time (cycles).

ASK *participants to describe the difference water content can make to milling.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that if the water content is too high, the mechanical action of the milling machine will be reduced.*

EXPLAIN THAT fabric must be wet, but not too wet, as too much water reduces the mechanical action. Normally the fabric is not soaking wet but contains ~150% water on weight fabric.

pH in milling

NOTE THAT pH affects the rate of felting. Fabrics felt/mill most rapidly under acid and alkaline conditions, as illustrated on the slide.

As a consequence, the pH must be controlled during the miling process.

ROTARY MILLING FOR BATCH (ROPE) MILLING

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the rotary milling or batch (rope) milling operation.

PLAY *video (1:40 minutes)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

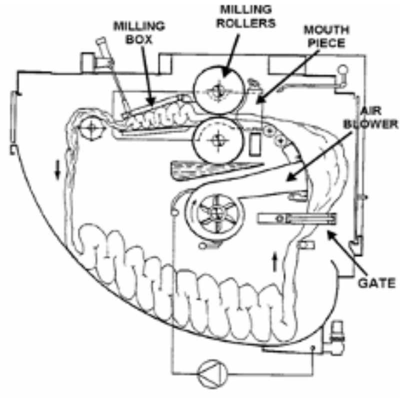
DESIGN IMPROVEMENTS

Design improvements include:

- air turbines before the throat
- driven rollers at the end of the milling box
- the use of belts and rollers to replace the milling box
- simultaneous milling of multiple ropes
- counters to ensure control of the number of cycles.

Air turbines:

- A strong blast of air is directed onto the fabric when lifted by the squeeze rollers.
- Air blast causes the fabric to balloon and redistribute the folds.



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

49 - **Module 3:** Wet finishing operations

EXPLAIN THAT there have been many design improvements made to rotary milling machines over the years:

- Air turbines before the throat to refold the fabric reducing running marks.
- Driven rollers at the end of the milling box give greater control on felting.
- The use of belts and rollers rather than a wooden milling box to control felting.
- Simultaneous milling of multiple ropes.
- Counters to ensure control of the number of cycles to ensure reproducible milling.

Air turbines

INDICATE THAT a strong blast of air is directed onto the fabric when it is lifted by the squeeze rollers, as illustrated on the slide. This causes the fabric to balloon and redistribute the folds thus reducing the occurrence of running marks.

ASSESSMENT OF MILLING

Measure the shrinkage of the wet fabric in warp and weft direction.

Alternatively appearance and handle can be assessed subjectively.

Alternative tests include:

- fabric thickness
- tensile strength
- bias extensibility.

Milling faults include:

- uneven milling
- felted running marks
- chafing marks due to slippage of the roller
- cockling or other distortion
- curling selvedge
- colour bleeding
- unevenness in subsequent dyeing.

50 - **Module 3:** Wet finishing operations

EXPLAIN THAT it is important to assess fabrics both during and following milling. Different fabrics mill at different rates, and it can be difficult to determine when the milling is finished, without some form of assessment.

INDICATE THAT the most immediate method to assess the extent of milling, is to measure the shrinkage of the fabric in the warp and weft direction while the fabric is in the machine. The measurement is normally made on the wet fabric and is important for quality control purposes.

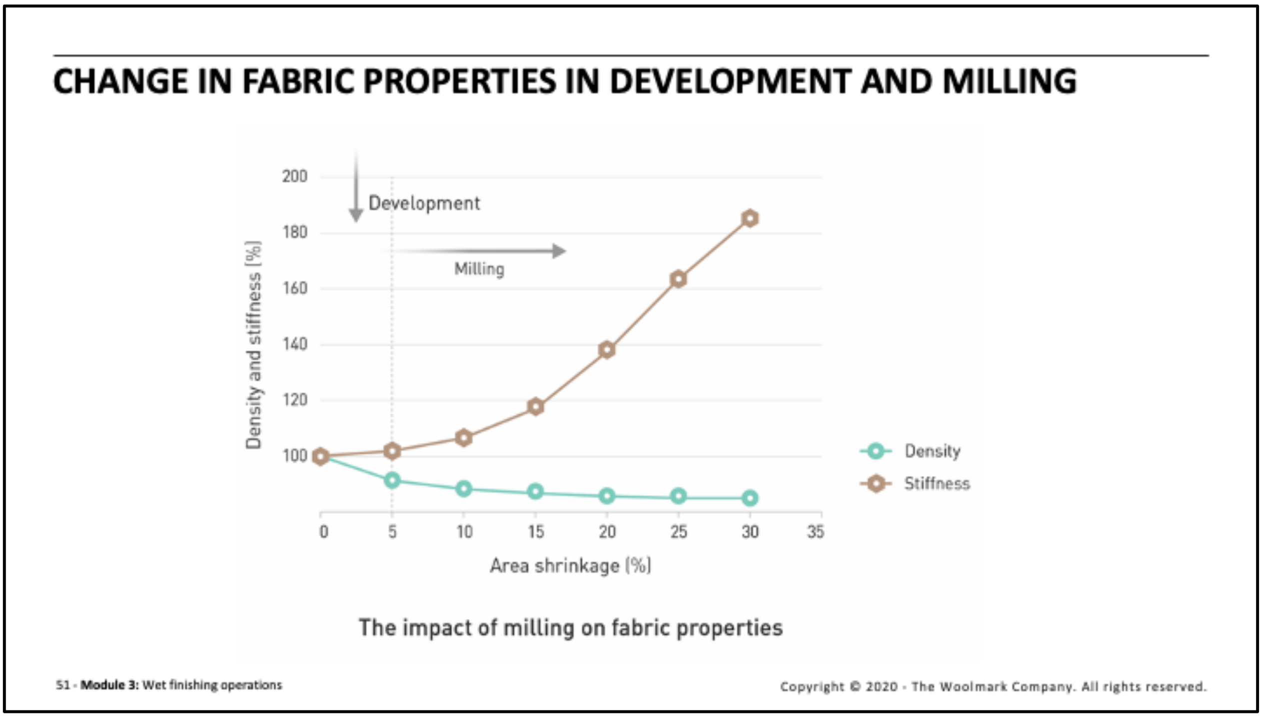
Alternatively appearance and handle can be assessed subjectively.

POINT OUT that after the fabric has been dried off, additional tests can be performed outside the machine.
These tests are important for the purposes of quality assurance and measure:

- fabric thickness
- tensile strength
- bias extensibility.

NOTE THAT some of the key faults that occur from milling are:

- uneven milling
- felted running marks
- chafing marks due to slippage of the roller on the surface of the fabric
- cockling or other distortion
- curling selvedge
- colour bleeding
- unevenness in subsequent dyeing.



EXPLAIN THAT both development (also called light milling) and milling are processes in which the wet fabric is subjected to mechanical action. The difference between development and milling is best described as:

- Development is carried out to soften the handle of the fabric and is sometimes called bursting or 'light milling'.
- Milling is carried out to induce controlled felting of the fabric.

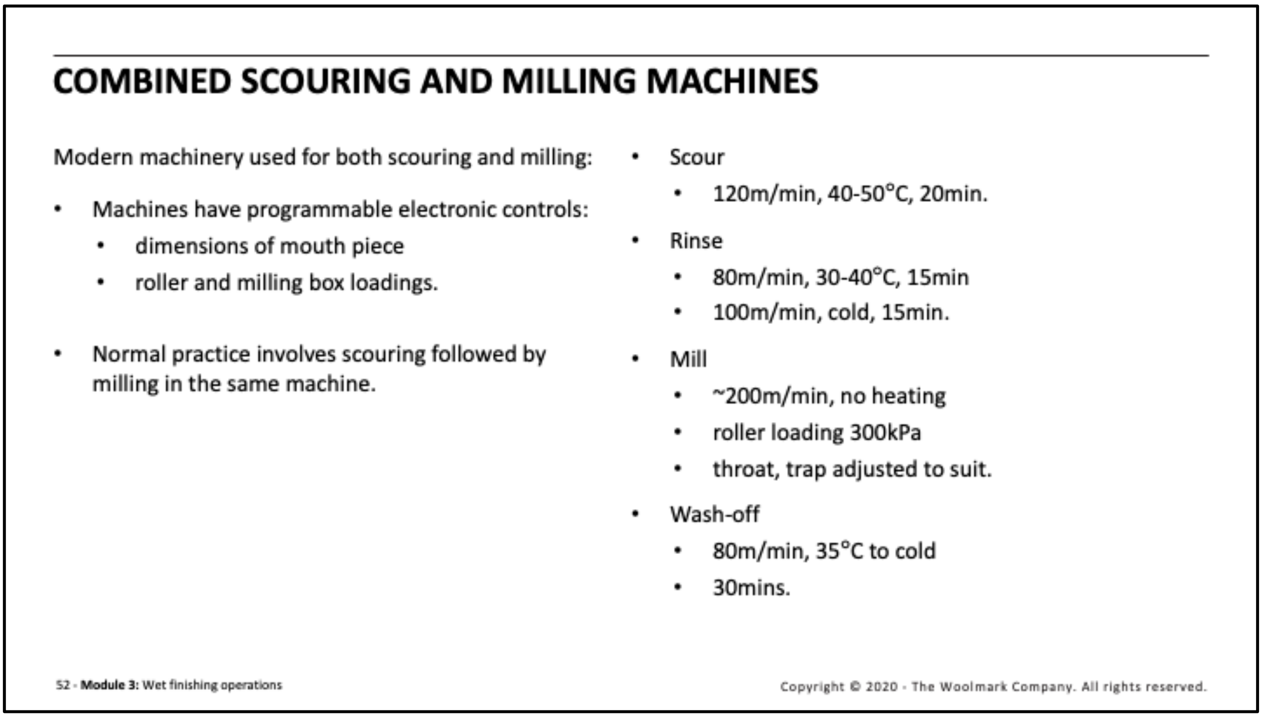
INDICATE THAT when a fabric is wet and subjected to mechanical action, two changes occur:

- a reduction in the density of the fabric, measured in kg/m^3
- a slower increase in the stiffness, seen as a reduction in bias extensibility of the fabric and an increase in the shear rigidity.

EMPHASISE THAT the reduction in **fabric density** is associated with small amounts of relative movement of the fibres, creating more space between them. It is sometimes called 'yarn bursting' and the fabric becomes thicker.

NOTE THAT during the initial stages the mechanical action has little effect on **fabric stiffness.** As felting proceeds the interaction between yarns increase as fibres entangle. This causes an increase in fabric stiffness.

EXPLAIN THAT the initial stages in which the fabric feels softer as a result of its lower density is called **development.** The second stage in which the fabric becomes stiffer due to increased fibre entanglement is called **milling.**



INDICATE THAT the most modern machinery can be used for both scouring and milling. Machines have programmable electronic control over the dimensions of the mouth piece as well as roller and milling box loadings.

NOTE: For fabrics that are to be given a milled finish, normal practice involves scouring followed by milling in the same machine.

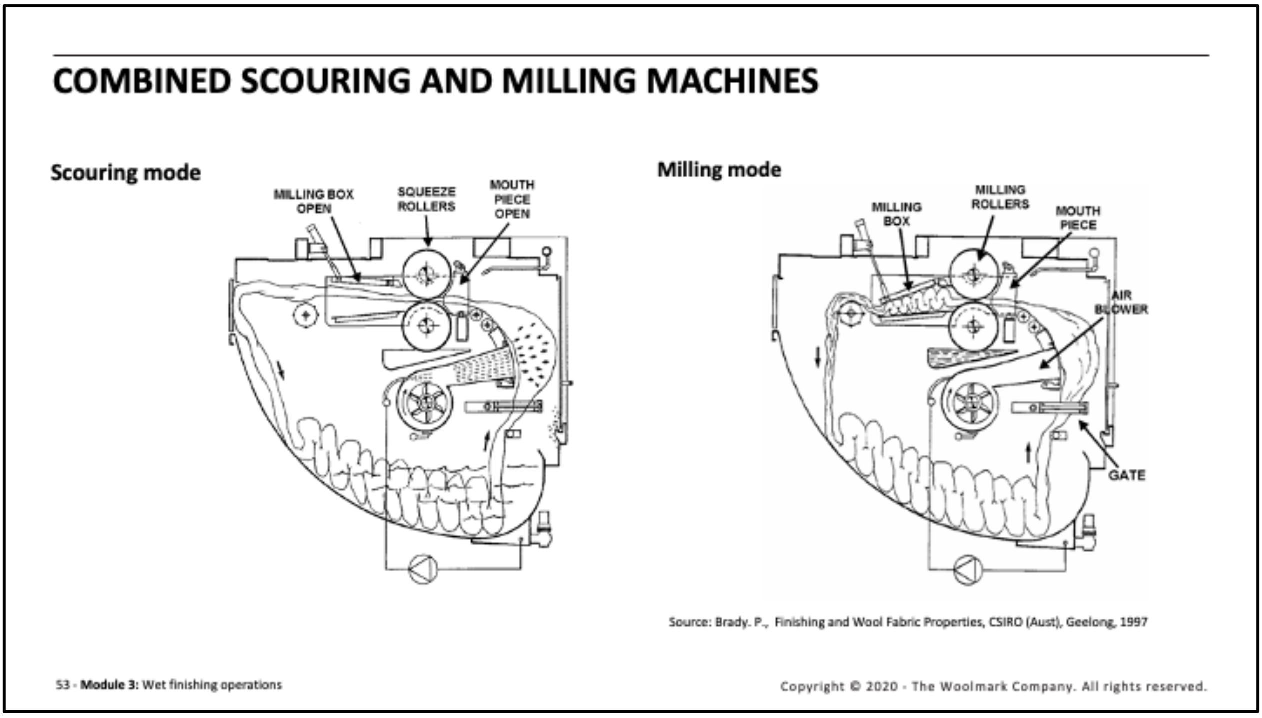
MENTION THAT the typical settings for combined scouring and milling machines are as follows:

Scour:
- 120m/min, 40–50°C, 20 minutes.

Rinse:
- 80m/min, 30–40°C, 15 minutes
- 100m/min, cold, 15 minutes.

Mill:
- ~200m/min, no heating
- Roller loading 300kPa
- Throat, trap adjusted to suit.

Wash-off:
- 80m/min, 35°C to cold
- 30 minutes.



POINT OUT the settings in a rotary milling machine, which distinguish scouring and milling can be seen in the diagrams on the slide.

NOTE the distinctions between scouring and milling mode are:

Scouring mode	Milling mode
Mouth piece open	Mouth piece closed
Milling box open	Milling box closed
Liquor level high	No free liquor

COMBINED SCOURING AND MILLING

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the combined scouring and milling processes.

PLAY *video (1:34 minutes)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

TRADITIONAL WOOLLEN MILLING

Woollen fabrics (e.g. coatings, blankets) are traditionally heavily milled to cover the weave.

Three conditions are used for woollen scour-milling:

1. **Mill in the grease**
   - Loom-state fabric (in the grease).
   - Alkali only to saponify the oils used in spinning.
   - This technology replaced by the use of synthetic detergents.
2. **Acid milling (pH=2-3)**
   - After scouring.
   - Where the dyes lack wet fastness.
   - On carbonised fabrics.
   - Favoured for fabric that requires very heavy milling.
   - The fabric mills faster than in soap solution.
   - Rinsing to remove soap is not necessary.
3. **Alkaline milling (pH=9-10)**
   - Fabric with good wet fastness.

55 - **Module 3:** Wet finishing operations

Milling woollen-spun fabric

INDICATE THAT woollen fabrics, especially coatings and blankets, are traditionally heavily milled to cover the weave.

Three conditions are used for traditional woollen scour-milling:

Mill in the grease:

EXPLAIN THAT 'mill in the grease' refers to a process for scouring and milling the loom-state fabric (in the grease) using alkali only to saponify the oils used in spinning. Traditionally, alkali (Na_2CO_3) was used to saponify residual oil (10% oleine) on woollen fabrics to create soap required for scouring and subsequent milling — usually in the same machine. This technology has been replaced by the use of synthetic detergents.

The term 'saponify' refers to the process of converting a fat into soap, by treating with an alkali.

Acid milling (pH=2–3)

POINT OUT that this occurs after scouring for fabrics where the dyes lack wet fastness. This method is favoured for fabric that requires very heavy milling. The fabric mills faster than in soap, and rinsing to remove soap is not necessary. The technique can be used for woollen fabrics that have been carbonised. After carbonising it is not necessary to neutralise the fabric if it is to be acid milled. Additionally it can be used where heavily-milled fabrics are subsequently piece dyed with acid levelling or 1:1 pre-metallised dyes.

Alkaline milling (pH=9-10)

NOTE THAT alkaline milling is done under the same conditions as scouring (but with different machine settings) for fabric with good wet fastness.

ASK *participants explain what the expression 'good wet fastness' means.*

ALLOW *participants time to respond.*

REINFORCE THAT *good wet fastness means the dye does not 'bleed' from the fibre during milling or other wet processes.*

PREVENTION OF RUNNING MARKS IN MILLING

- Flat setting or relaxing fabric before milling.
- Re-laying the fabric during milling using:
  - air turbines
  - double gating.

56 - **Module 3:** Wet finishing operations

EXPLAIN THAT running marks are difficult to remove when they are imparted during milling. In this instance the marks are formed by felting — not setting.

INDICATE THAT the formation of running marks during milling can be inhibited by:

- flat setting or relaxing fabric before milling
- re-laying the fabric during milling by using either:
  - air turbines
  - double gating the fabric.

NOTE THAT double gating involves sewing fabrics into a continuous loop, which are then threaded through separate ‘gates’ in the milling machine.

POINT OUT that normal gating is where two ropes are placed into the machine independently. Double gating is where the two ropes of fabric cross over between adjacent milling heads.

NEW MACHINES – ZONCO (ITALY)

Aqua

- Open-width washing.
- Tension control to avoid stretching.
- Crabbing chamber.

Eolo

- Rope scouring and development.
- Patented transport system, which combines conveyor belts and air.
- Drying in rope form.

Flexirapid 600

- High-speed scouring.
- 600kg capacity.

Flexicom 400 and 800

- Combined scouring and milling.
- Independent warp and weft milling controls.

Zonco Twin

- Scouring and milling machine.
- Two independently-controlled milling channels.
- Designed for small lots.

EXPLAIN THAT Zonco (from Italy) has developed and manufactured a number of new scouring and milling finishing machines.

The Aqua machine offers:
- open-width washing
- a tension control to avoid stretching
- a crabbing chamber.

The Eolo machine offers:
- rope scouring and development of the fabric
- a patented transport system, which combines conveyor belts and air drying in rope form. This is a benefit because it dries the fabric in relaxed form, giving it a totally different feel.

The Flexirapid 600 offers:
- high speed scouring
- 600kg capacity.
- the Flexirapid 600 is an example of the leading-edge machinery of its type of high-speed high-capacity scouring machine.

The Flexicom 400 and 800 offers:
- combined scouring and milling
- independent warp and weft milling controls
- the Flexicom 400 and 800 are both examples of the leading-edge technology, for this type of machine.

The Zonco Twin offers:
- a scouring and milling machine
- two independently-controlled milling channels.
- The Zonco Twin is specifically designed for small lots and is an advance on other machinery of its type because it offers simultaneous treatment of small lots under differing milling conditions.

NEW MACHINES — MAT DI BERTOLDI SPA (ITALY)

Rotormat

- High-speed scouring to 1000m/min.
- Drum transport without squeeze rollers.
- Liquor exchanged using perforated baffle.
- Drying in rope form to enhance softening action.

Mistral

- High-speed scouring.
- Belt and air transport.
- Drying in rope form for enhanced softening.

Source: http://www.mat.it/site_eng/start.html

58 - **Module 3:** Wet finishing operations

INDICATE THAT the wet finishing machinery manufactured by MAT includes the Rotomat and Mistral.

The Rotormat offers:

- High-speed scouring to 1000m/min
- drum transport without squeeze rollers
- liquor exchanged using perforated baffle
- drying in rope form to enhance softening action.

The Mistral offers:

- high-speed scouring
- belt and air transport
- drying in rope form for enhanced softening.

PIECE DYEING

- Piece dyeing is a colouration process.
- Several dyeing systems for wool:
  - acid dyes
  - pre-metallised dyes
  - reactive dyes
  - chrome dyes.
- Appropriate tests include:
  - colour measurement for shade
  - visual inspection for evenness
  - fastness tests, which include:
    - wash fastness
    - perspiration fastness
    - rubbing fastness.

59 - **Module 3:** Wet finishing operations

EMPHASISE THAT piece dyeing is a colouration process and has a large effect on fabric properties, so must be considered in wet finishing.

INDICATE THAT several different dyeing systems are used for wool fabrics varying in pH, auxiliaries required and the time required for the process. These include :

- levelling acid dyes
- 1:1 pre-metallised dyes
- reactive dyes
- chrome dyes.

NOTE THAT depending on the dye systems, the appropriate tests for piece dyeing include:

- Colour measurement for shade
- Visual inspection for evenness
- Fastness tests
  - wash fastness
  - perspiration fastness
  - rubbing fastness.

The dyeing process is covered in detail in the Woolmark Wool Science, Technology and Design Education Program course *The dyeing of wool*.

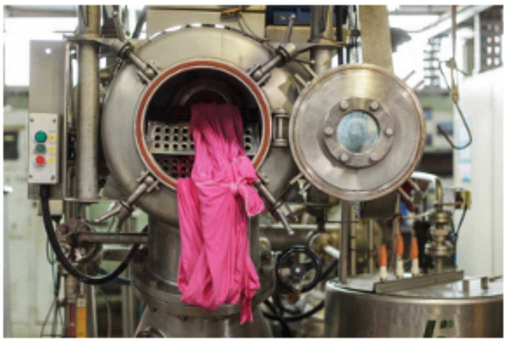
PIECE DYEING

Piece dyeing in rope form:

- Conditions chosen to avoid mechanical action.

Overflow jet machines:

- Gentle circulation of the fabric.



Side effects include:

- softer and 'fuller' fabric handle
- permanent setting of running marks
- uncontrolled relaxation of the fabric (cockling)
- facing up (hairiness on the fabric surface).

60 - **Module 3:** Wet finishing operations

INDICATE THAT piece dyeing of wool fabrics is normally carried out in rope form. Conditions are chosen that avoid mechanical action (preventing development or felting).

EXPLAIN THAT overflow jet machines are commonly used to ensure gentle circulation of the fabric through the machine.

NOTE THAT the side effects associated with piece dyeing include:

- softer and 'fuller' fabric handle
- permanent setting of running marks
- uncontrolled relaxation of the fabric causing cockling
- facing up (hairiness) caused by mechanical action.

UNWANTED EFFECTS OF PIECE DYEING

Dyeing imparts large amounts of permanent set to the fibres.

In addition to running marks, the fabric can:

- consolidate (shrink)
- increase in weight per course area
- increase hygral expansion.

Image courtesy of CSIRO Australia

61 - **Module 3:** Wet finishing operations

INDICATE THAT piece dyeing usually imparts large amounts of permanent set to the fibres. In addition to the formation of running marks, the fabric can:

- consolidate (shrink)
- increase the fabric weight per course area
- increase the hygral expansion, especially in all-wool gabardines and all-wool plain weaves.

HYGRAL EXPANSION

- A reversible change in the dimensions of wool fabrics when the fibres absorb water in a humid environment.
- The dimensional change can result in distortions in garment panels.
- Increase in hygral expansion caused by dyeing can be reduced by:
  - preventing permanent set forming during dyeing
  - including anti-setting agents in the dyebath.

Image courtesy of CSIRO Australia

62 - **Module 3:** Wet finishing operations

EXPLAIN THAT hygral expansion is a reversible change in the dimensions of wool fabrics, which occurs when the fibres absorb water in a humid environment.

DEMONSTRATION: HYGRAL EXPANSION

Resources required:

- *bone dry length of fabric (stored in plastic bag)*
- *whiteboard*
- *whiteboard marker*
- *spray bottle with water.*

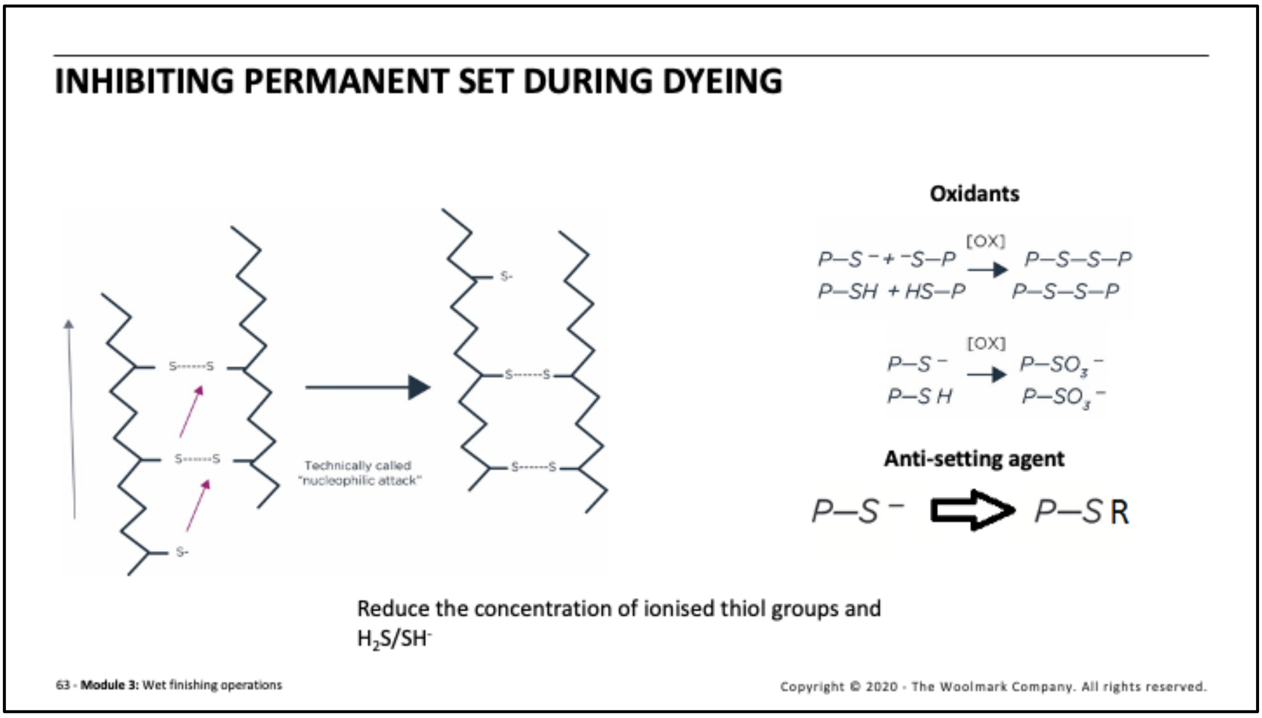
REMOVE the *'bone dry' length of fabric from its plastic bag.*
HANG *the fabric on the whiteboard and mark the length using the whiteboard marker.*
SPRAY *the fabric with water.*
NOTE *the increase in fabric length.*

NOTE THAT this dimensional change can result in distortions in garment panels.

EXPLAIN THAT the increase in hygral expansion caused by dyeing can be reduced by preventing permanent set from forming during the dyeing operation.

INDICATE THAT solutions include:

- dyeing at low pH with acid levelling or 1:1 pre-metallised dyes
- the inclusion of anti-setting agents in the dyebath, such as Basolan AS (BASF).



INDICATE THAT anti-setting technology to minimise permanent setting during dyeing was commercially introduced during the mid 1990s.

POINT OUT that two methods have been used and the chemical reactions involved are illustrated on the slide:

- Inclusion of oxidants in the dyebath, which remove free thiol groups.
- Inclusion of substantive electrophilic compounds, which react with free thiol groups.

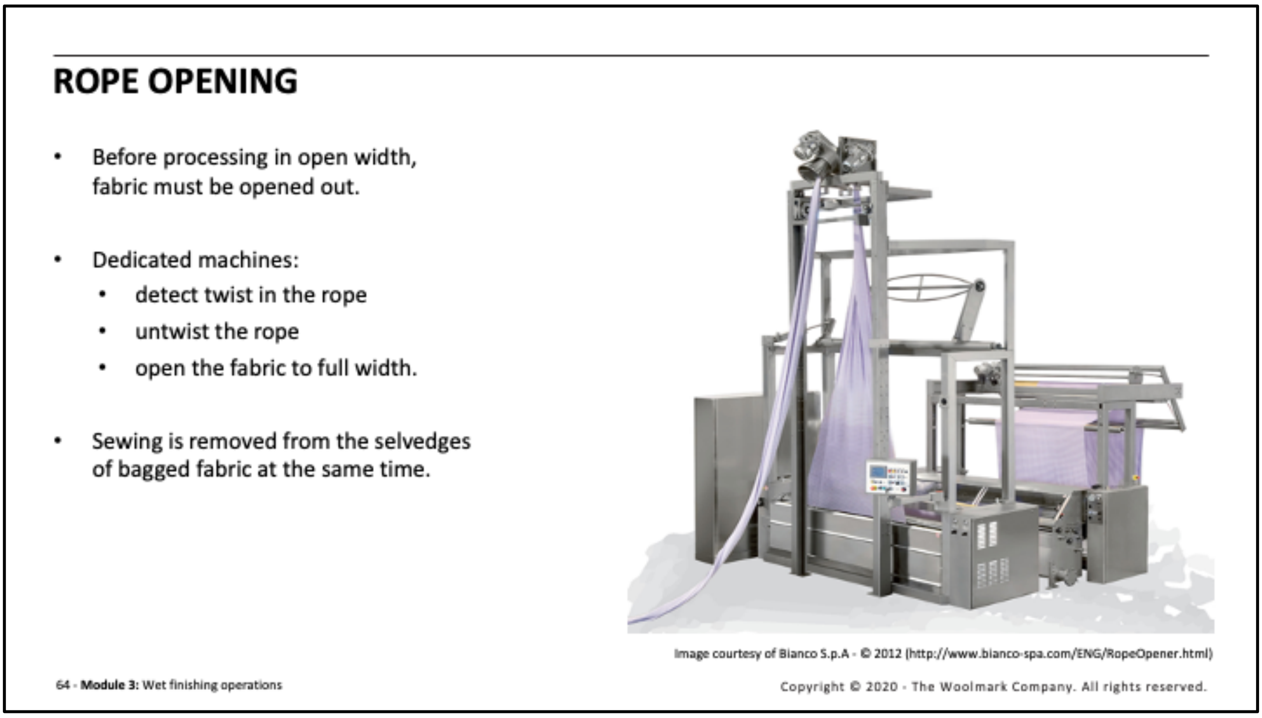
MENTION THAT currently-available technology relies on the addition of:

- a hydrogen peroxide activator and a small quantity of hydrogen peroxide to the dyebath
- addition of maleic anhydride or a maleic acid ester

EXPLAIN THAT the auxiliary and/or hydrogen peroxide are added at the start of dyeing and the process is then carried out as normal. Peroxide can only be used with dyes that are not sensitive to oxidation. Both products reduce the number of free thiol groups in the fibre and thus the rate of permanent setting.

Formaldehyde also reacts with free thiols, so formaldehyde release agents can also reduce permanent setting.

NOTE THAT high levels (>3.0%) of reactive dyes have effective anti-setting properties so additional agents are therefore unnecessary.



EXPLAIN THAT before fabric that has been treated in rope form can be processed in open width, it must be opened out. This is done continuously by dedicated machines, which detect twist in the rope, untwist the rope and then open the fabric to full width.

If the fabric has been bagged, the sewing will be removed from the selvedges at the same time.

NOTE THAT this slide shows photos of the rope opening machine.

The picture in the middle is the input. You can see the device untangling the fabric.

Once in open width form, the fabric is folded (‘cuttled’) into a stack.

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the rope opening process.

PLAY *video (30 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

DE-WATERING – HYDROEXTRACTION

- After wet finishing the fabric must be dried.
- Drying using heat is expensive.
- Mechanical means are usually used to remove excess water.
- Ideally the moisture content should be reduced to 60-70% or less.

Spin hydroextraction:

- Fabric is centrifuged at high speed and it is:
  - simple
  - inexpensive
  - batch process in rope form.

Suction slot:

- Open-width continuous process.
- Excess water is sucked from fabric as it passes over a narrow slot.
- Forced air blast assists the suction.

Mangle:

- An open-width, continuous process.
- Fabric is squeezed between two rollers.

66 - **Module 3:** Wet finishing operations

POINT OUT that after wet finishing, the fabric must be dried.

EXPLAIN THAT drying using heat is expensive, so mechanical means are usually used to remove excess water from the wet-finished fabric before applying heat. Ideally the moisture content should be reduced to 60–70%, or lower where possible.

INDICATE THAT mechanical drying can occur via three different processes:

Spin hydroextraction.
The fabric is centrifuged at high speed. This process is simple and inexpensive, but is a batch process requiring loading and unloading.

Suction slot
An open-width continuous process in which excess water is sucked from the fabric as it passes over a narrow slot. A forced air blast may assist the suction.

Mangle
In this process, the fabric is squeezed between two rollers.

STENTER (TENTER) DRYING

- The fabric is dried using hot air.
- The dimensions of the fabric are adjusted to those required.
- Stenters may be:
  - single layer
  - multi-layer.
- The temperatures in each bay are independently controlled.

67 - **Module 3:** Wet finishing operations

EXPLAIN THAT stenter (or tenter) drying is one of the critical operations in finishing. Not only is the fabric dried, but the dimensions of the fabric are adjusted to those required. This is used to correct any stretching that may have occurred in wet processing.

NOTE THAT stenters may be single layer or multi-layer. Normally the temperatures in each bay or level are independently controlled.

POINT OUT that meters monitor:

- the temperature of the air in each bay
- the humidity of the air, which is controlled by allowing exhaust if the humidity is too high
- the temperature of the fabric on exit from the machine.

STENTER (TENTER) DRYING

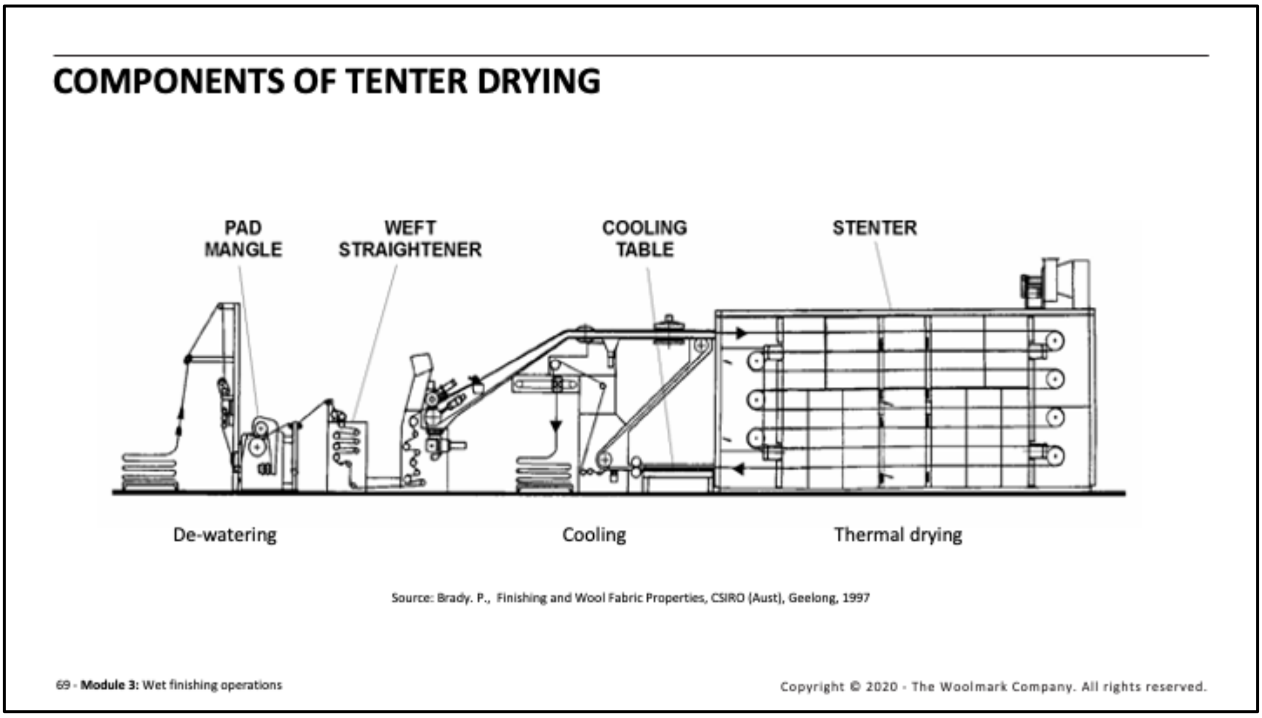
Operation:

- Fabric selvedges fed onto clips or pins attached to an endless chain.
- Chain runs on rails through a number of high-temperature chambers (110°C-150°C).
- The open-width fabric dries rapidly in the high-temperature air.
- On exit, the dry fabric is cooled before it is removed from the pins.

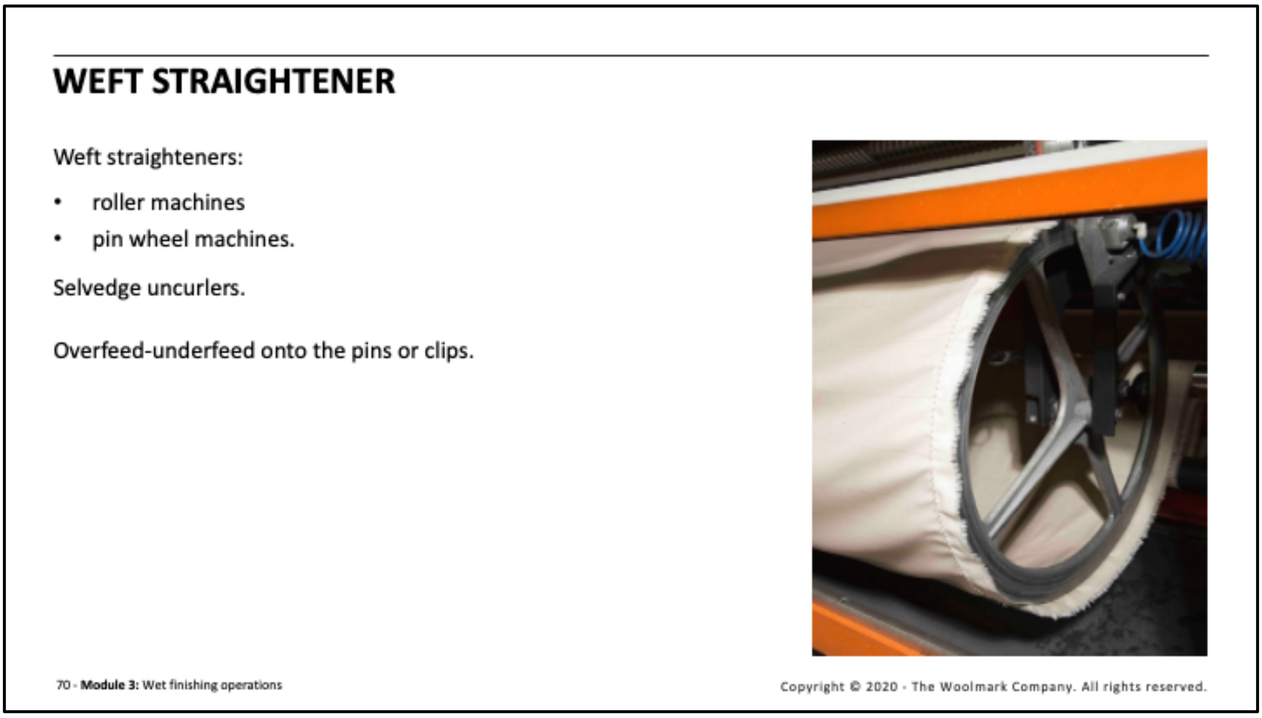
68 - **Module 3:** Wet finishing operations

POINT OUT that in stenter drying, the selvedges of the fabric are fed onto clips or pins attached to an endless chain. The chain and fabric run on rails through a number of high-temperature chambers (110°C–150°C).

INDICATE THAT the open-width fabric dries rapidly in the high-temperature air. The dried fabric is cooled in an air draught, or by air suction, before it is removed from the pins.



EXPLAIN THAT the slide illustrates the key components of a multi-layer tenter (sometimes called stenter) drying operation, which will be described in greater detail over the following slides.



EXPLAIN THAT before entering the stenter, the fabric passes through weft straighteners, which remove skew and bowing in the fabric.

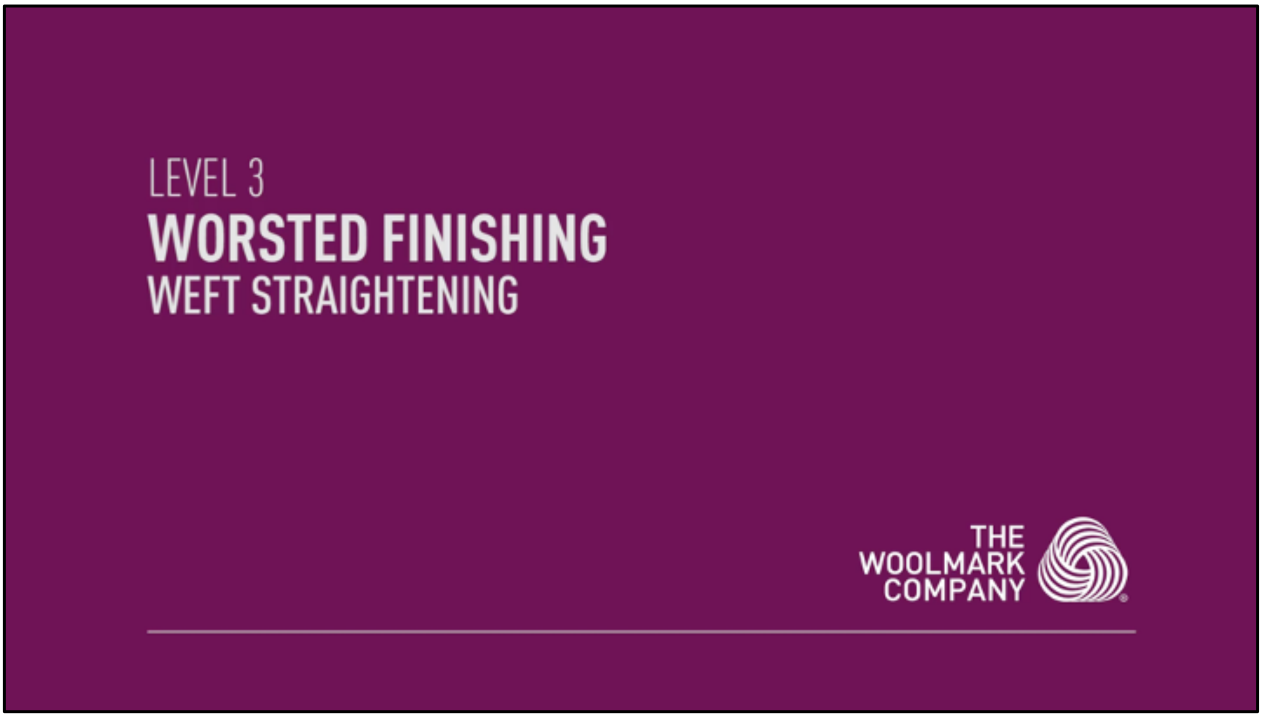
INDICATE THAT two types of weft straighteners are common:

- Roller machines — where sensors detect any skew in the fabric and roller orientation is adjusted to correct any skew or bow in the fabric.
- Pin wheel machines — in which the selvedge of the fabric is pinned to freely-rotating wheels, which are inclined to the machine axis. The tension generated in the fabric causes one wheel to rotate faster, correcting any skew.

Selvedge uncurlers

NOTE THAT selvedge uncurlers prevent rolling of the selvedges, which will affect the pinning of the fabric.

MENTION THAT overfeed-underfeed controllers control the rate at which the fabric is fed onto the pins.

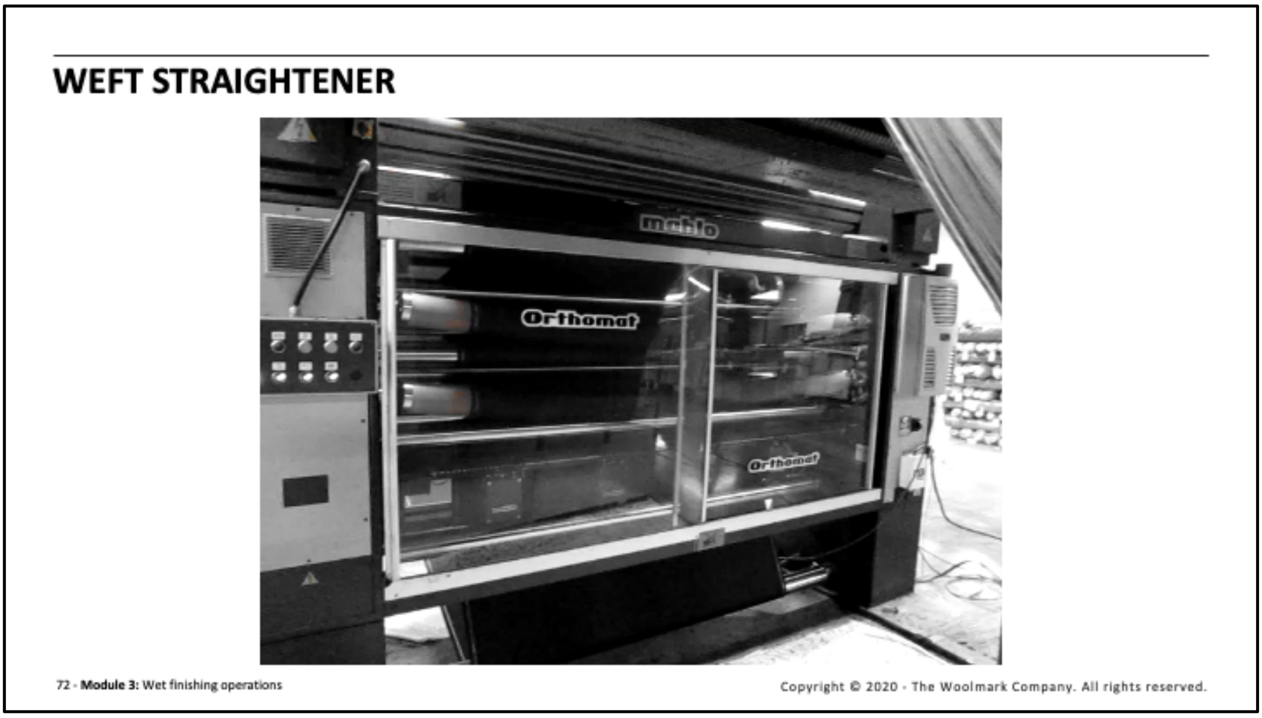


EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of a pin-wheel weft straightener in operation.

PLAY *video (38 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*



EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of a roller weft straightener in operation.

PLAY *video (38 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of a multi-layer stenter dryer in operation.

PLAY *video (38 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), shows a single layer stenter, used by some finishers to dry the fabric.

NOTE THAT this video contrasts to the multi-layer stenter of the previous video.

PLAY *video (21 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond.*

DRYING THE FABRIC

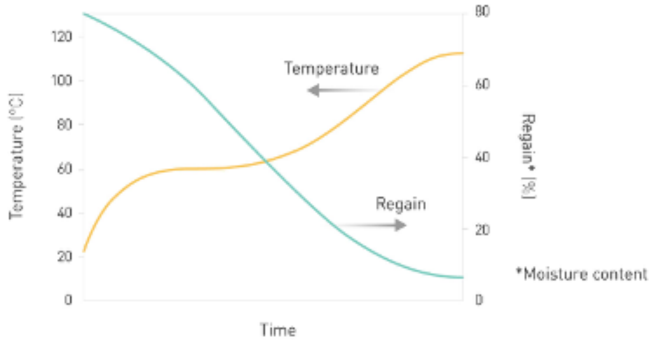
Drying chambers

Stenters may be:

- gas fired
- oil fired
- steam heated.

Gas-fired machines are most common as these:

- provide flexible and rapid temperature control
- avoid stains from unburnt fuel components.



75 - **Module 3:** Wet finishing operations

INDICATE THAT the air within the drying chambers of stenters may be heated by:

- direct gas fire
- oil fire (direct)
- steam heated (indirectly heated).

NOTE THAT the gas-fired machines are most common as they:

- provide flexible and rapid temperature control
- avoid stains from unburnt fuel components of oil.

EXPLAIN THAT the diagram on the slide illustrates the drying curves for fabric as it dries in the stenter drying chamber. Initially there is an increase in fabric temperature as the hot air heats the wet wool. The temperature then is relatively constant until all the liquid water is removed from the fibre surface (~30%) moisture. The temperature of the fabric then rises again as the absorbed water is removed from the fibre. Only when the fabric is almost completely dry does the fabric temperature reach that of the air being used to dry it.

EMPHASISE THAT ideally the fabric should be dried to 10% moisture content, but fabric is often overdried to allow for wet spots or uneven moisture content when it enters the stenter.

COOLING THE FABRIC

Cooling zone minimises creasing when the fabric is plaited onto a cart.

Controllers:

- **Temperature** meters to control the temperatures.
- **Air humidity** meters to:
  - control air humidity
  - ensure the correct amount of recirculation.
- **Fabric moisture meters:**
  - used to avoid over-drying or under-drying.

76 - **Module 3:** Wet finishing operations

EXPLAIN THAT the cooling zone within a stenter is normally an air draught. Efficient cooling of the fabric when it emerges from the drying chambers is required to minimise creases, as the fabric is plaited onto a cart. This concept of cohesive setting and cooling below the glass transition temperature was outlined when discussing the concept of glass transition in wool.

INDICATE THAT the stenter contains the following controllers:

- temperature meters are used to control the temperatures in each of the chambers.
- air humidity meters are used to control air humidity and the amount of recirculation.
- temperature meters also are used to measure the temperature of the emerging fabric.
- fabric moisture meters can be used to measure the moisture content of the emerging fabric and avoid over-drying.

CONTROLLING FABRIC WIDTH

The pins holding the fabric selvedge:

- carry the fabric through the stenter
- travel in rails driven by a chain.

The distance between the rails can be adjusted to pull the fabric to the required width.

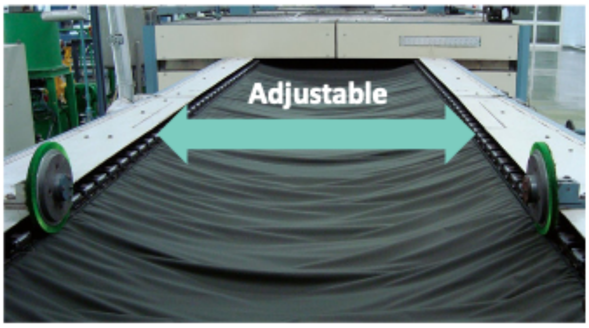


Image courtesy of Swastik Textile Engineers (India)

77 - **Module 3:** Wet finishing operations

NOTE THAT the stenter is the first finishing machine that allows the finisher to adjust the dimensions of the fabric length and width.

EXPLAIN THAT the fabric is continuously fed onto pins (or clips) that hold fabric selvedges. The pins sit on two rails, one each side of the fabric. A chain moves the pins through the stenter in a continuous loop carrying the fabric though the heated chambers where it is dried. The fabric is removed from the pins at the end of the dryer.

Width setting on the stenter

POINT OUT that the distance between the rails can be changed to alter the width of the fabric after drying.

Normally the width setting applied is described as the distance over the wet width of the fabric.

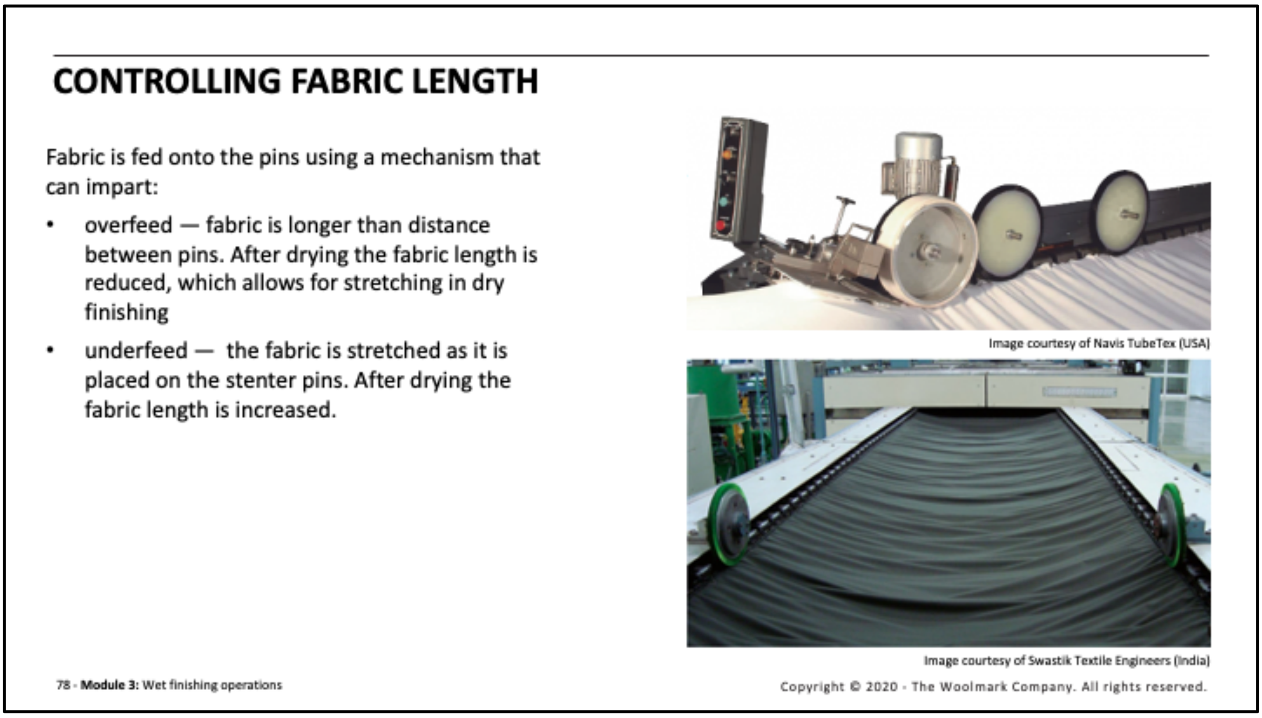
INDICATE THAT if this distance is positive, the fabric is stretched in the weft direction during drying. If this distance is negative (under wet width) the fabric will be allowed to shrink as it dries.

If the width setting is too low, the fabric may have insufficient tension to hold it on the pins and may blow off the pins in the drying chamber.

It is normal practice to dry fabric over wet width. This is done to offset the reduction in fabric width caused by the tension applied to fabric during the various stages of finishing.

POINT OUT that normally the width of the fabric must meet the specifications required by the customer. Delivery of a fabric under width can result in disputes and/or compensation.

MENTION THAT increasing the width during drying also helps the fabric shrink in the warp direction, allowing for any stretch that may occur during dry finishing.



INDICATE THAT the fabric is continuously fed onto the pins (or clips) that hold fabric selvedges by a feed roller and brushes; the speed of which is adjustable.

EXPLAIN THAT if the feed roller moves faster than the pin chain, more fabric is fed onto the pins than required for 1:1 transfer (called overfeed and measured as a percentage). The fabric will:

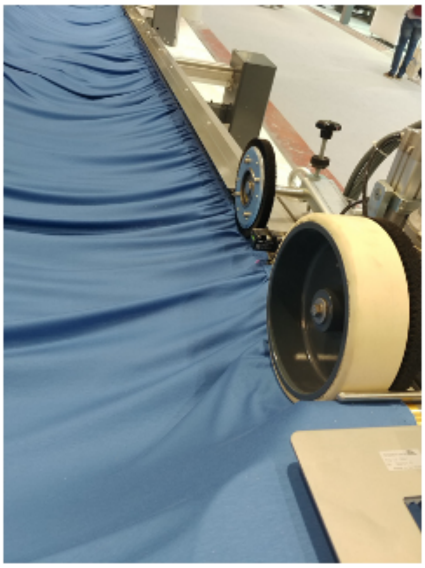
- be seen to bunch up as seen in the top image
- be able to shrink in the warp direction during the drying process
- shorten in length as it emerges from the dryer.

If the feed roller moves slower than the pin chain, the fabric is stretched in the warp direction as it is fed onto the chain (called underfeed and measured as a percentage). The fabric will:

- be stretched in the warp direction during drying
- lengthen as it emerges from the dryer.

MENTION THAT during drying it is normal practice to 'overfeed' fabric into the dryer. This is done to offset the tensions applied to fabric during the various stages of finishing, which stretch the fabric in the warp direction and reduce its extensibility.

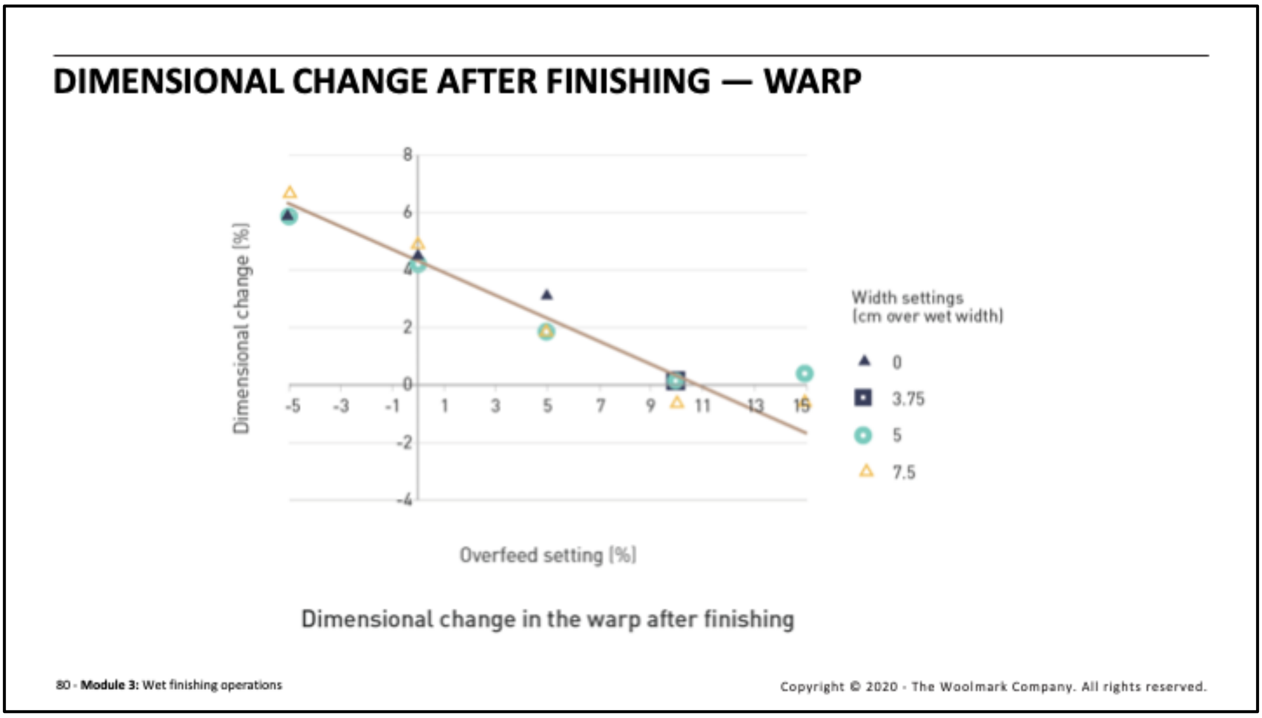
OVERFEED MECHANISM



79 - **Module 3:** Wet finishing operations

EXPLAIN THAT this image also shows the overfeed mechanism used on stenters and tenters.

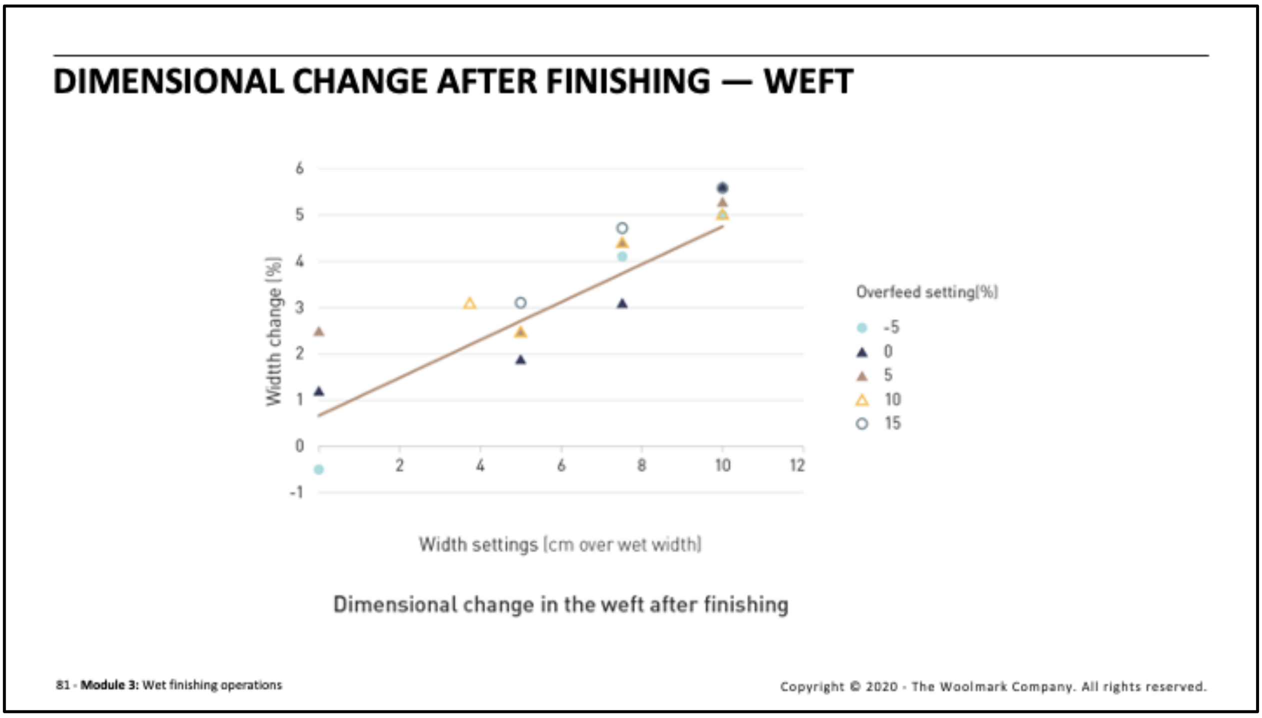
The overfeed on this machine is set to impart high levels of overfeed, creating the wrinkled selvedge.



POINT OUT that work was done at The Woolmark Company in Ilkley (UK) to quantify the relationship between stenter settings and fabric width and length.

REFER participants to the graph on the slide, which illustrates that increasing the overfeed (i.e. the length setting) reduced the length of the fabric after finishing. The effect of the width setting was relatively small.

NOTE THAT although not shown in this graph, increasing the overfeed also resulted in an increase in the extensibility of the fabric in the warp direction.



EXPLAIN THAT the graph on the slide illustrates that increasing the width setting of the stenter increased the width of the fabric after finishing. The effect of the overfeed setting was relatively small.

NOTE THAT this also resulted in a decrease in the extensibility of the fabric in the weft direction.

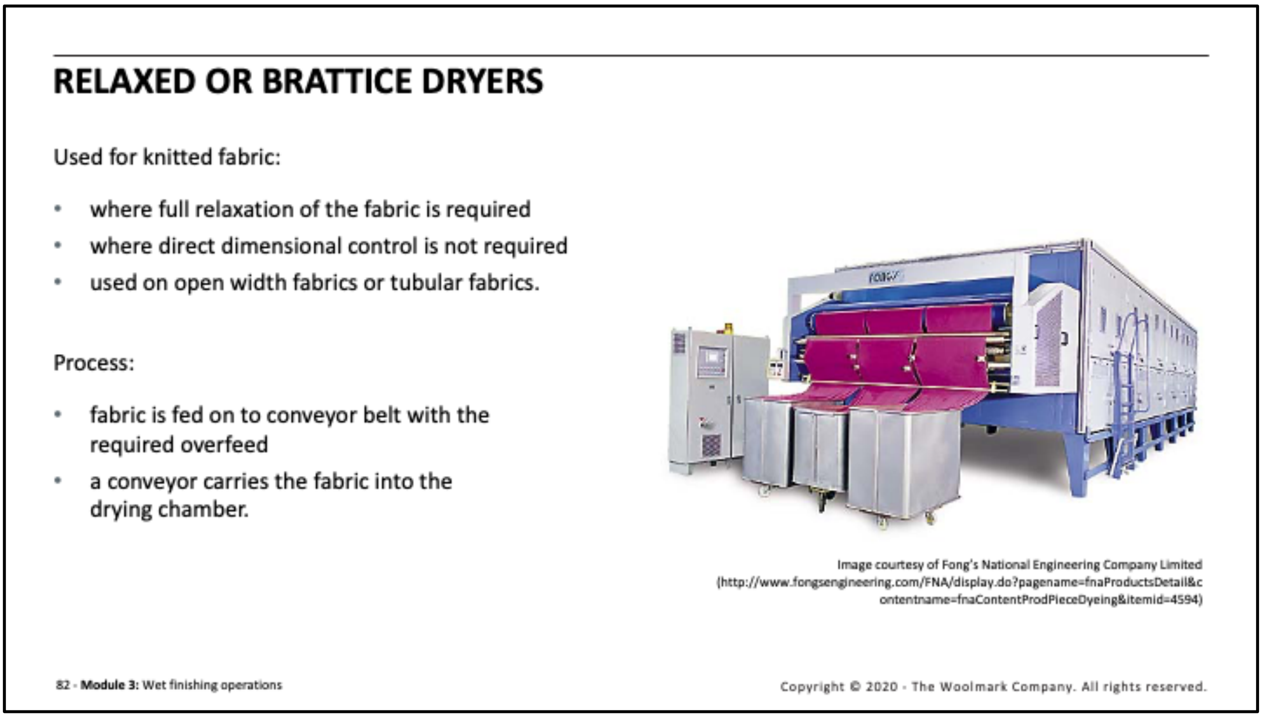
EMPHASISE THAT the relationship between the settings on the stenter and the change in dimensions achieved is not simple. Different fabrics will respond quantitatively differently in the warp direction.

A change in the overfeed will affect extensible fabrics, such as gabardines, more than inextensible fabrics, such as plain weaves.

Similarly, a setting of 5cm over wet width will not necessarily result in a fabric that is 5cm wider.

NOTE THAT different fabrics also respond quantitatively differently in the weft direction.

The finisher must evaluate the response of each fabric to changes in stenter settings.



POINT OUT that relaxed or brattice dryers are used where the fabric must be dried, fully relaxed.

NOTE THAT these machines are commonly used on knitted fabric:

- where full relaxation of the fabric is required
- where direct dimensional control is NOT required
- on open-width knitted fabrics or tubular fabrics.

EXPLAIN THAT the process is as follows — the fabric is fed on to the mesh-type conveyor belt with the required amount of overfeed. The conveyor carries the fabric into the drying chamber through a balanced draught of hot air (to avoid distorting the relaxed fabric).

DRUM DRYERS

- A series of heated drums are used to dry fabric.
- Used where dimensional control is NOT required.
- The drums heated to temperatures above 100°C.
- Fabric in contact with heated drums is dried by conduction.

83 - **Module 3:** Wet finishing operations

EXPLAIN THAT drum dryers consist of a series of heated drums, which can be used to dry fabric where dimensional control is NOT required. These dryers are less common in the wool industry, but can be found in many mills especially in association with continuous scouring.

ASK *participants to indicate when they might consider using drum dryers in the wool industry.*

ALLOW *participants sufficient time to respond.*

INDICATE THAT *drum dryers can be used:*

- *in wet finishing where it is planned to re-wet the fabric in subsequent processes*
- *where the fabric is to be padded with a finishing aid.*

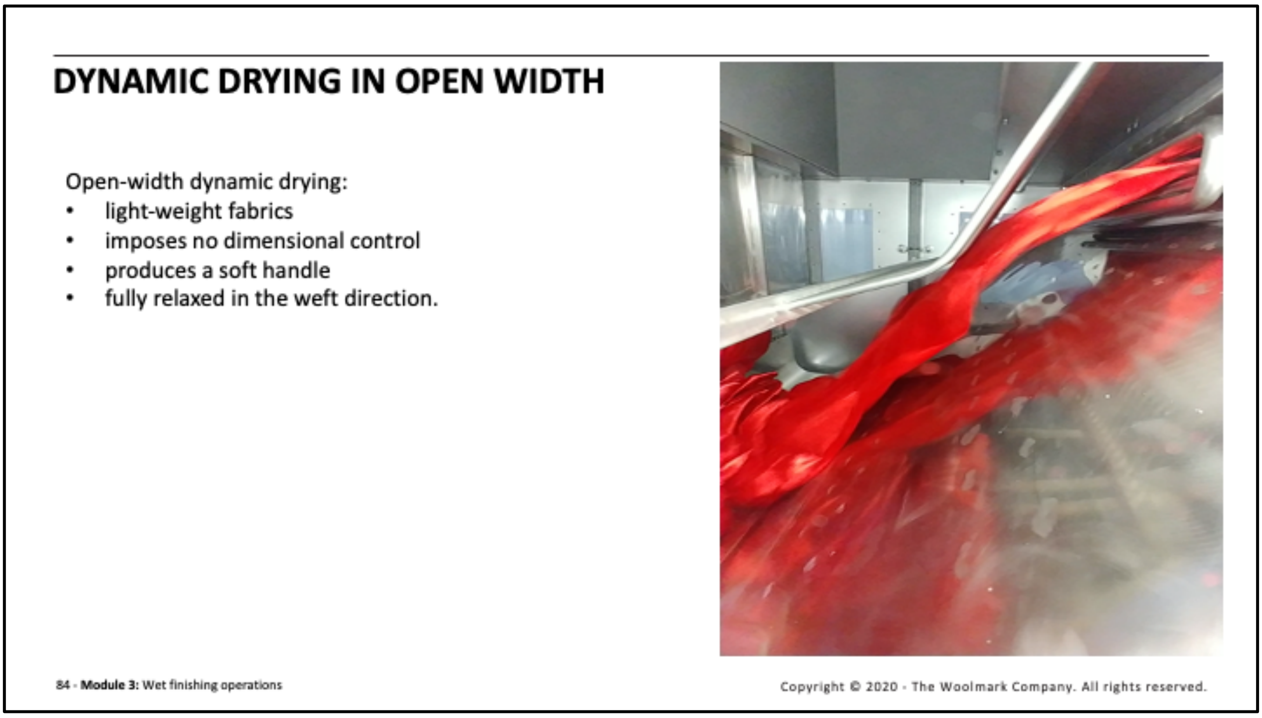
NOTE THAT *You almost never dry wool under conditions where you do not want dimensional control unless it is to be re-wet.*

INDICATE THAT the drums are heated to temperatures above 100°C and the fabric in contact with the heated drums is dried by conduction. These dryers do NOT dry the fabric in a relaxed state and the stretch imposed must be stabilised or removed at some later date.

A number of manufacturers, including MAT di Bertoldi from Italy, market these machines.

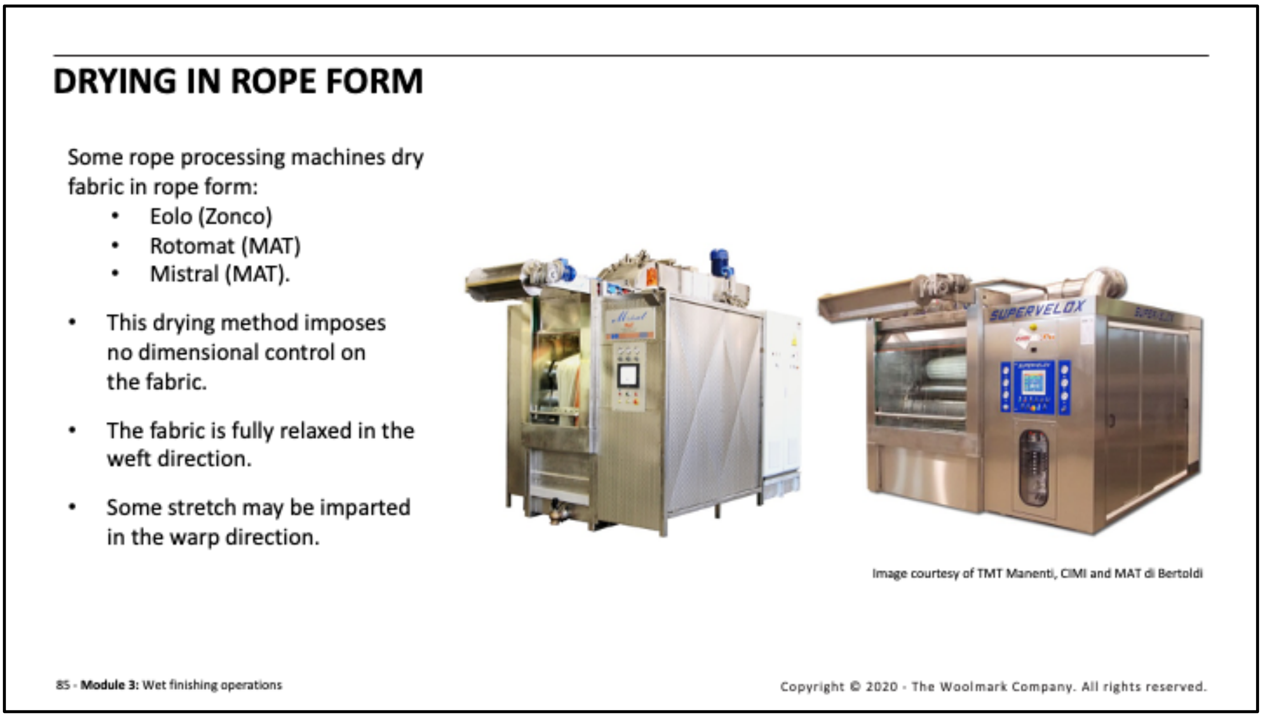
POINT OUT that drum dryers are used in the wool industry in wet finishing where it is planned to re-wet the fabric in subsequent processes, such as where the fabric is to be padded with a finishing aid.

MENTION THAT finishers rarely dry wool under conditions where they do not want dimensional control unless it is to be re-wet.



An innovation shown by a number of machinery manufacturers at the recent International Textile Machinery Exhibition (ITMA) is the open-width dynamic drying of fabrics.

Applicable primarily to light-weight fabrics, this drying method does not constrain the fabric and uses air drafts to impart some mechanical action, as shown in the video, to ensure the fabric has a soft handle and is fully relaxed in the weft direction.



INDICATE THAT some of the machines developed for rope scouring and fabric development also have a patented air transport system, which allows air drying in rope form.

Examples of these machines include:

- Eolo (Zonco)
- Rotomat (MAT)
- Mistral (MAT)

EXPLAIN THAT this drying method imposes no dimensional control on the fabric. The fabric is fully relaxed in the weft direction. Some stretch may be imparted in the warp direction.

NOTE THAT these machines dry the fabric in a relatively relaxed form, giving it a totally different handle.

SUMMARY — MODULE 3

Before finishing fabric must be:
- inspected for any gross faults
- mended
- formed into batches for processing.

The quality of the water used in finishing is important to get the desired result.

Pre-setting aims to prevent:
- distortions from the fabric-forming process
- formation of distortions in wet finishing.

Pre-setting involves:
- removing residual strains in the fabric
- permanently 'flat setting' the fabric.

Two types of pre-setting methods:
- batch processing
- continuous processing.

Scouring cleans the fabric, removing residual oils, dirt and other contaminants.

Both fabric development and milling are processes in which the wet fabric is subjected to mechanical action:
- Development is carried out to soften the handle of the fabric and is sometimes called bursting or 'light milling'.
- Milling is carried out to induce controlled felting of the fabric.

Modern machinery is available that allows scouring and milling to be carried out in the same machines using alternative settings.

86 - **Module 3:** Wet finishing operations

SUMMARISE this module by explaining that before finishing starts the fabric must be:
- inspected for any gross faults
- mended
- formed into batches for processing.

Water quality

REITERATE THAT the quality of the water used in finishing is important to get the desired result. The key quality attributes of water that determine its suitability for finishing, are: hardness, dissolved solids, suspended solids, pH and colour.

Pre-setting

REMIND participants that pre-setting aims to prevent:
- the emergence of distortions in the fabric from the fabric-forming process (cockling)
- the formation of distortions in wet finishing (running marks).

Pre-setting involves:
- removing residual strains in the fabric
- permanently 'flat setting' the fabric.

There are two types of pre-setting methods, which are also used for wet finishing:
- batch processing
- continuous processing.

Scouring

Scouring during fabric finishing operations is designed to clean the fabric, removing residual

longitudinally)
- running marks (explained later)
- felting, if the mechanical action is too severe.

Fabric development

REVIEW the fact that fabric development (also called light milling or 'bursting' the yarns) is a process in which the wet fabric is subjected to mild mechanical action. It is carried out to soften the handle of the fabric.

Milling

REMIND participants that milling is a process used to control felting of fabric. In this process the wet fabric is subjected to more severe mechanical action to induce controlled felting of the fabric. The process is designed to increase the thickness and cover and to reduce the air permeability of wool fabrics.

REITERATE THAT both fabric development and milling are processes in which the wet fabric is subjected to mechanical action. The difference between development and milling is best described as:
- Development is carried out to soften the handle of the fabric and is sometimes called bursting or 'light milling'.
- Milling is carried out to induce controlled felting of the fabric.

Modern machinery is available that allows

SUMMARY — MODULE 3

Piece dyeing is normally carried out in rope form.

The side effects associated with piece dyeing include:

- softer and 'fuller' fabric handle
- permanent setting of running marks
- uncontrolled relaxation of the fabric
- facing up (hairiness).

After wet finishing, the fabric must be dried. Mechanical drying can occur via three different processes:

- spin hydroextraction
- suction slot
- mangle.

Stenter (or tenter) drying is one of the critical operations in wet finishing. Not only is the fabric dried, but the dimensions of the fabric are adjusted to those required.

Stenters may be single layer or multi-layer.

The stenter is the first finishing machine that allows the finisher to adjust the dimensions of the fabric length and width.

Advances in finishing machinery include:

- larger machines to improve efficiency
- more flexible machines suitable for short runs
- reduced steam and energy requirements
- ability to impart a new feel in the fabric
- ability to improve the quality of the fabric.

87 - **Module 3:** Wet finishing operations

Piece dyeing
REMIND participants that piece dyeing is a colouration process and has a large effect on fabric properties, so must be considered in wet finishing.
Piece dyeing of wool fabrics is normally carried out in rope form. Conditions are chosen that avoid mechanical action (preventing development or felting).
The side effects associated with piece dyeing include:

- softer and 'fuller' fabric handle
- permanent setting of running marks
- uncontrolled relaxation of the fabric causing cockling
- facing up (hairiness) caused by mechanical action.

Mechanical drying
REITERATE THAT after wet finishing, the fabric must be dried. Mechanical drying can occur via three different processes:

- spin hydroextraction.
- suction slot
- mangle.

Thermal drying
REMIND participants that stenter (or tenter) drying is one of the critical operations in wet finishing. Not only is the fabric dried, but the dimensions of the fabric are adjusted to those required.

REVIEW the fact that stenters may be single layer or multi-layer.

The stenter is the first finishing machine that allows the finisher to adjust the dimensions of the fabric length and width.

There have been a number of advances in machinery suitable for finishing wool.

- Larger machines to improve efficiency (reduce handling time).
- More flexible machines suitable for short runs.
- New engineering to reduce steam and energy requirements.
- New drying methods to impart a new feel of the fabric.

A number of machines have been developed to achieve new effects in finishing. The major aims of these developments have been:

- impart a new feel of the fabric
- improve the quality of the fabric.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 4 Dry finishing operations*— and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

THE WOOLMARK COMPANY

MODULE 4

DRY FINISHING OPERATIONS

RESOURCES — MODULE 4: DRY FINISHING OPERATIONS

Contained in the *Wool fabric finishing* Demonstration kit you will find the following resources for use as you deliver **Module 4: Dry finishing operations**:

- sample of raised fabric
- sample of unraised fabric
- length of woven wool fabric

Additional resources to be sourced by the facilitator include:

- sandpaper

WELCOME participants to Module 2 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Review of setting and felting*.

NOTE TO FACILITATOR*: This module is lengthy and is designed to be spread over two lectures. The recommended break point is at the end of Slide 32:* Pressing.

EXPLAIN THAT this module will cover:

- dry finishing operations
- the aims and unwanted effects of each process
- how aims and unwanted effects are measured.

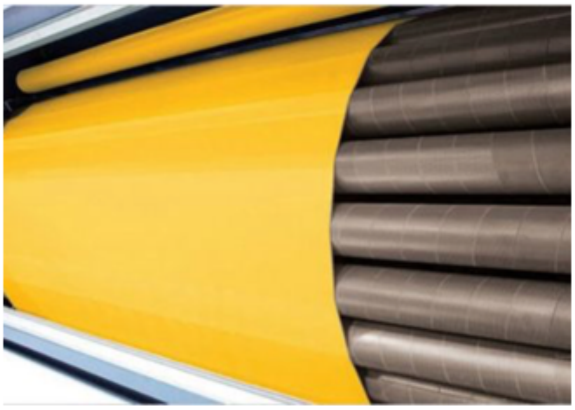
INFORM participants that by the end of this module, the participants will be able to:

- describe the finishing processes commonly used to dry finish wool and their aims
- describe the machinery used to carry out each process
- describe the advantages and disadvantages associated with different alternative dry finishing processes
- describe some of the unwanted effects that can occur with each process
- describe the process variables associated with decatising and how these impact the properties of the treated fabric.

RESOURCES REQUIRED FOR THIS MODULE:

- *sample of raised fabric*
- *sample of unraised fabric*
- *length of woven wool fabric*
- *sandpaper (facilitator to supply)*

MODULE 4 – DRY FINISHING OPERATIONS



Source: www.tradeindia.com/fp3318792/Planetary-Emery-Sueding-Machine.html

- Heat setting
- Shearing-cropping
- Singeing
- Conditioning
- Raising
- Pressing
- Decatising
- Sponging
- Steam framing

2 - **Module 4:** Dry finishing operations

INDICATE THAT dry finishing operations include the following processes:

- heat setting
- shearing – cropping
- singeing
- conditioning
- raising (wet and dry)
- pressing
- decatising
- sponging – relaxation
- steam framing.

NOTE THAT each operation will be discussed in this module along with the unwanted effects associated with the operation.

HEAT SETTING

- Heat setting is a high-temperature operation used to stabilise synthetic fibres in wool blend.
- A stenter is normally used for heat setting the synthetic fibres in blend fabrics.
- Provided the stenter has sufficient chambers and adequate controls, drying and heat setting can be conducted simultaneously, although for most stenters, two-stage drying, then heat setting, is the preferred approach.
- The dried fabric is heated to a high temperature for a short time.
- High temperatures can cause yellowing of the wool.
- Heat setting stabilises the synthetic fibres and can improve the dimensional stability of the blend.
- Blend fabrics are normally heat set before piece dyeing as this inhibits the formation of running marks.

3 - **Module 4:** Dry finishing operations

NOTE THAT heat setting is a high-temperature operation used to stabilise synthetic fibres in wool blend.

A stenter (tenter) is normally used for heat setting the synthetic component of wool blend fabrics, such as:

- wool/polyester
- wool/elastane (Lycra).

EXPLAIN THAT provided the stenter has sufficient chambers and adequate controls, drying and heat setting can be carried out simultaneously. However this approach can cause problems and is only recommended in modern stenters.

For most stenters, two-stage drying, then heat setting, is the preferred approach.

POINT OUT that during heat setting, the dried fabric is heated to a high temperature for a short time.

- Polyester 140 – 180°C for 30 seconds (depending on fabric weight).
- Elastane 160 – 185°C for 45 seconds. (depending on fabric weight).

NOTE THAT high temperatures can cause yellowing of the wool and change in white and pastel shades.

EMPHASISE THAT exposure to high temperatures should be minimised by heat setting at the lowest temperature possible or minimising the time of exposure. In some instances, such as on pale shades, heat setting at 140°C is recommended to avoid yellowing.

EXPLAIN THAT heat setting stabilises the synthetic fibres and can improve the dimensional stability of the blend as a whole. Wool blends are normally heat set immediately after drying.

NOTE THAT piece-dyed blend fabrics are normally heat set before piece dyeing as this inhibits the formation of running marks and improves dimensional stability.

SHEARING – CROPPING

Fibres protruding from the fabric surface are cut off:
- Clear finish — fibres are cut as short as possible.
- Pile fabric —fibres are cut to a uniform length.

The fibres are cut between:
- a fixed blade (ledger blade)
- a series of helical blades on a cutting cylinder.

Cylinder rotates at 800-1500rpm.

Three cutting heads:
- two for the face of fabric
- one for the back.

4 - **Module 4:** Dry finishing operations

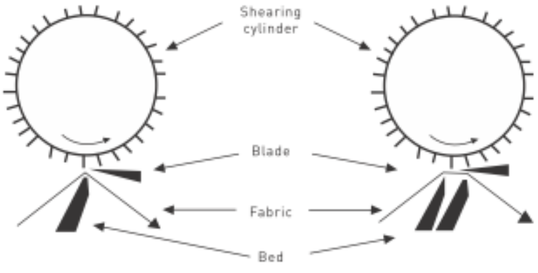
INDICATE THAT shearing is a process in which fibres protruding from the fabric surface are cut off. The process is also called cropping.

For a clear finish, the fibres are cut as short as possible; for a pile fabric, the fibres are cut to a uniform length.

EXPLAIN THAT the surface fibres protruding from the fabric are cut between a fixed blade (ledger blade) and a series of helical blades on a cutting cylinder. These blades rotate at 800–1500rpm.

NOTE THAT a cropping machine normally has three cutting heads; two for the face of the fabric and one for the back

SHEARING – CROPPING



Solid bed

Hollow bed

Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

5 - **Module 4:** Dry finishing operations

EXPLAIN THAT two types of ledger blade and bed combinations are used:

- solid bed (on left) for a precise and clean cut
- hollow bed for fabrics with uneven surfaces, or where fabric has a large number of mending knots.

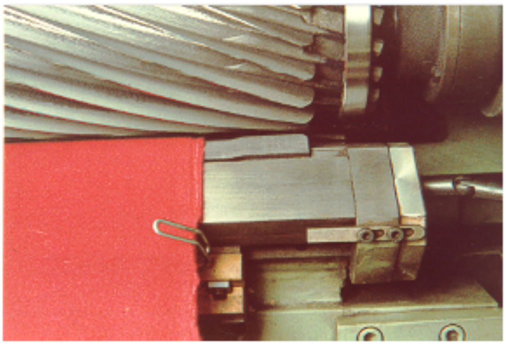
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the shearing – cropping operation.

PLAY *video (36 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

SHEARING – CROPPING



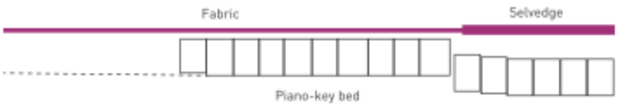
Brushes are used before the shear head:

- to raise the protruding fibres
- to remove any loose threads.

A piano-key bed:

- allows lowering section of the bed at edges of fabric
- protects selvedges from damage.

Metal detectors prevent damage to the shearing blades.



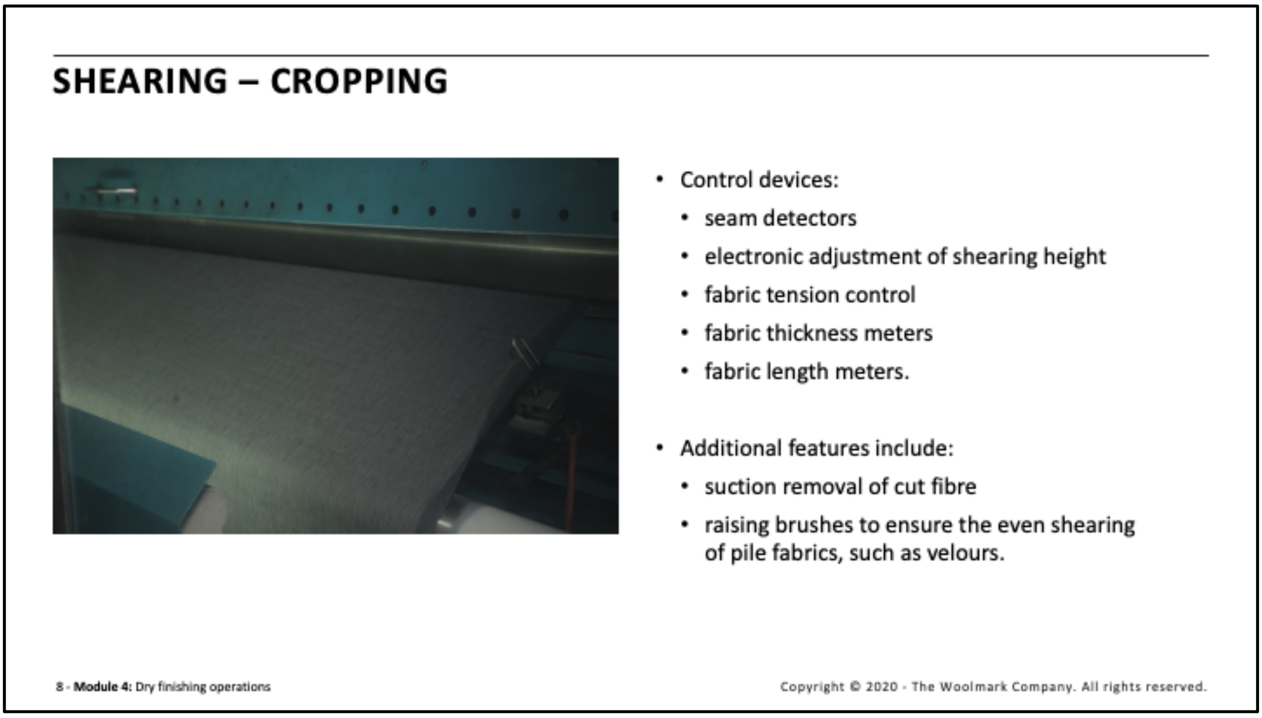
7 - **Module 4:** Dry finishing operations

INDICATE THAT brushes are used before the shear head to:

- raise the protruding fibres in a position for cutting
- remove any threads lying on the fabric surface.

NOTE THAT many shearing machines have a piano-key bed. This allows a section of the bed at the edges of the fabric to be lowered which protects the selvedges of the fabric from damage.

MENTION THAT metal detectors are used to prevent damage to the shearing blades.

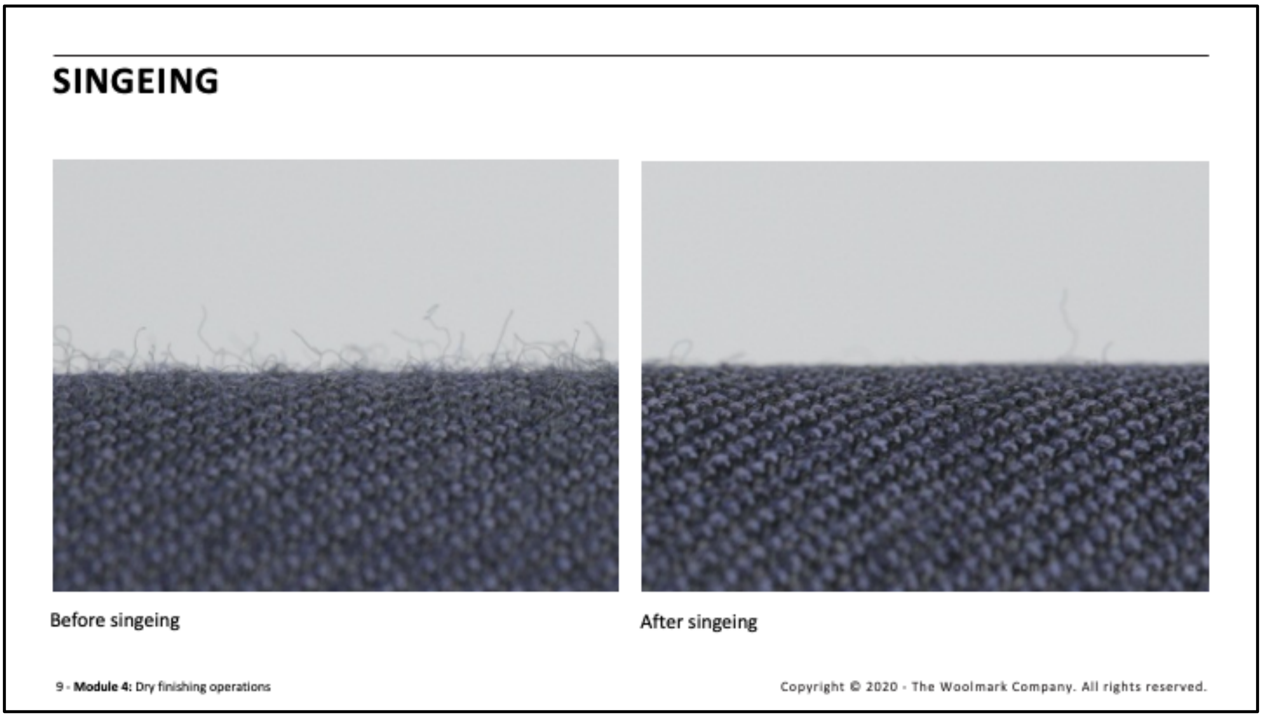


INDICATE THAT many shearing machines have a number of additional control devices:

- seam detectors to raise the shearing cylinder to allow passage of seams
- electronic adjustment of shearing height
- fabric tension control
- fabric thickness meters
- fabric length meters.

POINT OUT that some shearing machines also contain further features:

- suction mechanisms to remove the cut fibre,
- raising brushes to ensure the even shearing of pile fabrics, such as velours).

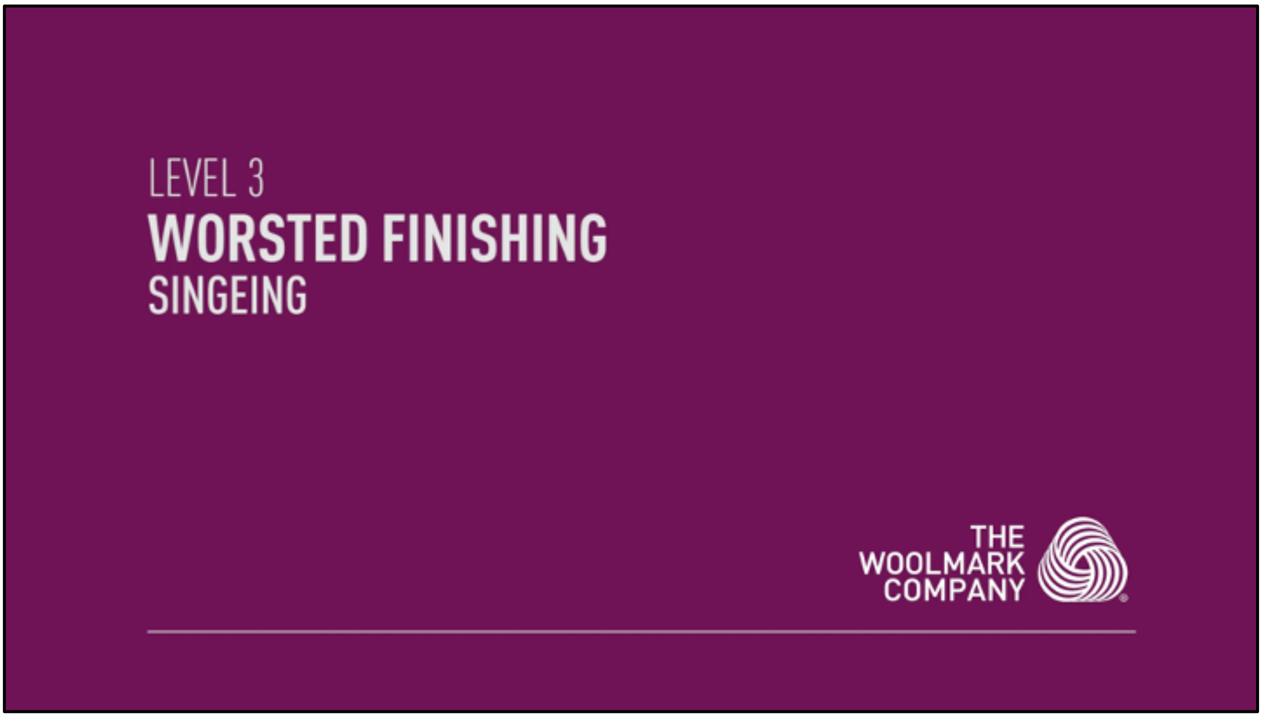


INDICATE THAT singeing is a process to burn fibres protruding from the surface of the fabric to create a very clean surface.

NOTE THAT the pictures on the slide show the difference in the fabric surface before and after singeing. Note how the hairiness of the fabric is significantly reduced.

EXPLAIN THAT singeing is often conducted on the loom-state fabric, or during dry finishing, but rarely both. The fabric must be washed off after singeing to remove dust, ash and the smell.

EXPLAIN THAT or this reason singeing is often conducted on loom-state fabric so the required scouring washes off the singed material as well as removing the usual fabric contaminants.



EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the singeing process.

***PLAY** video (29 seconds)*

***NOTE THAT** that beaters are used to remove the ash from the fabric.*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond before proceeding.*

SINGEING

11 - **Module 4:** Dry finishing operations

INDICATE the key components of singeing machines:

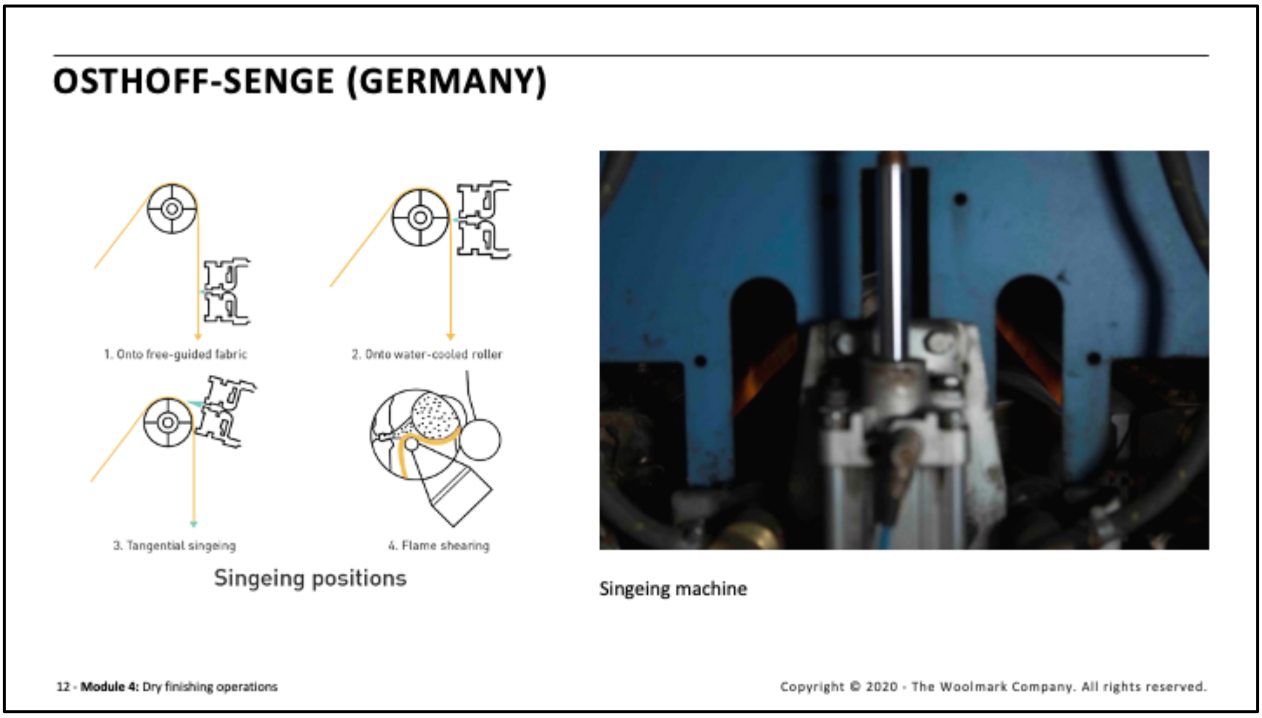
- a rotary brush to raise the protruding fibres
- flame jets to provide the flame
- fabric tensioning rollers to ensure there are no creases in the fabric
- anti-static bar, at the take-off point. when singeing fabrics (especially blends) it is possible to build up a level of static electricity, which must be discharged by an anti-static bar.

EXPLAIN THAT the factors that require monitoring and control during the singeing process include:

- flame intensity — the stronger the flame the greater the singeing action.
- flame direction — it is important to ensure the fabric is in the right part of the flame.
- fabric speed — the faster the fabric speed the less the singeing action.

NOTE THAT fabrics that are typically singed include:

- fine wool fabrics where the fibres can be difficult to shear
- fine wool fabrics where a very clean surface is required
- wool/mohair blends to remove any guard hairs from the mohair that are difficult to crop
- wool/polyester blends to remove the polyester, which is difficult to crop — the protruding polyester fibres are melted
- pure wool fabrics made from crossbred wool, which may be prone to prickle.



EXPLAIN THAT modern singeing machines offer several geometries of flame and fabric to optimise the singeing process across a wide range of fabrics.

INDICATE THAT some heat-sensitive fabrics require the use of a water-cooled support roller to avoid excessive heating of the bulk of the fabric.

NOTE THAT these are shown on the slide (images courtesy of Osthoff-Senge).

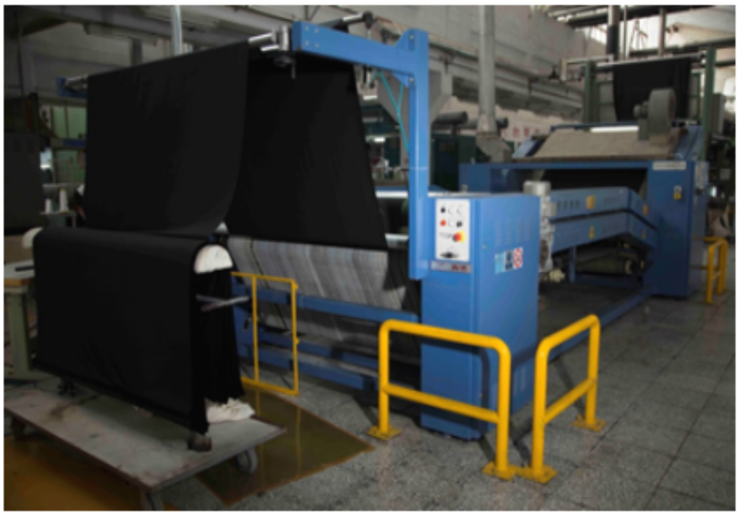
Osthoff-Senge singeing machines**
The direct singeing system forms the technological basis of all Osthoff-Senge singeing machines.

The advantage of the Osthoff-Senge singeing system is that it that allows:

- *a direct, intensive flame with the short contact time between flame and fabric*
- *the ignition flame temperature necessary for the melting of polyester.*

** http://www.osthoff-senge.com/?page_id=1781

FABRIC CONDITIONING



13 - **Module 4:** Dry finishing operations

INDICATE THAT 'conditioning' is a process designed to increase the moisture content of wool fabrics.

EXPLAIN THAT many processes dry out the wool fibres. After stenter drying, the moisture content (regain) of the wool is often less than 5% . Dry finishing is more effective if carried out on fabric with a moisture content of 10–15%.

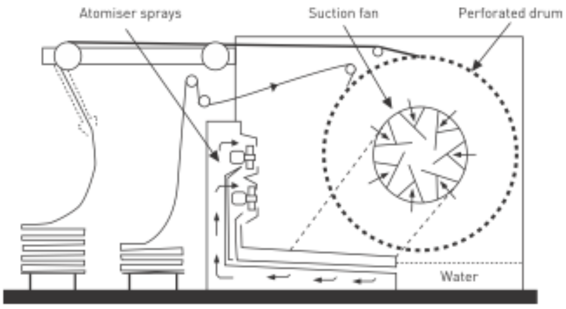
Fabrics left in stacks or rolls absorb moisture from the air, condition slowly and unevenly.

MENTION THAT three methods of conditioning are commonly used.

- Dewing: Cool, humid air is drawn through the fabric.
- Damping: The fabric is sprayed with water.
- Steaming: Steam is passed through the fabric which can be held or free to relax.

POINT OUT that the adsorption of water by wool is exothermic. Dry wool adsorbs water as it reconditions and the wool gets hot as a result.

FABRIC CONDITIONING – DEWING



Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

- Dewing is the process of passing cold, humidified air through the fabric.
  - The Sjostrom machine:
    - moves festooned wool between layers of wet felt.
  - Monforts fog machine:
    - blows a mist of water and air through the fabric.
  - The Juki machine:
    - sprays liquid nitrogen onto the fabric
    - water in the surrounding air condenses
    - on cold fabric.

14 - **Module 4:** Dry finishing operations

EXPLAIN THAT dewing is the process of passing cold, humidified air through the fabric. There are several machines that do this:

- The Sjostrom machine moves 'festooned' wool between layers of wet felt.
- The Monforts fog machine blows a mist of water into recirculating air, which is sucked through the fabric.
- The Juki machine sprays liquid nitrogen onto the fabric so water in the surrounding air condenses on the fabric.

INDICATE THAT the term 'festoon' describes loops of fabric hung from bars.

DEMONSTRATION: FESTOON FORMATION

DEMONSTRATE *a festoon using three volunteers.*

ASK *participants to stand side by side while holding one arm directly in front of them at shoulder height. 'Festoon' (drape) the length of fabric across the volunteers' arms.*

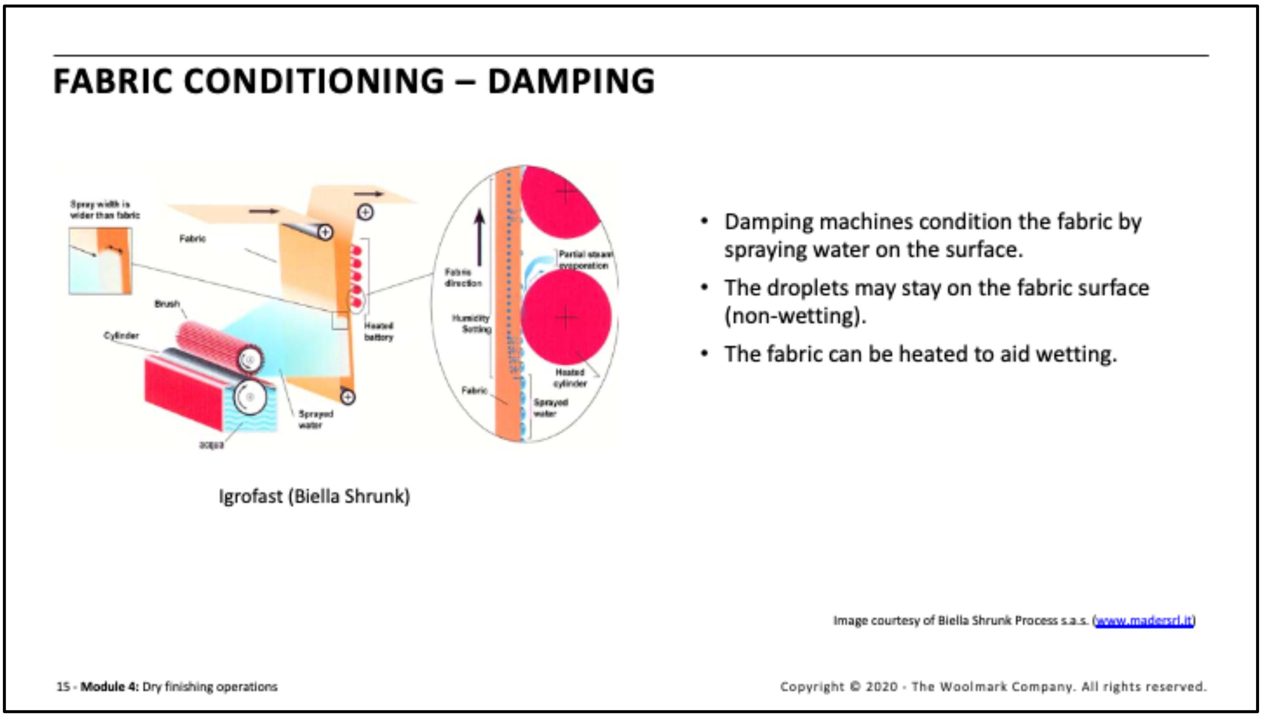
NOTE: *In a variation of this demonstration, volunteers can slowly shuffle left (or right) as new volunteers join the line at one end to 'receive' the fabric as it passes through the 'machine'. The first and second volunteers (at the opposing end of the line to the new volunteers) sequentially drop off as the fabric 'exits the machine'.*

NOTE THAT in a working dewing machine, the machine is full of humidified air.

Monforts fog machine (shown in slide) carries out both:

- dewing (the water spray cools and humidifies the air), and
- damping (the spray impinges on the fabric).

POINT OUT these machines use relatively old technologies. Newer machines with alternative mechanisms for conditioning the fabric are more commonly used.



INDICATE THAT damping machines condition the fabric by spraying water onto it.

In one machine the spray is made by a stiff brush rotating in contact with a wetted roller.

NOTE THAT WEKO and other manufacturers also make a series of regulated water sprayers that can be used to add water to fabric by attaching to the front of machinery.

EXPLAIN THAT after the fabric is sprayed it may be guided through a series of heated cylinders. In the absence of any 'assistance' the water droplets may stay on the fabric surface (wool usually has a non-wetting surface). The heated cylinders help to wet the fabric by reducing the surface tension of the water droplets and increasing the amount of water adsorbed by the fibre from the water droplets on the surface of the fabric.

INDICATE THAT the Igrofast machine (made by Biella Shrunk) is shown in the slide.

FABRIC CONDITIONING — STEAMING

- This process is relatively ineffective:
  - steam condenses on the fibres
  - the fabric is heated, preventing more condensation.
- The effect can be improved if the fabric is cooled before steaming.
- The process relaxes the fabric:
  - can release cohesive set
  - may or not be required.

Machines

- Unipolar (Kettling & Braun)
- Juki machine from Japan.

16 - **Module 4:** Dry finishing operations

EXPLAIN THAT a steaming process can be used to increase the moisture content of the fibres, but is relatively ineffective. As the steam condenses the fabric is heated, preventing more condensation. The effect can be improved if the fabric is cooled to below room temperature before steaming.

INDICATE THAT the process can release the cohesive set of the fabric (i.e. relaxes the fabric). Steaming raises the fibres above their glass transition. The release of cohesive set may, or may not, be required.

ASK *participants to explain why the steaming process releases some cohesive set.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *reinforce that the steaming process raises the fibres above their glass transition.*

POINT OUT that the following two machines steam the fabric to increase its moisture content:

- Unipolar (Kettling and Braun)
- Juki machine from Japan: As this machine cools the fabric before steaming it has both a dewing and steaming action.

EVALUATING FABRIC CONDITIONING


Meter for measuring fabric moisture content

- **Evaluation of fabric conditioning**
  - Increase in moisture content of fabric.
- **Appropriate measurements**
  - Moisture content of wool.
- **Unwanted effects**
  - Release of temporary set.
  - Reappearance of running marks or other fabric distortions.

17 - **Module 4:** Dry finishing operations

NOTE THAT fabric conditioning can be evaluated by determining how much the moisture content of fabric has increased.

POINT OUT that the appropriate measurement to take is the moisture content of the wool. Meters for measuring fabric moisture content can be used for online measurement, feedback and adjustment.

INDICATE THAT one of the meters used to measure fabric moisture content is shown on the slide.

EXPLAIN THAT some of the unwanted effects that can occur during conditioning are:

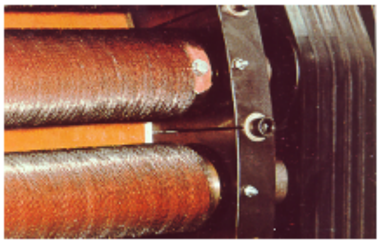
- the release of temporary set, which can be measured as a change in thickness or dimensions of the fabric
- the reappearance of running marks or other distortions.

RAISING

Raising:
- draws fibres to the surface of a fabric (called a pile)
- also known as teazelling, gigging or napping.

The aims are to:
- cover the weave
- create a pile surface
- modify the handle of fabric
- make the fabric thicker, loftier and warmer.

Raising is achieved by:
- inserting the end of a wire (or other needle-like object) into the fabric
- withdrawing it so it pulls some fibres to the surface.



18 - **Module 4:** Dry finishing operations

EXPLAIN THAT raising is a process used to draw fibres to the surface of a fabric (called a pile). The process of raising may also be called teazelling, gigging or napping, depending on the type of machine used.

HAND OUT *samples of raised and unraised fabric to participants.*

ASK *participants to identify the difference between the two samples.*

ALLOW *participants sufficient time to respond before proceeding.*

IF NECESSARY *note that the raised sample has a hairy surface and feel softer.*

INDICATE THAT the aim of raising may be to:
- cover the weave so individual threads are less visible
- create a pile surface
- modify the handle of the fabric
- make the fabric thicker, loftier and warmer.

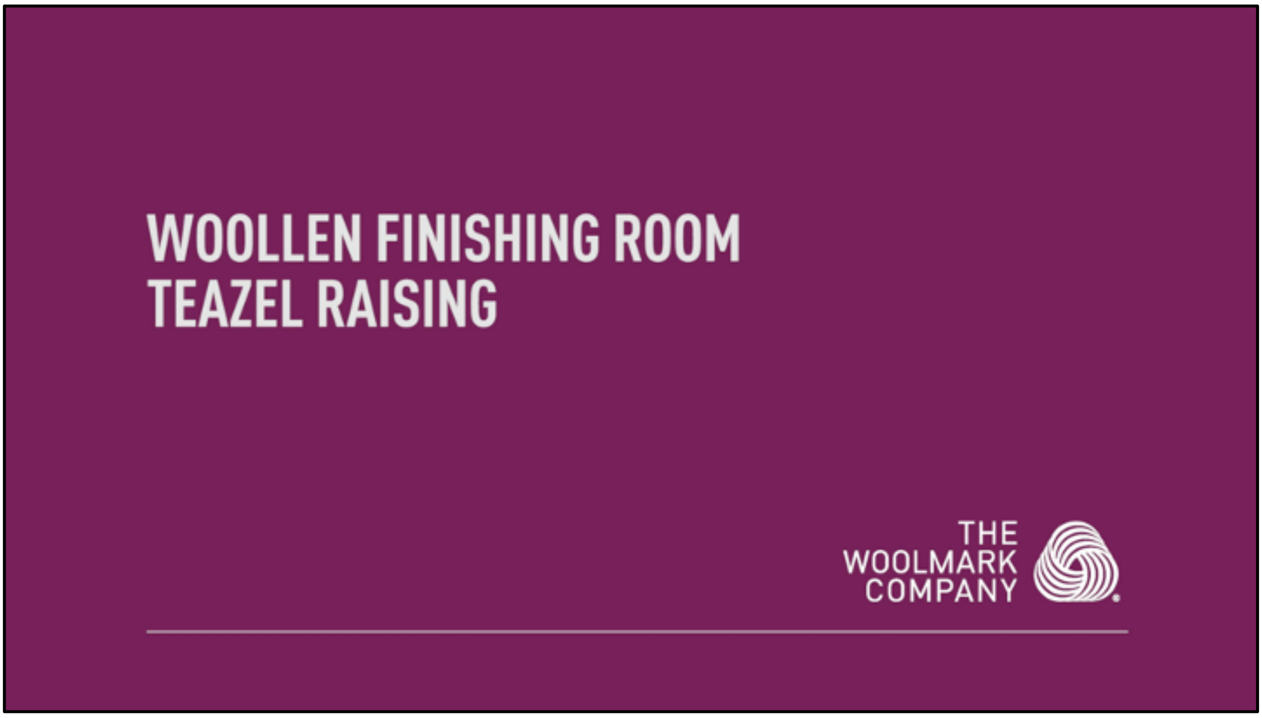
NOTE THAT raising is achieved by:
- inserting the end of a wire (or other needle-like object) into the fabric
- withdrawing it so it pulls some fibres to the surface.

EXPLAIN THAT fabrics were traditionally raised using machines called teazel gigs.

Teazels are the dried head of a specific thistle plant. The teazels are fitted into special bars on the raising machine. The bars are, in turn, fitted on the outside of a freely-rotating drum. The fabric is pulled in open width around the drum in contact with the teazels.

NOTE THAT teazels are used in gentle action machines, which are required for delicate wool/cashmere fabrics.

POINT OUT that synthetic teazels (plastic or wire) have been developed to replace the natural (and expensive) teazels, which are still grown commercially for use in the textile industry.



EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of teazel raising using a single raising drum.

NOTE the position of the teazels in the bars.

PLAY *video (51 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

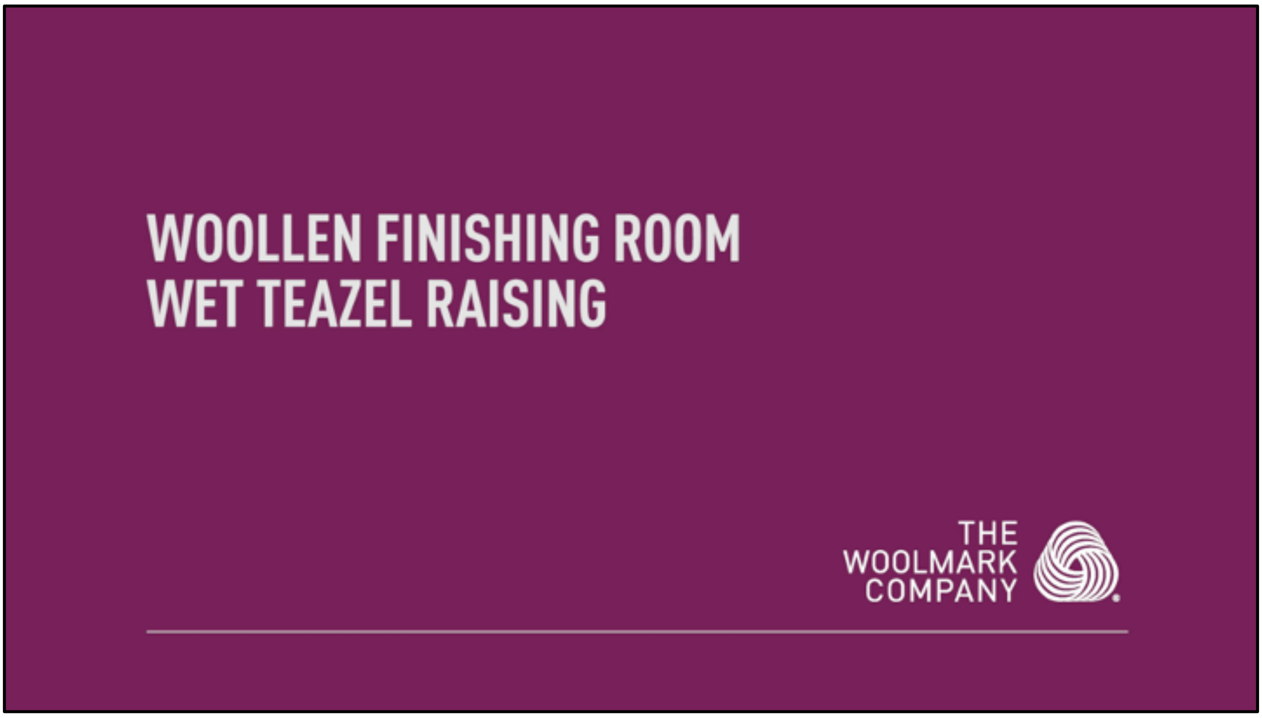
ALLOW *sufficient time for participants to respond before proceeding.*

EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of a teazel raising using two raising drums.

***PLAY** video (59 seconds)*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond before proceeding.*



EXPLAIN THAT teazel raising also can be conducted on wet fabric. Wet fibres have different tensile properties than dry fibres; they are more extensible and have good recovery.

NOTE THAT wet teazel raising is used to raise delicate fabrics and to obtain a long pile, which can be laid in a particular direction by subsequent brushing.

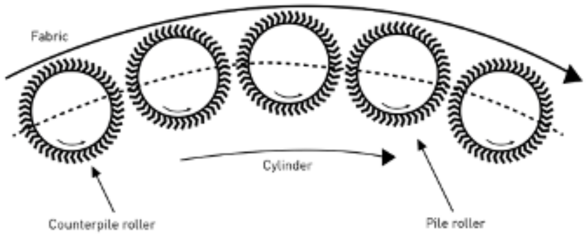
POINT OUT that the following video, produced by The Woolmark Company (TWC), offers an overview of the wet teazel raising process.

***PLAY** video (38 seconds)*

***ASK** participants if they have any questions or comments regarding the video content.*

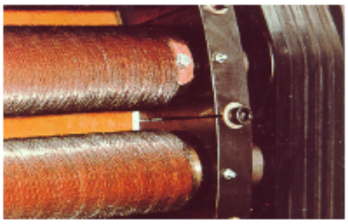
***ALLOW** sufficient time for participants to respond before proceeding.*

WIRE RAISING



Modern machines use a planetary action:

- The wires are bent so that they contact the fabric at 45 degrees with the surface.
- Degree of raising depends on the relative speeds of the fabric and card wire points.



23 - **Module 4:** Dry finishing operations

NOTE THAT modern raising machines use a planetary action, which was first developed in the 1800s.

EXPLAIN THAT the planetary action is as follows:

- The modern raising machine has 24–36 rollers. Each roller is covered in card wire and mounted on the outside of a larger cylinder (or drum).
- The drum and rollers rotate in opposite directions.
- The fabric is pulled over the drum in the direction of the cylinder.

INDICATE THAT the wires in the raising machine are bent, so they contact the fabric at an angle of 45 degrees with the surface of the fabric.

- Pile rollers — The wires point in the direction of the movement of the fabric
- Counterpile rollers — The wires point against the direction of the movement of the fabric.

EMPHASISE THAT the degree of raising depends on the relative speeds of the fabric and card wire points.

WIRE RAISING

Types of machines:
- Single action — pile rollers only.
- Double action — pile and counterpile.

Control points in raising include:
- speed of drum
- type of rollers (pile or counterpile)
- speed of rollers – independent
- speed of fabric
- tension on fabric
- type of card wire
- lubricants used
- number of passes.

Other components of raising machines:
- automated zero raising point determination
- fabric tension control
- dust extractors.

Wet raising:
- 50–70% moisture content.
- The fibres are less stiff.
- Friction controlled by a lubricant (silicone).

24 - **Module 4:** Dry finishing operations

INDICATE THAT there are two types of wire raising machines:
- single action — having only pile rollers
- double action — having both pile and counterpile rollers.

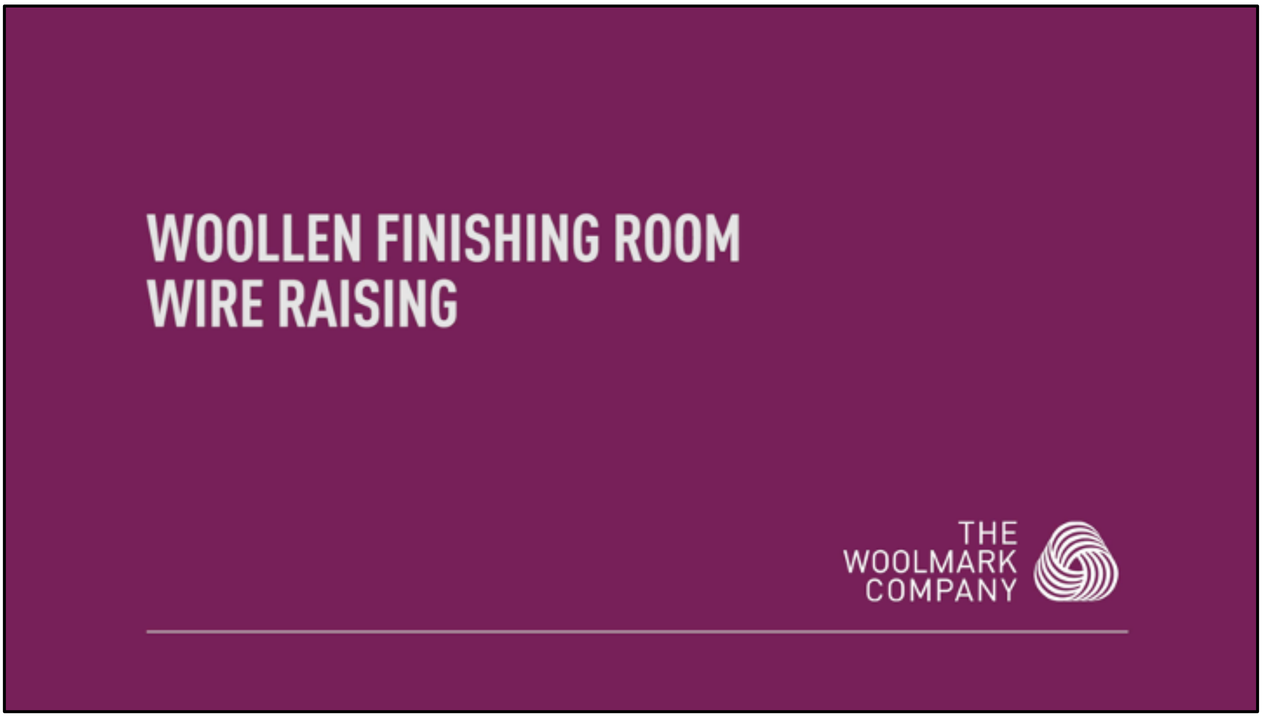
NOTE THAT the controls for monitoring raising include:
- speed of drums
- type of rollers (pile or counterpile)
- speed of rollers—independent
- speed of fabric
- tension on fabric
- type of card wire
- lubricants used
- number of passes.

POINT OUT that some of the other components of raising machines include:
- automated zero raising point determination
- fabric tension control
- dust extractors.

Wet raising

EXPLAIN THAT woollen fabric is often raised when the fabric is wet (50–70% moisture content). This is known as wet raising**.** Wet raising is usually conducted in the wet finishing area.

In wet teazel raising, the fibres are less stiff so they are easier to manipulate. Friction is controlled by the use of a lubricant (silicone).



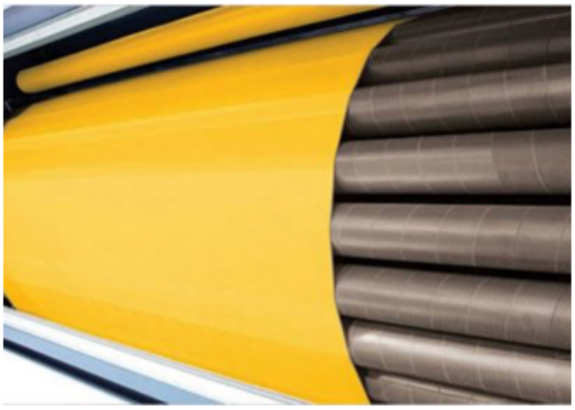
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the wire-raising process.

PLAY *video (1.27 minutes)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

OTHER VARIATIONS ON RAISING



Source: www.tradeindia.com/fp3318792/Planetary-Emery-Sueding-Machine.html

Sueding (emerising):
Rollers are covered with a emery paper.
The emery paper draws fibres to the fabric surface.

Brushing:

- raises fibre on the fabric surface before shearing, or
- lays pile already on the surface of the fabric.

Brushing machines to lay pile, usually consist of:

- 4–5 rotating rollers (~50cm diameter)
- a short bristle covering.

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NOTE THAT there are two other variations of raising:

- sueding
- brushing.

EXPLAIN THAT sueding is otherwise known as 'emerising' because of the fact that it uses emery paper to raise the fibre. In sueding machines the rollers are covered with an emery paper (rather than wires) as shown on the slide. The emery paper draws fibres to the fabric surface.

INDICATE THAT brushing machines are used to raise fibre on the fabric surface before shearing, or to lay pile already on the surface of the fabric.

POINT OUT that brushing machines, which produce or lay a pile on the fabric, usually consist of four or five rotating rollers approximately 50cm in diameter with a short bristle covering.

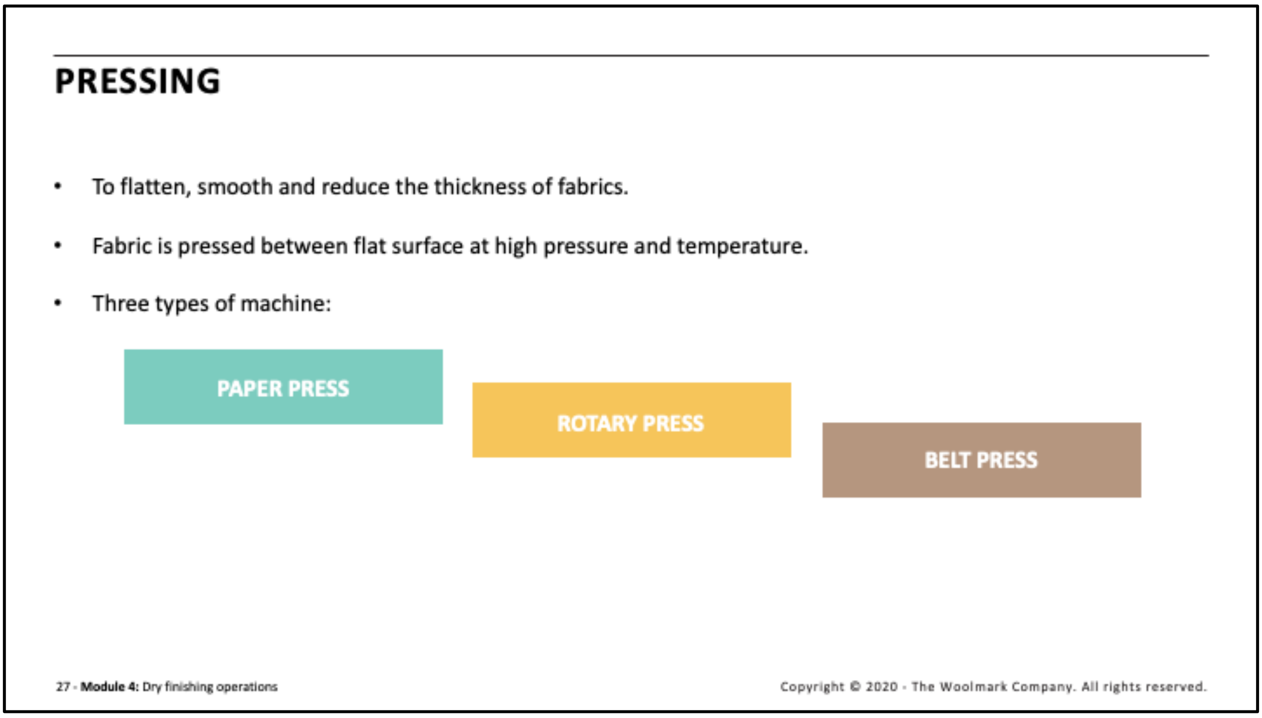
Both sueding and brushing machines draw a short 'nap'. Nap is the raised (fuzzy) surface that appears on certain fabrics.

DEMONSTRATION: EMERISING
Resources required:

- sandpaper
- sample of wool fabric

RUB sandpaper across fabric surface to raise the fibres.

ENSURE participants have the opportunity to see the raised fibres on the surface of the fabric.



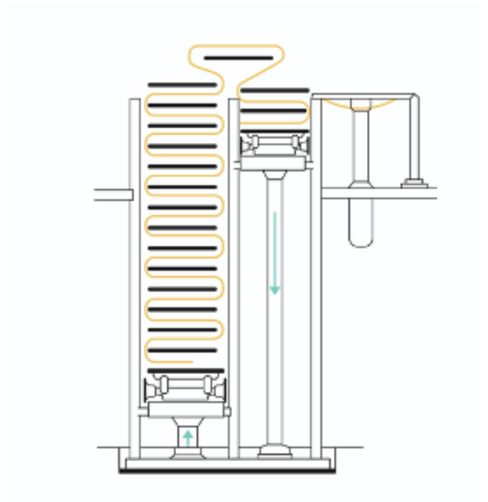
EXPLAIN THAT pressing operations are designed to flatten, smooth and reduce the thickness of fabrics by pressing them between flat surfaces at high pressure and temperature.

Three types of pressing machine are commonly used:

- paper press
- rotary press
- belt press.

INDICATE THAT these machines are described in more detail on the following slides.

PAPER PRESSING



Paper press:

- imparts a highly prized smooth handle
- expensive and labour intensive
- fabric layered between individual cardboard sheets
- the 'stack' is pressed using a hydraulic press
- the cardboard sheets raised to 60°c or higher
- the stack cooled slowly
- the fabric not stretched in process
- after the initial pressing the fabric is re-positioned and re-pressed to remove edge marks.

28 - **Module 4:** Dry finishing operations

EXPLAIN THAT the paper press imparts a highly-prized smooth handle, but is expensive and labour intensive.

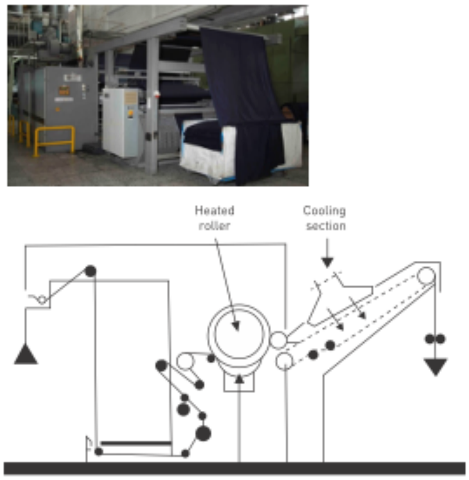
INDICATE THAT the diagram on the slide illustrates how a paper press is used:

- The fabric is layered between individual cardboard sheets.
- The 'stack' is pressed using a hydraulic press.
- The cardboard sheets normally have heating elements to raise the temperature to 60°C or higher.
- The stack is heated and allowed to cool slowly.

NOTE THAT the machine is normally loaded manually so the fabric is not stretched in the process.

POINT OUT that at the edges of the cardboard sheets, the fabric is not pressed. After the pressing, the fabric must be re-positioned and re-pressed to remove these edge marks.

ROTARY PRESSING



Rotary press

- The fabric is pressed onto a heated cylinder by a polished plate called the 'shoe'.
- Continuous and inexpensive.
- Process stretches the fabric.
- Reduces fabric extensibility.

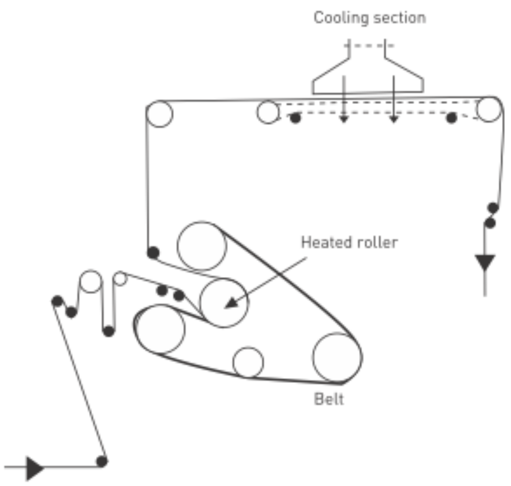
Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

29 - **Module 4:** Dry finishing operations

INDICATE THAT with a rotary press the fabric is pressed onto a rotating, heated (130°C) cylinder by a polished plate called the 'shoe'. The process is continuous and inexpensive.

However, a major problem with the rotary press is that it stretches the fabric, reducing its extensibility.

BELT PRESSING



Belt press

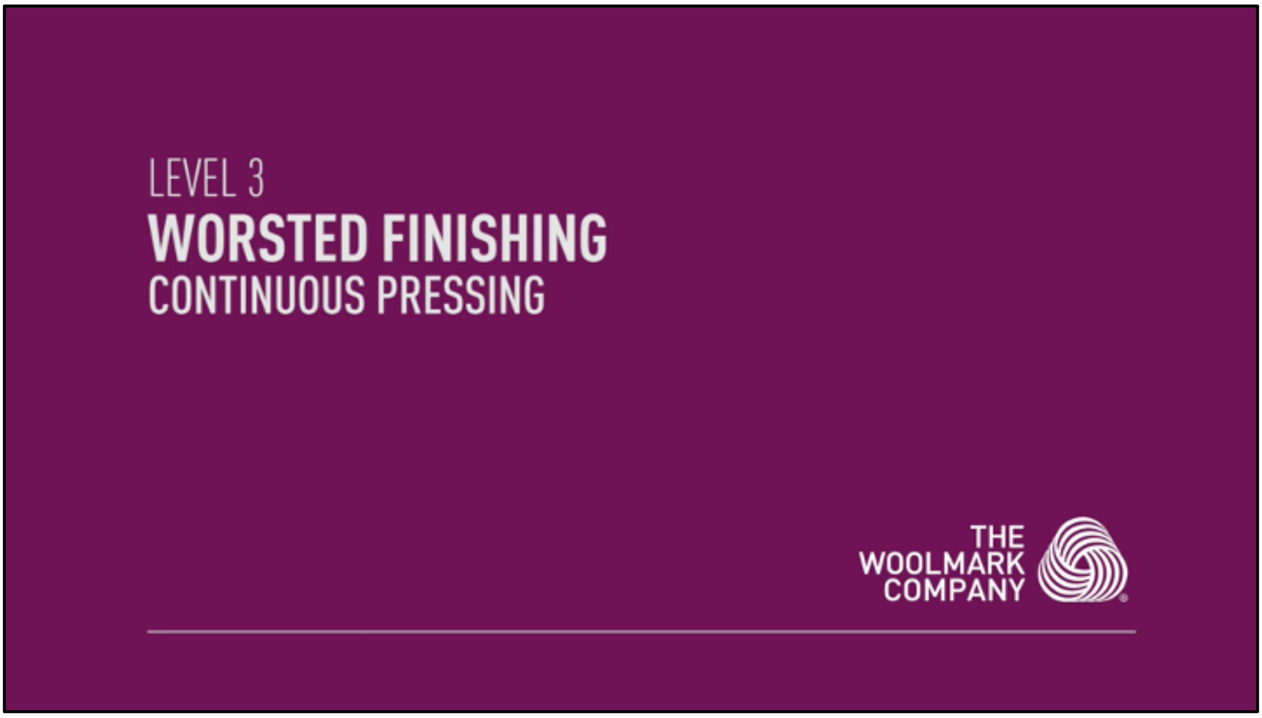
- Fabric is pressed onto a heated cylinder by an impermeable belt.
- Continuous and inexpensive.
- Fabric is cooled after pressing.
- Process stretches the fabric (although not as much as the rotary press).
- Less effective than rotary press.

Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

30 - **Module 4:** Dry finishing operations

EXPLAIN THAT with a belt press the fabric is pressed onto a rotating heated cylinder (up to 160°C) by a continuous impermeable silicone coated belt. The process is continuous and inexpensive. The fabric is cooled after pressing.

NOTE THAT the process does not stretch the fabric as much as the rotary press, but, in many instances, the process may not be as effective in pressing the fabric as a rotary press.



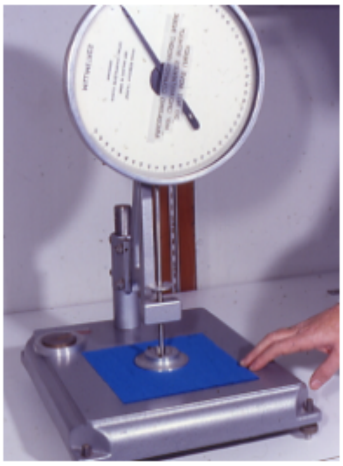
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the belt pressing process.

PLAY *video (42 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding .*

EVALUATING THE PRESSING OPERATION



Fabric thickness meter for assessing pressing

- Evaluation of the effectiveness of the pressing operation:
  - fabric thickness
  - stability of fabric thickness (to water or steam).
- Unwanted effects of pressing include stretching the fabric in warp direction.
- Appropriate tests:
  - warp dimensions
  - warp relaxation shrinkage
  - warp extensibility.

32 - **Module 4:** Dry finishing operations

INDICATE THAT the effectiveness of the pressing operation is evaluated by monitoring and measuring:

- fabric thickness
- the stability of the fabric thickness (to water or steam).

EMPHASISE THAT unwanted effects of pressing include the stretching of fabric in the warp direction.

NOTE THAT appropriate tests carried out to evaluate pressing effectiveness include:

- warp dimensions
- warp relaxation shrinkage
- warp extensibility.

NOTE TO FACILTATOR: *This is an appropriate point to break the module and end the first lecture.*

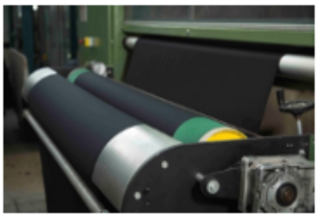
ASK *participants if they have any questions about the content covered in this module so far.*

DECATISING

- Fabric is interleaved with a cotton wrapper cloth and rolled onto a perforated drum.
- Saturated steam is forced through the fabrics.
- Vacuum-drawn air is drawn through the fabrics to cool the wool.

The wrapper cloth:

- high-quality closely-woven cotton fabric
- occasionally cotton/polyester
- ensures no embossing or faults on the fabric surface.



33 - **Module 4:** Dry finishing operations

WELCOME participants back to the lecture covering the second part of the module *Dry finishing operations.*

EXPLAIN THAT decatising was discussed earlier in the *Wool fabric finishing* course, when wet pre-setting was discussed.

***ASK** participants what they remember about the process of decatising.*

***RECORD** the participant responses on a whiteboard or flipchart.*

***REFER** to these responses as you cover the relevant information on the slides.*

REITERATE THAT decatising is a process in which:

- wool fabric is interleaved with, or held by, a cotton wrapper cloth (permeable to steam and air) onto a perforated drum
- saturated steam is forced through the fabrics and wrapper to heat the wool (and wrapper)
- a vacuum pump is used to draw air through the fabrics to cool the wool, usually before it is unrolled.

DEMONSTRATION: BATCH DECATISING

Resources required:

- cardboard tube
- cotton fabric
- wool fabric

ROLL the wool fabric onto cardboard tube followed by the cotton fabric .

DESCRIBE how steam is forced through the cardboard to heat the fabric.

DESCRIBE how, at the same time, air is sucked back through the roll to cool the fabric.

NOTE THAT the wrapper cloth is a high-quality closely-woven cotton fabric (occasionally cotton-polyester), which ensures there is no embossing of faults on the surface of the fabric.

DECATISING

The aims:

- Flat set the fabric to:
  - improve dimensional stability
  - improve fabric suppleness
  - improve fabric smoothness.

Two forms of decatiser:

- batch decatisers
- continuous decatisers.

34 - **Module 4:** Dry finishing operations

NOTE TO FACILITATOR: *Adapt how this slide is presented, based on the responses given to the question on the previous slide.*

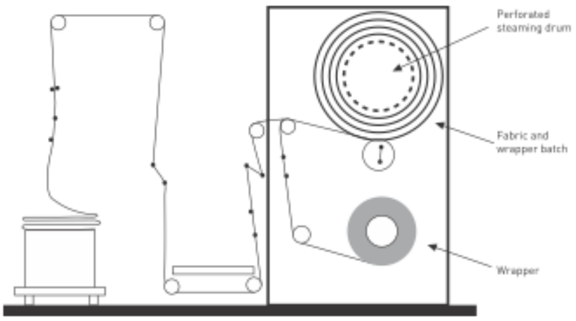
EXPLAIN THAT the aims of decatising are to:

- flat set the fabric — cohesive, temporary and permanent set can all be imparted to the fabric depending on the conditions used
- improve dimensional stability
- improve fabric suppleness
- improve fabric smoothness.

NOTE THAT there are two forms of decatiser normally used in dry finishing:

- batch decatisers
- continuous decatisers.

BATCH DECATISER



- Fabric is rolled onto a perforated drum.
- Fabric is interleaved with a cotton wrapper cloth.
- Saturated steam is forced through the roll.
- Air is drawn through the roll to cool the fabric.
- The fabric and wrapper are unrolled.
- Wrapper is rolled onto a separate roller for use with the next batch.

The wrapper cloth is:
- high-quality closely-woven cotton or cotton/polyester fabric
- clear finished or napped depending on the finish.

Source: Brady. P., Finishing and Wool Fabric Properties, CSIRO (Aust), Geelong, 1997

35 - **Module 4:** Dry finishing operations

REITERATE THAT in a batch decatiser, the fabric is rolled onto a perforated drum, interleaved with a cotton wrapper cloth, which is permeable to steam and air.

Saturated steam is forced through the roll to heat the wool (and wrapper) to temperatures around 100°C.

A vacuum pump is used to draw air through the roll to cool the fabric.

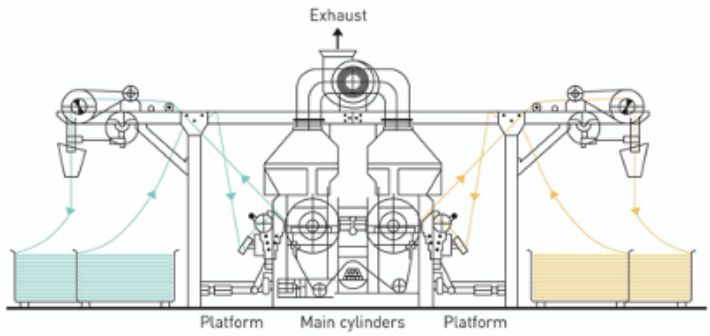
The fabric is then unrolled with the wrapper being rolled onto a separate roller for use with the next batch.

REINFORCE THAT like other types of decatising, the wrapper cloth is a high-quality closely-woven cotton fabric. The wrapper may be clear finished or napped, depending on the finish required on the wool fabric.

EXPLAIN THAT to avoid end-to-end effects caused by the difference in pressure on the fabric between the inside and outside of the roll, the fabric is often rewound and re-treated. This can be called **'full decatising**'.

NOTE THAT machines with two drums are used to facilitate this re-winding and double steaming.

BATCH DECATISER — FULL DECATISING



Full decatising machine

- Fabric is rewound and re-treated to avoid end-to-end differences.
- Two drums are used to facilitate this re-winding and double steaming.

POINT OUT that in the full decatising machine there are two cylinders. The fabric is rolled on the first cylinder and treated. It is then rolled in the reverse direction onto the second cylinder and treated again.

ASK *participants if they can explain why the fabric is rewound and treated twice.*

ALLOW *sufficient time for participants to respond and if necessary reinforce that the fabric is rewound and treated twice to avoid end-to-end differences in the fabric.*

NOTE THAT finally the fabric is unrolled and cuttled into a stack.

EFFECT OF UNROLLING TEMPERATURE

DECATISING		FABRIC THICKNESS (mm)	
Time (min)	Unrolling	Initial	Relaxed*
0.5	cold	0.64	0.80
2	cold	0.64	0.77
5	cold	0.66	0.74
10	cold	0.62	0.68
15	cold	0.63	0.68
2	hot	0.73	0.76

* Relaxed in water at 20°C for 30 minutes and reconditioned.

37 - **Module 4:** Dry finishing operations

INDICATE THAT the length of time the fabric has been decatised, and whether the fabric is unrolled cold or hot, affects the fabric characteristics. The effect on fabric thickness is shown in the table above.

EXPLAIN THAT unrolling the fabric when it is hot, results in a thicker fabric.

ASK *participants if they can explain why unrolling the fabric when it is hot results in a thicker fabric.*

ALLOW *participants sufficient time to respond before proceeding.*

INDICATE THAT if the constraint on the thickness is released while the fabric is still above its glass transition temperature, the fabric can relax giving it a thicker finish. If the fabric is cooled before it is unwrapped the cohesive set formed as the fabric cools holds the fabric at a thinner dimension.

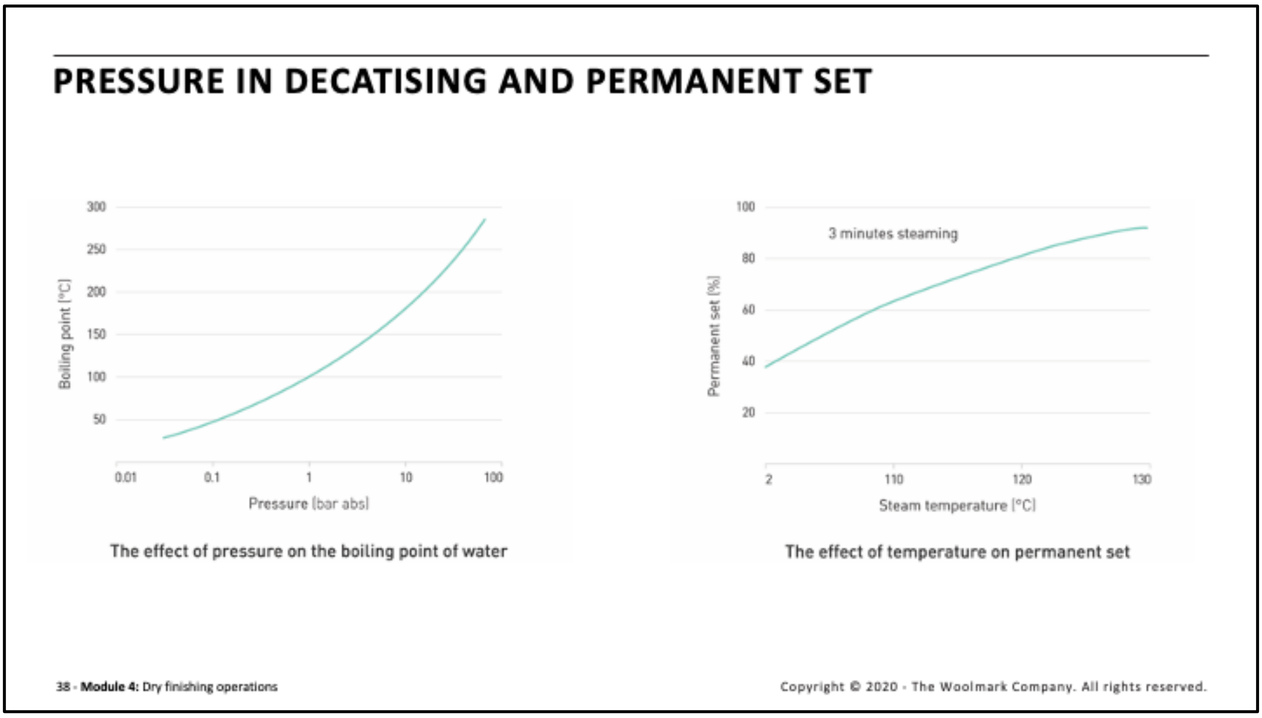
NOTE THAT after subsequent relaxation of the sample in steam, the hot-released fabric and cold-released fabric have the same thickness.

EMPHASISE THAT with an increase in the decatising time, the subsequently-relaxed thickness of the fabric becomes smaller even though the initial thickness is unchanged.

ASK *participants if they can explain why the relaxed thickness of the fabric gets smaller with decatising time, when the initial thickness is unchanged.*

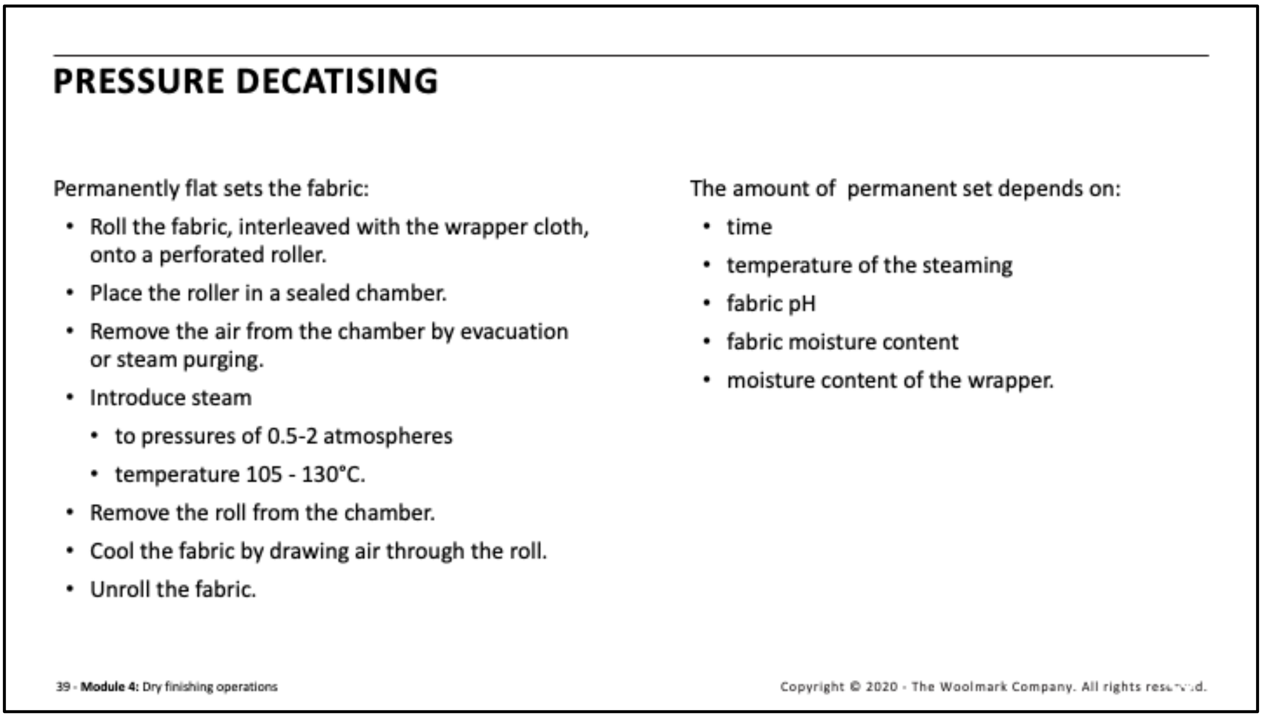
ALLOW *participants sufficient time to respond before proceeding.*

INDICATE THAT the initial thickness is held by cohesive set, which forms quickly during decatising, provided the fabric is cooled before release. The relaxed thickness is held by permanent set, which forms only slowly at 100°C.



REFER participants to this slide, which shows the effect of pressure on the temperature of the steam during decatising and the amount of permanent set in wool.

NOTE THAT if the temperature of the steam can be raised by increasing the pressure during decatising then a greater amount of permanent set can be imparted.



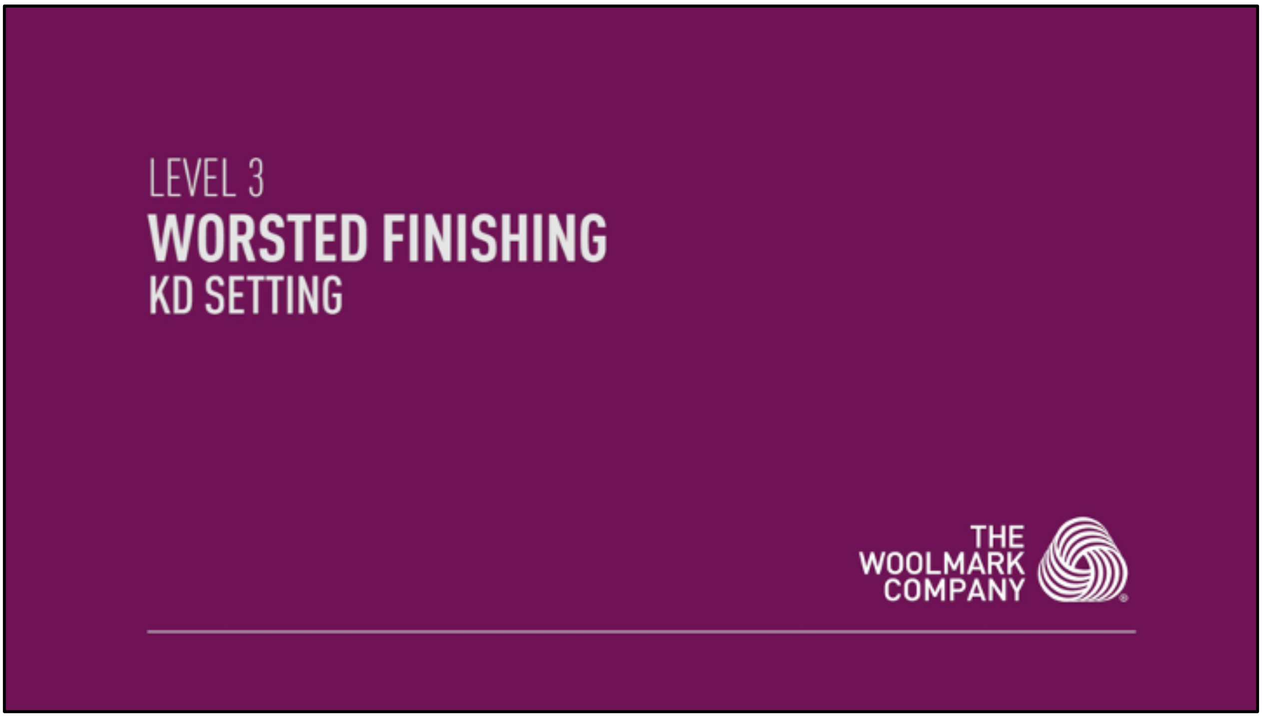
INDICATE THAT pressure decatising is designed to permanently flat set the fabric.

EXPLAIN THAT the process is achieved by:
- rolling the fabric interleaved with the wrapper cloth onto a perforated roller
- placing the roller in a sealed chamber
- removing the air from the chamber by evacuation or steam purging
- introducing steam to pressures between 0.5 and 2 atmospheres (this raises the temperature to between 105°C and 130°C)
- removing the roll from the chamber
- cooling the fabric by drawing air through the roll.
- unrolling the fabric.

POINT OUT that the air is removed from the chamber because the presence of oxygen causes the wool to yellow at these high temperatures.

NOTE THAT the amount of permanent set achieved by pressure decatising depends on the:
- time
- temperature of the steaming
- fabric pH
- fabric moisture content
- moisture content of the wrapper.

MENTION THAT these variables are described in greater detail in later slides.



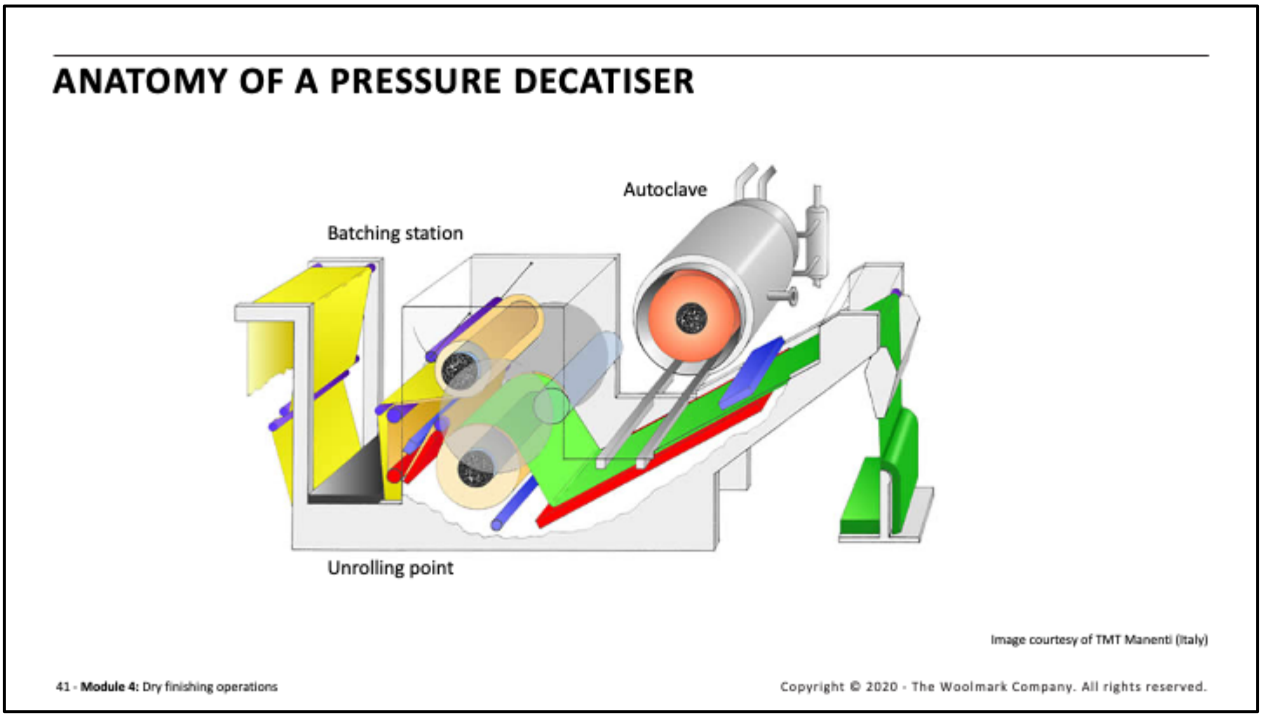
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the pressure decatising process.

NOTE THAT traditionally pressure decatising was called KD (kier decatising) setting.

PLAY *video (42 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*



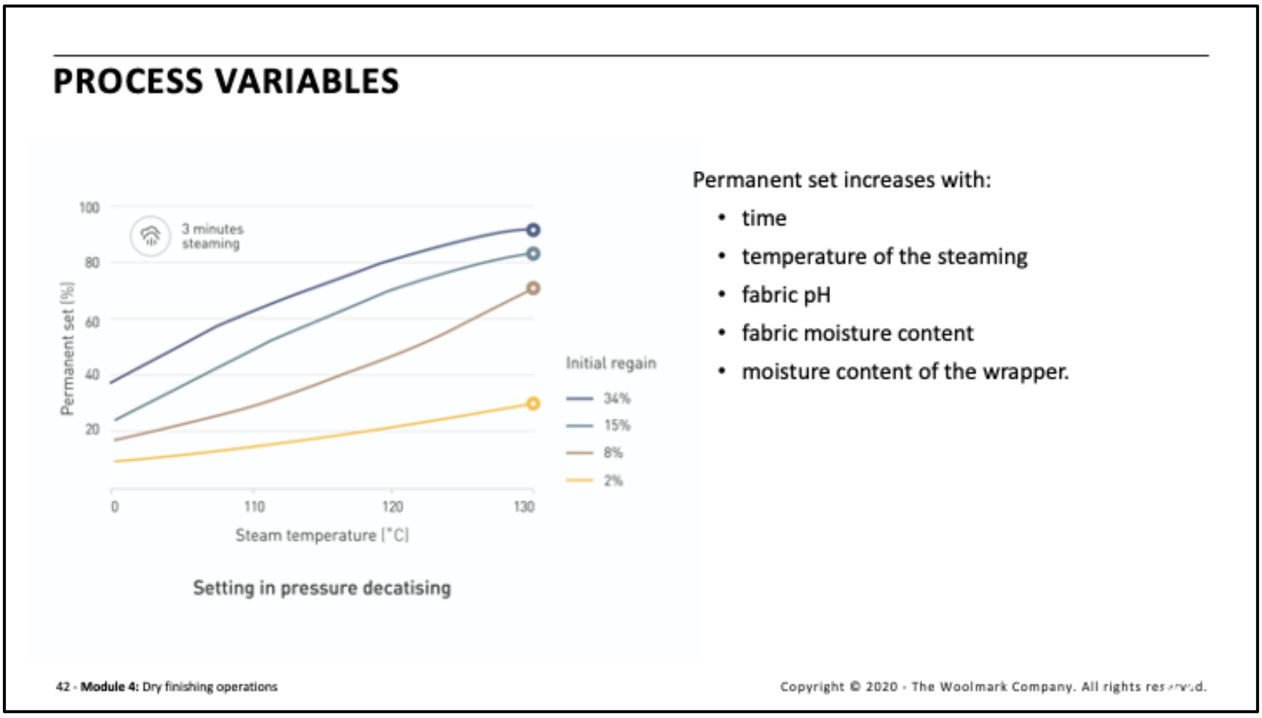
INDICATE THAT the key components of a pressure decatiser, include the:

- batching station
- autoclave
- wrapper fabric.

POINT OUT that in a conventional pressure decatiser, three cylinders are used so the process can be run semi-continuously:

1. One cylinder is unrolling the interleaved wrapper and decatised wool fabric. The wrapper is transferred directly to the second cylinder.
2. One cylinder is at the batching station rolling up the new wool fabric interleaved with the transferred wrapper cloth.
3. The third cylinder is in the autoclave chamber, where the fabric is decatised.

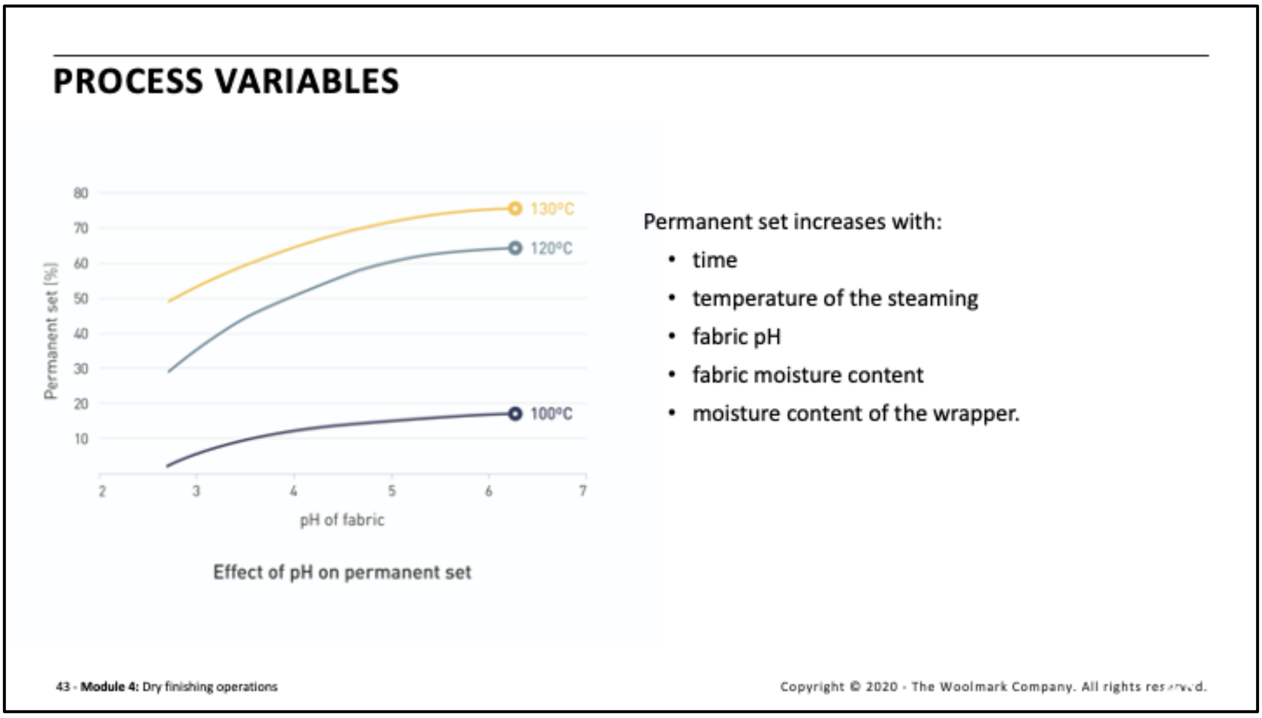
MENTION THAT to improve productivity, Biella Shrunk makes a pressure decatiser with two autoclave chambers (not shown on slide).



NOTE THAT the amount of permanent set imparted during pressure decatising increases with:

- the temperature of the steaming
- the moisture content of the fabric.

POINT OUT that as illustrated on the slide — as the initial moisture content (regain) of the fabric increases, the amount of permanent set increases. As the temperature increases, the amount of permanent set increases. Temperature is more effective at inducing a high level of permanent set when the wool has a higher initial moisture content.



INDICATE THAT the amount of permanent set imparted in pressure decatising also increases with fabric pH.

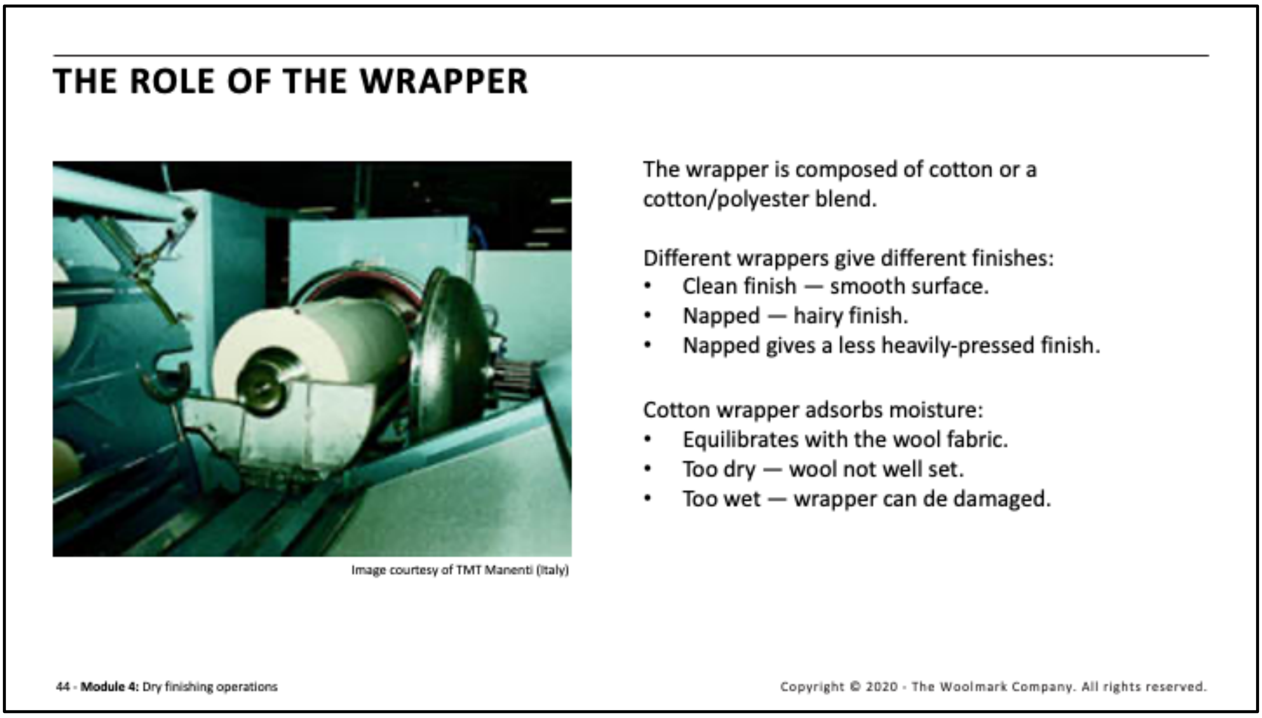
POINT OUT that as illustrated on the slide:

- As the temperature increases (from 100°C to 130°C), the amount of permanent set increases.
- As the pH of the fabric increases (from 3–6), the amount of permanent set increases. Temperature is more effective at inducing a permanent set when the wool has pH=6, compared with pH=3.

NOTE THAT in practice, the pH of wool fabric is normally in the range 5 – 7 during dry finishing. If the pH is:

- any higher, the wool can yellow
- any lower, the amount of permanent set is reduced.

MENTION THAT the pH of piece-dyed fabric often depends on the dye system used.



NOTE THAT the wrapper used in decatising is composed of cotton or a cotton/polyester blend.

EXPLAIN THAT different wrappers give different finishes to the wool fabric. They may:

- be made with a clean finish to give a smooth surface to the wool
- have a napped (hairy) finish to gives a less heavily pressed finish to the wool.

INDICATE THAT cotton in the wrapper adsorbs moisture when steam is introduced during decatising. During decatising an equilibrium forms between the moisture in the wrapper and that in the wool fabric.

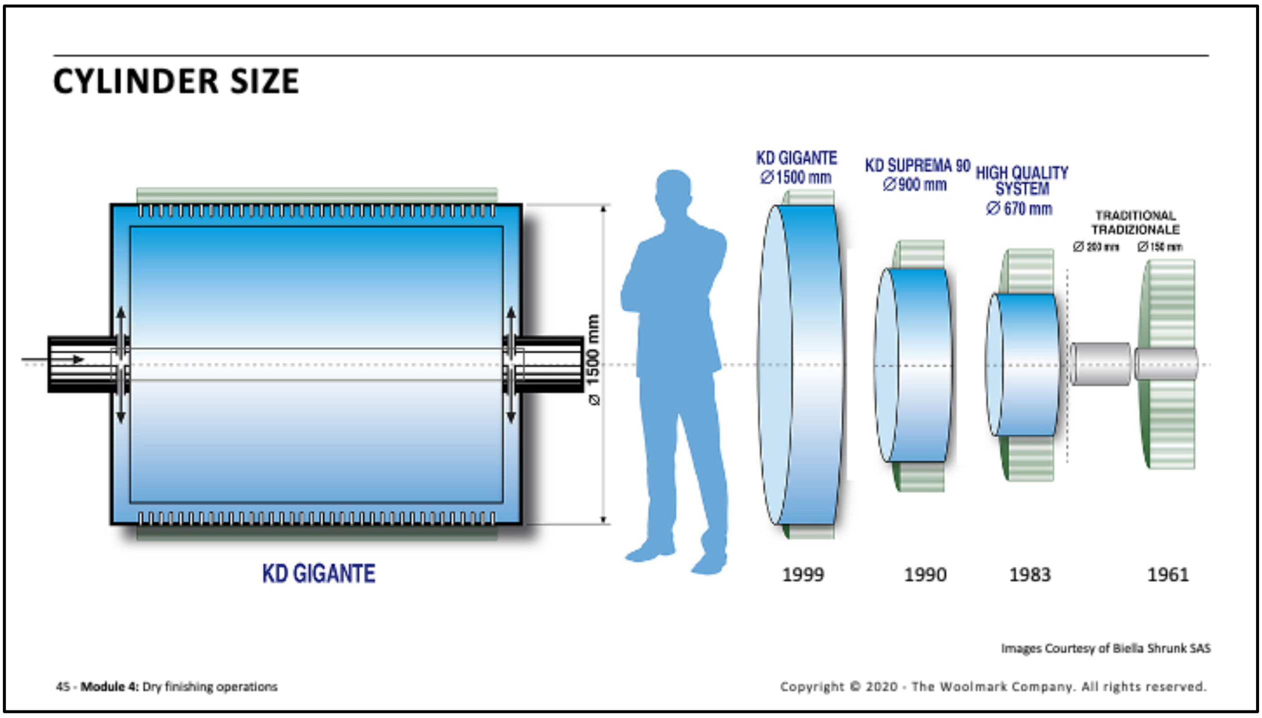
If the wrapper is too dry:

- the wool will dry out
- the wool will be less well set.

If the wrapper is too wet:

- setting of the wool is good
- the wrapper can de damaged.

POINT OUT that normally it requires 2–3 cycles to bring the wool fabric and wrapper to the same moisture conditions. If the moisture content of the wool being introduced to the decatiser varies, the setting effect of the pressure decatiser can vary as well.



NOTE THAT in the earliest pressure decatisers the size of the perforated cylinders on which the fabric and wrapper were wound was relatively small. This led to significant differences in the tension in the wrapper cloth and wool fabric from the inside to the outside of the cylinder-wrapper-fabric package.

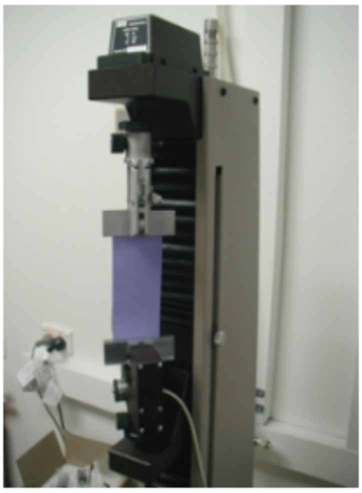
EXPLAIN THAT one of the reasons for 'full decatising', in which the fabric was decatised at atmospheric pressure (100ºC) twice with the fabric wound in the opposite direction, was to avoid such end-to-end effects in the fabric caused by the difference in tension from inside the package to the outside.

INDICATE THAT in pressure decatising, re-decatising the fabric would make the process uneconomically slow. To avoid end-to-end affects manufacturers have used bigger cylinders with wrapper tension controls.

POINT OUT that the bigger cylinders means:
- the thickness of the total rolled wrapper and fabric package is much smaller than on a small drum
- the differences in tension from outside to inside are smaller
- the end-to-end differences in the wool fabric are much smaller, because of the shorter time taken for the steam front to fully penetrate the larger cylinder.

MENTION THAT the increase in cylinder size is seen in the figures on the slide:
- 1961 — initial 150-200mm
- 1983 — cylinder 670mm
- 1990 — cylinder 900mm
- 1999 — KD Gigante 1500mm

PROCESS VARIABLES AND UNWANTED EFFECTS



Process variables:
- wrapper tension
- extent of cooling before unrolling.

Unwanted effects:
- uneven treatment (end-to-end)
- stretch in warp direction
- yellowing.

Appropriate tests:
- bias extensibility
- thickness
- air permeability
- warp dimensions
- warp extensibility
- colour/yellowness.

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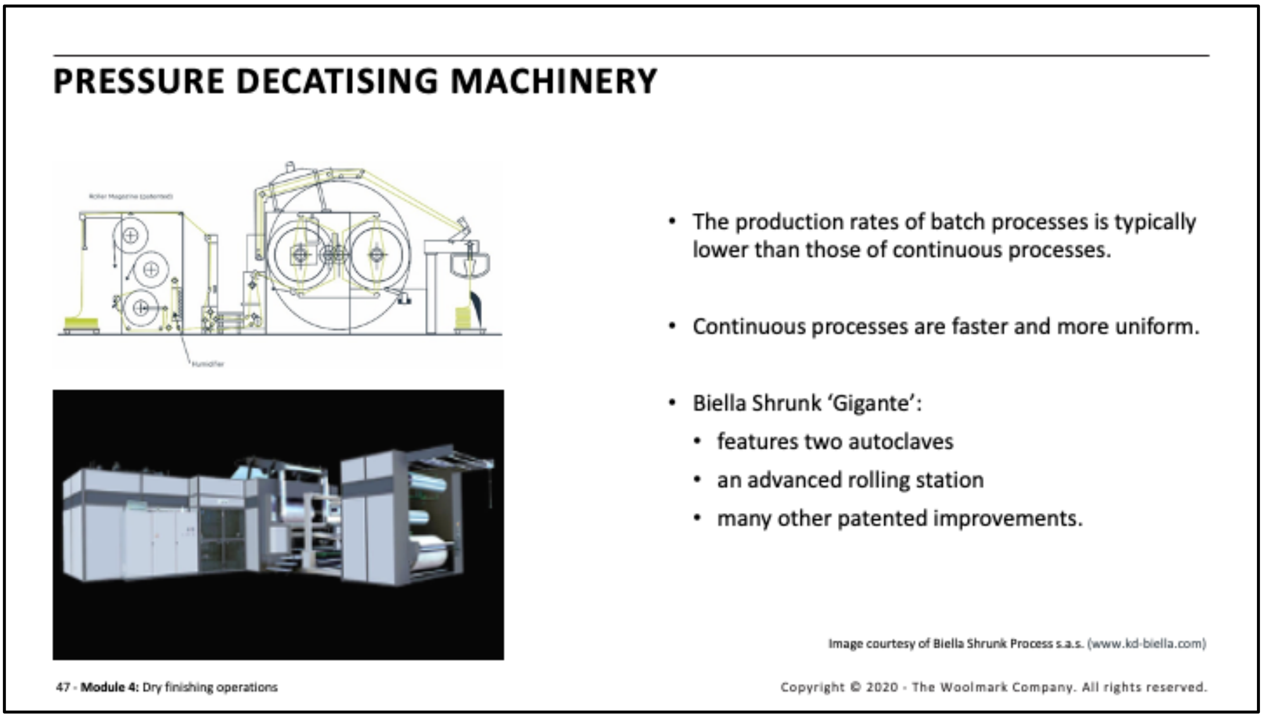
EXPLAIN THAT in addition to the five parameters mentioned (time, temperature, fabric pH, fabric moisture content and moisture content of the wrapper), there are some process variables that can also affect the level of press and permanent set achieved during decatising. These are:
- wrapper tension
- extent of cooling before unrolling, which controls the amount of cohesive set imparted in the fabric.

INDICATE THAT the unwanted effects that can occur from decatising are:
- uneven treatment (end-to-end) (The solution to this problem lies in the use of bigger drums, which require fewer wraps and automated tension control in winding.)
- stretch in warp direction
- yellowing of the wool caused by the use of an excessive temperature.

MENTION THAT the appropriate tests used to measure the extent of any unwanted effects are:
- bias extensibility (for measuring end-to-end effects)
- thickness (for measuring end-to-end effects)
- air permeability (for measuring end-to-end effects)
- warp dimensions
- warp extensibility
- colour/yellowness.



EXPLAIN THAT one of the problems associated with batch pressure decatising processes is poor production rate. Generally continuous processes are faster and more uniform than batch processes.

NOTE THAT Biella Shrunk has addressed the productivity issue with their 'Gigante' machine, which features

- two autoclaves
- an advanced rolling station
- many other patented improvements.

INDICATE THAT this machine has large drums capable of holding several pieces of fabric, which reduces end-to-end effects in individual pieces and has two autoclaves to process the fabric.

BIELLA SHRUNK (ITALY)

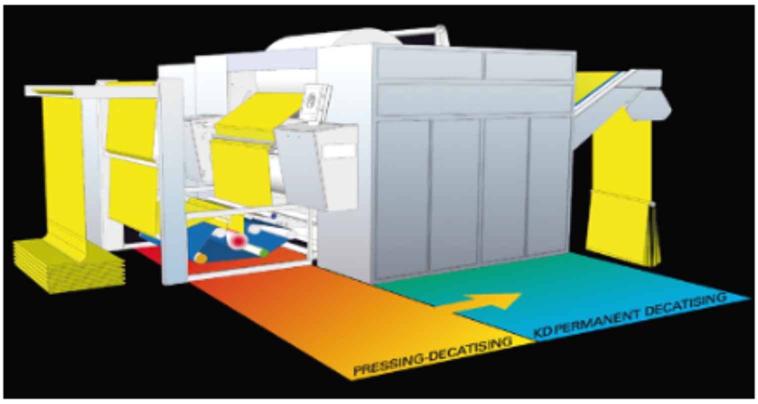


Image courtesy of Biella Shrunk Process s.a.s. (www.kd-biella.com)

Biella KD Jubilee

- Pressure decatising system with integrated fabric pressing.

48 - **Module 4:** Dry finishing operations

NOTE THAT another recently-developed machine by Biella Shrunk is the Biella KD Jubilee Pressure Decatising System** with integrated fabric pressing course. The machine has been patented.

EXPLAIN THAT the Biella KD Jubilee machine simultaneously carries out the operations of fabric pressing and winding for the preparation of rolls that are destined to be pressure decatised. This overcomes the difficulty of the pressed fabric potentially swelling over the time, which would result in a thicker fabric to the pressure decatiser and a less 'pressed' finish.

INDICATE THAT at the fabric entry of KD Jubilee, immediately upstream of the winding area, there is a calendering/pressing/decatising device consisting of a heating roller. This heating roller has a chrome mirror surface that is wound with a special high-thermal-efficiency felt.

POINT OUT that the fabric is pressed between the tensioned high-thermal-efficiency felt and the heated roller, using the well-known principle of modern silicone belt-pressing systems.

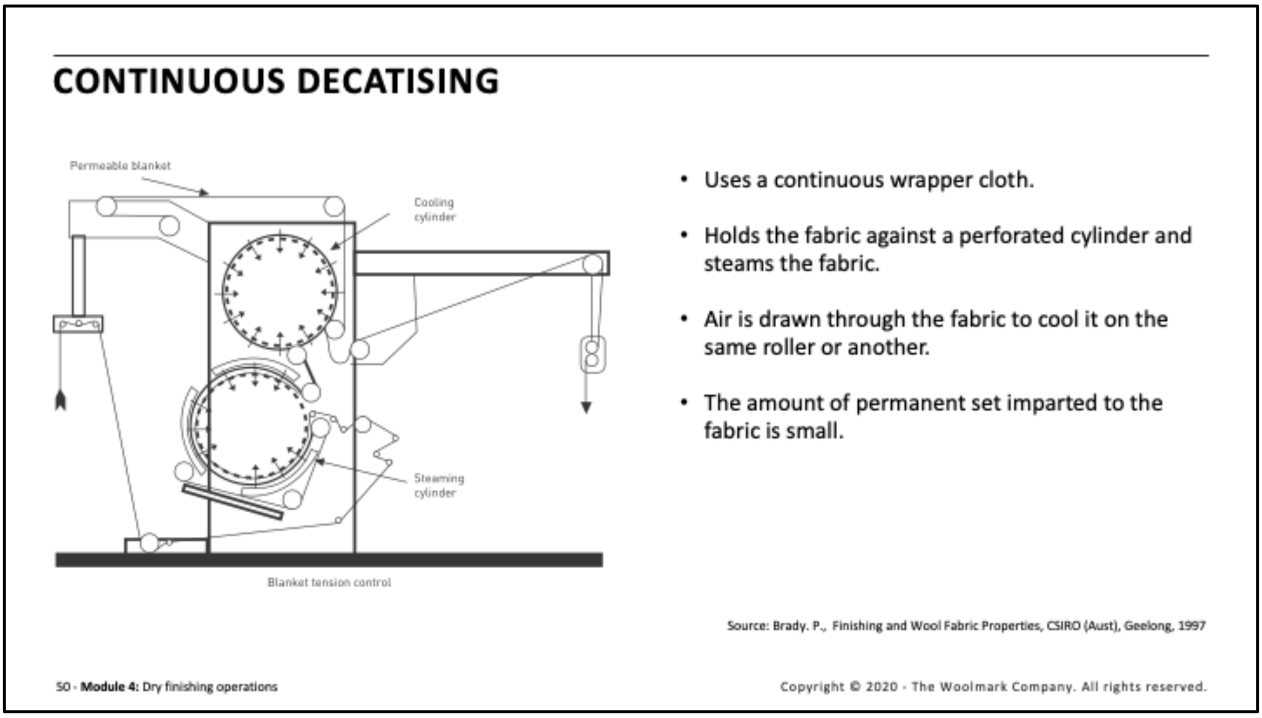
NOTE THAT immediately after this operation the fabric and the wrapper cloth are then wound around the decatising roller, to generate the roll to be subsequently processed in an autoclave.

EXPLAIN THAT high-lustre and chintz effects can be obtained for wool fabrics using pressing and decatising machinery.

EXPLAIN THAT high-lustre fabrics are produced by heavily pressing the fabric and then pressure decatising at a minimum of 120^{o}C with high wrapper tension and using an out-to-in steam flow.

NOTE THAT chintz is a term originally applied to cotton fabrics (often printed), but now can apply to all (mainly plain-weave) fabrics with a flat, glazed finish. Chintz effects are achieved by using a setting agent and a polymeric finish to further enhance the flattening and setting effect achieved by the heavy pressing and intense decatising used to create high-lustre fabrics.

EXPLAIN THAT such fabrics are normally not ‘relaxed’ further after this process, as this may reduce the fabric’s lustre.



INDICATE THAT continuous decatisers use a continuous wrapper cloth to hold the fabric against a perforated cylinder where it is subjected to steam.

While the wrapper is still controlling the wool fabric, air is drawn through the fabric to cool it — either on the same or another roller.

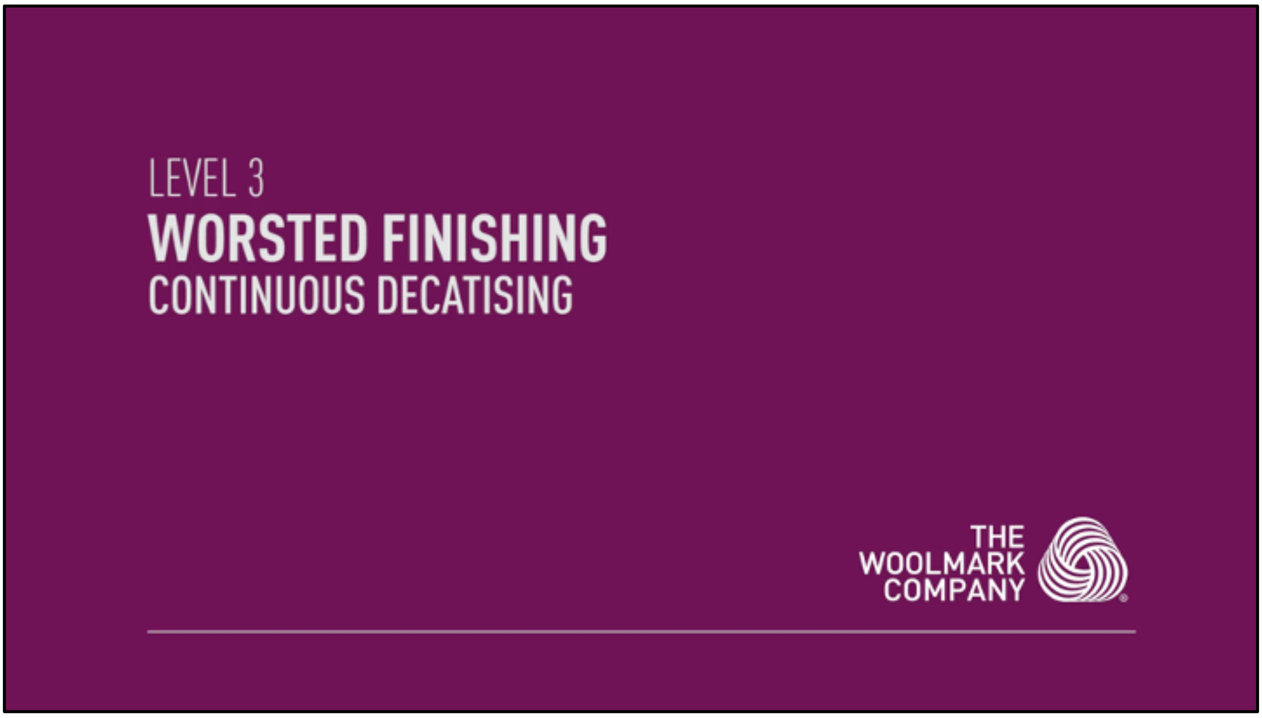
NOTE THAT although quicker and less expensive to run than a batch decatiser, the amount of permanent set imparted to the fabric is small.

***ASK** participants to explain why the amount of permanent set imparted to the fabric is small in a continuous decatiser.*

***ALLOW** participants sufficient time to respond before explaining that the amount of permanent set imparted to the fabric is small in a continuous decatiser because it only spends a short time at 100°C maximum.*

POINT OUT that the illustration on the slide outlines the key components of a continuous decatiser:

- the permeable blanket
- the steaming cylinder
- the cooling cylinder
- the blanket tension control.



EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the continuous decatising process.

PLAY *video (39 seconds)*

ASK *participants if they have any questions or comments regarding the video content.*

ALLOW *sufficient time for participants to respond before proceeding.*

CONTINUOUS DECATISING MACHINERY

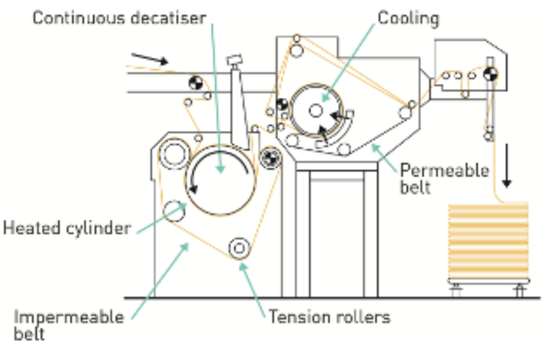
ThermoDuplex (Biella Shrunk)

Image courtesy of Biella Shrunk Process s.a.s. (www.kd-biella.com)

52 - **Module 4:** Dry finishing operations

INDICATE THAT the slide shows an example of a continuous decatising machine. More examples of modern continuous decatising machines can be found on www.kd-biella.com

CONTINUOUS DECATISING — AN ALTERNATIVE CONCEPT



Alternative machines use an impermeable belt to hold the dry fabric against a heated cylinder.

- Usually spray water onto fabric before entry.
- Water enhances the setting effect.
- Not enough to wet out the fabric.
- The amount of permanent set imparted is small.

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INDICATE THAT machines that use an impermeable belt to hold the conditioned (but not wet) fabric against a heated cylinder can also impart a decatising effect.

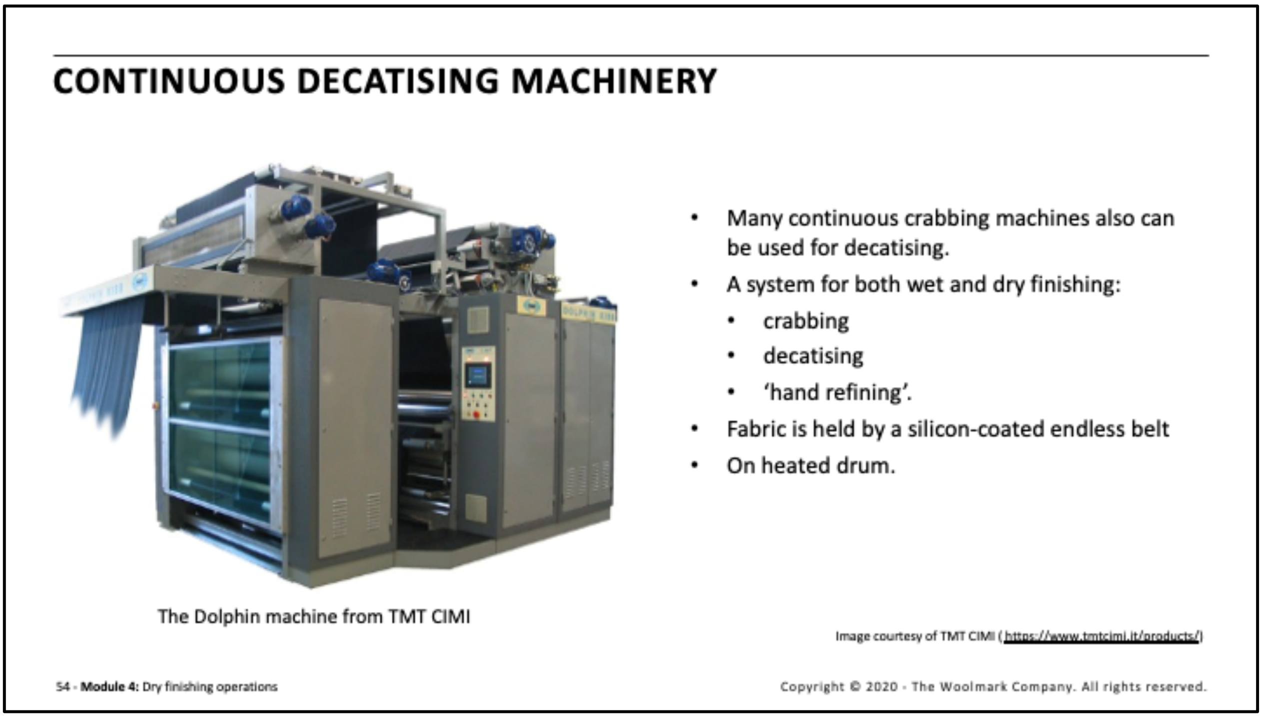
EXPLAIN THAT usually these machines spray water onto the fabric before it reaches the heated cylinder to enhance the setting effect, although not enough to wet out the fabric. These machines do not force steam through the fabric, but generate steam inside the impermeable blanket from the water added.

NOTE THAT the differences to belt-pressing machines lie only in the belt tension and the water spray.

The amount of permanent test imparted is still small.

POINT OUT that the illustration on the slide shows the key components of a continuous decatiser:

- the impermeable blanket
- the heated cylinder
- the cooling cylinder
- the blanket tension control.



MENTION THAT many continuous crabbing machines are designed to act as (alternative-type) decatising machines as well.

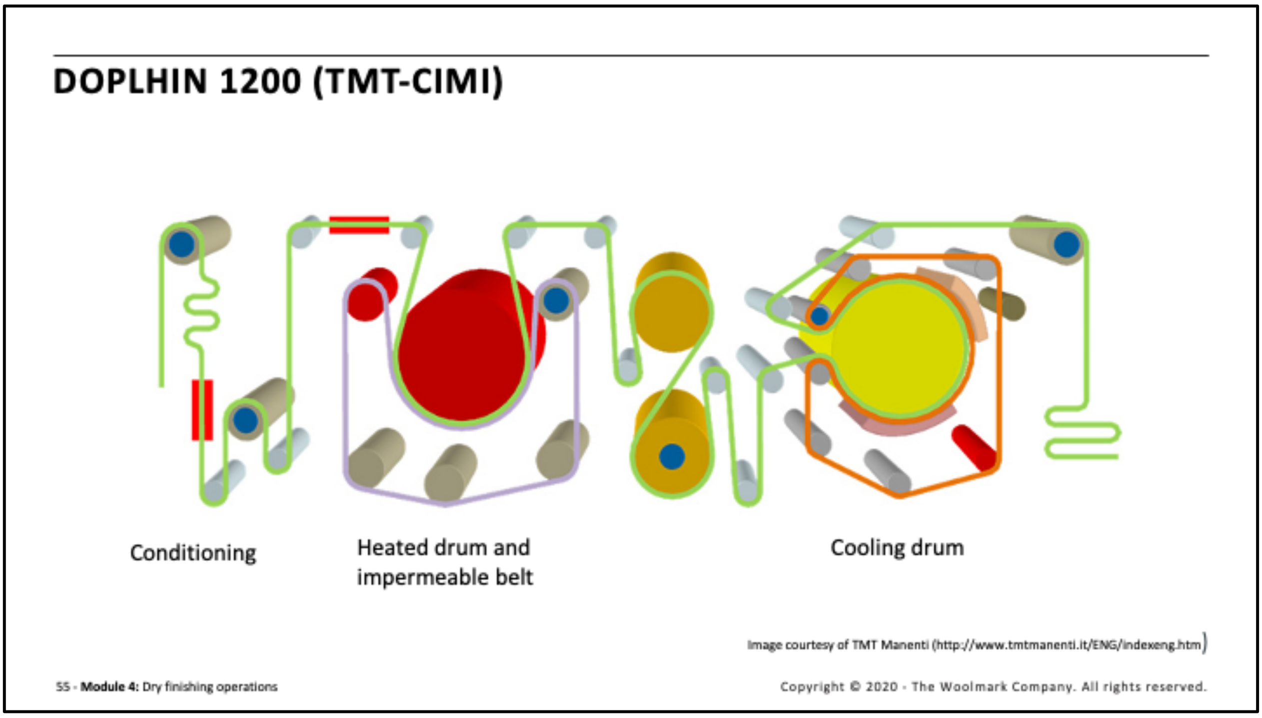
EXPLAIN THAT when the fabric is wet they act as continuous crabbing machines. When used on normal (conditioned — dry) fabric they act as a continuous decatiser.

INDICATE THAT the machine pictured on the slide is an example of one of these machines.

The Dolphin machine from TMT CIMI is claimed to be a system for both wet and dry finishing processes, including crabbing, pressing and decatising.

The fabric is sandwiched by a silicon-coated endless belt and a heated drum.

NOTE THAT the process, called by the manufacturer, 'hand refining' is also termed by the manufacturer 'dawning steam decatising'.

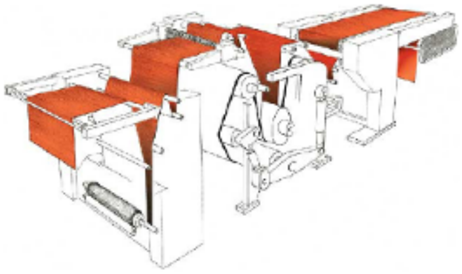


EXPLAIN THAT this slide shows a schematic diagram of the Dolphin 1200, from TMT-CIMI. As outlined on the previous slide, its modular components, allow the machine to be used in:

- crabbing (the fabric is wet and the operation is followed by scouring and/or drying).
- pressing
- continuous decatising (a moisture content of 10–15 per cent is recommended).

The flexibility of such machines increases the options available to finishers.

BIELLA SHRUNK (ITALY)



Formula 1 and Formula 1 Multipla

- permanent chintz
- decatising
- paper press touch
- calendering
- pressing
- intense wet setting.

Image courtesy of Biella Shrunk Process s.a.s. (www.kd-biella.com)

56 - **Module 4:** Dry finishing operations

INDICATE THAT the Formula 1 and Formula 1 Multipla** are other examples of multi-functional finishing machines manufactured by the Italian manufacturer, Biella Shrunk.

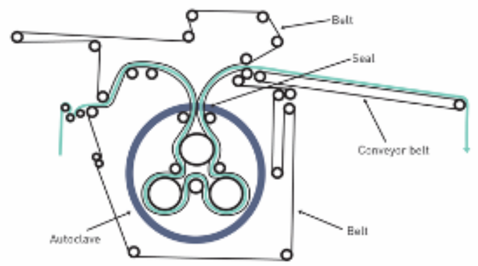
NOTE THAT the Mutipla has two cylinders for treating the fabrics whereas the Formula 1 has only the single cylinder.

POINT OUT that Biella Shrunk claims this process offers:

- permanent chintz
- improved SiroFAST™ formability parameters
- decatising
- paper press touch
- calendering
- pressing
- intense wet setting (crabbing).

http://www.kd-biella.com/en/

CONTINUOUS DECATISING MACHINERY



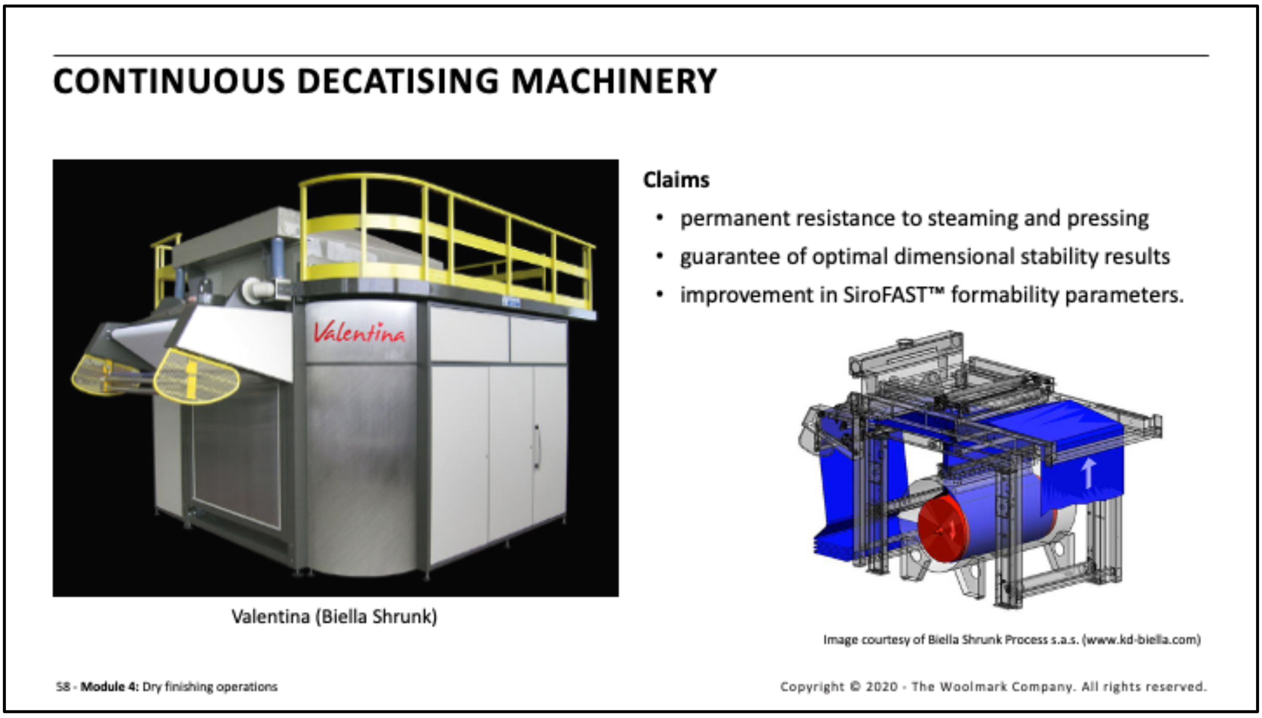
Ekofast continuous pressure decatiser

- Continuous treatment of fabric in pressure chamber.
- Imparts permanent set.
- Developed by Mather & Platt (UK) in the 1980s.
- Still used.

MENTION THAT at least one machine has been successfully developed for continuous treatment of wool fabric under pressure.

EXPLAIN THAT this is called the Ekofast and was developed by Mather and Platt (UK) in the 1980s. It imparts a level of permanent set and was until recently still used successfully by WT Johnson and sons in Huddersfield, England UK.

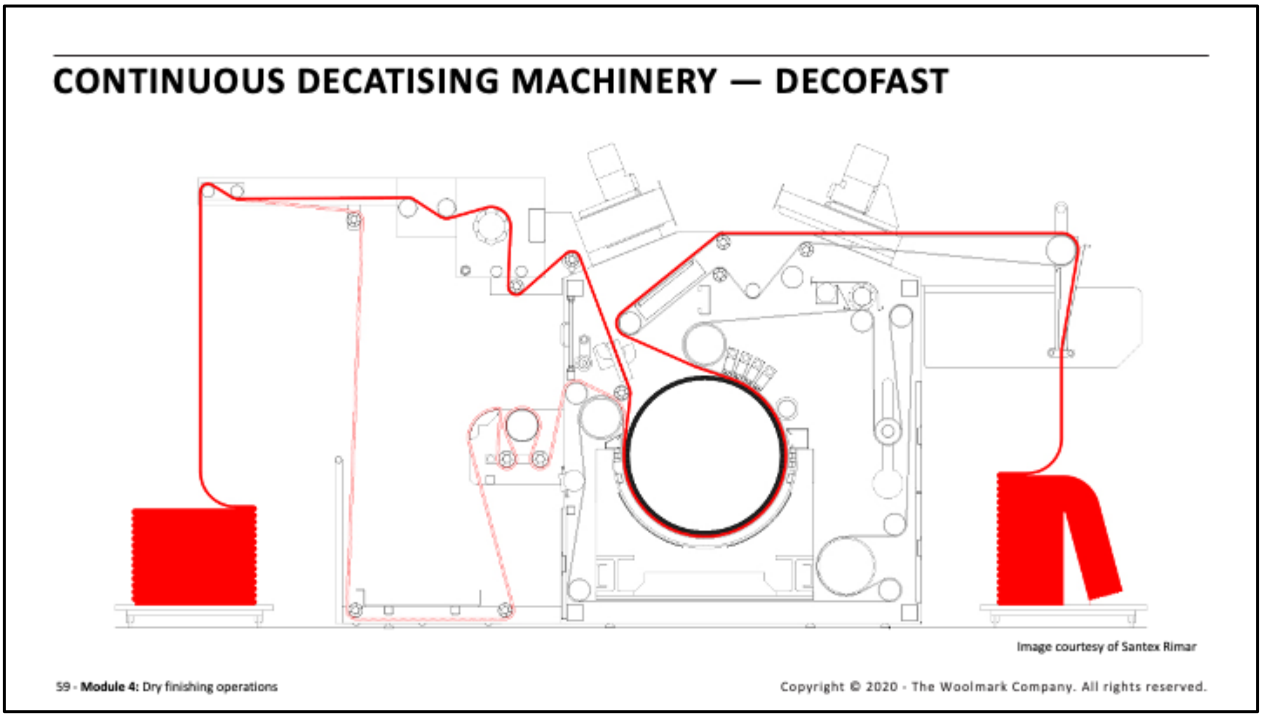
REFER participants to the illustration on the slide, which outlines the key components used by the Ekofast machine. Two belts are used to enclose the wool fabric during the decatising process. The machine operates around 130°C. Special seals allow entry and exit of the fabric and wrappers to the autoclave while under pressure.



INDICATE THAT the **Valentina machine** from Biella Shrunk is also claimed to impart a pressure-decatised finish in a continuous manner.

NOTE THAT Biella Shrunk claims this machine provides:

- permanent resistance to steaming and pressing
- a guarantee of optimal dimensional stability results
- an improvement in SiroFAST™ formability parameters.

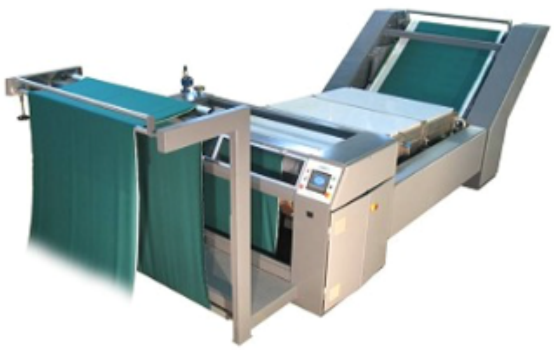


INDICATE THAT the DecoFAST-4, shown on the slide, is an alternative design of machine, which claims to impart a more permanent finish to the fabric than conventional continuous decatising by ensuring the temperature of the fibres is raised above 100°C without drying out.

EXPLAIN THAT specially designed seals allow the pressure inside the machine to be higher than atmospheric pressure.

Image courtesy of Santex Rimar

SPONGING



A steaming processes to relax and/or shrink fabric.

Designed to improve dimensional stability.

Sometimes called ‘London Shrinking’ or ‘London Shrunk’.

Process:

1. Water is added.
2. The fabric is overfed onto a supporting belt.
3. The fabric is steamed.
4. The fabric may be heated to dry after the steaming.
5. The fabric is cooled before removal from the supporting belt.

Image courtesy of TMT Manenti (http://www.tmtmanenti.it/ENG/indexeng.htm)

60 - **Module 4:** Dry finishing operations

EXPLAIN THAT the terms ‘sponging’ and ‘relaxation’ are used to describe steaming processes designed to relax and/or shrink fabric and thus remove any residual relaxation shrinkage that might remain after finishing.

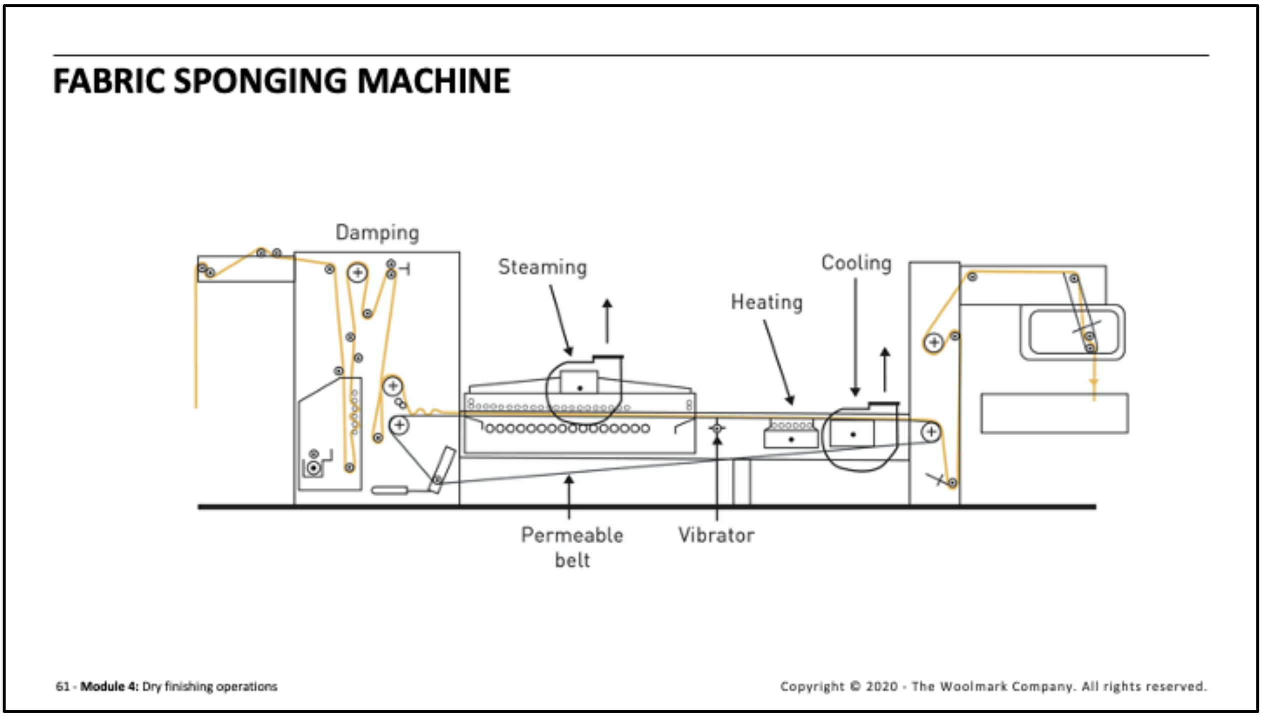
The process is designed to improve dimensional stability.

The process is sometimes called ‘London Shrinking’ or ‘London Shrunk’.

INDICATE THAT the steps in the sponging process are as follows:

- Water may added to improve the relaxation process.
- The fabric is overfed onto a supporting belt.
- The fabric is then steamed.
- The fabric may be heated to dry off excessive moisture after the steaming.
- The fabric is cooled before it is removed from the supporting belt.

NOTE THAT the fabric is cooled before removal from the machine to reduce the temperature below the glass transition temperature of the fibres and inhibit cohesive setting of any subsequent distortion.



REFER participants to the illustration on the slide, which outlines the key components of a sponging machine:

- damping
- permeable belt
- steaming
- vibrator — to help the relaxation process
- heating
- cooling.

SPONGING

- Used for woollen and worsted fabrics.
- Unwanted effects:
  - loss of the 'finish' and lustre of the fabric where this is held only by cohesive set
  - can impair dimensional stability if not performed correctly.
- Steam usage can be a problem:
  - some machines hold the steam in a chamber through which the tensionless fabric proceeds
  - this reduces steam usage.

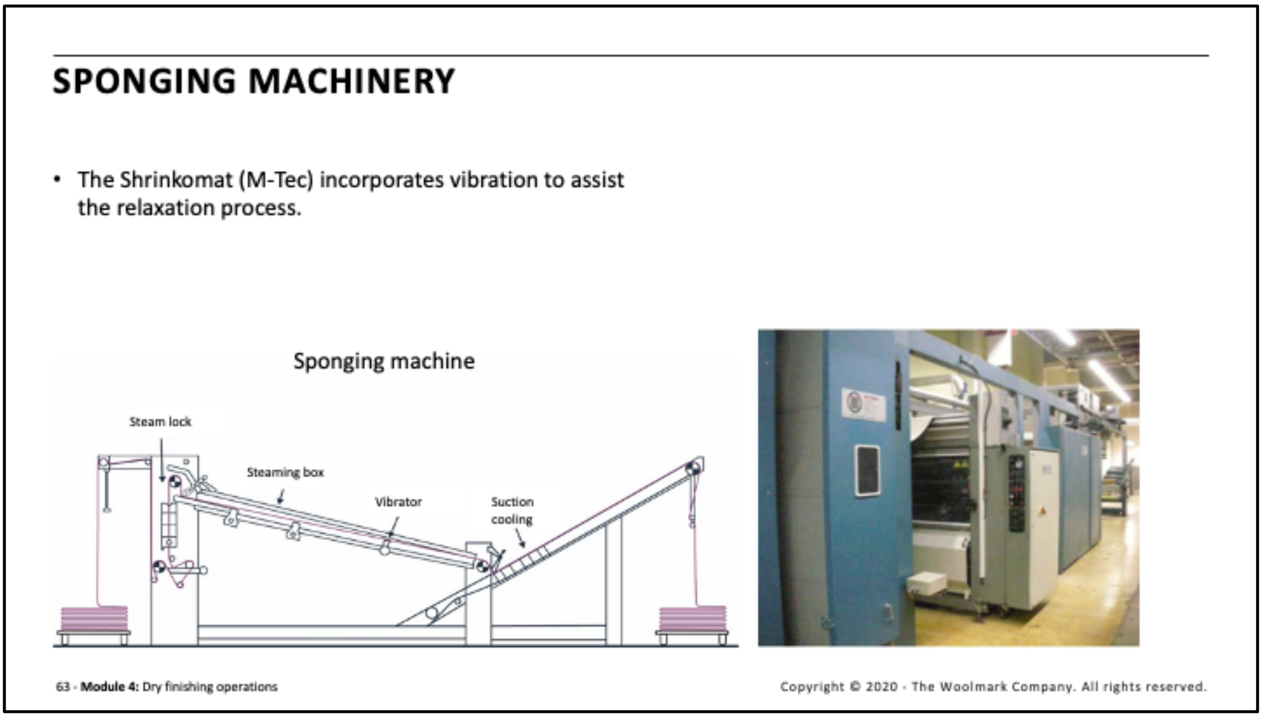
62 - **Module 4:** Dry finishing operations

EXPLAIN THAT sponging is used for many woollen and worsted fabrics. It is often used on fabrics that have a pile or are thick and have not been pressure decatised to remove excessive relaxation shrinkage.

INDICATE THAT the unwanted effects of sponging are:

- the loss of the 'finish' and lustre of the fabric where this is held only by cohesive set
- impairment of dimensional stability if not performed correctly.

NOTE THAT high steam usage can be a problem. Some machines are designed to hold the steam in a chamber through which the tensionless fabric proceeds. This reduces steam usage.



NOTE THAT the Shrinkomat machine (made by M-Tec) includes a vibrator to assist the relaxation process and is illustrated on the slide.

SPONGING MACHINERY

Image courtesy of TMT Manenti
(http://www.tmtmanenti.it/ENG/indexeng.htm)

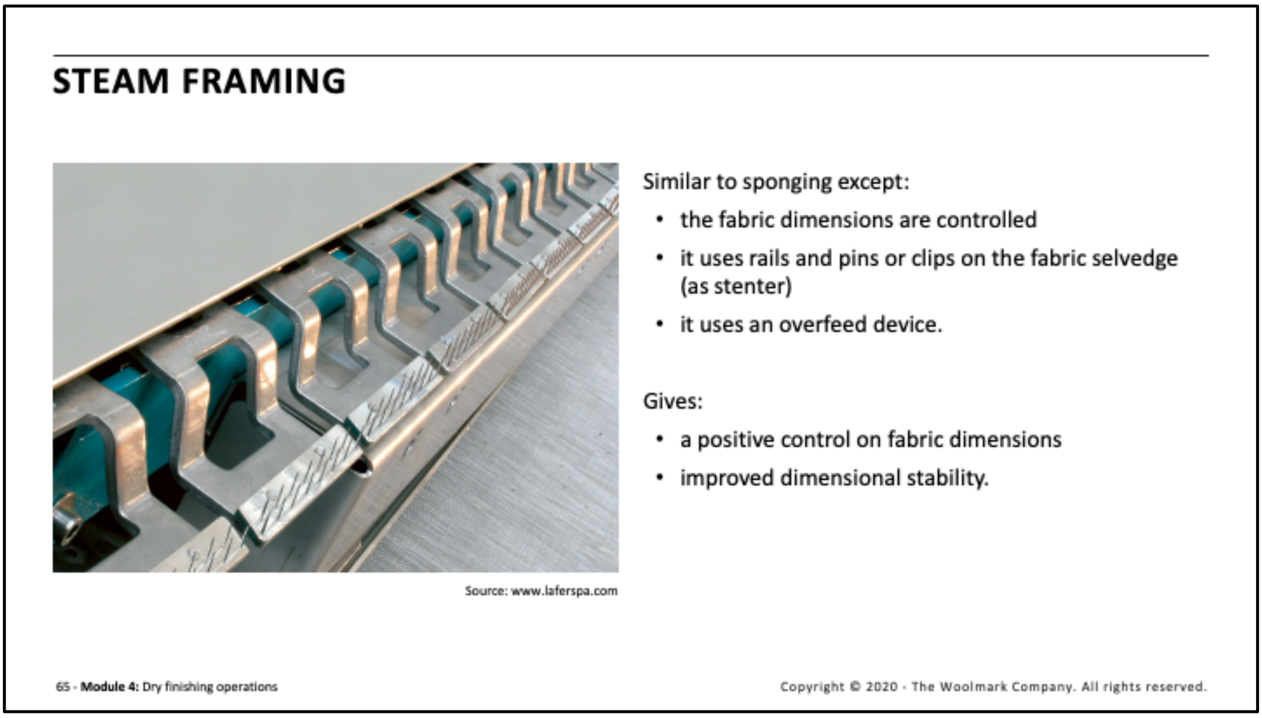
Vapor 2000 (TMT Manenti)

- Only 30% of the steam compared with standard machines.
- Saturated steam chamber.
- Right volume and touch.
- Woven and knitted fabrics.
- For pure wool and wool blends.
- For woollen and worsted fabrics.

64 - **Module 4:** Dry finishing operations

INDICATE THAT the **Vapor 2000 machine** made by TMT Manenti is a sponging machine, which claims to use 30% less of the steam than standard sponging machines.

NOTE THAT the cycle, in the saturated steam chamber, is claimed to guarantee the right volume and touch, both to woven and knitted fabrics, in woollen and worsted pure wool and wool-blend fabrics.



EXPLAIN THAT steam framing is a process similar to sponging, except the fabric dimensions are controlled in the same way as a stenter frame — using rails and pins or clips on the fabric selvedge. An overfeed device is also required. This gives a positive control on fabric dimensions and consequently greater dimensional stability.

INDICATE THAT a steam frame controls the dimensions of the fabric by:

- raising the temperature of the fabric above its glass transition temperature
- stretching the fabric to the appropriate dimensions
- cooling the fabric while it is held.

NOTE THAT the new dimensions are held by cohesive set. Any difference between the new dimensions and the relaxed dimensions will be observed as relaxation shrinkage.

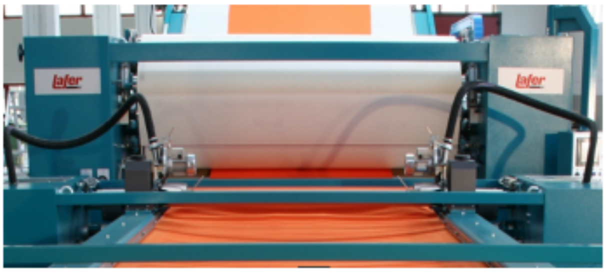
EXPLAIN THAT the following video, produced by The Woolmark Company (TWC), offers an overview of the steam framing process.

***PLAY** video (2.31 minutes)*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond before proceeding.*

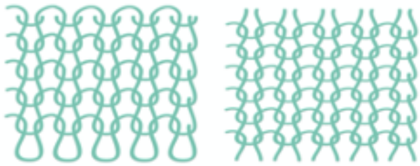
COMPACTING MACHINERY



Source: www.laferspa.com

Lafer KS-A/T 500 Runner

- Felt-compacting machine.
- Used for reducing warp relaxation shrinkage in knits.
- Has pin belt to control width.



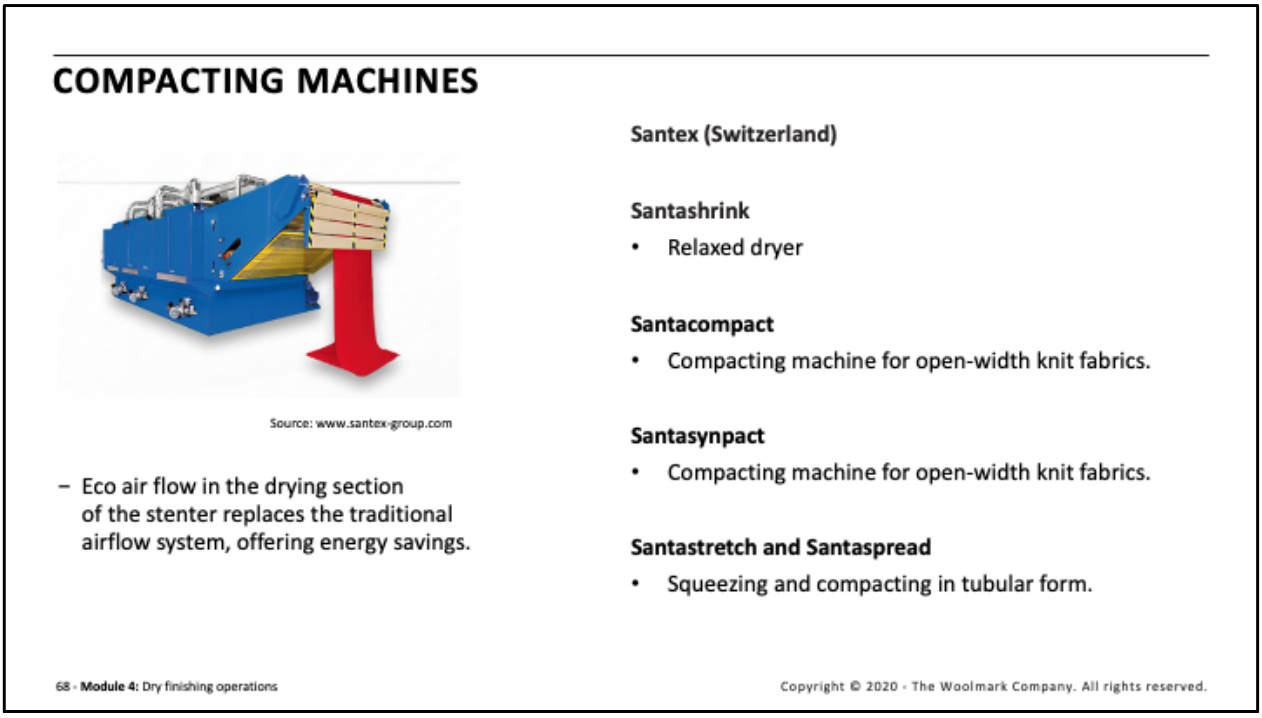
Before compacting   After compacting

67 - **Module 4:** Dry finishing operations

MENTION THAT occasionally machines used in the cotton industry to control dimensional stability of fabrics are also used in the wool industry — especially in knitted fabrics.

NOTE THAT the **KS-A/T 500 Runner** is a felt-compacting machine, which can be used for reducing warp relaxation shrinkage in knits. It also has a pin belt to control fabric width.

INDICATE THAT the KS-A/T 500 Runner is an example of the machinery that can be used to engineer the dimensions and properties of wool fabrics.



INDICATE THAT Santex has developed several machines, mostly for the finishing of cotton-based fabrics, which also can have use In the wool industry.

Santashrink
Relaxed dryer, which makes use of an economical airflow in the drying section of the stenter. This replaces the traditional airflow system, resulting in significant energy savings.

Santacompact
Compacting machine for open-width knit fabrics.

Santasynpact
Compacting machine for open-width knit fabrics.

Santastretch and Santaspread 4.
Squeezing and compacting in tubular form.

SUMMARY — MODULE 4

The following dry finishing operations and the aim of the process have been outlined:

- Heat setting: to set the synthetic component of blends.
- Shearing (cropping): to remove surface fibres.
- Singeing: to remove surface fibres.
- Conditioning: to add moisture to the fabric.
- Raising (wet and dry): to draw fibres to the fabric surface.
- Pressing: to flatten the fabric.
- Decatising: to flat set and stabilise the fabric.
- Sponging: to relax the fabric.
- Steam framing: to relax and cohesively setting of dimensions of the fabric.

The side effects of these operations were also discussed.

There are a number of advances in machinery suitable for dry finishing wool:

- Larger machines to improve efficiency.
- More flexible machines suitable for short runs.
- Reduce steam and energy requirements.
- Impart a new feel of the fabric.

SUMMARISE the module by explaining dry finishing operations include the following processes:

- Heat setting: to set the synthetic component of blends.
- Shearing (cropping): to remove surface fibres.
- Singeing: to remove surface fibres.
- Conditioning: to add moisture to the fabric.
- Raising (wet and dry): to draw fibres to the fabric surface.
- Pressing: to flatten the fabric.
- Decatising: to flat set and stabilise the fabric.
- Sponging: to relax the fabric.
- Steam framing: to relax and cohesively setting of dimensions of the fabric.

REITERATE THAT for each process the following features were outlined:

- aims
- mechanical processes used
- side effects
- how these effects can be measured.

REMIND participants that there are a number of advances in machinery suitable for finishing wool:

- Larger machines to improve efficiency (reduce handling time) (e.g. Biella Shrunk KD Gigante).
- More flexible machines suitable for short runs.
- New processes to improve the quality of the fabric (e.g. Biella KD Jubilee).
- Modifications to reduce steam and energy requirements (e.g. Vapor 2000 and also others).
- Modifications to impart a new feel of the fabric.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 5 Typical worsted finishing routes* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

MODULE 5

THE WOOLMARK COMPANY

TYPICAL WORSTED FINISHING ROUTES

RESOURCES —
MODULE 5: TYPICAL WORSTED FINISHING ROUTES

No additional resources are required to deliver **Module 5: Typical worsted finishing routes**.

WELCOME participants to Module 5 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Typical worsted finishing routes*

EXPLAIN THAT the topics that will be covered in this module are:

- worsted finishing routes, including:
    - all-wool colour-woven plain weave
    - all-wool colour-woven flannel
    - all-wool colour-woven gabardine
    - all-wool piece-dyed gabardine
    - wool/polyester colour-woven gabardine
    - wool/polyester piece-dyed plain-weave
    - wool/mohair colour-woven suiting
- a route for all-wool knitted fabric.

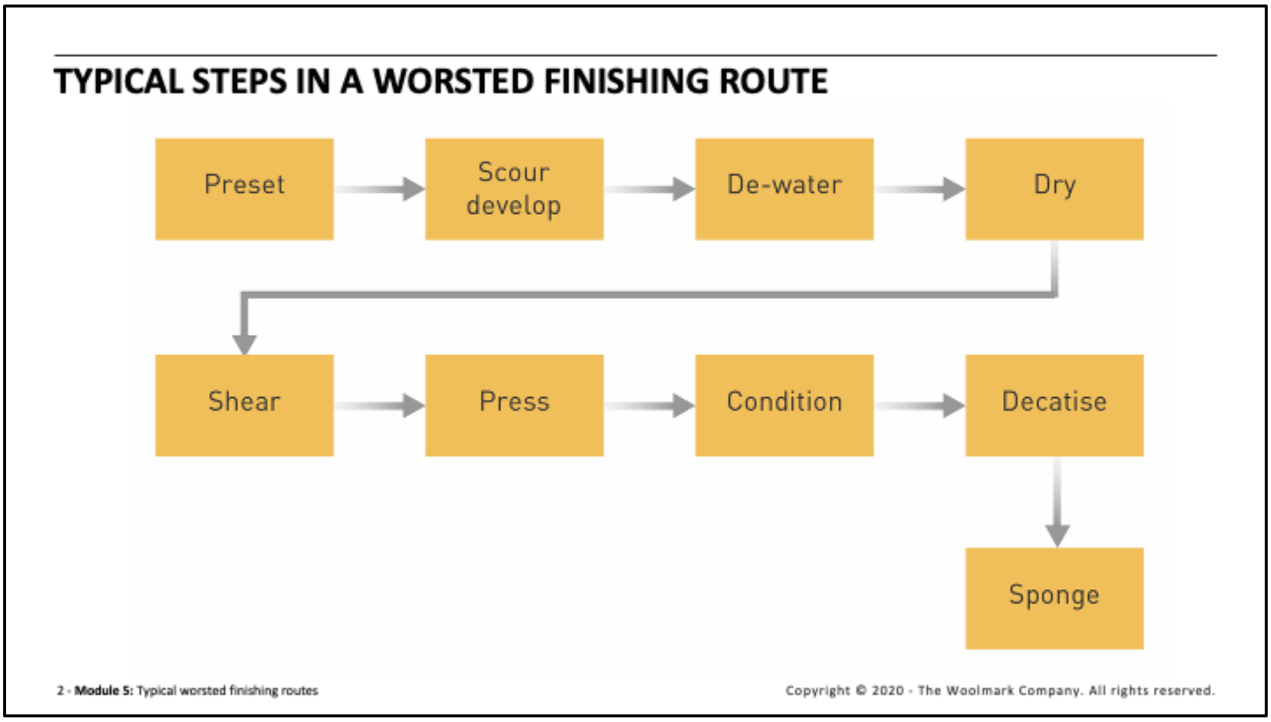
NOTE THAT not all finishers use the same routine or conditions for a single cloth. The route used depends on:

- the finish sought,
- the requirements of the customer
- the experience of the finisher.

INFORM participants that by the end of this module they will be able to:

- describe the typical steps taken to finish common worsted fabrics
- describe the typical steps taken to finish all-wool knitted fabrics
- explain the relevance and importance of each step in the finishing process.

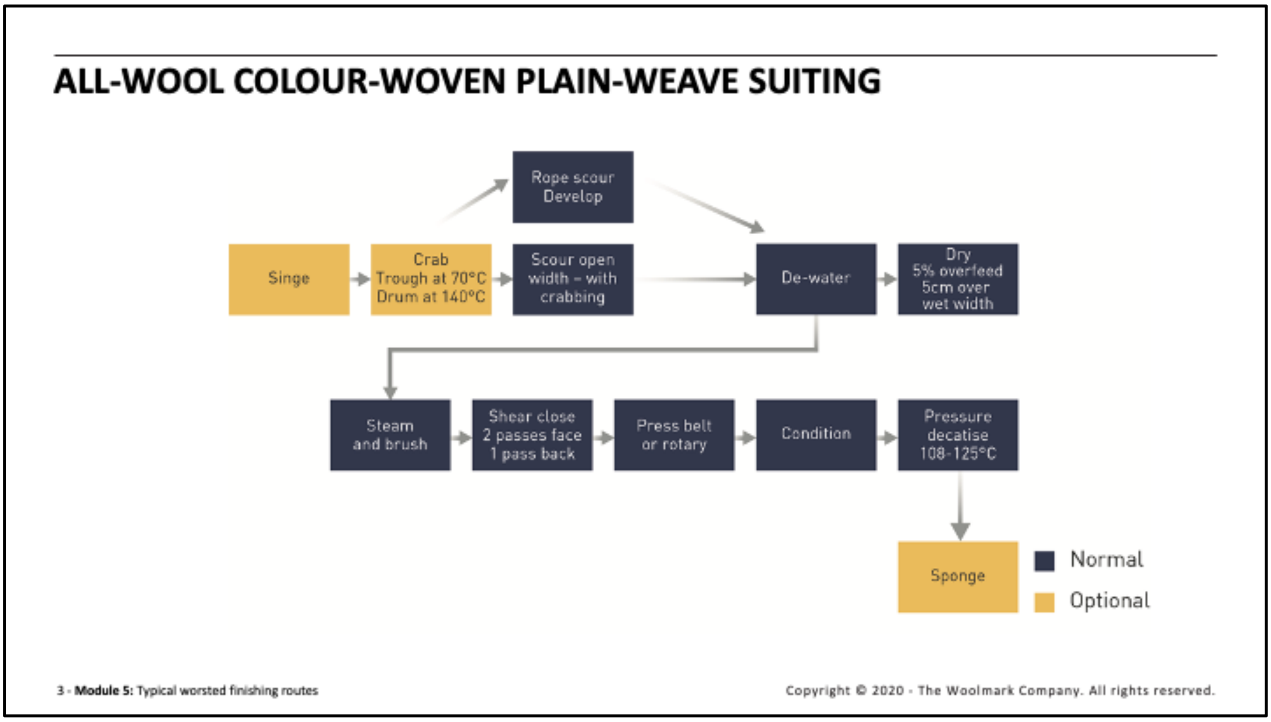
NO RESOURCES REQUIRED



INDICATE THAT the typical steps in a worsted finishing route are:

- pre-setting
- scouring, fabric develop or milling
- de-watering
- drying
- shearing (including steam and brush)
- pressing
- conditioning
- decatising
- sponging.

NOTE THAT the above steps are a guide only. The actual steps taken vary according to the specific wool fabric being finished, the machinery available and the experience of the finisher, as covered in the following slides.



EXPLAIN THAT a typical finishing route for all-wool colour-woven plain-weave suiting is:

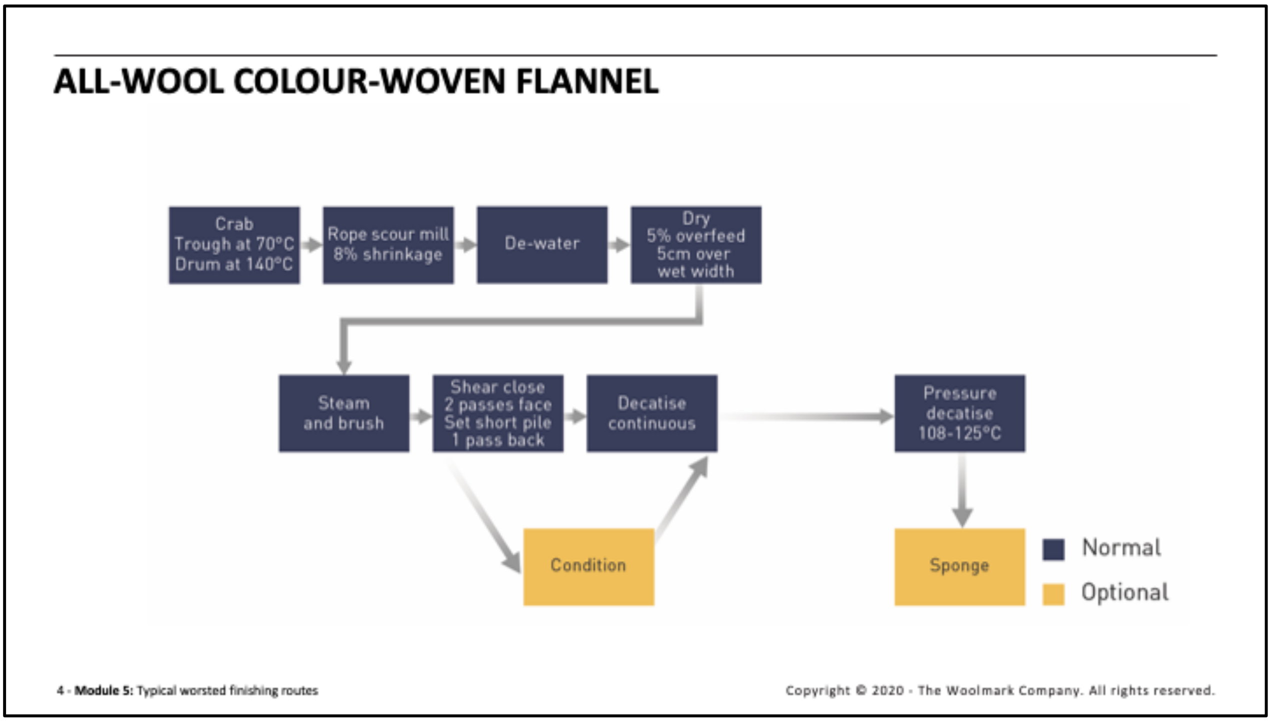
- Singeing (optional)
- Crabbing (optional) — continuous crab — trough 70°C — drum 140°C
- Scouring — open-width: If fabric rope scoured initial crabbing desirable
- De-water
- Drying — ~5% overfeed — ~5cm over wet width
- Steaming and brushing
- Shearing — two close passes on face — one pass on back
- Pressing — rotary or belt machine
- Conditioning
- Pressure decatising — 108ºC–125°C for 2 minutes — 3 minutes cooling
- Sponging (optional).

***ASK** participants to explain why is it important to add moisture to the fabric by conditioning.*

***ALLOW** participants sufficient time to respond before proceeding.*

REINFORCE THAT it important to ensure adequate moisture content of the wool for effective permanent setting during decatising. In many fabrics it may be necessary to add moisture to the fabric during the conditioning stage.

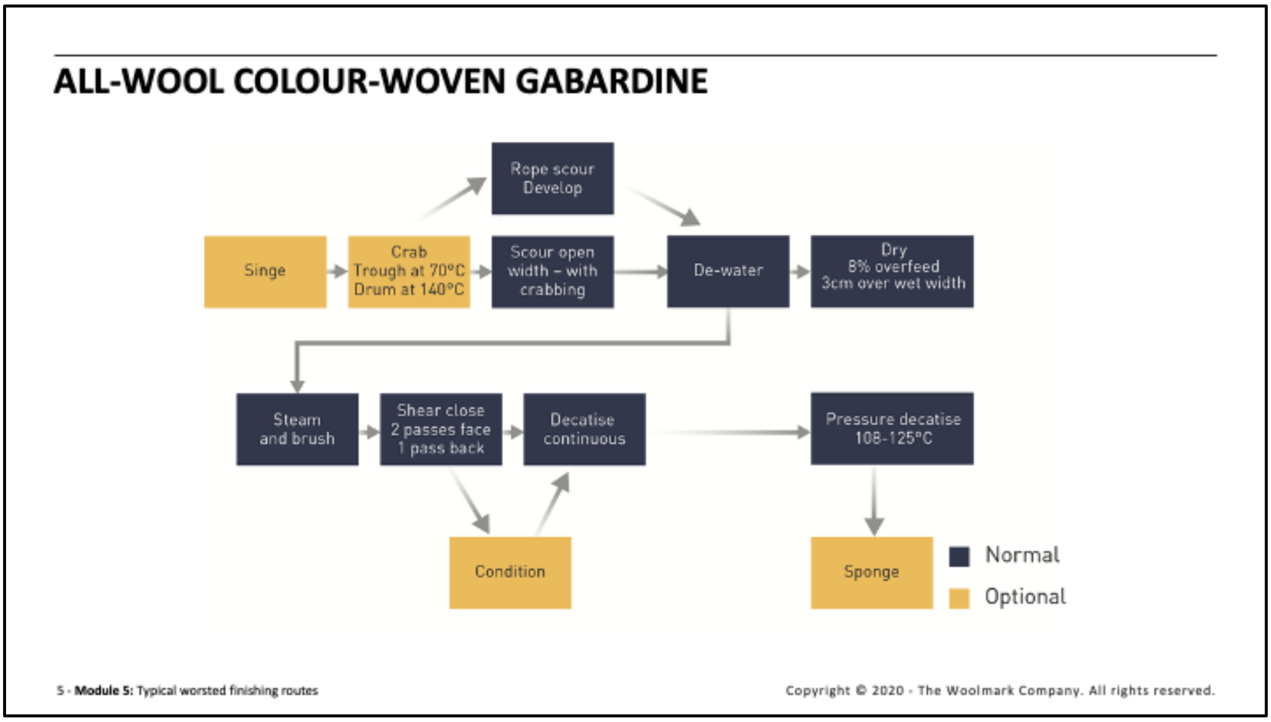
NOTE THAT at many mills, they singe before scouring in order to remove the surface fibre and avoid the need to wash off after singeing later in the finishing routine.



NOTE TO FACILITATOR: *Flick back and forth between Slides 3 and 4 to compare 'all-wool colour-woven flannel' with 'all-wool colour-woven plain weave suiting'.*

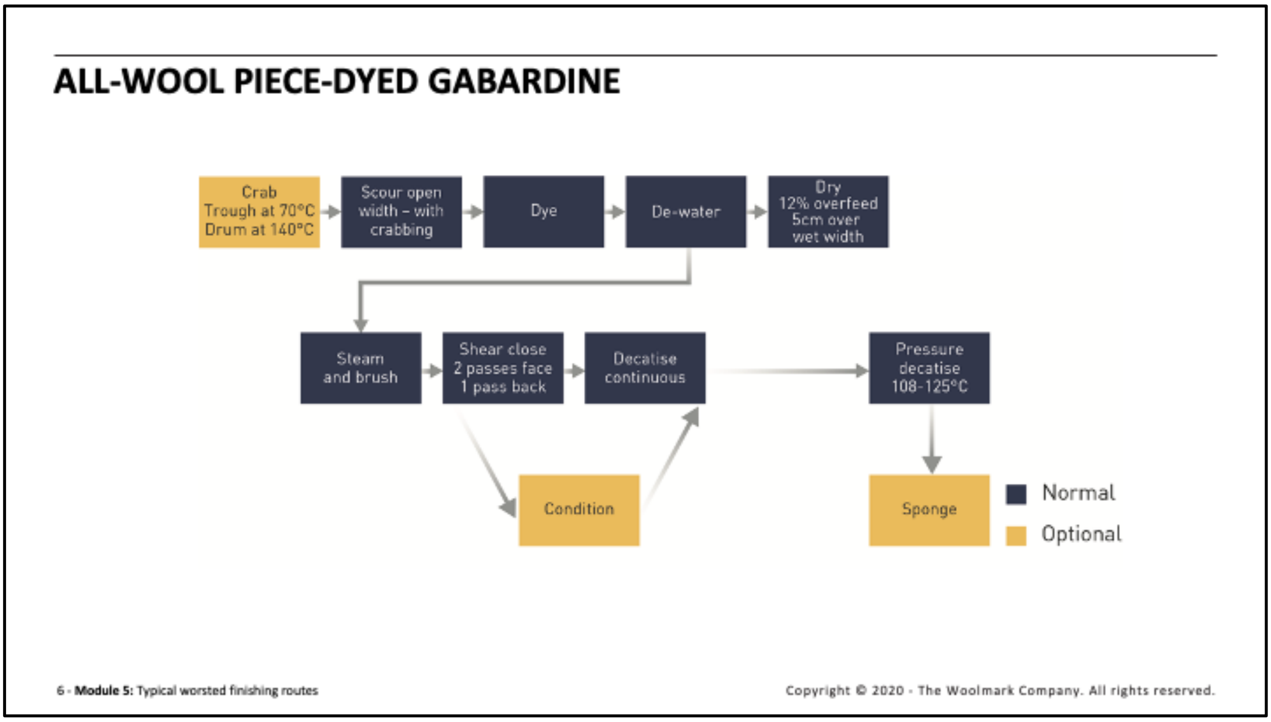
EXPLAIN THAT the finishing route for 'all-wool colour-woven flannel' is similar to 'all-wool colour-woven plain weave suiting', except that:

- Crabbing is not optional if the fabric is rope scoured.
- The fabric is not pressed as it undergoes continuous decatising before being pressure decatised. This is necessary because rotary or belt pressing may put too much shine on the fabric.
- Conditioning is optional instead of normal. Some conditioning can occur in continuous decatising. If this is not sufficient and the fabric is still too dry for pressure decatising, a conditioning process should be included.
- Shearing does not need to be close. Some fibre on the surface can be required by the customer. Instead the shearing machine is set for a short pile, with two passes face and the one pass back.
- Sponging is not optional — it is necessary to relax the fabric and remove any shine.



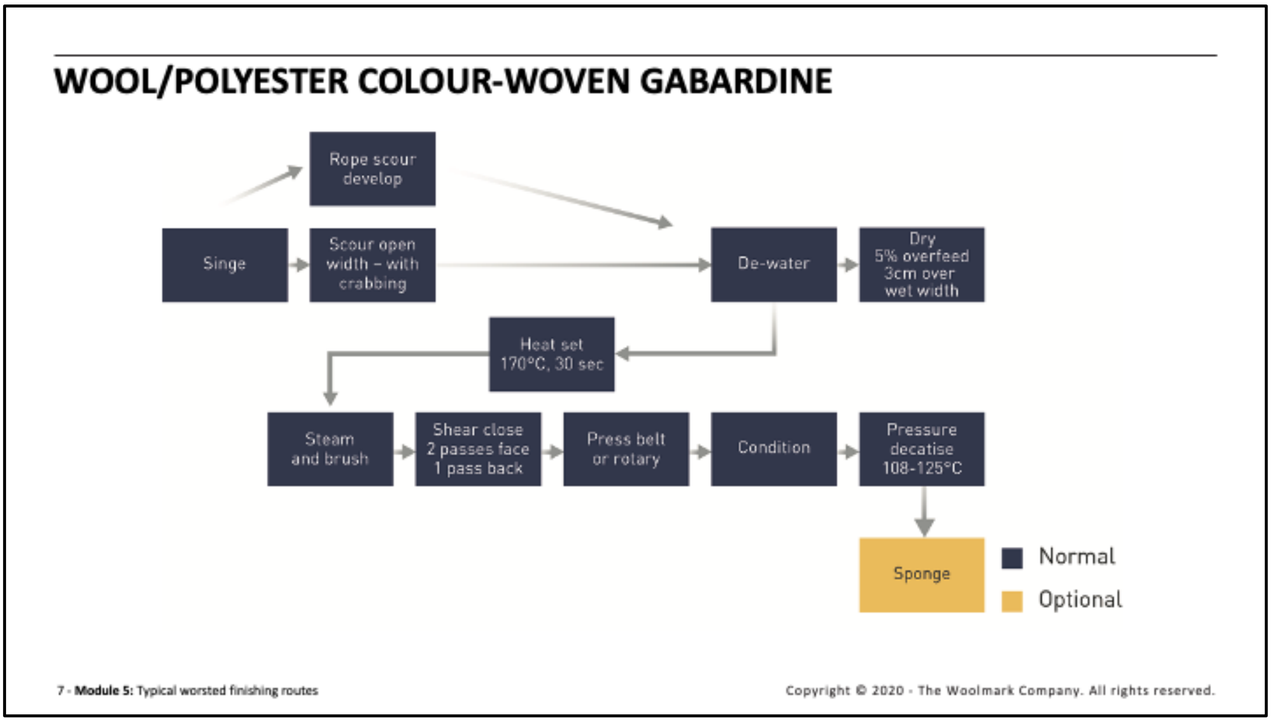
EXPLAIN THAT the finishing route for 'all-wool colour-woven gabardine' is the same as for 'all wool colour-woven flannel', except:

- Crabbing is optional and not necessary, if the fabric is crabbed in open width scouring. Crabbing is required if the fabric is rope scoured.
- Drying occurs using ~8% overfeed and ~3cm over wet width, as opposed to ~5% overfeed and ~5cm over wet width. More overfeed is required with fabrics that are extensible in the warp direction, such as gabardines.
- The shear requires a close blade setting and two passes face and one pass back to produce a clean finish, especially of the fabric is rope scoured.
- Pressure decatising is conducted at a slightly higher range in temperature (108–125°C instead of 108–115°C). It depends on the fabric colour. A low temperature in pressure decatising is used if the fabric is a pale shade, which can change as a result of some yellowing of the wool in the high temperature steam.
- Sponging is also optional. It depends on the relaxation shrinkage in the fabric after pressure decatising and how heavily pressed the finish is required to be.



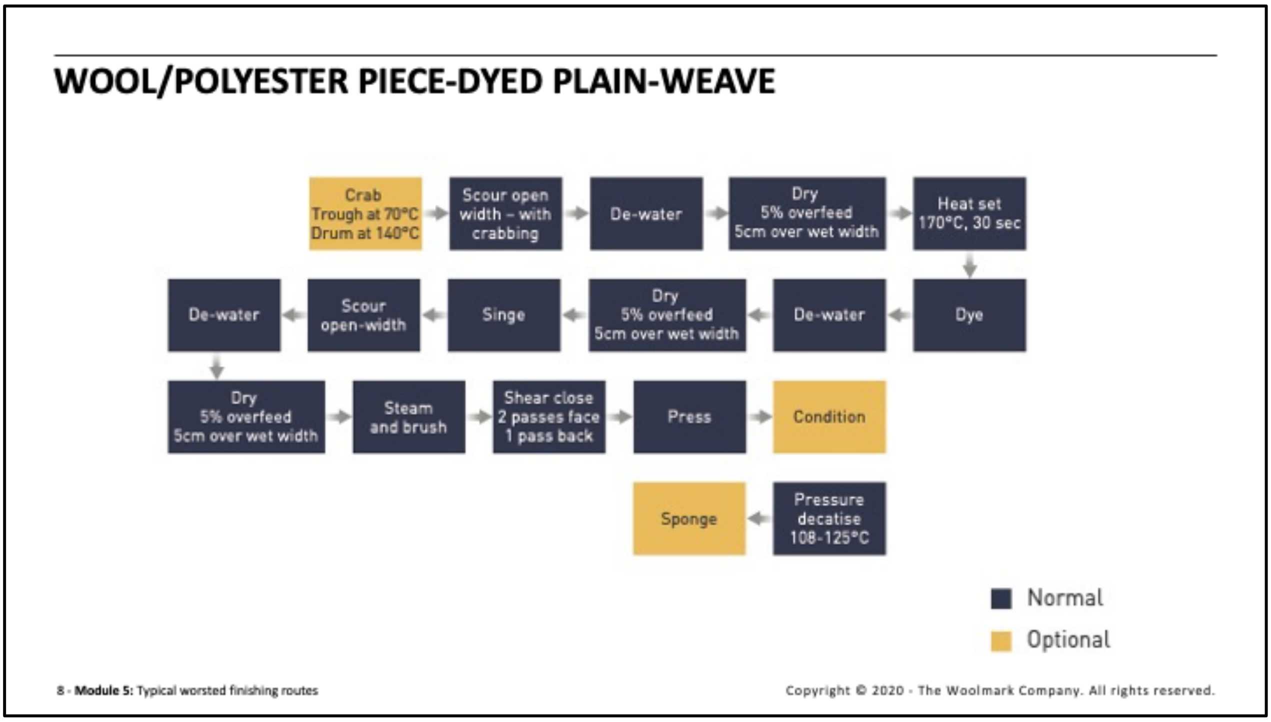
EXPLAIN THAT the finishing route for ‘all-wool piece-dyed gabardine’ is the same as ‘all-wool colour-woven gabardine’, except:

- An initial crab is essential instead of optional. If the fabric is to be piece dyed, good stability must be achieved before dyeing and to avoid the possibility of uneven dyeing.
- There is an additional step in-between scouring and de-watering, where dyeing takes place. The dyeing that occurs at this point, is normally conducted on still-wet fabric. The fabric can be dried for logistical reasons (e.g. storage).
- The drying is done at ~12% overfeed and 5cm over wet width. Instead of 8% overfeed and ~3cm over wet width, because piece-dyed gabardines are often highly extensible in the warp direction.



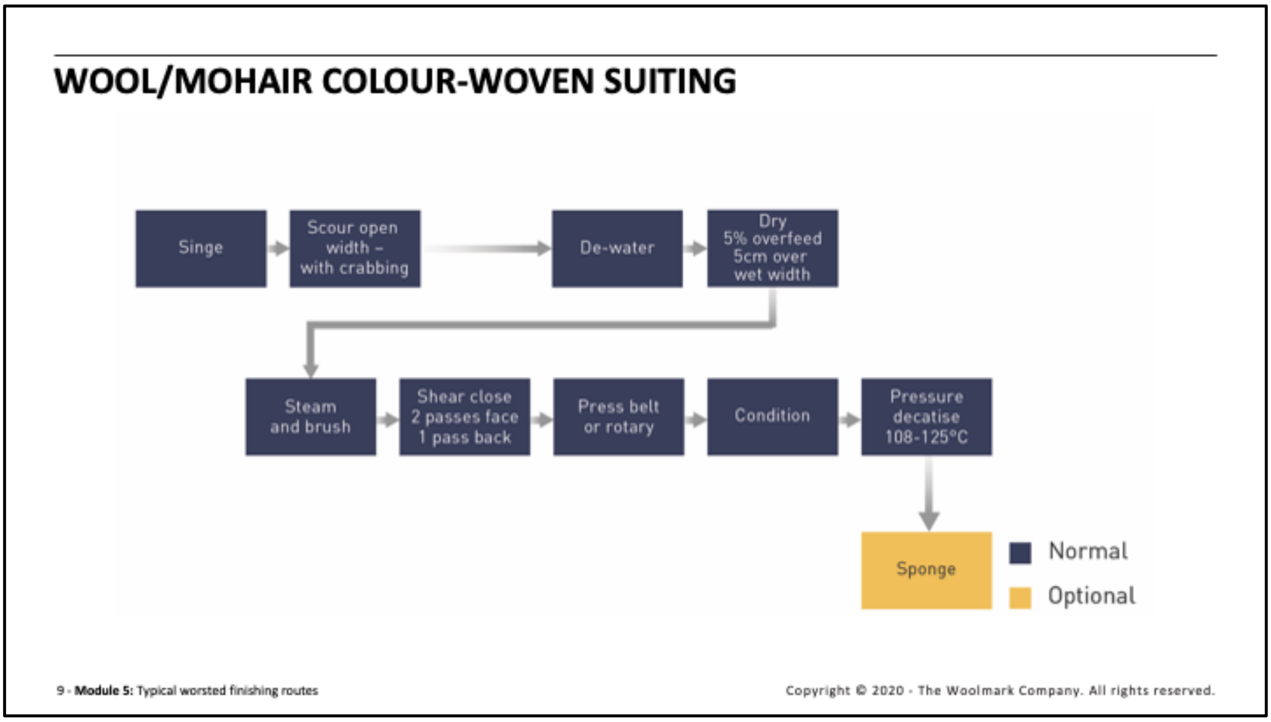
EXPLAIN THAT the finishing route for 'wool/polyester colour-woven' is the same as 'all-wool colour-woven gabardine', except:

- The fabric needs to be singed before being scoured, to remove polyester fibres sticking out of the fabrics surface that will be difficult to crop. The protruding wool fibres are also burnt off.
- The drying occurs with a ~5% overfeed and 3cm over wet width, instead of a ~8% overfeed and ~3cm over wet width, as with all-wool colour-woven fabrics.
- The fabric is heat set to stabilise the polyester fibres.
- The fabric needs to be pressed (on a belt or rotary machine) to produce a smooth flat finish.
- The fabric must be conditioned before it is pressure decatised, to ensure it has adequate moisture.



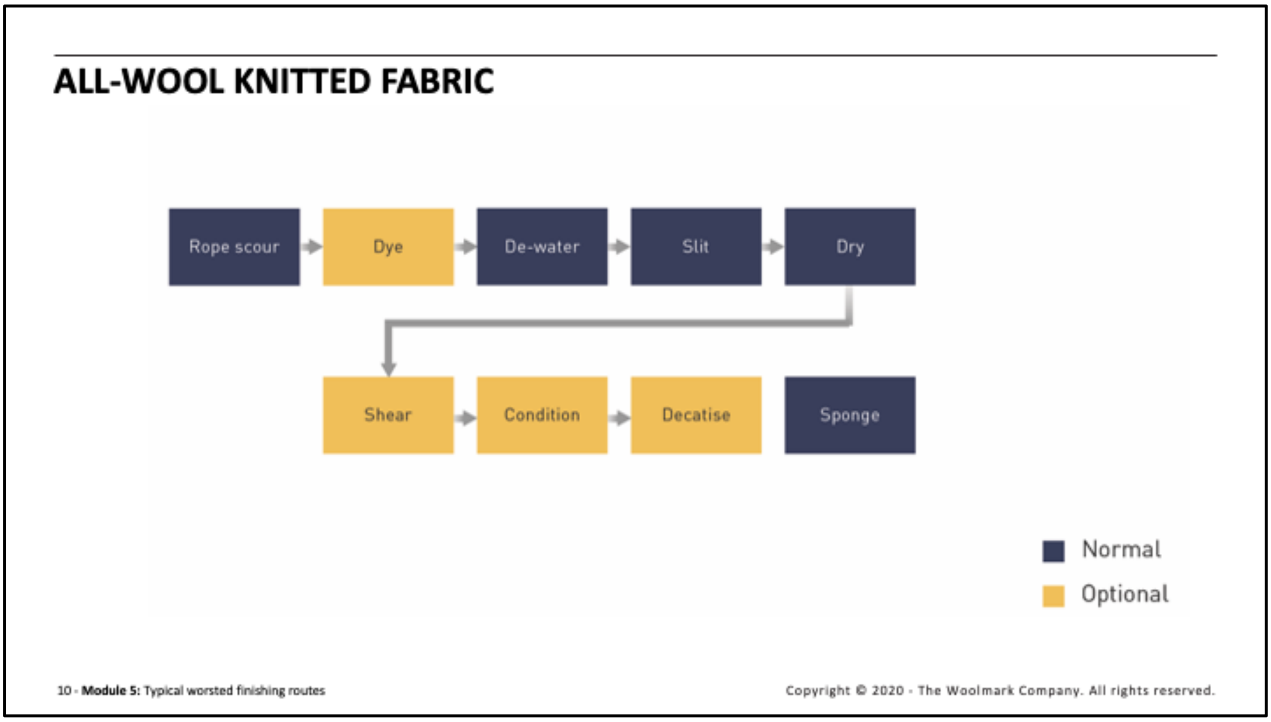
INDICATE THAT the finishing route for 'wool/polyester piece-dyed plain-weave' may look complex, but in reality it is similar to the finishing route for 'all-wool piece-dyed gabardine', except that:

- It requires a number of additional steps in between 'drying' and 'steaming and brushing', where the fabric is dyed, singed and re-scoured.
- These additional steps are necessary because piece-dyed fabrics should be singed after dyeing as singeing can affect dye uptake. The fabric must be scoured after singeing and before dyeing.
- The initial dry requires a 3 cm over wet width, instead of a ~5 cm over wet width because the relaxation shrinkage imparted to the fabric is not a major issue, if it is to be re-wet.



POINT OUT that the finishing route for 'wool/mohair colour-woven' suiting is similar to that for 'wool/polyester colour-woven gabardine' except:

- The fabric is not heat set. It is dried using ~5 cm over wet, rather than 3 cm over wet.
- This is because heat setting is not effective on mohair and wool-mohair fabrics have more hygral expansion than wool-polyester blends.



EXPLAIN THAT the finishing route for 'all-wool knitted fabric' is relatively simple and requires fewer steps than the other finishing routes covered in this module.

INDICATE THAT knitted fabric needs to be rope scoured instead of open-width scoured because the open-width machines do not handle extensible knitted fabrics well.

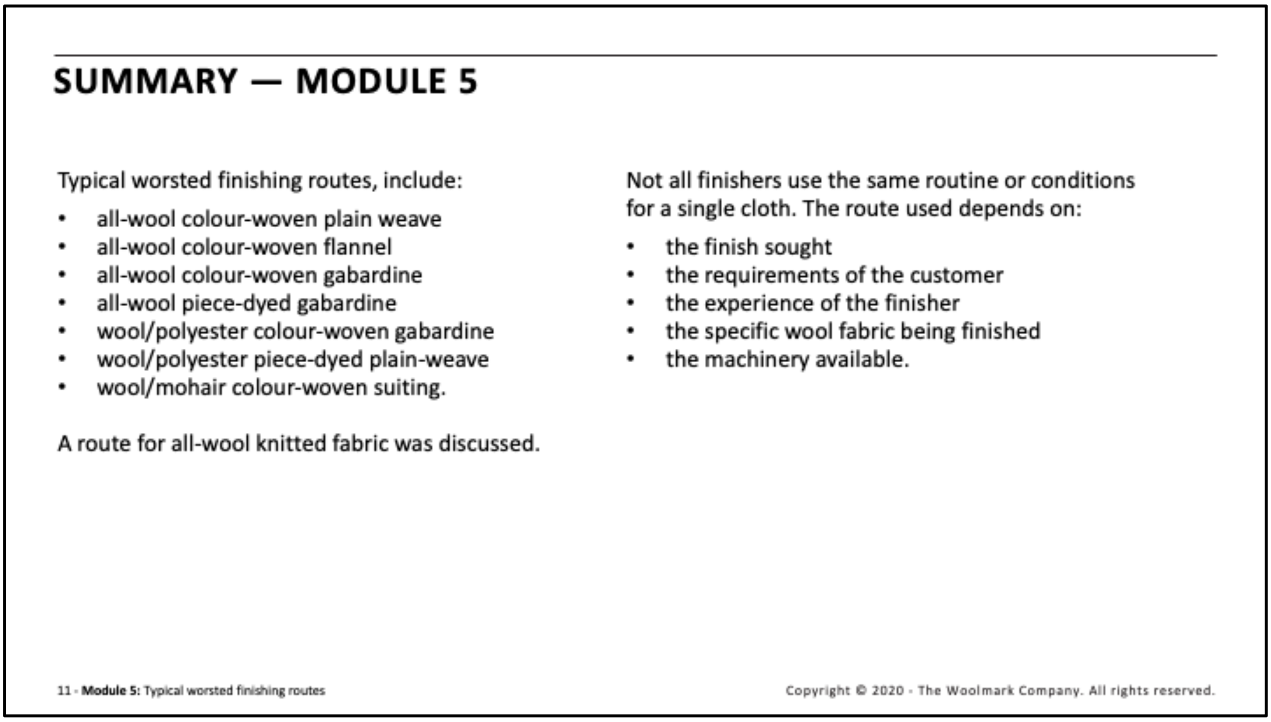
The need to piece dye depends on the fabric production route (coloured or ecru yarns).

MENTION THAT specialised equipment is available to process knitted fabrics in tubular form. If this machinery is not available, knitted fabric needs to be slit. In other words, the tube of fabric needs to be cut along its length, so the fabric can be processed in open width.

The fabric is slit before it is dried so it can be dried on a stenter. If the fabric is dried relaxed it can be slit after drying, but this is not normal.

NOTE THAT shearing, conditioning and decatising are optional. Their use depends on the requirements of the customer.

The fabric is normally sponged, to ensure it is relaxed.



SUMMARISE this module by explaining typical worsted finishing routes, include:

- all-wool colour-woven plain weave
- all-wool colour-woven flannel
- all-wool colour-woven gabardine
- all-wool piece-dyed gabardine
- wool/polyester colour-woven gabardine
- wool/polyester piece-dyed plain-weave
- wool/mohair colour-woven suiting.

REITERATE THAT a route for all-wool knitted fabric was discussed.

REMIND participants that finishing routes vary according to:

- the finish sought
- the requirements of the customer
- the experience of the finisher
- the specific wool fabric being finished
- the machinery available.

REVIEW the fact that not all finishers use the same routine or conditions for a single cloth.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 6 Chemical finishing methods* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

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MODULE 6

CHEMICAL FINISHING

RESOURCES — MODULE 6: CHEMICAL FINISHING

Contained in the *Wool fabric finishing* Demonstration kit you will find the following resources for use as you deliver **Module 6: Chemical finishing**:

- woollen fabric containing vegetable matter
- sample of optically brightened white cotton
- sample of non-optically brightened white cotton
- sample of optically brightened wool (half-yellowed)
- sample of softened cotton towelling
- sample of unsoftened cotton towelling
- sample of cotton with water-repellent finish
- sample of cotton without water-repellent finish

Additional resources to be sourced by the facilitator include:

- optical brightening agent solution
- black (UV) light, if available

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WOOL FABRIC FINISHING

MODULE 6: Chemical finishing methods

WELCOME participants to Module 6 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Chemical finishing methods*.

EXPLAIN THAT this module will cover some of the chemical finishes that can be applied to wool to impart certain functional attributes (e.g. felt resistance).

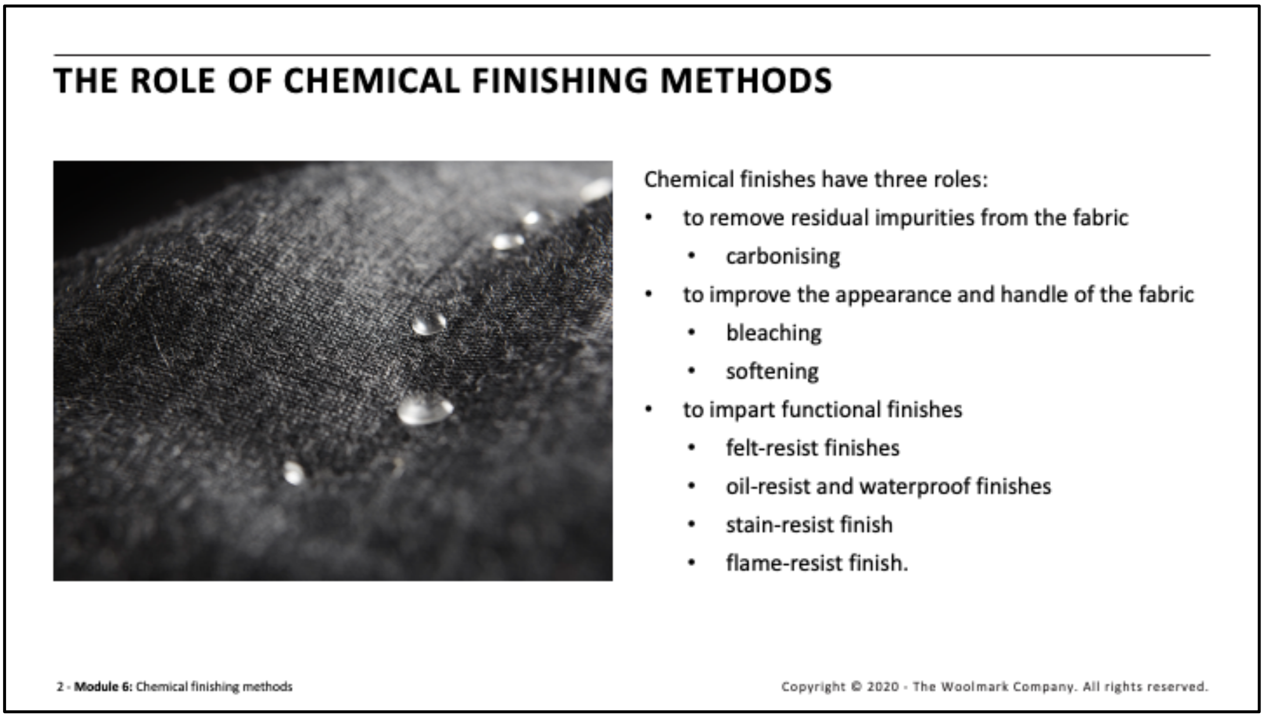
INFORM participants that by the end of this module, they will be able to:

- describe the chemical finishes used to:
    - remove residual vegetable matter from the fabric (e.g. carbonising)
    - improve the appearance and handle of the fabric (e.g. bleaching and softening)
    - impart functional finishes (e.g. felt-resist finishes, oil and water-repellent finishes).
- describe the benefits associated with chemical finishing, as well as the potential problems
- describe some of the unwanted effects that can occur as a result of chemical finishing and how to reduce these
- discuss the environmental concerns associated with chemical finishing and how these are currently being addressed.

NOTE: *Additional functional finishes are covered in other courses of the* Wool Science, Technology and Design Education Program.

RESOURCES REQUIRED FOR THIS MODULE

- *woollen fabric containing vegetable matter*
- *black (UV) light (to be sourced by facilitator)*
- *sample of optically brightened white cotton*
- *sample of non-optically brightened white cotton*
- *optical brightening agent solution(to be sourced by facilitator)*
- *sample of optically brightened wool fabric (half of which has been exposed to sunlight, showing yellow effect)*
- *sample of softened cotton towelling*
- *sample of unsoftened cotton towelling*
- *sample of cotton with water-repellent finish*
- *sample of cotton without water-repellent finish*



NOTE THAT chemical finishes have three roles:

- to remove residual impurities from the fabric
    - carbonising
- to improve the appearance and handle of the fabric
    - bleaching
    - softening
- to impart functional finishes to the fabric
    - felt-resist finish
    - oil-resist and waterproof finish
    - stain-resist finish
    - flame-resist finish.

FABRIC CARBONISING

Carbonising removes cellulosic contaminants from wool.

- Normally carried out on scoured loose wool that contains excessive amounts of vegetable matter.
- Often conducted on woollen-spun fabrics.
- The process involves:
  - impregnating the fabric with acid (5–10% sulphuric acid)
  - drying and baking (~135°C) the fabric:
    - to degrade the cellulose
    - wool is more resistant to acid than cellulose.
- Crushing the degraded cellulose.
- Washing out the dust.

NOTE THAT carbonising is a process used to remove cellulosic contaminants (usually vegetable matter, seeds etc.) from wool.

HAND OUT *the sample of woollen fabric containing vegetable matter.*

ENCOURAGE *participants to observe the amount of vegetable matter in the sample.*

EXPLAIN THAT carbonising is normally carried out on scoured loose wool that contains excessive amounts of vegetable matter. However, the process can be carried out on woollen-spun fabrics made from wools with a relatively low vegetable matter content. In such situations, small amounts of vegetable matter can travel through woollen carding and spinning processes and subsequently impair the appearance of the final fabric.

INDICATE THAT the process of carbonising involves:

- impregnating the fabric with acid (5–10% sulphuric acid)
- drying and baking (~135°C) the fabric to degrade the cellulose. Wool is more resistant to acid than cellulose.
- crushing the degraded cellulose, by running the fabric dry in a rotary milling machine for up to 15 minutes
- washing out the dust.

ISSUES FOR CARBONISING

- Wool is damaged by carbonising. This damage must be controlled by:
  - using an open width immersion to impregnate the fabric with acid, then
  - padding to remove excess liquid.
- Neutralisation is required to prevent further damage, unless the fabric is to be acid milled or dyed.
- Both carbonising and neutralising are usually carried out before milling.
- Subsequent dyeing behaviour can be affected.

4 - **Module 6:** Chemical finishing methods

NOTE THAT wool is damaged by carbonising, so it is important to control any damage.

EXPLAIN THAT evenness of the carbonising is critical. If the carbonising is not even it can cause:

- uneven damage
- uneven dye uptake in subsequent dyeing.

INDICATE THAT unevenness can be reduced by:

- using an open-width immersion to impregnate the fabric with acid
- padding to remove excess liquid.

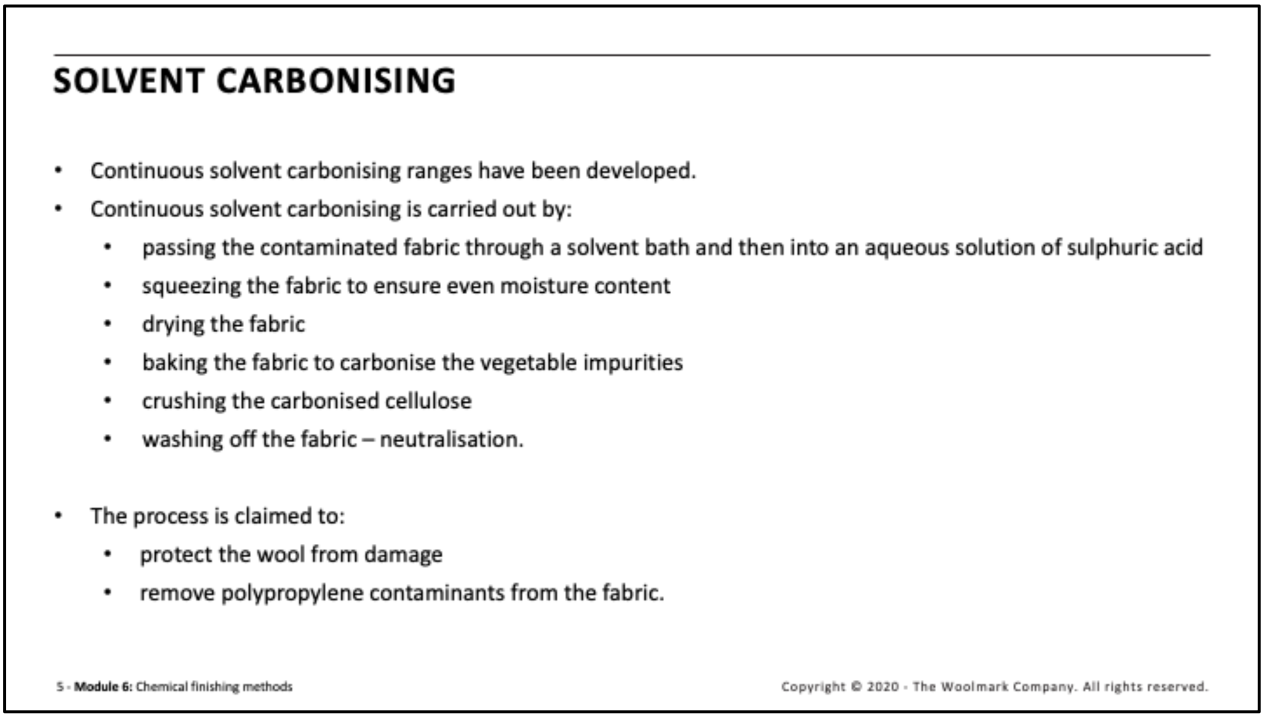
EXPLAIN THAT neutralisation of the acid is required after carbonising to prevent further damage to the wool, unless the fabric is to be acid milled or dyed under strong acid conditions.

The process of neutralisation involves scouring in rope form, in a water bath containing sodium carbonate (3–6%) at ~40°C for 30–60 minutes.

POINT OUT that an aqueous extract is required to determine the ‘internal’ pH of the fibre to ensure adequate neutralisation.

INDICATE THAT both carbonising and neutralising are usually carried out before fabric milling, since vegetable matter and dust may be more difficult to remove after milling. The particles of vegetable matter may be locked in by the felting action.
It is possible subsequent wet processes (neutralisation, scouring, milling), may be carried out in the same machine.

EXPLAIN THAT the dyeing behaviour of the wool fabric can be affected by carbonising. Since carbonised wool requires strong acid conditions, 1:1 pre-metallised and acid levelling dyes, which are applied under strong acid conditions, can be used.



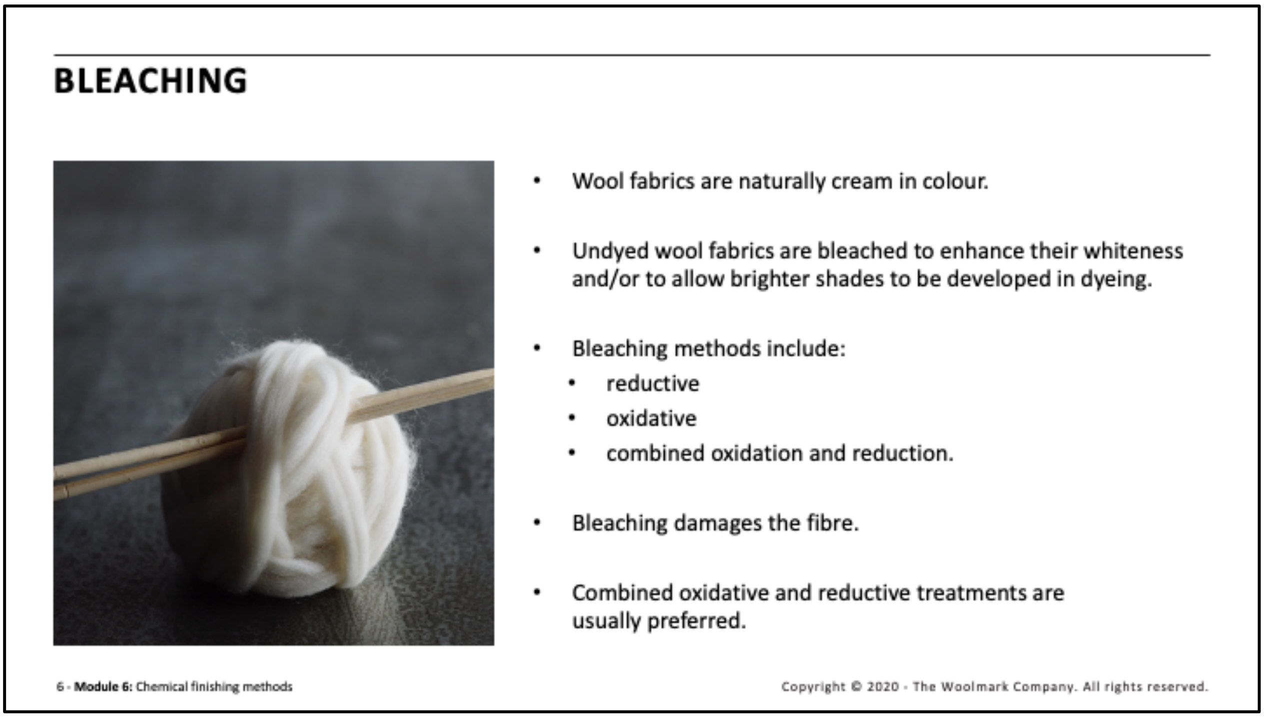
MENTION THAT in addition to batch 'aqueous' carbonising, continuous solvent carbonising ranges have also been developed.

NOTE THAT continuous solvent carbonising is carried out by:

- passing the contaminated wool through a solvent bath (perchloroethylene) and then into an aqueous solution of sulphuric acid
- squeezing the fabric to ensure even moisture content
- drying the fabric (with solvent recovery)
- baking it to carbonise the vegetable impurities
- washing off—neutralisation.

EXPLAIN THAT the solvent carbonising process is claimed to:

- protect the wool from damage. It is claimed that when the wool is saturated with the solvent perchloroethylene, the aqueous acid solution cannot penetrate the wool fibre and preferentially wets the vegetable material instead
- remove polypropylene contaminants from the fabric.



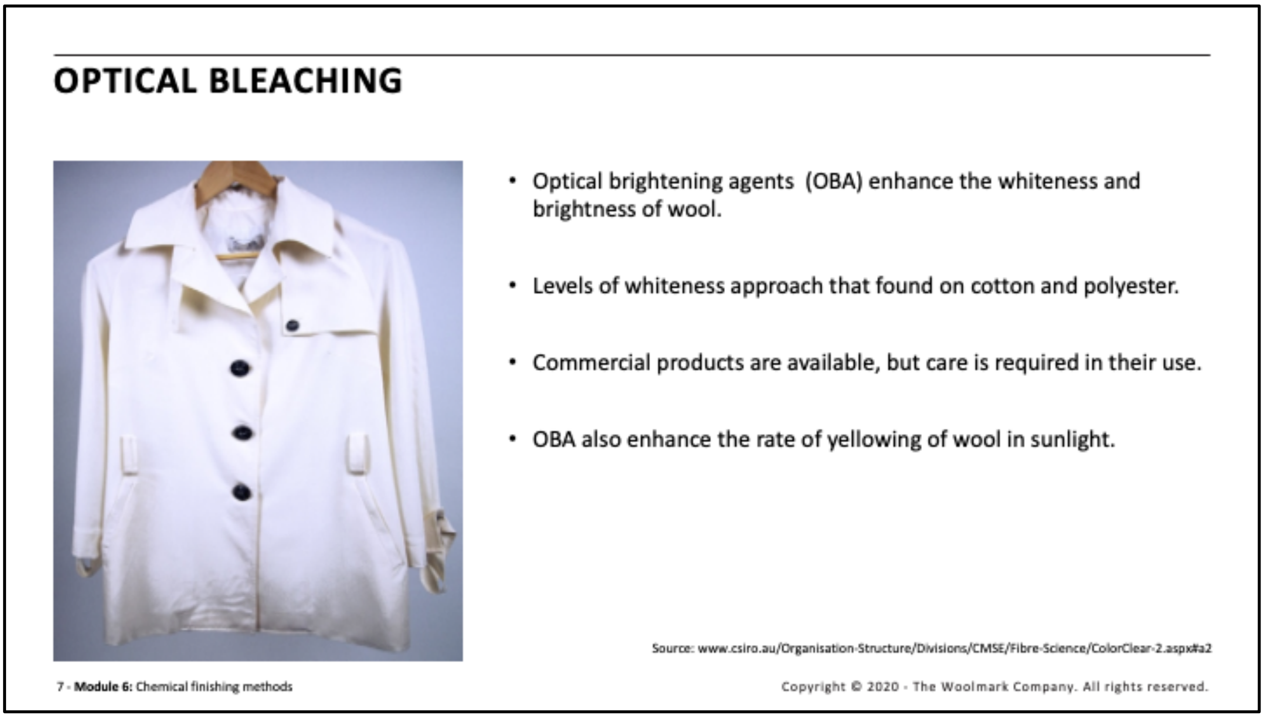
NOTE THAT wool fabrics are naturally cream in colour. Undyed wool fabrics therefore need to be bleached to enhance their whiteness and/or to allow brighter shades to be developed in dyeing.

MENTION THAT bleaching methods include:
- reductive (e.g. hydrosulphite)
- oxidative (usually stabilised peroxide)
- combined oxidation and reduction (two-steps).

EXPLAIN THAT bleaching damages the fibre. The whiteness imparted by bleaching is balanced by the damage to the fibre. Combined oxidative plus reductive treatments are usually preferred.

INDICATE THAT CSIRO has developed a new two-step bleaching process that uses ColorClear™ WB, marketed by Rohm and Haas Company (USA) in the reductive step. This method utilises the reaction between sodium borohydride and sodium bisulphite, resulting in improved whiteness compared with other techniques.

POINT OUT that the subject of bleaching is covered in detail in The Woolmark Wool Science, Technology and Design Education Program course on *The dyeing of wool*.



EXPLAIN THAT optical brightening agents (OBA) can also be used to enhance the whiteness and brightness of wool. Improved levels of whiteness can be achieved although they still remain inferior to bleached cotton and polyester.

INDICATE THAT the optical brightening agents absorb UV light and re-emit blue light. The addition of blue light to the reflected light of the wool product offsets the natural cream colour of the wool fibres and makes the product appear whiter and brighter.

DEMONSTRATION : OPTICAL BRIGHTENING

NOTE TO FACILITATOR: *This demonstration can only be carried out if a black (UV) light can be sourced.*

Resources required:

- *black (UV) light*
- *optically brightened white cotton*
- *untreated cotton*
- *optical brightening agent*

SHINE the *black (UV) light on optically brightened white cotton and normal white cotton and ask participants to note the difference (i.e. the treated fabric will emit a blue light)*

SHINE *the UV light on a solution of optical brightening agent and ask participants to note the blue colour emitted by both liquid.*

ENSURE *all participants can observe the results closely.*

HAND OUT *samples of optically brightened wool fabric, half of which has been exposed to sunlight.*

ASK *participants to observe the difference in colour between the exposed and unexposed sections of the wool fabric.*

NOTE THAT commercial products are available, but care is required in their use. These agents also enhance the rate of yellowing in sunlight.

EXPLAIN THAT wool yellows slowly when exposed to sunlight, the OBA makes the wool product appear whiter initially but also makes it yellow faster in sunlight so that the whitening effect can be short-lived.

EMPHASISE THAT the chemistry of yellowing is covered in detail in The Woolmark Wool Science, Technology and Design Education Program course on *Wool fibre science*.

SOFTENING

- Commonly used to improve the handle both worsted and woollen fabrics.
- Products used:
  - silicones
  - cationic, anionic and non-ionic surfactants.
- Methods:
  - exhaust application (~1%) in final rinse
  - pad application (10–20g/l)
  - other low liquor techniques (e.g. foam).

EXPLAIN THAT softeners are commonly used to improve the handle of both worsted and woollen fabrics. They reduce fibre-to-fibre friction (especially of damaged wool) making the fabric easier to deform (i.e. softer).

HAND OUT *samples of softened and unsoftened cotton towelling to the participants.*

ENCOURAGE *participants to note the difference in handle of the two samples.*

ASK *participants to note if they can feel any softener residue on their fingers when they stop handling the fabric.*

EXPLAIN THAT softness may be measured as:

- an increase in bias extensibility, or
- a reduction in shear rigidity and/or hysteresis in deformation of the fabric.

MENTION THAT the products used include:

- silicones generally applied as macro- or micro-emulsions
- cationic, anionic and non-ionic surfactants generally applied as a solution in water.

EXPLAIN THAT the methods used for applying softeners are:

- exhaust application (~1%) in final rinse after scouring or milling
- pad application (10–20g/l)
- other low-liquor application techniques (e.g. foam).

NOTE THAT cationic dispersions are required for exhaust applications.

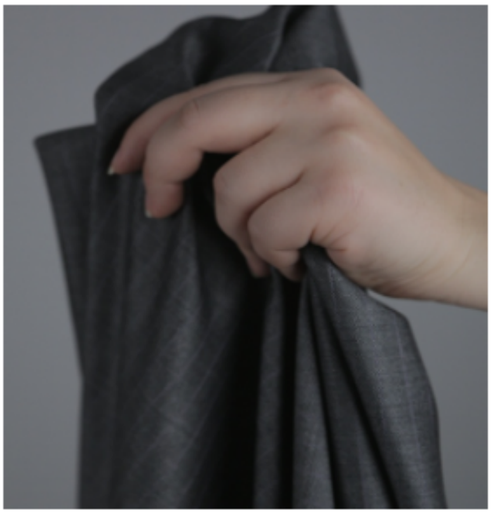
NOTE THAT the size of the emulsion particles affects the distribution of the softener through the yarns and fibres. Micro- and nano-emulsions are preferred.

ASK *participants if they can explain how silicones soften the handle of the fabric.*

ALLOW *participants sufficient time to respond.*

IF NECESSARY *explain that silicones reduce fibre-to-fibre friction so the fibres are freer to move.*

SILICONE SOFTENERS



Softness may be measured as:
- an increase in bias extensibility, or
- a reduction in shear rigidity and/or hysteresis of the fabric.

Benefits of using silicone softeners include:
- High levels of softness are imparted.
- Can provide limited stability to machine washing.
- Can also act as raising aids.
- Can 'repair' damage to the handle.

Challenges when using silicone softeners include:
- shade change
- spotting
- pilling
- seam slippage
- rub fastness.

9 - **Module 6:** Chemical finishing methods

INDICATE THAT silicones soften the handle of the fabric by reducing fibre-to-fibre friction so fibres are freer to move.

NOTE THAT softness may be measured as:
- an increase in bias extensibility, or
- a reduction in shear rigidity and/or hysteresis in deformation of the fabric.

EXPLAIN THAT the benefits of silicone softeners are:
- they impart high levels of softness to the fabric
- some silicones provide limited stability to machine washing
- they can also act as raising aids
- they can 'repair' damage to the handle
- they are most effective where the handle has been impaired by a chemical process.

POINT OUT that some of the potential challenges associated with silicone softeners are:

Shade change
This refers to an unwanted change in the shade of the colour. Silicones softeners can change the shade of some fabrics (especially bright blues), so it is critical they are applied evenly.

Spotting
Unwanted white spots can appear, which are caused by small particles of cured polymer lying on the fabric surface.

Pilling
Pilling is the formation of small balls of fibre, which form on fabric during wear.
Silicone treatments can worsen pilling by facilitating greater fibre movement within the fabric.

Seam slippage
Seam slippage refers to the fabric's inability to hold together when sewn. As a consequence the fabric or garment pulls apart at the seams.
Silicones can worsen seam slippage, by lubricating yarn movement.

Rub fastness
Rub fastness is the ability of the dye to be permanent and not rub off. Silicones can make rub fastness worse, where rub fastness is already a problem.

FELT RESISTANCE

- Garments shrink in machine washing by two mechanisms:
  - relaxation shrinkage
  - felting shrinkage.
- Felt-resist treatment is required for fabric used in garments with machine wash and tumble-dry performance.
- Fabric can be:
  - woven from felt-resist treated yarns (most common for knitted fabrics)
  - treated in fabric form (most common for woven fabrics).
- Two methods are used to treat fabric for felt-resistance:
  - a polymer, which forms bonds between the fibres, is applied
  - an oxidative pre-treatment is applied, followed by a polymer.

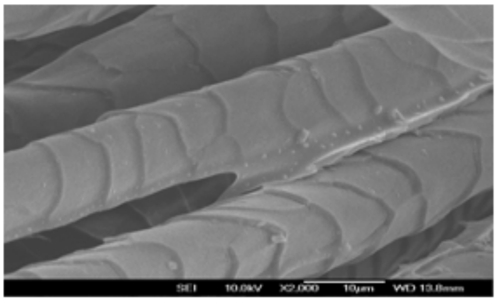


Image courtesy of AgResearch NZ

10 - **Module 6:** Chemical finishing methods

NOTE THAT wool garments can shrink in machine washing by two mechanisms as discussed in *Module 2 Review of setting and felting*:

- relaxation shrinkage: controlled by correct finishing
- felting shrinkage: requiring a special finish.

EXPLAIN THAT fabric felt-resistance is required for the production of garments that can be machine washed or tumble dried without shrinking. Garments that are felt-resistant are shrink-resistant provided the relaxation shrinkage is properly controlled.

INDICATE THAT fabric can be:

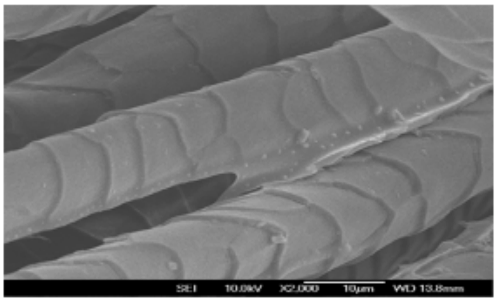
- woven from felt-resistant treated yarns (this is most common for knitted fabrics)
- treated in fabric form to impart felt resistance (this is most common for woven fabrics).

POINT OUT that two methods are used to impart felt resistance to wool fabrics:

1. A polymer is applied, which forms bonds between the fibres preventing relative fibre movement.
2. An oxidative pre-treatment is applied, followed by a polymer. The mechanism is a combination of scale masking and formation of interfibre bonds.

POLYMER-ONLY TREATMENTS FOR FELT RESISTANCE

- Most commonly used for woven fabrics.
- Polymer applied after shearing and before decatising.
- A number of polymer formulations can be used:
  - a reactive polyurethane pre-polymer
  - silicones
  - a mixture of the reactive polyurethane with:
    - silicones
    - polyacrylate emulsions
    - polurethane dispersions.
- All are applied to fabrics from an aqueous solution by padding.



11 - **Module 6:** Chemical finishing methods

INDICATE THAT polymer-only treatments are the most commonly used approach to impart felt resistance in woven fabrics.

Ideally the polymer is applied to the fabric after shearing and before decatising.

NOTE THAT a number of polymer formulations can be used to impart felt resistance to fabrics (and garments):

- a reactive polyurethane pre-polymer
- silicones
- a mixture of the reactive polyurethane with:
  - silicones
  - polyacrylate emulsions
  - polurethane dispersions.

MENTION THAT all treatments are applied to fabrics from an aqueous solution by padding and are heat treated to cure the polymer after drying.

POLYMER-ONLY TREATMENTS FOR FELT RESISTANCE

Process:

- Fabric pH ~ 5.–7.5.
- Polymer applied to fabric by padding.
- Fabric is dried and cured immediately.
- Fabric is pressed and/or decatised after polymer application.
- A wash-off may be necessary.

12 - **Module 6:** Chemical finishing methods

EXPLAIN THAT the process of imparting felt resistance to woven fabrics is as follows:

- The pH of the fabric should approximately be between 5.5 and 7.5 before the polymer is applied.
- The polymer is applied by padding. The amount of polymer required depends on the construction of the fabric:
    - urethane prepolymer 25–45g/l
    - bicarbonate ~ 5g/l.
- The fabric is then dried and cured immediately in a single pass by stenter drying at 150°C–160°C. This completes the curing of the polymer, which is important in assuring the final performance.
- The fabric is pressed and/or decatised after polymer application.

HAND OUT *the treated and untreated fabric samples to participants.*

ASK *participants to note the difference in the stiffness of the fabric samples.*

ASK *participants to explain why the polymer impairs the handle of the fabric.*

IF NECESSARY, *explain that the polymer inhibits the relative movement of fibres and yarns, increasing the stiffness of the fabric .*

POLYMER-ONLY TREATMENTS FOR FELT RESISTANCE

- The polymer increases fabric stiffness.
- Stiffness can be reduced by:
  - a wash-off (in rope form)
  - a silicone softener
    - applied in the wash-off
    - applied by padding.
- After either process, the fabric is dried and decatised.

Products:

- Reactive urethane polymers:
  - Synthappret BAP (Tanatex)
  - Dicrylan WSR (Huntsman)
  - Evo Lan WAP (Dystar)
- Polyacrylate emulsion
- Polyurethane dispersions:
  - Impranil DLN
  - Impranil DLH (Bayer)
- Silicone

13 - **Module 6:** Chemical finishing methods

EXPLAIN THAT the polymer treatments used to impart felt-resistance to fabric also impair fabric handle by increasing the stiffness of the fabric. The polymer inhibits the relative movement of fibres and yarns, which makes the fabric stiffer.

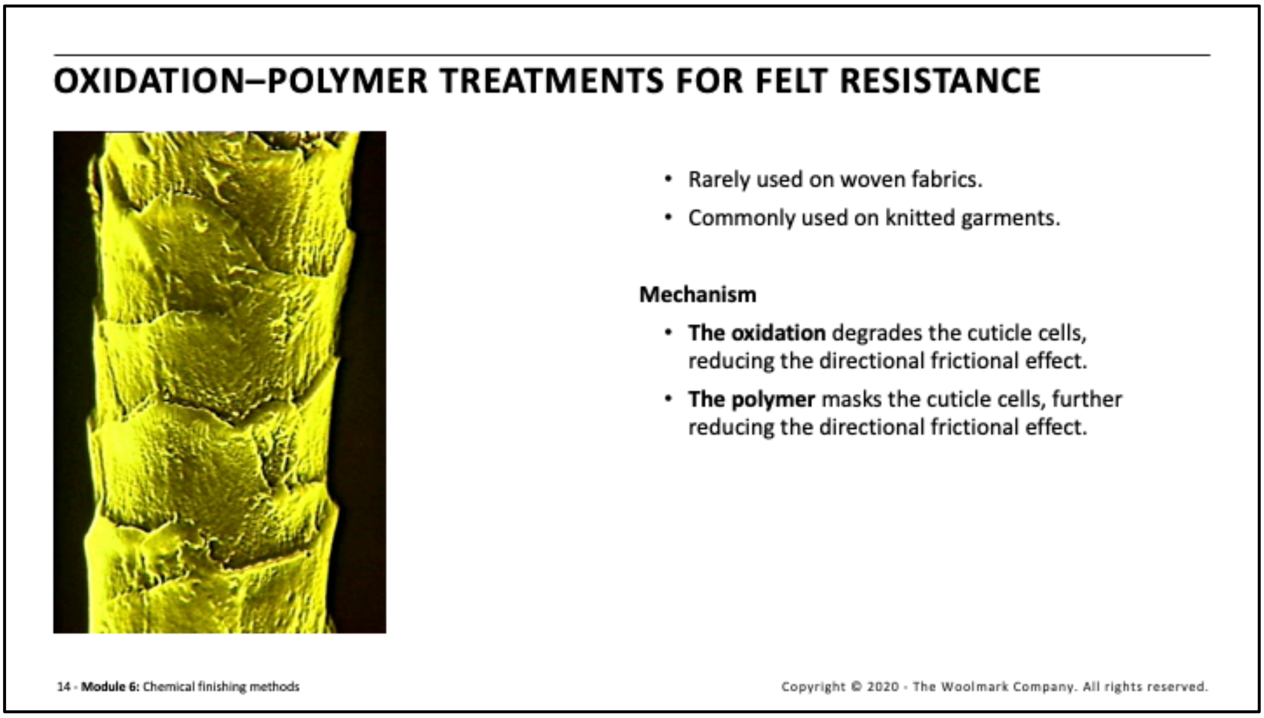
NOTE THAT this fabric stiffness can be reduced by:

- a wash-off — this is carried out in rope form and is often required to break some of the inter-fibre bonds
- a silicone softener — this may be applied in the wash-off or subsequently applied by padding.

After both processes, the fabric is dried and decatised.

INDICATE THAT some of the polymer treatments for wool fabric available on the market are:

- Reactive urethane prepolymer
  - Synthappret BAP (Tanatex)
  - Dicrylan WSR (Huntsman)
  - Evo Lan WAP (Dystar)
- Polyacrylate emulsion
- Polyurethane dispersions
  - Impranil DLN and DLH (Bayer)
- Silicone.



EXPLAIN THAT oxidation-polymer treatments for felt resistance are rarely used on woven fabrics, but are commonly used on knitted garments and knitted fabrics

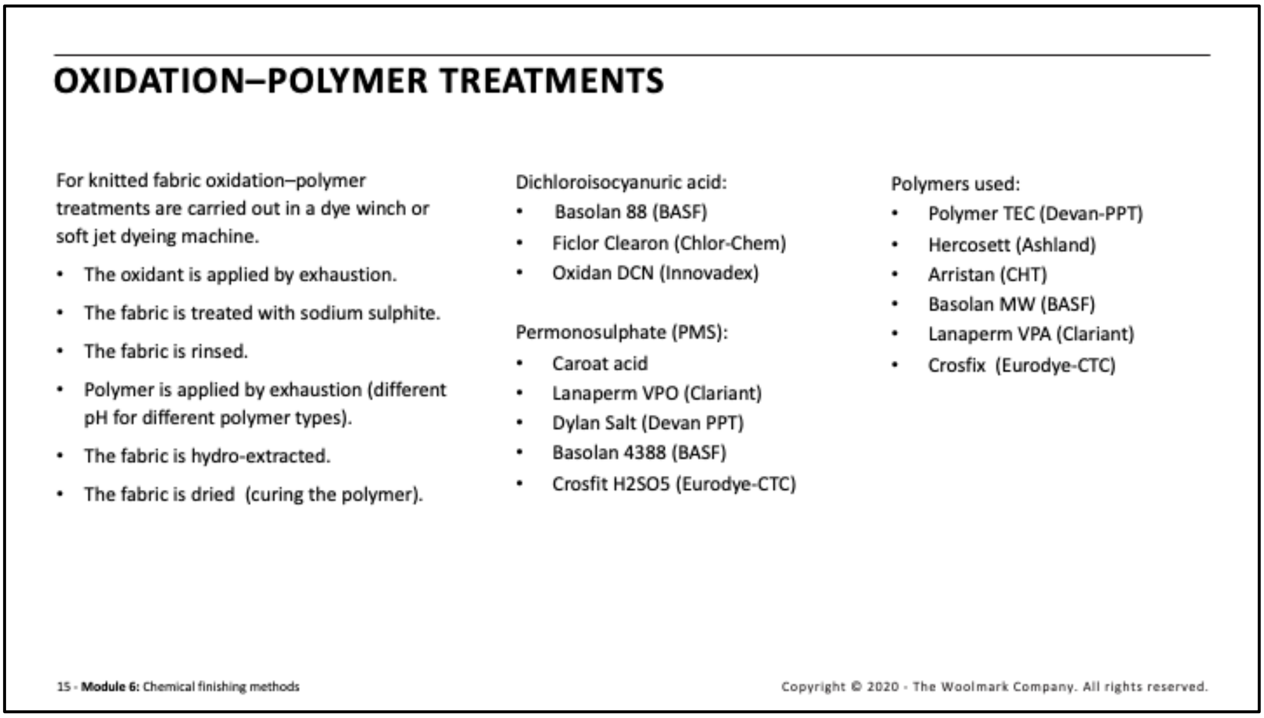
INDICATE THAT the mechanism that oxidation-polymer treatments use to impart felt resistance is as follows:

- The oxidation degrades the cuticle cells on the fibre reducing the directional frictional effect (DFE) and modifying the fibre surface so the polymer adheres more effectively.

- The most common oxidants are chlorine or permonosulphate salts (PMS). The latter is preferred for environmental reasons. Plasma may also be used.

- The polymer masks the cuticle cells, further reducing the directional frictional effect.

- The most common polymers applied in this process are silicones, although Hercosett (a epichlorhydrin-polyamide) or other proprietary products can be used.



NOTE THAT for knitted fabrics, the oxidation–polymer treatment is normally carried out in a dye winch of a soft jet dyeing machine.

EXPLAIN THAT the process of oxidation–polymer treatments is as follows:

The oxidant is first applied by exhaustion:

- chlorine from dichloroisocyanuric acid (DCCA) ~ 4% oww
- permonosulphate(PMS) ~ 4-6% oww.

The fabric is given a treatment with sodium sulphite at suitable pH

- ~3% oww after DCCA
- ~10% oww after PMS.

The fabric is rinsed.

The polymer is applied by exhaustion (different pH for different polymer types).

The fabric is hydro-extracted through padding rollers or using a suction slot.

The fabric is dried to complete the curing of the polymer, then dry finished.

INDICATE THAT products used in the oxidation–polymer process are listed on the right hand side of the slide.

OIL AND WATER REPELLENCE

- Outdoor and activewear, as well as outdoor textiles.
- Performance is dependant on:
  - fabric construction
  - finish.
- Products used for water repellency include:
  - waxes
  - soap/metal salt complexes
  - silicones
  - fluorocarbons.
- Oil-repellency is conferred by fluorocarbon finishes.
- Commercial formulations contain a range of differing polymer types and emulsification aids.
- Additives to improve durability.

16 - **Module 6:** Chemical finishing methods

EXPLAIN THAT water and oil-repellent finishes have been developed for outdoor and activewear as well as outdoor textiles.

How well a fabric performs at repelling water is dependent on both:

- the fabric's construction, and
- how it is finished.

NOTE THAT there is a wide range of products used for water repellent finishes, including:

- waxes
- soap/metal salt complexes
- silicones
- fluorocarbons.

POINT OUT that oil repellence is normally conferred by fluorocarbon finishes, which are based on perfluorinated polyacrylate emulsions.

Commercial products are normally cationic in nature so they can be applied by exhaustion.

INDICATE THAT there are numerous different commercial formulations, which contain a range of differing polymer types and emulsification aids.

MENTION THAT additives to improve durability are also often added.

FLUOROCARBON (FC) PRODUCTS

Applied by padding, spraying, or exhaustion.

Different formulations.

Process:

1. Application 0.15–0.3% solids
2. Fabric dried 110–130°C
3. Polymer cured 150–170°C

Products include:

- Nuva TTC (Clariant)
- Ruco-Guard (Rudolph Group)
- Phobol CP (Huntsman)

Environmental considerations:

- Persistence of fluorocarbons (FC) in the environment.
- Aquatic and human health.

Environmental solutions:

- Some products replaced with more environmentally-friendly FC formulations.
- Some FC production routes changed.

17 - **Module 6:** Chemical finishing methods

EXPLAIN THAT fluorocarbon (FC) products can be applied by padding, spraying etc. or by exhaustion. Different formulations are used in different application methods.

NOTE THAT the process for using fluorocarbon (FC) products for oil and water repellence is as follows:

- Application 0.15–0.3% solids on weight of fabric.
- Fabric pH = 5–7
- Fabric dried 110–130°C
- Polymer cured 150–170°C (30–45 seconds).

POINT OUT that the fluorocarbon products commonly used include:

- Nuva TTC (Clariant)
- Ruco-Guard (Rudolph Group)
- Phobol CP (Huntsman).

EMPHASISE THAT the use of fluorocarbons during finishing has raised some environmental issues, which need to be considered. These are as follows:

- concerns over the persistence of FC (especially perfluorooctanoic acid and its derivatives) in the environment
- concerns over aquatic and human health.

MENTION THAT in order to address these concerns, the following environmental solutions have been implemented:

- Some products have been phased out and replaced with more environmentally-friendly FC formulations.
- Some FC production routes have been changed so they now use more environmentally-friendly precursors.

NOTE THAT fluorocarbon-free products are now available where only water (not oil) repellence is required. (e.g. Phobotex (Huntsman).

FLAME-RESIST TREATMENTS

Finishes to enhance flame retardance include:

- Zirpro — using zirconium and titanium complexes.
- Phosphate compounds — also or in combination with metal complexes.

18 - **Module 6:** Chemical finishing methods

EXPLAIN THAT wool is naturally flame retardant, making it suitable for a wide range of domestic interior applications. However methods have been developed to enhance this retardance for high-risk applications (e.g. clothing for race car driver, safety wear, aircraft seat covers, interior textiles, military applications etc).

INDICATE THAT a number of processes have been developed. The most important of these is the Zirpro process developed by the former International Wool Secretariat (IWS) during 1977. This process is based on the exhaust application of zirconium and/or titanium complexes, notably using zirconium hexafluoride complex.

NOTE THAT a range of formulations were developed to meet the differing requirements of individual applications and the associated test methods including:

- ease of ignition
- smoke development or toxicity
- rate of spread of flame.

The use of this process is now limited to specialised applications.

EXPLAIN THAT the treatment for upholstery involves exhaust application from a bath containing formic acid, citric acid, potassium hexafluorozirconate and zirconium acetate at 70ºC for 30 minutes. For carpets or other wool textiles different formulations and application levels are used

POINT OUT that other compounds, such as those based on phosphate complexes and on boron salts, have also been found to enhance the flame retardance of wool, but are not widely used commercially.

EMPHASISE THAT environmental and toxicity concerns have precluded the use of many flame retardants especially those based on boron salts.

INDICATE THAT stain-resist and stain-release agents are commonly used on interior textiles to inhibit staining by natural dyes, commonly found in food and drinks, during use.

EXPLAIN THAT typically the process involves applying high concentrations of colourless dyes, which 'block' sites within the fibre and on the fibre surface to which the coloured molecules of the stain can attach.

Many commercial products are based on condensates of sulphonated aromatic compounds crosslinked using formaldehyde.

NOTE THAT these products can be used in combination with oil and water repellent finishes, discussed earlier, to create products with excellent stain-resist performance.

SUMMARY — MODULE 6

The following chemical finishes have been described:

Carbonising:
- to remove vegetable matter
- using strong acids.

Bleaching:
- to whiten the fabric
- reducing and/or oxidising agents
- whiteness balanced against fibre damage.

Softening:
- to improve the handle of fabric
- effective on damaged wool
- cationic silicones.

Felt-resist finishes:
- to prevent felting in machine washing and/or tumble drying
- two types of process:
  - polymer only processes
  - oxidation plus polymer treatment.

Oil and water repellent finishes:
- a range of chemicals used to impart water repellence
- fluorocarbon emulsions required to achieve oil repellence
- environmental concerns over fluorocarbons.

SUMMARISE the module by revising the following concepts:

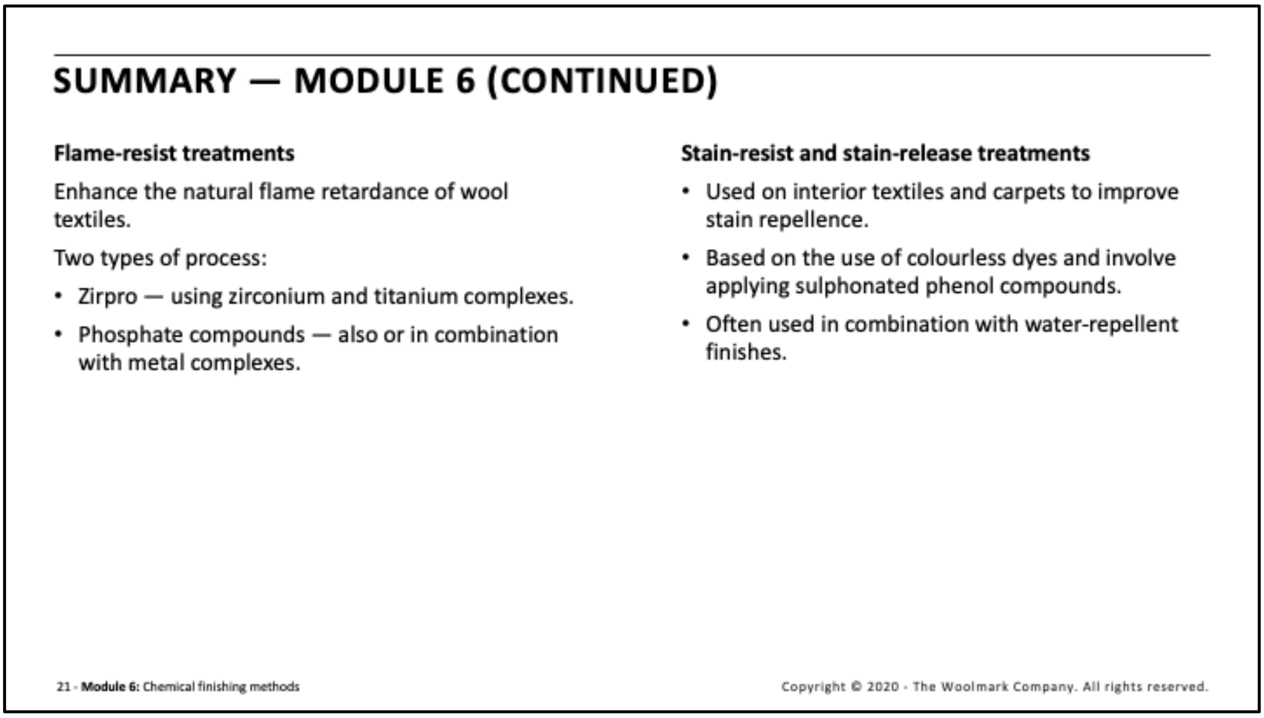
Carbonising
- Treatment with strong acid to remove residual vegetable matter from wool fabric.
- Used on woollen fabrics manufactured from uncarbonised wool.

Bleaching
- Treatment with reducing or oxidising agents to whiten fabric so it can be dyed to pastel shades or used ‘white’.
- Whiteness must be balanced against damage to the wool fibres.

Softening
- Treatment to improve the handle of fabric, especially if damaged by chemical processes.
- Cationic silicones favoured for wool.

Felt-resist finishes
- To prevent felting of the fabric in machine washing and/or tumble drying
- Two types of process
  - polymer only processes
  - oxidation plus polymer treatment.

Oil-resist and waterproof finishes
- A range of chemicals used to impart water repellence.
- Fluorocarbon emulsions required to achieve oil repellence.
- Environmental concerns over fluorocarbons.



REMIND participants of the following treatments:

Flame-resist treatments

- Enhance the natural flame retardance of wool textiles.
- Two types of process
  - Zirpro — using zirconium and titanium complexes.
  - Phosphate compounds — also or in combination with metal complexes.

Stain-resist and stain-release treatments

- used on interior textiles and carpets to improve stain repellence.
- based on the use of colourless dyes and involve applying sulphonated phenol compounds
- often used in combination with water-repellent finishes.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 7 Assessment of fabric finishing* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

THE WOOLMARK COMPANY

MODULE 7

ASSESSMENT OF FABRIC FINISHING

RESOURCES — MODULE 7: ASSESSMENT OF FABRIC FINISHING

Contained in the *Wool fabric finishing* Demonstration kit you will find the following resources for use as you deliver **Module 7: Assessment of fabric finishing**

- woven fabric sample cut in warp and weft
- woven fabric sample cut in bias
- dimensional stability sample
- knitted fabric sample
- broad-wool fabric sample
- fine-wool fabric sample

Additional resources to be sourced by the facilitator include:

- cut-off large funnel (plastic)
- cut-off small funnel (to look like a cone)

WELCOME participants to Module 7 of *Wool fabric finishing — Assessment of fabric finishing*

EXPLAIN THAT the module will provide an overview of:

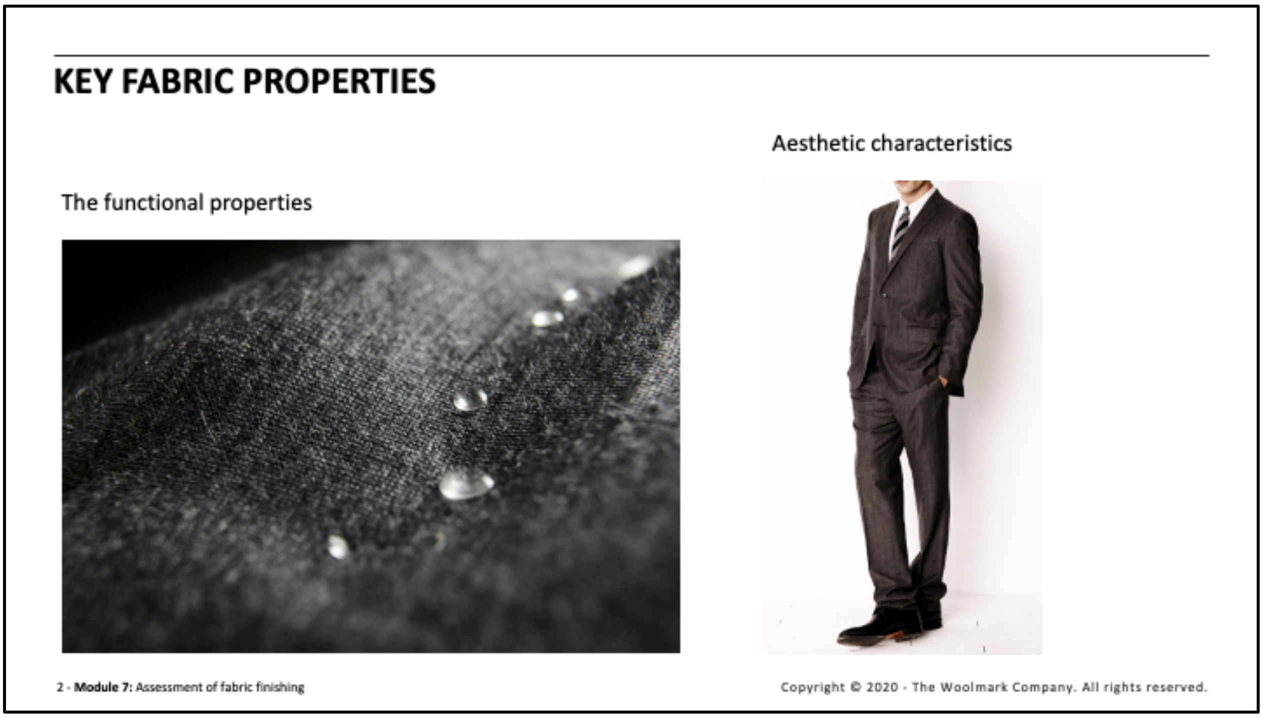
- the key properties of fabrics modified during finishing that affect quality
- the options for instruments to measure these properties.

INFORM participants that by the end of this module they will be able to:

- describe the functional properties and aesthetic characteristics that are modified during finishing and affect quality
- list the instruments commonly used to assess the key fabric properties affected by finishing
- identify what each instrument measures and how it measures the specific fabric properties.
- calculate properties from the measurements taken by the SiroFAST instrument (e.g. bending rigidity, shear rigidity, formability, finish stability)
- explain the methods used to interpret the results from SiroFAST, KES-F, Phabrometer and wool handle meter.

RESOURCES REQUIRED FOR THIS MODULE:

- *woven fabric sample cut in warp and weft*
- *woven fabric sample cut in bias*
- *dimensional stability sample*
- *cut-off large funnel (plastic) (facilitator to supply)*
- *cut-off small funnel (to look like a cone) (facilitator to supply)*
- *knitted fabric sample*
- *broad-wool fabric sample*
- *fine-wool fabric sample*



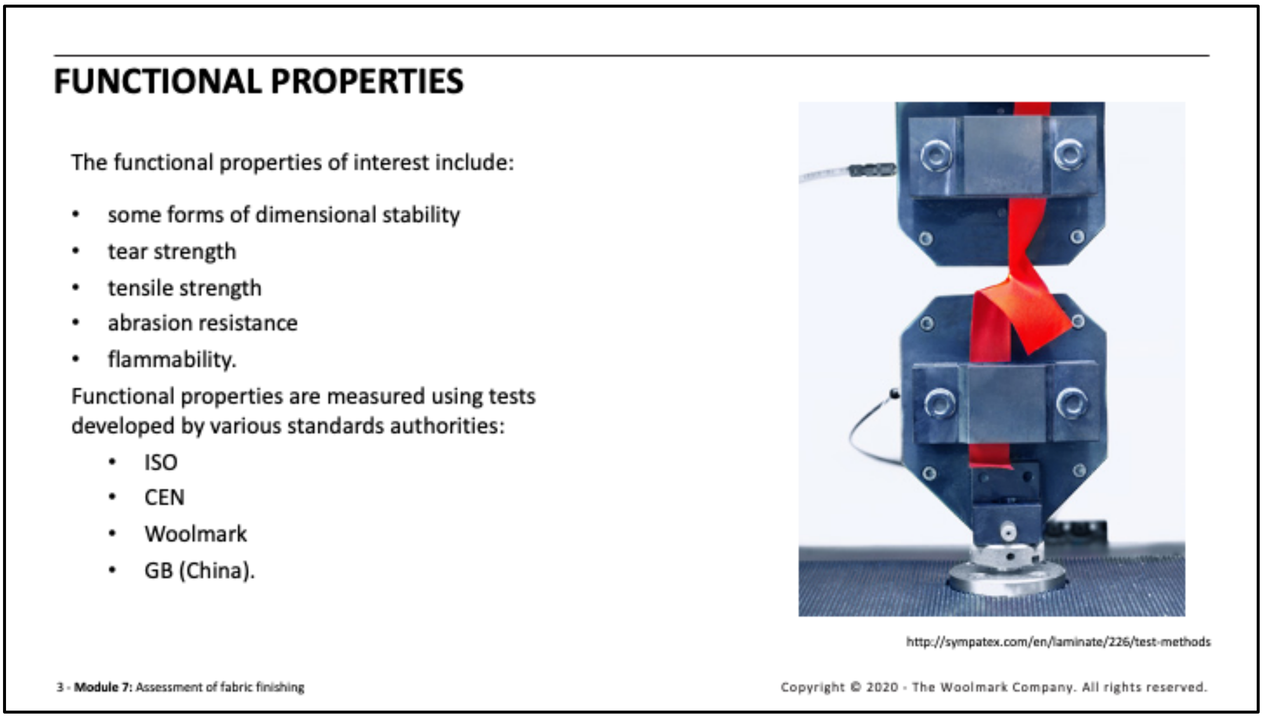
NOTE THAT the difference between the functional and aesthetic properties of wool fabric was discussed at the start of this course.

REITERATE THAT functional properties are measurable attributes, which define the fitness for purpose of a textile product. Examples are tear strength, abrasion resistance, flame resistance, insect resistance, easy care, shrink resistance, crease resistance, waterproofing and so on.

INDICATE THAT assessment of functional properties using standard tests forms the basis of quality assurance programs.

REITERATE THAT aesthetic characteristics are qualities perceived through the senses, such as sight and touch. Aesthetic qualities are perceived by the brain as being desirable or undesirable, beautiful or ugly. In the case of textiles, these are attributes such as shapely appearance, drape, handle, comfort and colour.

INDICATE THAT of these aesthetic qualities, only colour can be measured with a high degree of accuracy. Many attempts have been made to find correlations between mechanical and aesthetic properties using physical tests, with varying degrees of success.



EXPLAIN THAT the key functional properties of interest during finishing are:

- some forms of dimensional stability (e.g. resistance to felting)
- tear strength
- tensile strength
- abrasion resistance
- flammability.

MENTION THAT these are measured using the following tests, which have been developed by various standards authorities:

- ISO
- CEN
- IWTO
- Woolmark
- GB (China).

NOTE THAT these tests involve the application of forces or conditions that destroy the fabric.

AESTHETIC CHARACTERISTICS

- Involve the application of low-stress mechanical forces
- Conditions that do not destroy the fabric – merely deform it
- Handle:
  - firmness
  - smoothness
  - stiffness.
- Dimensional stability
- Performance during garment manufacture:
  - cutting
  - sewing
  - pressing.
- Appearance of garment after manufacture and during wear:
  - garment distortion
  - seam pucker
  - wrinkling.

4 - **Module 7:** Assessment of fabric finishing

INDICATE THAT the tests for aesthetic properties involve the application of low-stress mechanical forces and conditions that do not destroy the fabric, but merely deform it.

EXPLAIN THAT the aesthetic characteristics of fabrics of key importance during finishing are those associated with handle, dimensional stability and performance of the garment during manufacture and wear.

Handle:

- firmness
- smoothness
- stiffness.

Dimensional stability

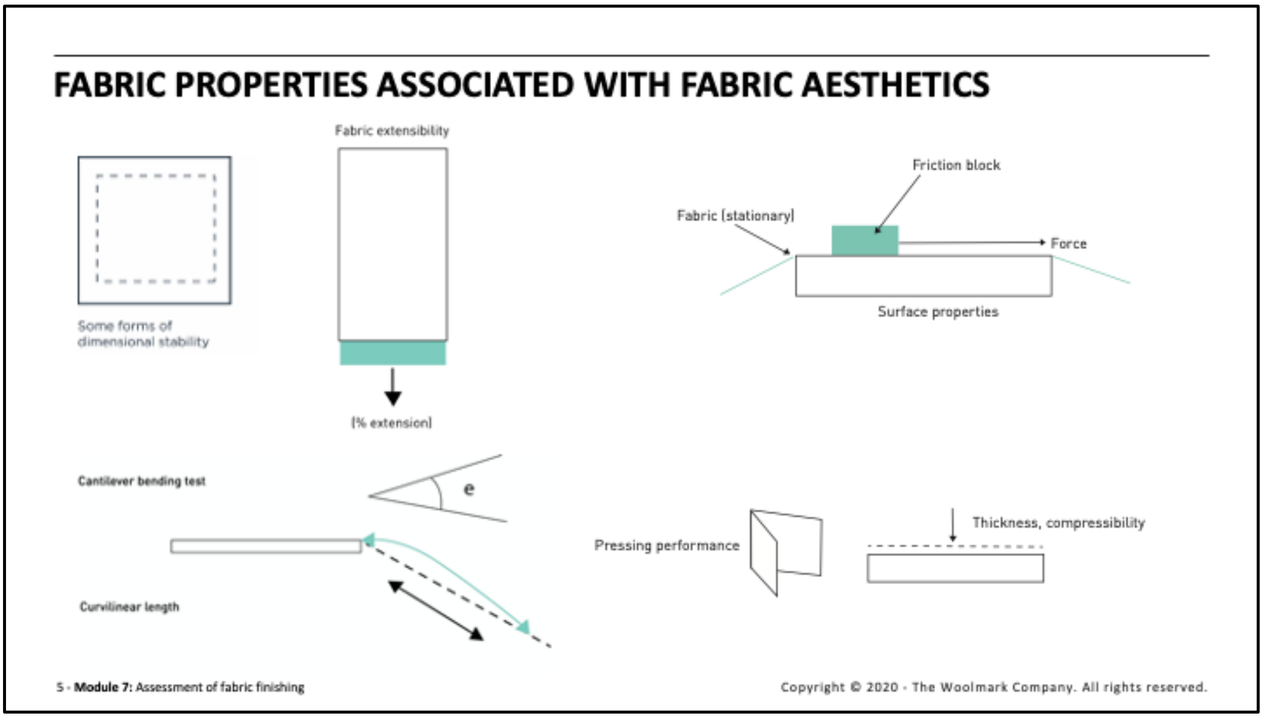
Performance during garment manufacture:

- performance in cutting
- performance in sewing (shape distortion, seam pucker)
- performance in pressing (smooth seams, no bubbling).

Appearance of garment after manufacture and during wear is influenced by wear:

- garment distortion
- seam pucker
- wrinkling.

NOTE THAT those properties associated with the aesthetic characteristics of the fabric are the subject of the rest of this module.



NOTE THAT the measurable fabric properties associated with fabric aesthetics are as follows:

- extensibility and recovery
- bending properties
- shear properties
- compression properties
- surface properties (contour and friction)
- pressing performance.
- some forms of dimensional stability

Tensile properties: include extensibility and recovery.

Bending properties: include bending rigidity and recovery.

Shear properties: Shear forces distort a piece of fabric by pushing the top to the right and the bottom to the left or vice versa. The shear force and recovery are important. The force required to extend the fabric in the bias direction can be used to determine the shear rigidity.

Compression properties: Thickness and compressibility are measured under prescribed load. The compressibility is the difference between the thickness under light and heavy loads.

Surface properties

- **Contour:** The amount the surface rises and falls is the contour of the fabric surface.
- **Friction:** The force required to drag an object across the fabric is the frictional force.

Pressing performance

This is a measure of the stability of creases and seams pressed into the fabric during garment making.

Dimensional stability: The aspects of dimensional stability normally measured include those associated with the release of cohesive set (e.g. relaxation dimensional change) or changes in moisture content of the fibres (e.g. hygral expansion).

DEMONSTRATION: FABRIC PROPERTIES

Using the samples of woven fabric (cut in warp and weft, and cut in bias) demonstrate the concepts behind the testing of the following aesthetic properties.

***Tensile properties** — try to stretch each fabric fabric in the warp direction and then in the weft direction.*

***Bending properties** — bend each fabric backwards and forwards with the fold in the warp direction.*

***Shear properties** — try to distort each fabric by pushing the top to the right and the bottom to the left.*

***Compression properties** — lay a piece of fabric on the bench and compress it with your hand.*

***Contour properties** — lay a piece of fabric on the bench and draw the sharp end of a vertical pen across the fabric.*

***Friction properties** — lay a piece of fabric on the bench and draw your finger over the surface of the fabric.*

***Dimensional stability** — show participants the dimensional stability sample and note the process to measure dimensional stability will be covered later in this module.*

REVIEW – DIMENSIONAL (IN)STABILITY

Dimensional stability

Dimensional changes that occur during wear or aftercare, or in response to a change of environment.

- A key aesthetic characteristic — finish stability and wrinkle recovery
- A key functional property — felting shrinkage.

Forms of dimensional instability include:

- relaxation shrinkage and growth
- hygral expansion
- the stability of the finish
- recovery from deformation
- felting shrinkage.

INDICATE THAT dimensional stability describes the dimensional changes that can occur in fabric as a response to a change of environment — during wear or aftercare.

REITERATE THAT dimensional stability is both:

- a key aesthetic characteristic (finish stability and wrinkle recovery)
- a key functional property of fabrics (felting shrinkage).

EXPLAIN THAT there are five forms of dimensional instability in fabrics:

- relaxation dimensional change (shrinkage and growth)
- hygral expansion
- the stability of the finish
- recovery from deformation
- felting shrinkage.

MENTION THAT most of these properties have already been covered earlier in the course.

Relaxation dimensional change
Relaxation dimensional change is the change in dimensions (shrinkage or growth) when a fabric is allowed to relax in water and redried without tension.

Hygral expansion
This property is the change in dimensions of wool fabrics that occurs when the moisture content of the fabric increases. It is reversible — the dimensional change is reversed as the fabric dries out.

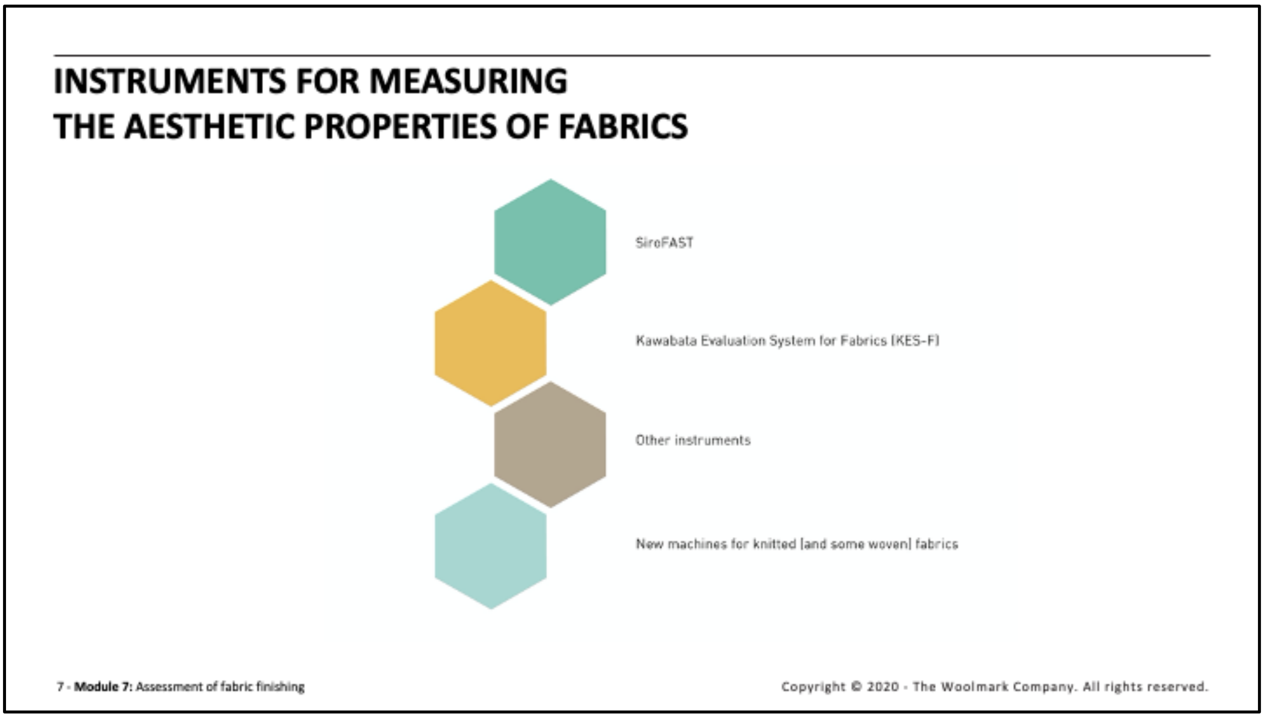
Finish stability
Finish stability is a measure of the change in fabric 'finish' or 'feel' during garment manufacture or use. It can be measured as the change in thickness of a fabric when it is relaxed in water or steam and re-conditioned.

NOTE THE similarity between finish stability and relaxation dimensional change.

Recovery from deformation
Recovery from deformation describes the extent to which a fabric springs back to its original shape when the deforming force is removed. An example is wrinkle recovery.

Felting shrinkage
This is the shrinkage that occurs when fibres move and lock in a new position during washing and is caused by the scale structure of the fibre.

EMPHASISE THAT felting shrinkage is not an aesthetic property of a fabric. it is a functional property. If a garment felts it is effectively destroyed.



EXPLAIN THAT there are several groups of instruments used to measure those properties of fabrics associated with their aesthetic characteristics.

These groups are:

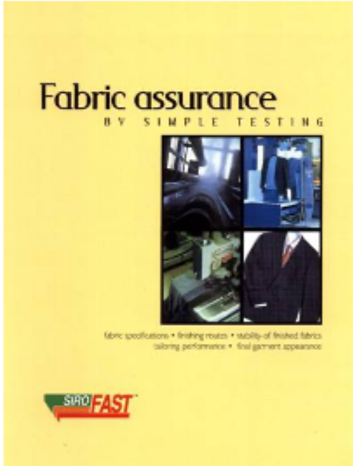
- SiroFAST
- Kawabata Evaluation System for Fabrics (KES-F)
- Other simple and more complex instruments
- New instruments designed for knitted (and some woven) fabrics.

MENTION THAT these instrument groups will now be discussed.

SiroFAST

- A set of instruments developed in Australia.
- Three simple instruments and related test methods.
- Simple to use.
- Suited to a mill environment.

- The SiroFAST software and manuals contain detailed information to guide interpretation of data allowing the evaluation of fabric and the identification and correction of finishing faults.



Source: CSIRO, Geelong

8 - **Module 7:** Assessment of fabric finishing

EXPLAIN THAT SiroFAST is a set of instruments developed by CSIRO Textile and Fibre Technology in Australia. The system uses three simple instruments and related test methods to measure key fabric properties, is simple to use and well suited to a mill environment.

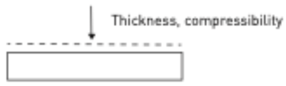
NOTE THAT the SiroFAST software and manuals give detailed information to guide interpretation of data relevant for evaluating and correcting fabrics and several finishing faults.

INDICATE THAT these manuals are available with the SiroFAST system, but the information can be accessed in various publications.

SIROFAST-1: THICKNESS METER

- Measures the thickness of the fabric under two separate loads.
- Determines 'surface thickness' (measure of compressibility).
- Measurements on conditioned fabric:
  - as finished fabric
  - after fabric relaxation.
- Predicts:
  - fabric softness and smoothness
  - fabric 'fullness'.
- Measures:
  - effectiveness of pressing operations
  - stability of the finish.

Source: CSIRO, Geelong



9 - **Module 7:** Assessment of fabric finishing

EXPLAIN THAT the SiroFAST-1 instrument measures:

- the fabric thickness at two loads (0.195 kPa and 9.807 kPa)
- fabric compressibility.

The measurements are made on the conditioned fabric (finished and relaxed). Relaxation is carried out in water after which the specimen is dried and conditioned, or in steam, after which the specimen is re-conditioned.

INDICATE THAT the measures help predict the:

- fabric softness and smoothness — the thinner the fabric, the smoother the handle
- fabric 'fullness' — the thicker the fabric, the fuller the handle.

The instrument also measures:

- the effectiveness of pressing operations — effective pressing operations create a thinner fabric
- the stability of the finish imparted — if the finish is stable, there will be little difference between the initial and the relaxed thickness measurements.

MENTION THAT SiroFAST-1 has introduced new innovations related to thickness measurements.

A proximity meter

NOTE THAT before the development of SiroFAST-1, most thickness meters were based on the movement of a plate, which was brought in contact with the surface of the fabric. The movement of the rod to which this plate was attached was measured using an electrical device called an LVDT, through which the rod passed.

EMPHASISE THAT by using a proximity meter to detect the position of a metal cup before and after the fabric was interposed between the cup and detector, a simpler measurement could be made without the need for moving parts in the detector.

The measurement of surface thickness

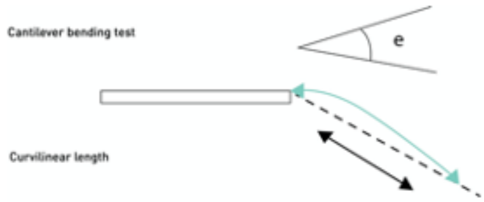
EXPLAIN THAT surface thickness is a measure of the compressibility of the fabric, which is an important measure of one aspect of fabric handle. The surface thickness is defined as the change in thickness in the fabric between the two applied loads — 0.195 kPa and 9.807 kPa.

NOTE THAT measurements have also been introduced to assess the pressing of the fabric during finishing and the stability of the flat press imparted.

SIROFAST-2: BENDING METER

- Measures the bending length (BL) of fabric.
- Used to calculate the bending rigidity (BR) of the fabric:
  - BR (µNm) = W x $(BL)^3$ x 9.81 x 10^{-6}
- Bending rigidity predicts fabric stiffness.
- Bending rigidity is used to derive formability (a predictor for seam pucker).

Source: CSIRO, Geelong



10 - **Module 7:** Assessment of fabric finishing

INDICATE THAT the SiroFAST-2 instrument uses an old concept of 'cantilever bending', which dates back to 1930. The instrument measures bending length (BL) of the fabric.

DEMONSTRATION: CANTILEVER BENDING

***TAKE** a sample of woven fabric, cut square (along warp and weft).*

***LAY** the fabric on a flat bench top and push one end of the sample over the edge of the table keeping the fabric flat on the table surface.*

***NOTE** that the sample 'cantilevers' down and the angle formed between the end of the cantilevered fabric, the edge of the table and the horizontal.*

- *The 'bending length' is calculated from the cantilever length (length of fabric extending over the edge of the bench) and the angle.*
- *At 7.1º, the cantilever length is the bending length.*
- *At 41.5º, the cantilever length is twice the bending length.*
- *At 70º, the cantilever length is three times the bending length.*

REINFORCE THAT the relationship between the cantilevered length (CL) of the fabric and its bending length (BL) depends on this angle at which CL is measured:

- At 7.1º BL = CL
- At 41.5º BL = CL/2
- At 70º BL = CL/3

In the FAST-2 instrument the fabric cantilevers to an angle (shown as θ) of 41.5º. At this angle the curvilinear length of the fabric is twice the BL.

NOTE THAT the Shirley bending meter used in British Standard BS3356 also measures BL using this angle.
From this, bending rigidity (BR) of the fabric, can be calculated using the following formula:
BR (µNm)
= weight per unit area (W) x $(BL)^3$ x 9.81 x 10^{-6}

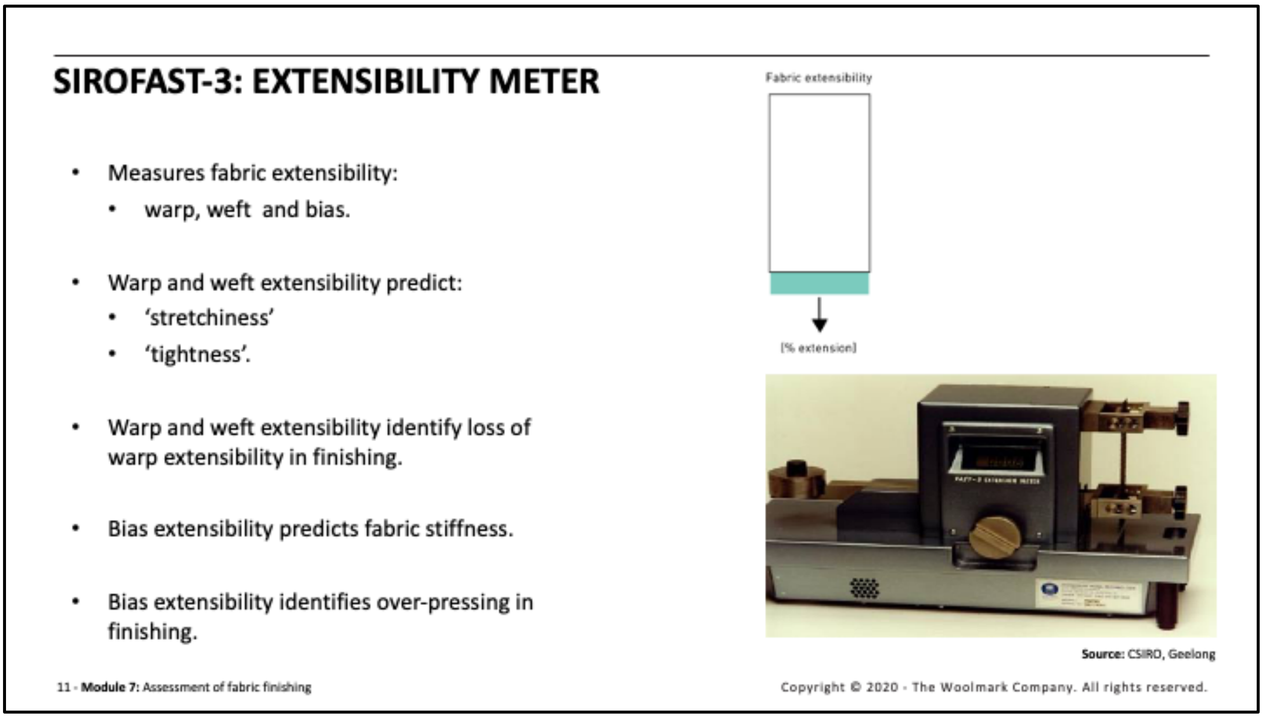
MENTION THAT bending rigidity also predicts:

- fabric stiffness
- whether the fabric has been over pressed during finishing.

Bending rigidity is used to derive 'formability', which is a predictor for seam pucker.

EXPLAIN THAT although the concept of the measurement is old, the mechanisms used in the instrument are have innovative features:

- The instrument mechanically measures the movement of the fabric as it is pushed over the 'edge' to form a cantilever.
- This is more effective than using a ruler on the side of the instrument, which was the case previously.
- In addition, the point at which the fabric crosses the plane of bending is measured using a photocell, rather than by eye using mirrors.
- The old method of measurement (by eye) was difficult and tiring for the operator.



INDICATE THAT SiroFAST-3 measures fabric extensibility of:

- warp and weft direction at three loads — 4.9, 19.6 and 98.1N/m (i.e. 5, 20 and 100gf/cm)
- bias direction at 4.9N/m(i.e. 5gf/cm).

EXPLAIN THAT the innovation in SiroFAST-3 lies in:

- the simple use of a balanced beam to load the fabric
- the use of a proximity meter to measure the movement of the beam.

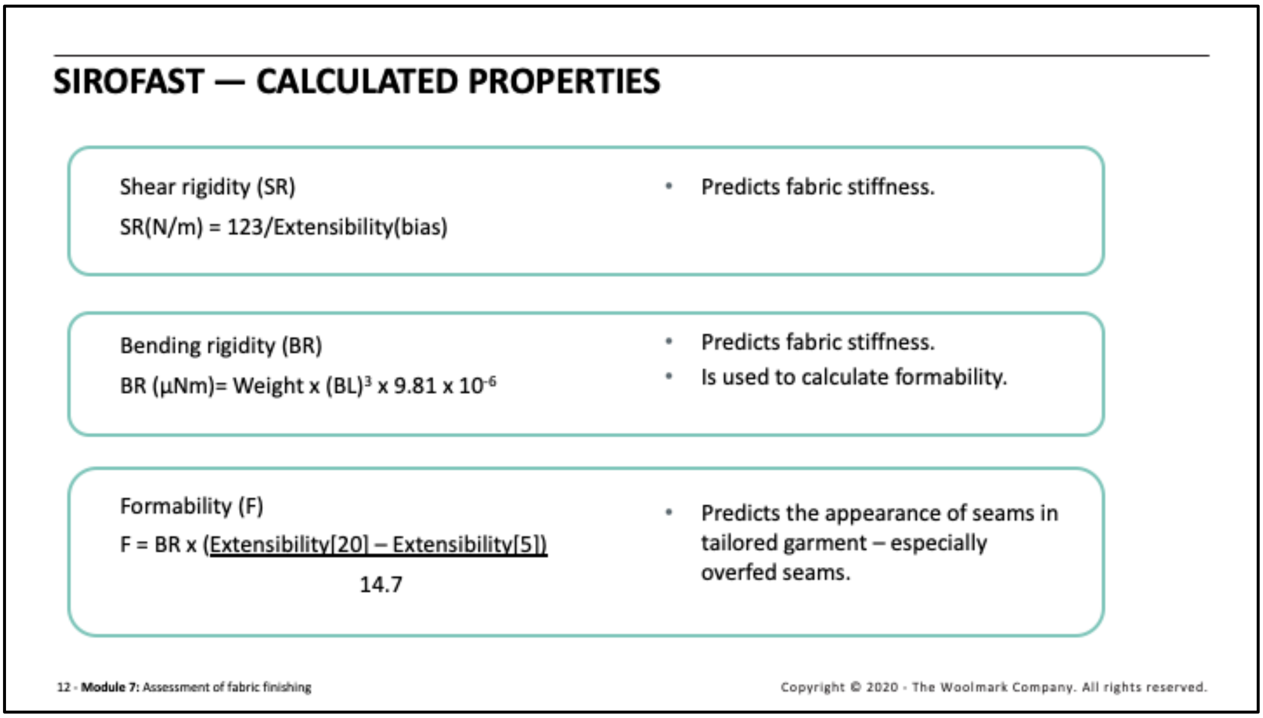
NOTE THAT warp and weft extensibility predicts

- 'stretchiness'
- 'tightness'.

POINT OUT that bias extensibility predicts:

- fabric stiffness
- over-pressing during finishing.

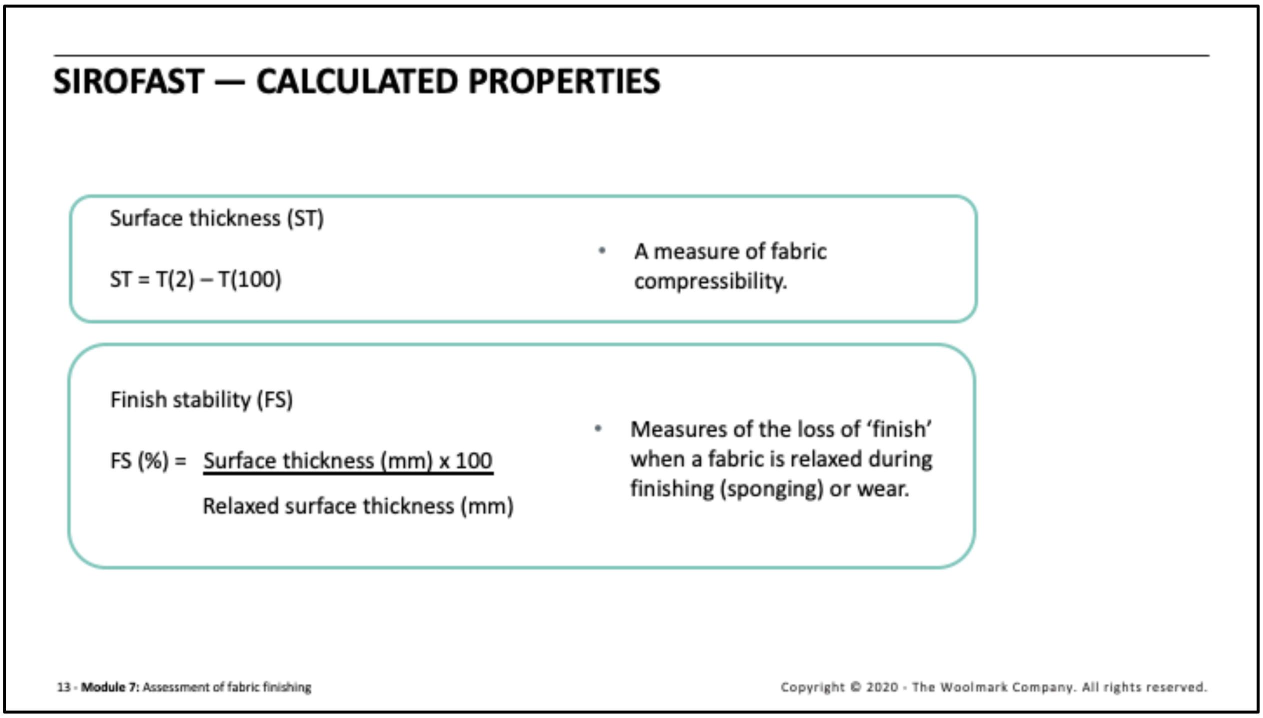
MENTION THAT from bias extensibility, the shear rigidity of the fabric also can be calculated.



INDICATE THAT there are a number of properties that can be calculated from the measurements taken from the SiroFAST Instruments:

- Shear rigidity (N/m) = 123/extensibility[bias]
- Bending rigidity (N/m) = Weight x (BL)3 x 9.81 x 10^{-6}
- Formability (mm^2 x 100) = BR x (extensibility[20] – extensibility[5])/14.7

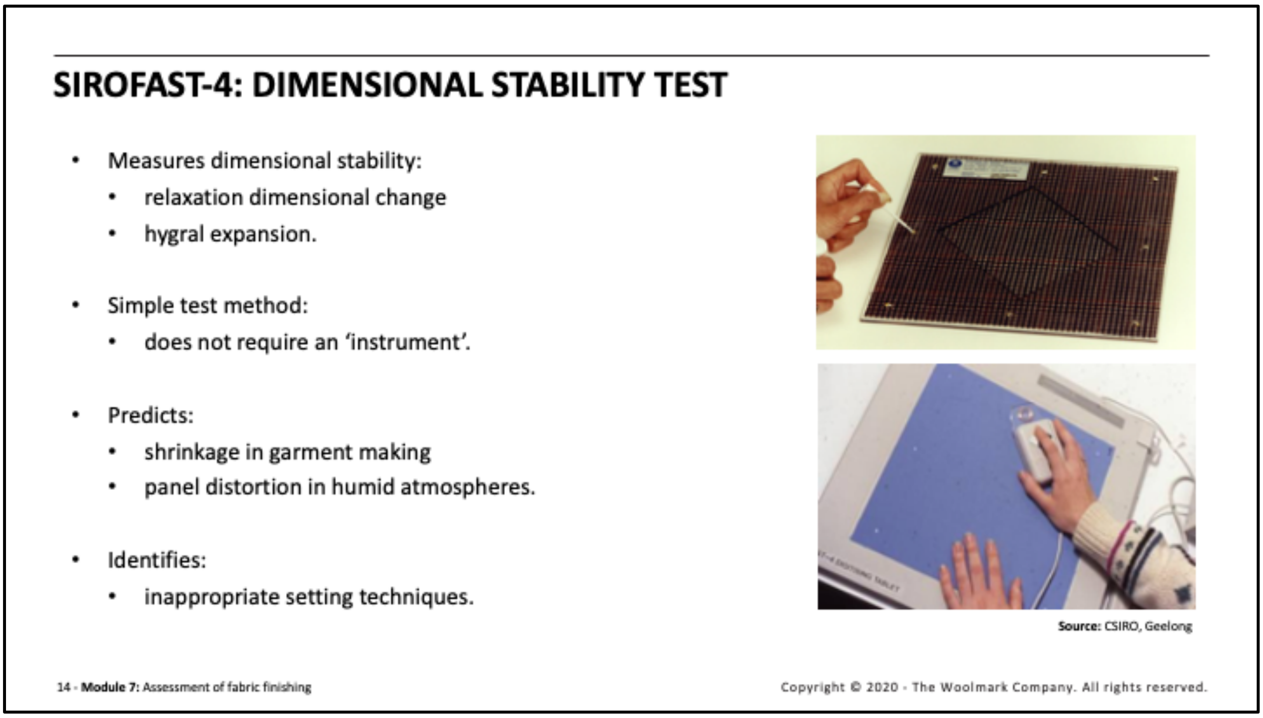
NOTE THAT formability predicts the appearance of seams in tailored garments, especially for overfed seams.



NOTE THAT also calculated from the measured properties are:

- surface thickness — a measure of fabric compressibility
- finish stability (FS)
- $\text{FS (\%)} = \dfrac{\text{Surface thickness (mm) x 100}}{\text{Relaxed surface thickness (mm)}}$

EXPLAIN THAT finish stability measures the loss of 'finish' when a fabric is subsequently relaxed during finishing (sponging) or wear.



POINT OUT that SiroFAST-4 is not an instrument, but a simple test method, which measures two components of the dimensional stability of wool:

- relaxation dimensional change
- hygral expansion.

INDICATE THAT the test method requires the following measurements, made sequentially:

- dimensions oven dry
- dimensions wet
- dimensions oven dry again.

Relaxation dimensional change (DCR)

$$DCR (\%) = \frac{(\text{Initial(dry)} - \text{final(dry)})}{\text{Initial(dry)}} \times 100$$

Hygral expansion (HE)

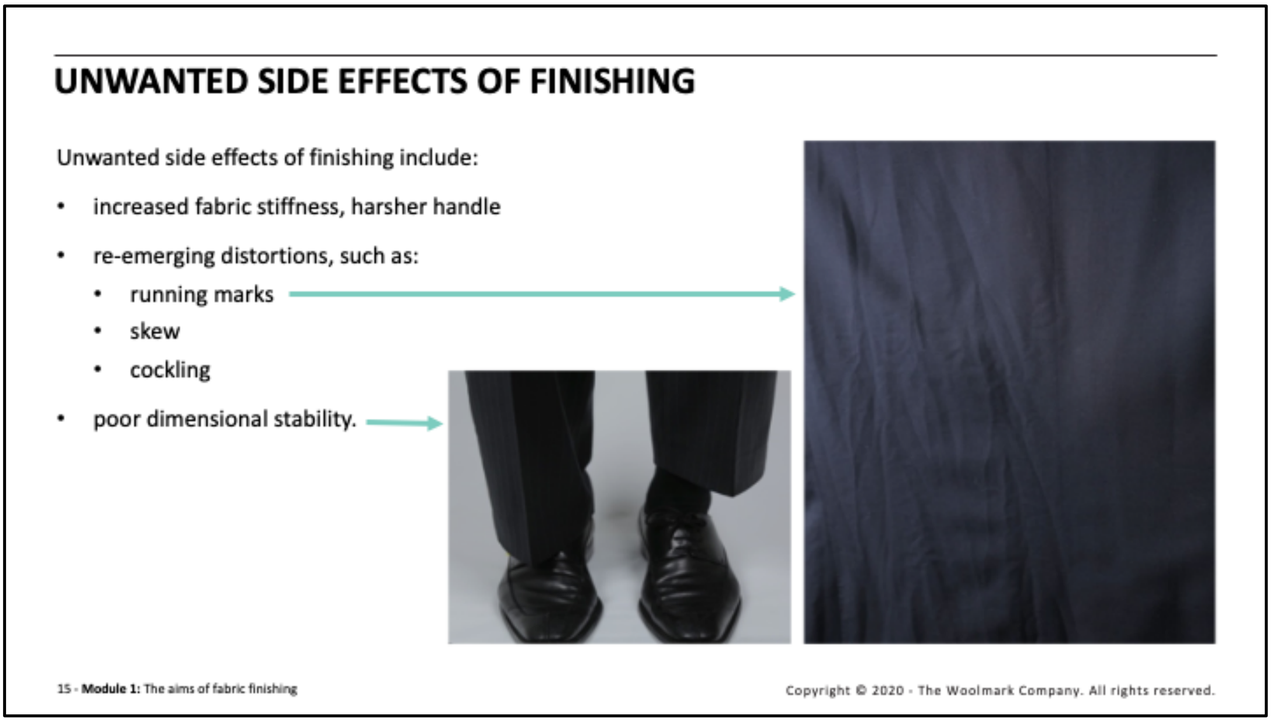
$$HE (\%) = \frac{(\text{Wet} - \text{final (dry)})}{\text{Final(dry)}} \times 100$$

NOTE THAT the SiroFAST-4 predicts:

- shrinkage during garment making
- panel distortion in humid atmospheres.

MENTION THAT the SiroFAST-4 instrument helps to identify inappropriate setting techniques during finishing.

EXPLAIN THAT the dimensions of the fabric at the various stages of the SiroFAST-4 test can also be measured using a digitising tablet (as pictured).

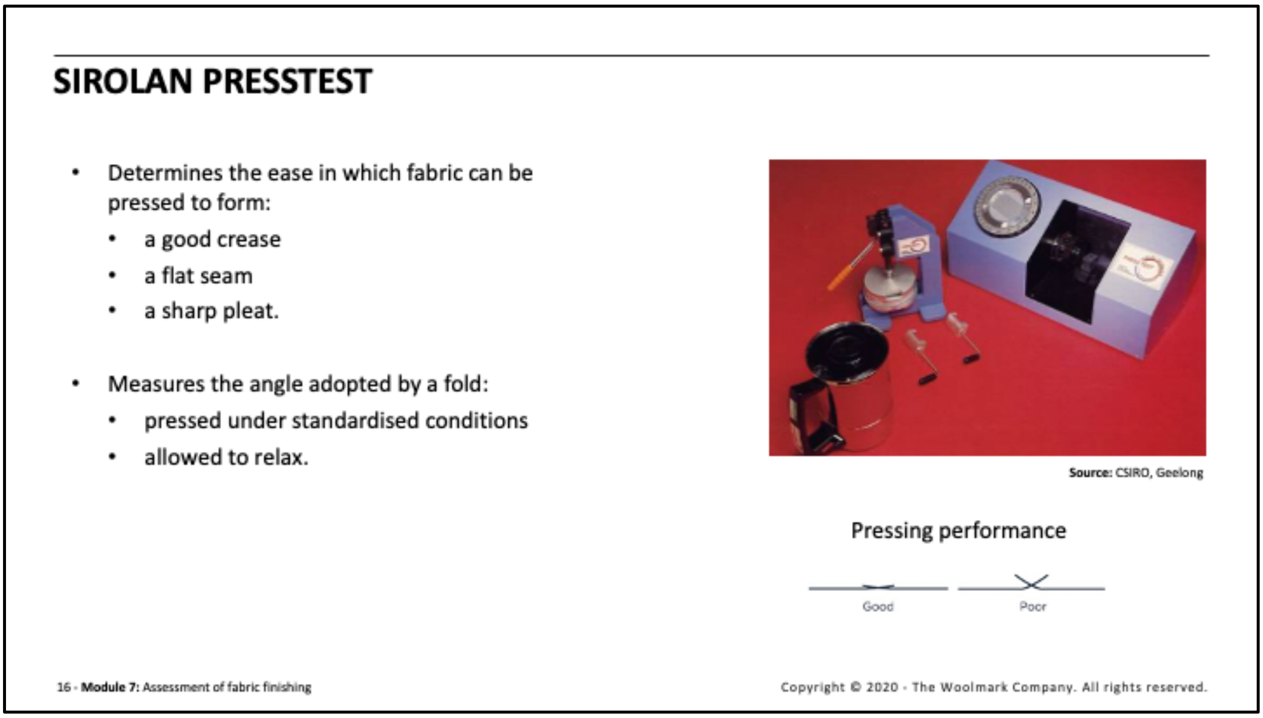


EXPLAIN THAT there can be some unwanted effects of finishing, which must be avoided or at least controlled.

These unwanted effects include:

- increased fabric stiffness, giving a harsher handle than required
- re-emerging distortions, including:
    - running marks (crease marks normally running in the warp direction in finished goods)
    - skew (occurs when weft yarns are straight from one end to another end, but angled across the width of the fabric)
    - cockling (wrinkling or puckering of the fabric)
- poor dimensional stability.

NOTE THAT finishing processes must be managed to maximise the benefits and minimise the unwanted side effects.



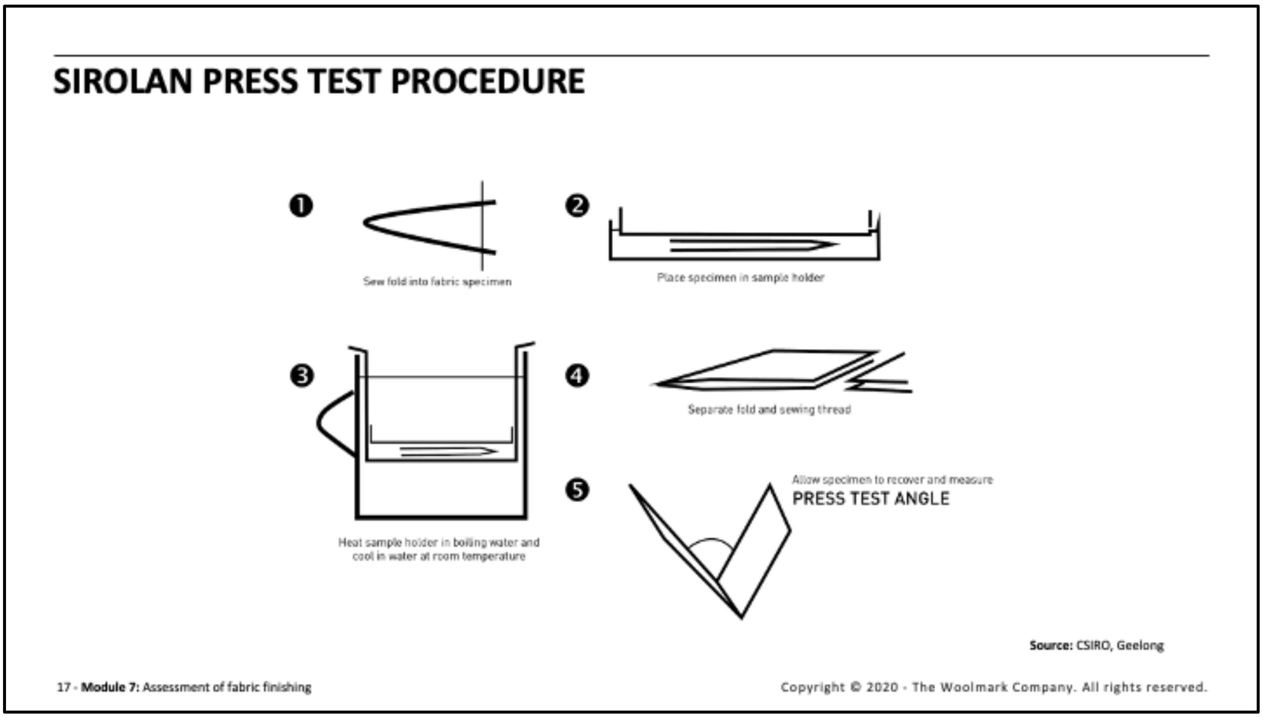
INDICATE THAT the Sirolan PressTest determines the ease in which fabric can be pressed to form:

- a good crease
- a flat seam
- a sharp pleat.

EXPLAIN THAT it does this by measuring the angle adopted by a 180 degree fold pressed under standardised conditions and allowed to relax.

POINT OUT that the innovative process behind the Sirolan PressTest lay in:

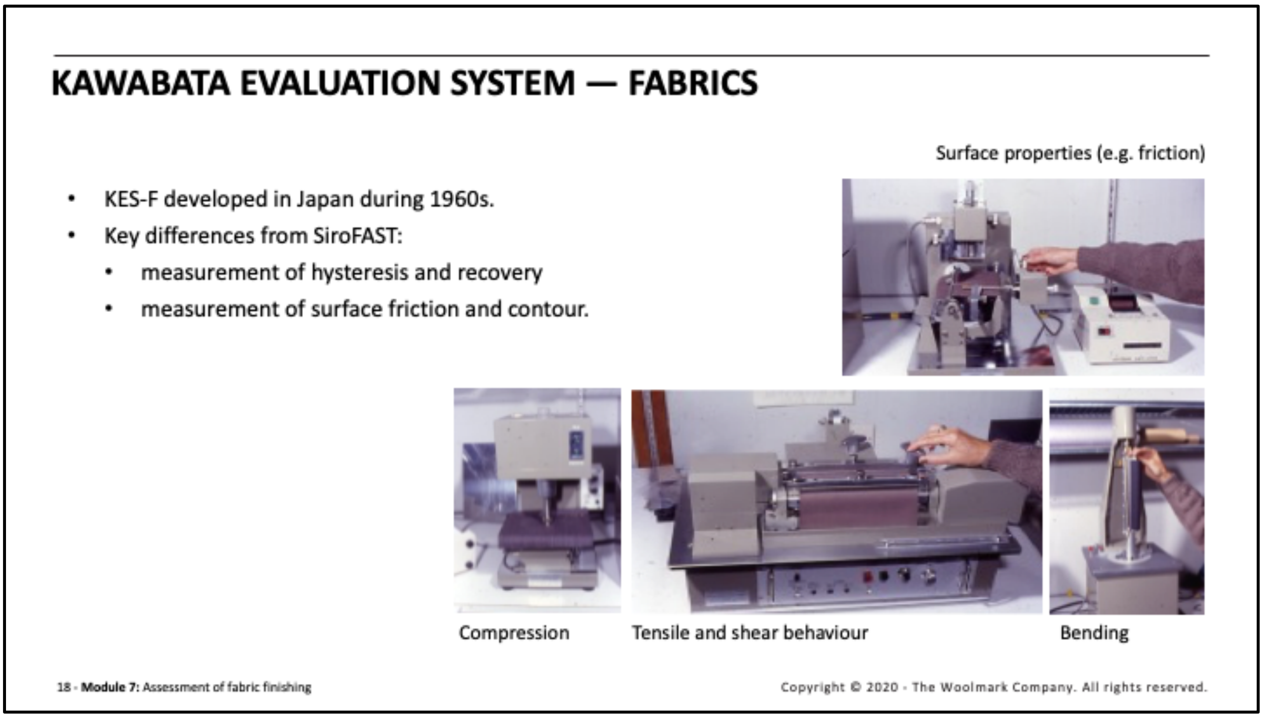
- recognition of the problem
- the development of the standardised way of pressing fabric
- the development of an instrument for measuring the effect achieved
- the development of the background information required to correct the problem in fabrics before they were cut and sewn.



INDICATE THAT the test procedure for measuring pressing performance is illustrated on the slide:

- Sew fold in fabric specimen.
- Place specimen in the sealed sample holder.
- Heat sample holder in boiling water before cooling the sample holder in water at room temperature.
- Separate fold and the sewing thread.
- Allow the specimen to recover and measure the ‘Press Test Angle’.

NOTE THAT the adoption of Sirolan PressTest improved the predictive power of the SiroFAST system and is now an integral part of the system.



EXPLAIN THAT SiroFAST is not the only set of instruments for fabric objective measurement. There is also the Kawabata Evaluation System — Fabrics; also referred to as KES-F.

The KES-F was developed in Japan during 1960s.

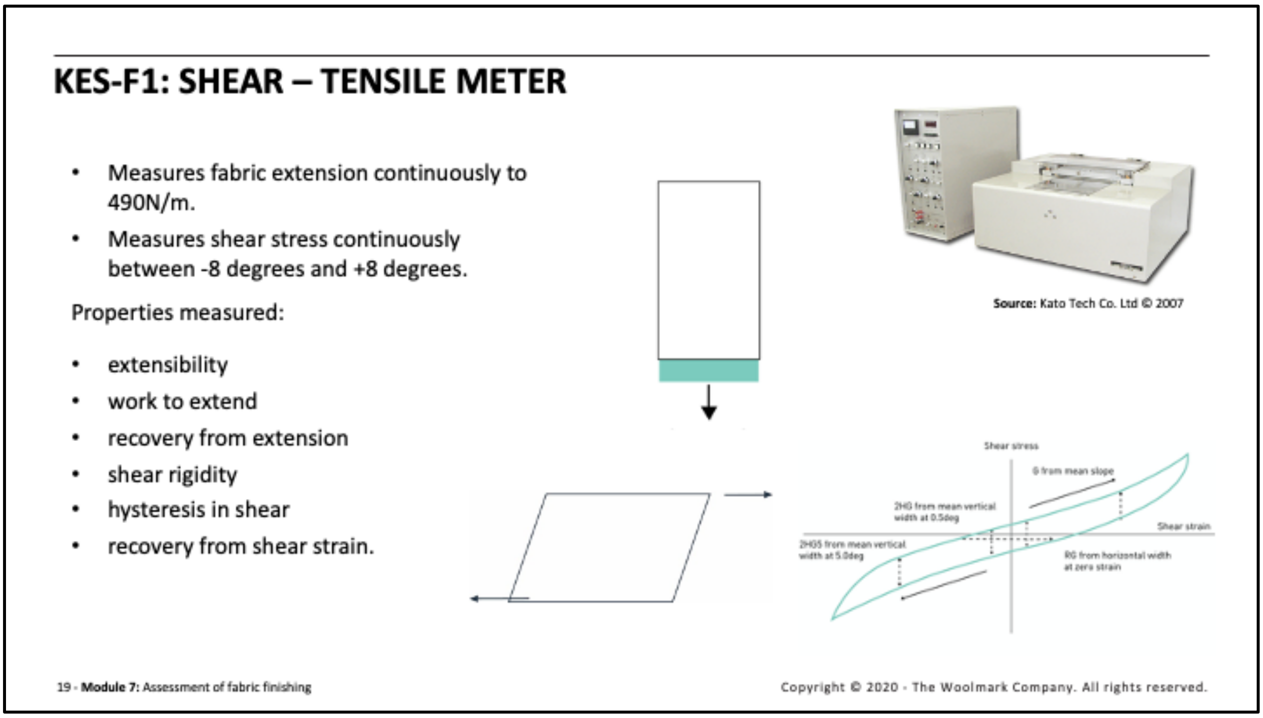
KES-F has four instruments:

- tensile and shear behaviour
- bending
- compression
- surface properties (e.g. friction).

NOTE THAT the key differences between KES-F and SiroFAST are related to:

- measurement of hysteresis and recovery
- measurement of surface friction.

MENTION THAT these differences will be explained later in this module.



INDICATE THAT KESF-1 measures fabric extensibility continuously to a load of 490 N/m (500 gf/cm). It also measures shear stress between -8 degrees and +8 degrees.

NOTE THAT the properties measured by this instrument include:

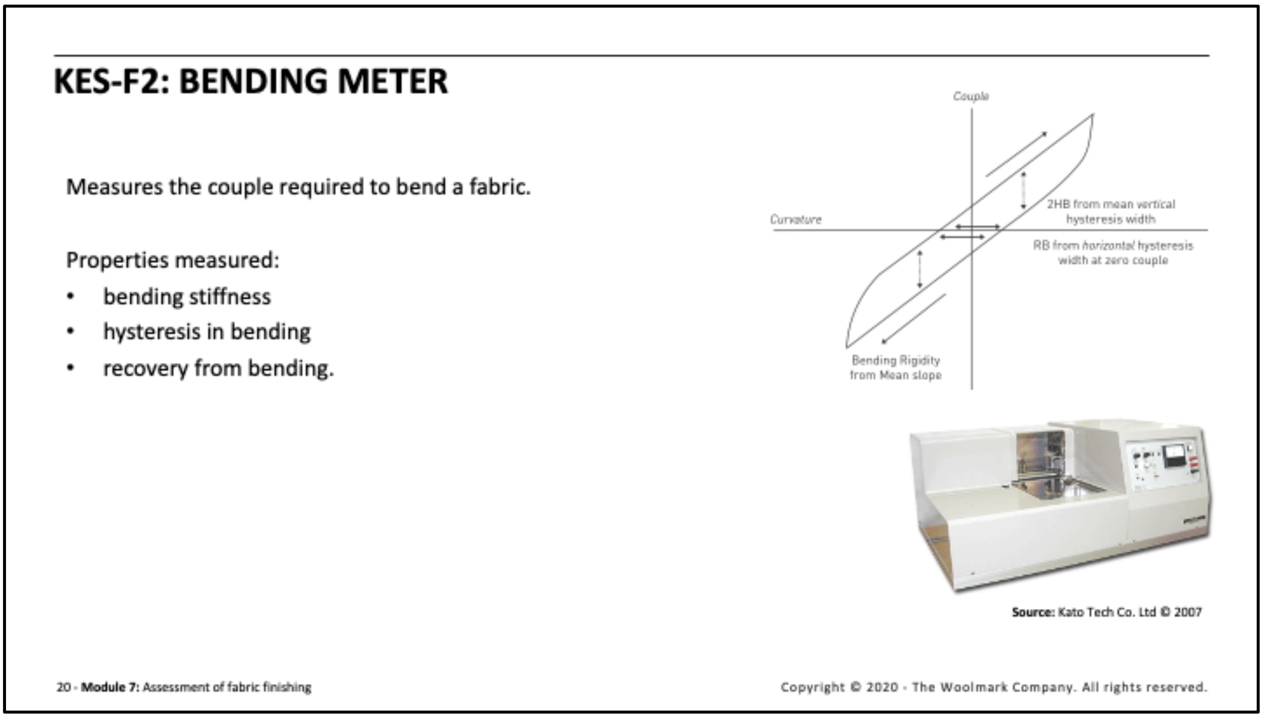
- extensibility
- work to extend
- recovery from extension*
- shear rigidity
- hysteresis in shear: hysteresis is the vertical height between the two curves
- recovery from shear strain**.

EXPLAIN THAT the different parameters are determined from the graph draw by the machine:

- G from mean slope
- RG from horizontal width at zero strain
- 2HG from mean vertical width at 0.5 degrees
- 2HG5 from mean vertical width at 5 degrees.

**Recovery from extension is a measure of the ratio of the work to end the fabric to the energy recovered on recovery. These are determined from the areas under the extension and recovery curves.*

***Recovery from shear is measured as the residual strain in the fabric when the shear load is zero.*



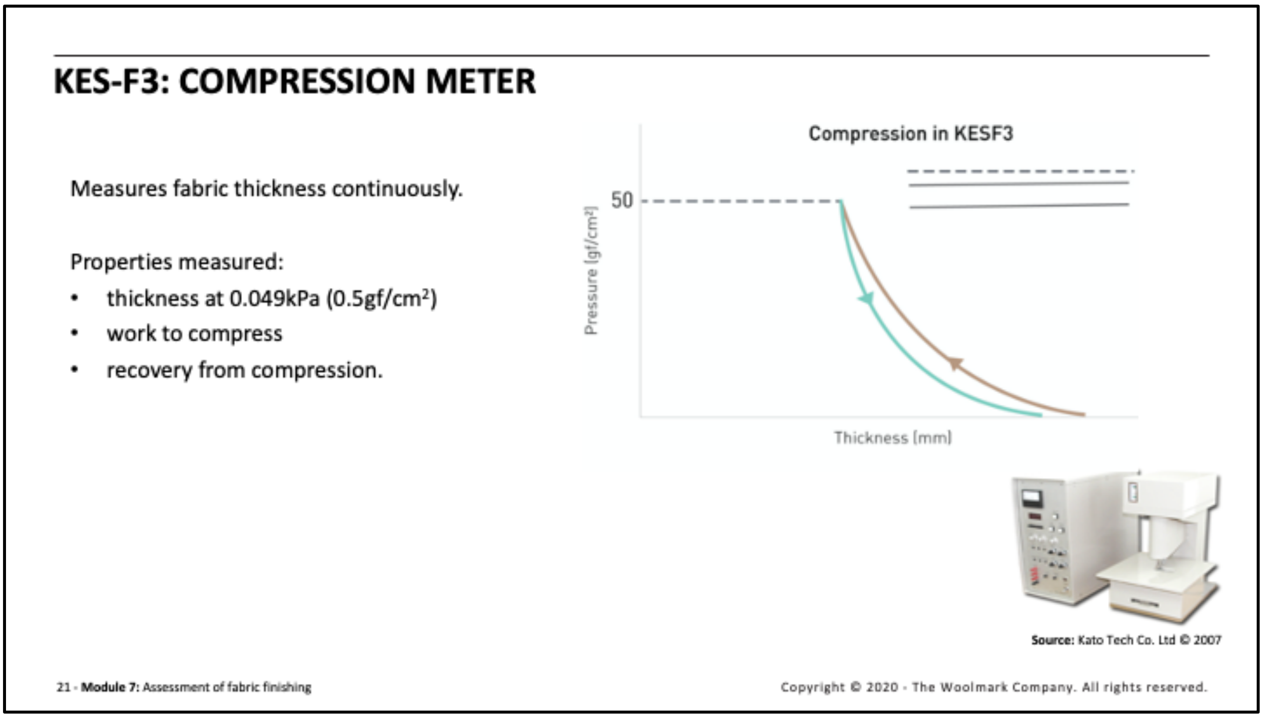
INDICATE THAT KESF-2 measures the couple required to bend a fabric between -250m-1 and +250m-1.

- Couple (µN) — the force used to bend the fabric.
- Curvature (m-1) — the extent to which the fabric bends.

NOTE THAT the properties measured by the KES-F2 are:

- bending rigidity
- bending hysteresis
- recovery from bending.

EXPLAIN THAT bending rigidity is determined from the mean slope. Bending hysteresis is determined from the mean vertical hysteresis width. Residual curvature is determined from horizontal hysteresis width at zero couple.



INDICATE THAT KESF-3 measures fabric thickness continuously to a maximum load of 4.9kPa (50gf/cm2).

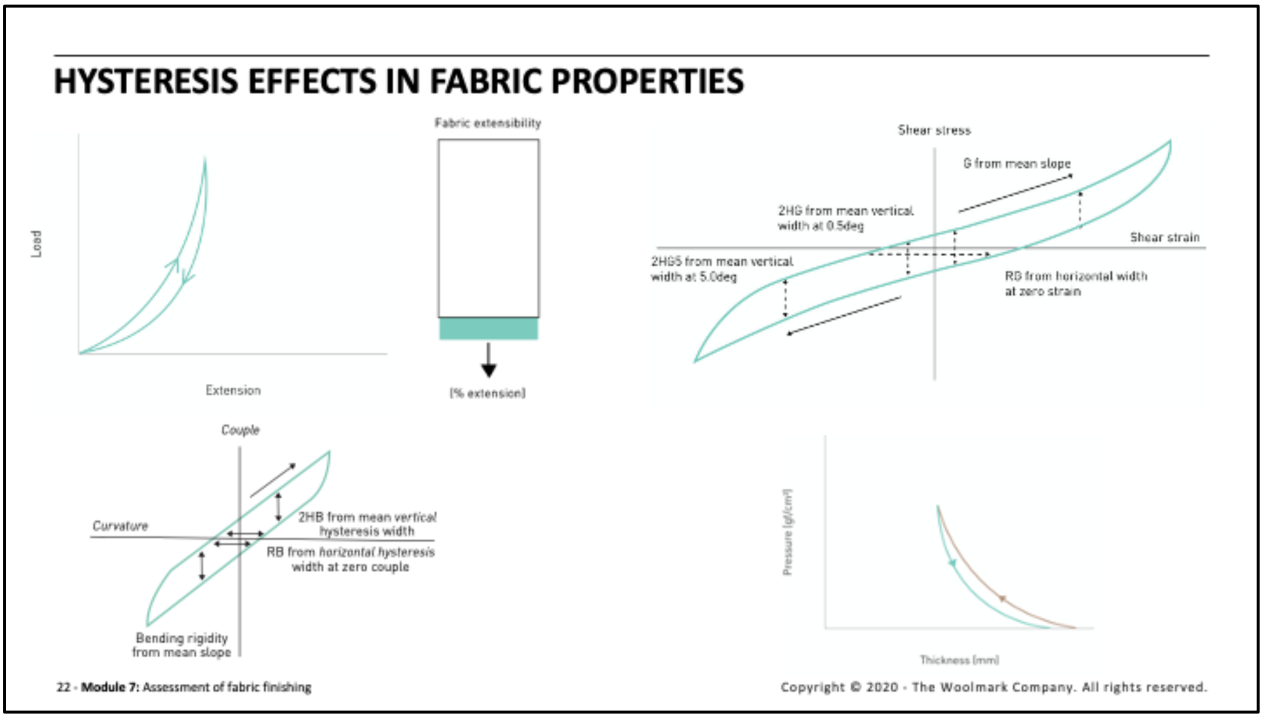
NOTE THAT the properties measured by the KES-F3 are:

- thickness at 0.049kPa (0.5gf/cm^2)
- thickness at 4.9kPa (50gf/cm^2)
- work to compress
- energy of recovery from compression.

As the pressure increases, the thickness decreases (i.e. compression increases). As the pressure is removed the fabric recovers.

EXPLAIN THAT as illustrated on the slide, the work to compress and energy recovered are determined from the areas under the two respective curves. The area between the curves represents the energy lost.

POINT OUT the thicker the fabric, the more compressible the fabric.



NOTE THAT when a fabric is deformed, the force required for the deformation is greater than the force exerted in the recovery.

POINT OUT that illustrations on the slide show the deformation curves for tensile (top left), shear (top right), bending (lower left), shear and compression (lower right).

EXPLAIN THAT energy is lost in the deformation-recovery cycle. This is the energy associated with:

- the relative movement of adjacent fibres in the yarns during deformation. Polymeric finishes that bind adjacent fibres and prevent their relative movement reduce hysteresis in deformation and improve recovery.
- stress relaxation effects within the fibre, which are affected by ageing processes within the fibre. Aged fibres stress relax more slowly than un-aged fibres.

INDICATE THAT in all forms of deformation, the hysteresis is seen as the area between the curves.

MENTION THAT in tensile and compression tests, the recovery of the fabrics is measured as the ratio of the energy to deform and the energy of recovery.

Resiliency (%) =

$$\frac{100 \times \text{energy of recovery}}{\text{energy to deform}}$$

In bending and shear the recovery is measured directly as residual strain

Residual strain

EXPLAIN THAT in simple deformation (tensile and compression) the residual strain is measured at low load as measurement at zero load is often difficult.

NOTE THAT in cyclic deformation (bending and shear) there is a relationship between the width of the hysteresis and the residual strain

- Residual strain =

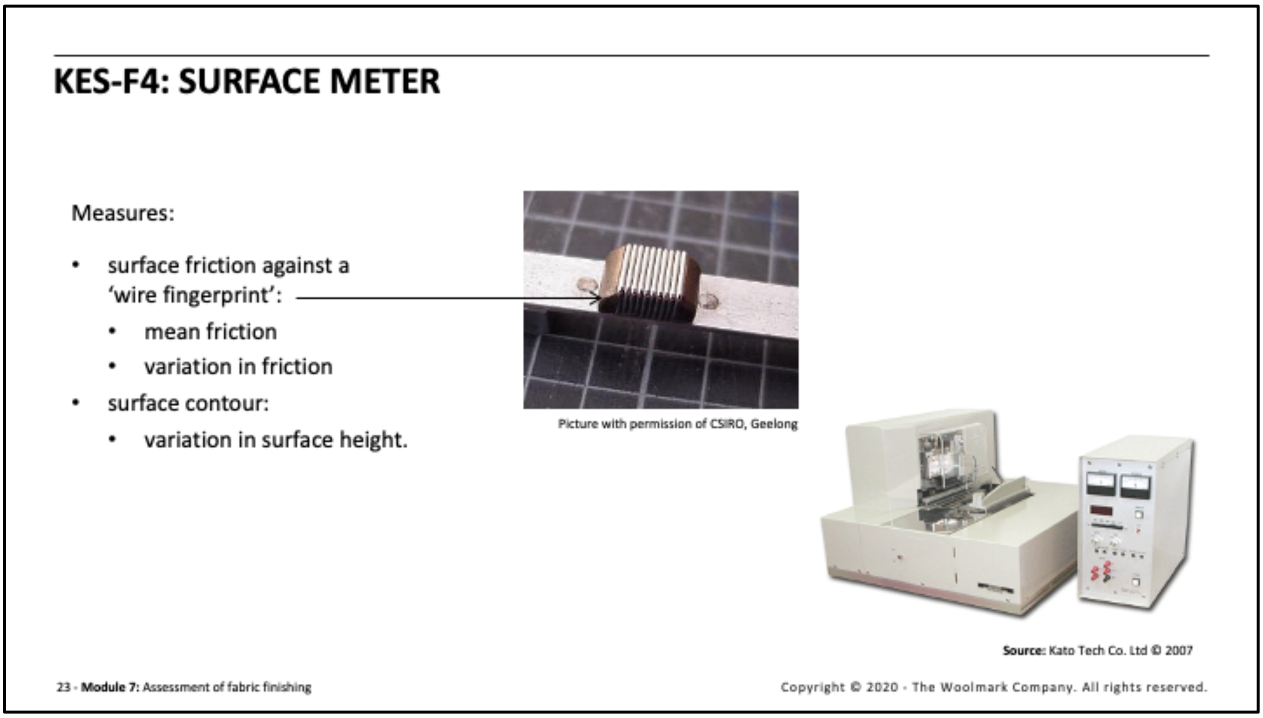
$$\frac{\text{Vertical hysteresis width} \times 0.5}{\text{Modulus of deformation}}$$

INDICATE THAT residual strain has long been proposed as a good indicator of the effectiveness of fabric finishing operations. Well finished fabrics have low residual strain.

POINT OUT that the residual strain gives information on the recovery of the fabric from strains imposed in wear. It can predict some aspects of :

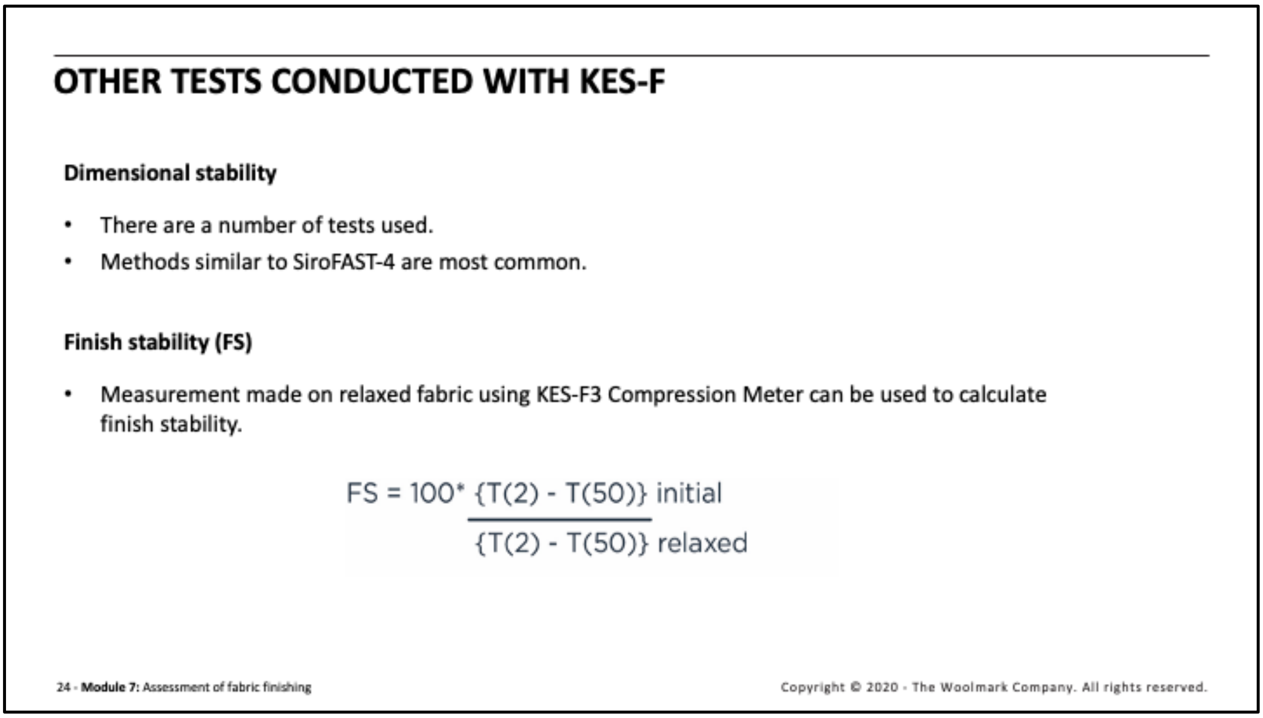
- wrinkling
- bagging.

EMPHASISE THAT wrinkling and bagging are complex properties involving more than just recovery from simple deformation. Nevertheless the residual strain measurement can predict these properties (in part).



INDICATE THAT KESF-4 is a surface meter and measures:

- surface friction against a 'wire fingerprint':
    - mean friction
    - variation in friction
- surface contour
    - variation in surface height.



EXPLAIN THAT two other tests can be conducted as part of the KES-F system — dimensional stability and finish stability.

NOTE THAT these tests are similar to those measured in the SiroFAST system.

Dimensional stability
There are a number of alternative tests that can be used to measure dimensional stability, such as:

- Woolmark test
- Australian standard
- IWTO TM51.

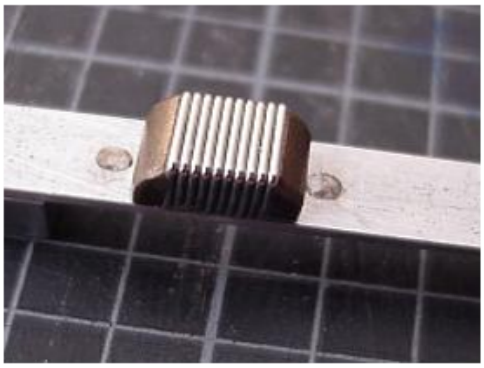
POINT OUT that methods similar to that described in SiroFAST-4 dimensional stability are most common.

Finish stability (FS)
The measurement made on relaxed fabric using the KES-F3 compression meter can be used to calculate finish stability.

$$FS = 100 \times \frac{(T(2) - T(50))\ \text{initial}}{T(2) - T(50)\ \text{relaxed}}$$

DIFFERENCES BETWEEN KES-F AND SIROFAST

- KES-F measures hysteresis – recovery effects in deformation:
  - Useful indicator of potential wrinkling and bagging.
  - Useful indicator of effectiveness of decatising.
- KES-F measures fabric friction and surface contour.
  - Important aspects of handle.
- SiroFAST is simpler to operate:
  - More suitable for mill environment.



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INDICATE THAT KES-F and SiroFAST instruments have differences, as follows:

KES-F measures hysteresis – recovery effects in deformation, where as SiroFAST measures only the deformation properties. Recovery is a useful indicator of potential wrinkling and bagging as well as being a useful indicator of effectiveness of decatising.

MENTION THAT KES-F measures fabric friction and surface contour, whereas SiroFAST does not. Friction and contour are important aspects of handle (smoothness).

NOTE THAT SiroFAST is simpler to operate making it:

- more suitable for a mill environment
- suitable for quality control.

EXPLAIN THAT KES-F is complex, but provides much more information for R&D facilities, such as:

- universities
- product developers.

LIMITS ON KES-F AND SIROFAST

- Designed for woven or non-woven fabrics.
- Not all knitted fabrics can be tested.
- Difficult or impossible to test knitted fabrics that tend to curl (e.g. single jersey).
- For such fabrics other test methods are preferred.

Source: http://www.wildaboutwoolies.com/wild-child-woolies/2011/01/types-of-wool-an-introduction.html

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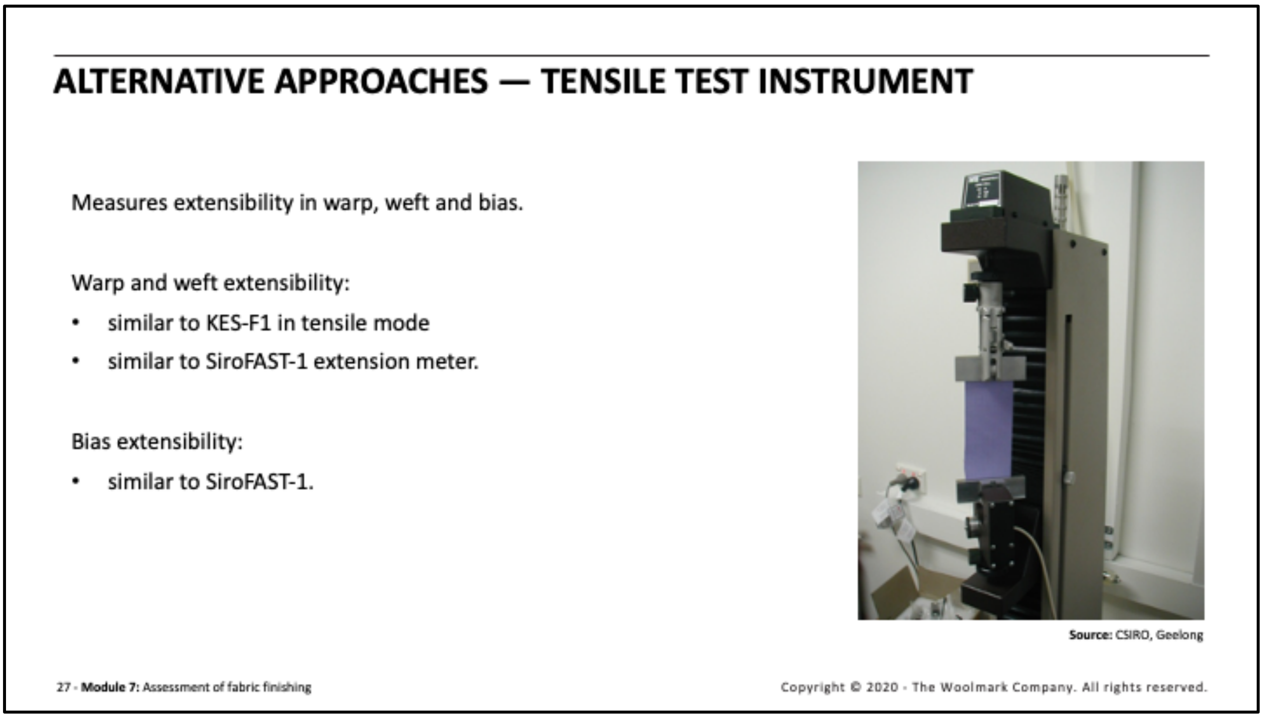
NOTE THAT KES-F and SiroFAST instruments have the following limitations:

- KES-F and SiroFAST were designed for woven or non-woven fabrics.
- Not all knitted fabrics can be tested. It is difficult or impossible to test knitted fabrics that tend to curl (e.g. single jersey). For such fabrics other tests are preferred.



INDICATE THAT other instruments can be used to measure the same or similar properties as those measured by SiroFAST or KES-F.

EXPLAIN THAT almost any 'tensile test instrument' can be used to measure the fabric's extensibility in warp weft and bias direction.

Warp and weft extensibility:

- measures recovery similar to KES-F1 in tensile mode
- measures extensibility similar to SiroFAST-1 extension meter.

Bias extensibility:

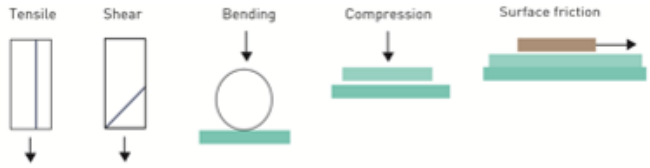
- is similar to SiroFAST-1
- can also measure recovery.

NOTE THAT this simple instrument is rarely used because mills lack the expertise to set the conditions of testing so that the results can be interpreted using the information gained using the SiroFAST or KES-F system.

TENSILE TEST INSTRUMENT

MEASUREMENT CONDITIONS	TENSILE	SHEAR	BENDING	COMPRESSION	FRICTION
Sample length (mm)	76 (100)	76 (100)	38	38	200
Sample width (mm)	13 (50)	13 (50)	19	38	100
Crosshead (mm/min)	1 (10)	1 (10)	10	0.5	10
Displacement (mm)	2 (load)	2 (10)	2	To 2.5g/cm^2	40

Source: Frydrych & Matusiak



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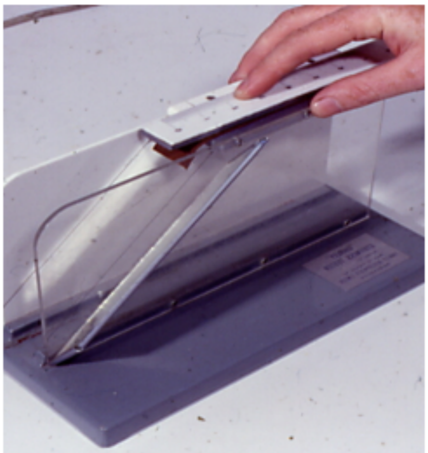
EXPLAIN THAT using the conditions listed in the slide the Tensile test instrument can be also used to measure:

- tensile properties of the fabric
- shear
- bending
- compression
- surface friction.

POINT OUT that this approach is rarely used because mills lack the expertise to set the conditions of testing so that the results can be interpreted using the information gained using the SiroFAST or KES-F system.

SHIRLEY BENDING METER

- Measures bending length according to BS:3356(1961).
- Measurement identical to SiroFAST bending meter.
- Cannot be used on knitted fabrics that tend to curl.



Source: CSIRO, Geelong

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Cantilever bending test

INDICATE THAT the Shirley bending meter BS:3356(1961) measures the bending length of the fabric. The measurement is identical to that measured in SiroFAST bending meter.

EMPHASISE THAT this meter cannot be used on knitted fabrics that tend to curl.

NOTE THAT this instrument is rarely used because mills lack the expertise to set the conditions of testing so that the results can be interpreted using the information gained using the SiroFAST or KES-F system.

POINT OUT that this instrument does not measure recovery from bending.

THICKNESS METER

- Measures thickness at specific loads.
- Measurements can be made at the same loads used in:
  - SiroFAST-1 thickness meter
  - KESF-3 compression meter.

Source: CSIRO, Geelong

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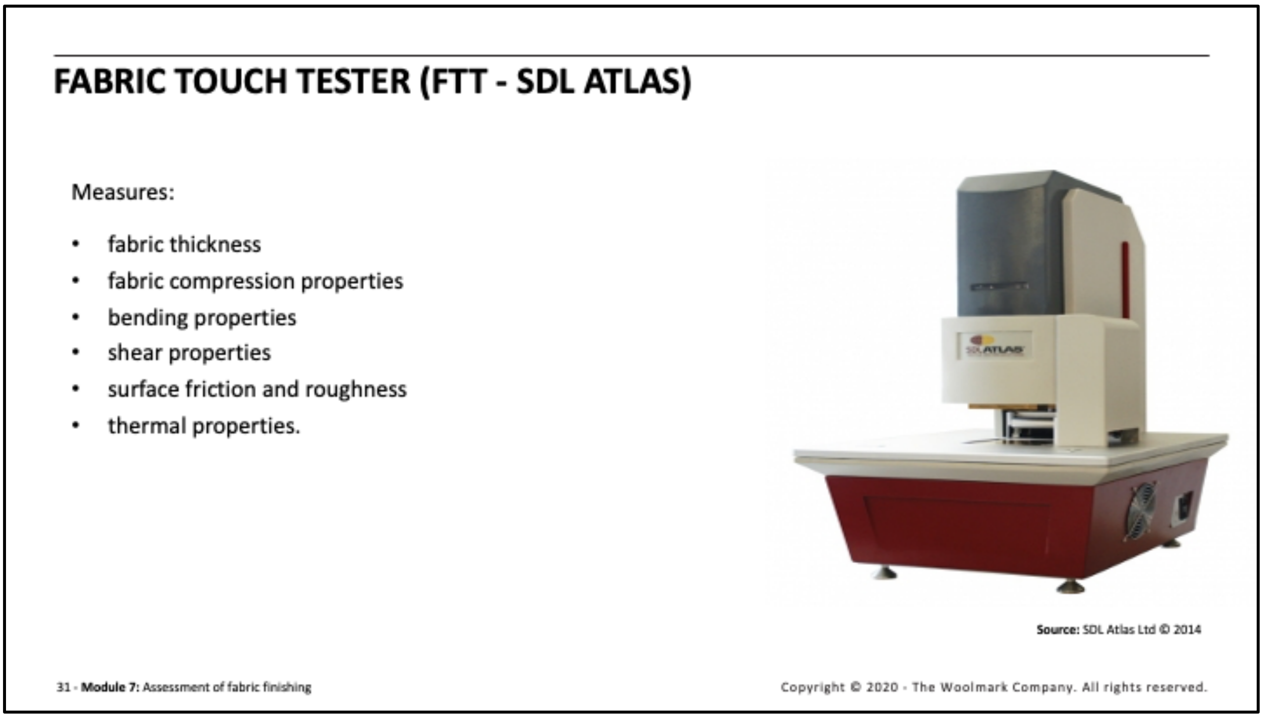
INDICATE THAT the 'thickness meter' measures fabric thickness at specific loads. Measurements can be made that are identical to those measured in:

- SiroFAST-1 thickness meter
- KESF-3 compression meter.

POINT OUT that this instrument is rarely used because mills lack the expertise to set the conditions of testing so that the results can be interpreted using the information gained using the SiroFAST or KES-F system.

NOTE THAT this type of instrument does not measure recovery from compression.



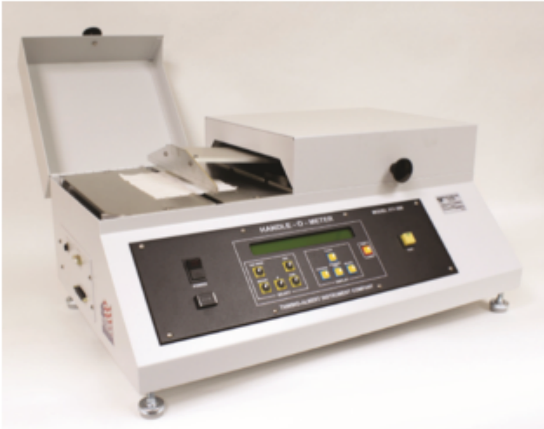
INDICATE THAT the fabric touch tester (FTT) instrument, made by SDL Atlas, can measure:

- fabric thickness
- fabric compression properties
- bending properties
- shear properties
- surface friction and roughness
- thermal properties.

NOTE THAT this is a relatively new machine that has yet to be widely adopted.

More information can be found at https://sdlatlas.com/products/ftt-fabric-touch-tester

THWING-ALBERT HANDLE-O-METER



Source: http://www.thwingalbert.com/handleometer-touch.html

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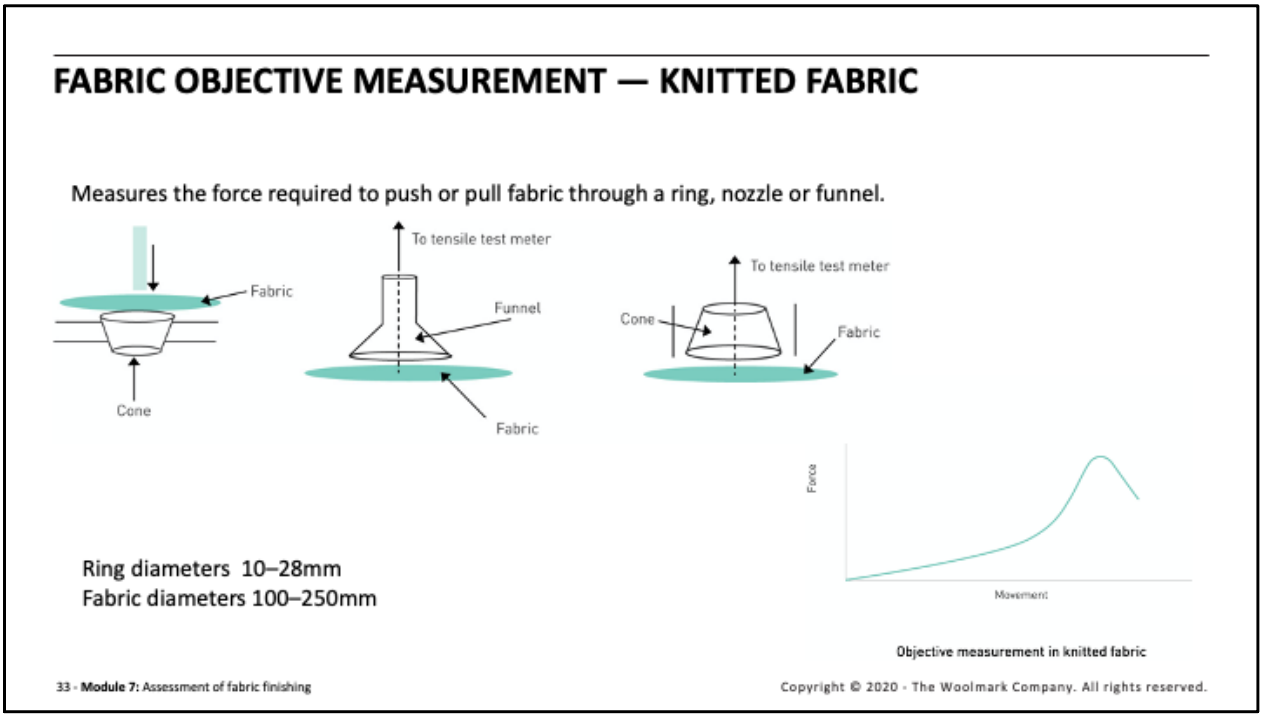
INDICATE THAT this instrument measures the combined effects of fabric flexibility and surface frictional properties.

EXPLAIN THAT the instrument forces the fabric through a slot (that is wider than the specimen) and measures the force required continuously. Rough and stiff fabrics require more force than smooth flexible fabrics.

Information on handle is obtained from the load – movement chart.

NOTE THAT this instrument does not appear to measure recovery effects.

More information can be found at http://www.thwingalbert.com/handleometer-touch.html



INDICATE THAT a fabric objective measurement more suitable for knitted fabric measures the push or pull-through force using a ring, nozzle or funnel.

The diagrams on the slide illustrate how the measurement is taken.

DEMONSTRATION: HANDLE MEASUREMENT

Resource required:

- *sample of knitted fabric*
- *large cut-off funnel*
- *small cut-off funnel*

PULL *the fabric through the large cut-off funnel and then the small cut-off funnel .*

INDICATE *to participants the force required to do this is a measure of the handle of the fabric.*

NOTE THAT *the force required to pull the fabric through the smaller funnel is greater than that required to pull the fabric through the larger funnel.*

EXPLAIN THAT the graph shows the force generated as you attempt to pull a piece of fabric through the cone. The shape and height of the curve can differ according to the fabric. The amount of force generated is assessed at various points to characterise the fabric.

POINT OUT the features of the graph that are measured are:

- the slope
- the maximum
- the inflection.

NOTE: The higher the number on the y-axis the stiffer the fabric; the lower the number the lower the friction.

MENTION THAT the exact measurements and equations used will depend on what the operator is trying to determine. For example:

- stiffness
- smoothness
- overall handle.

PHABROMETER (NU CYBERTEK INC)

- Measures the force required to push a fabric through an orifice.
- Used for any flat material (paper, textiles etc.).
- The results are compared against a standard set of fabrics.

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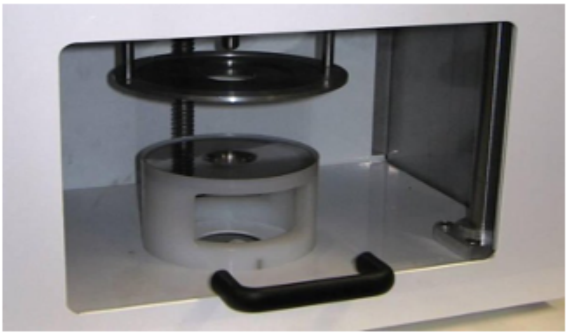
NOTE THAT the Phabrometer instrument made by Nu Cybertek Inc. measures the force required to push a fabric through an orifice.

INDICATE THAT this instrument is used for any flat material (paper, textiles etc.). The results are compared against those of a standard set of fabrics.

WOOL HANDLE METER

- Based on the measurement of force required to push a fabric through a circular orifice.
- Designed for light-weight knitted fabric.
- Handle properties measured:
  - rough – smooth
  - hard – soft
  - loose – tight
  - light – heavy
  - clean – hairy
  - warm – cool
  - greasy – dry
  - overall handle.



Source:http://www.sheepcrc.org.au/images/pages/information/newsletters/1365399444/Wool_HandleMeter_photo_2013_cropped.jpg

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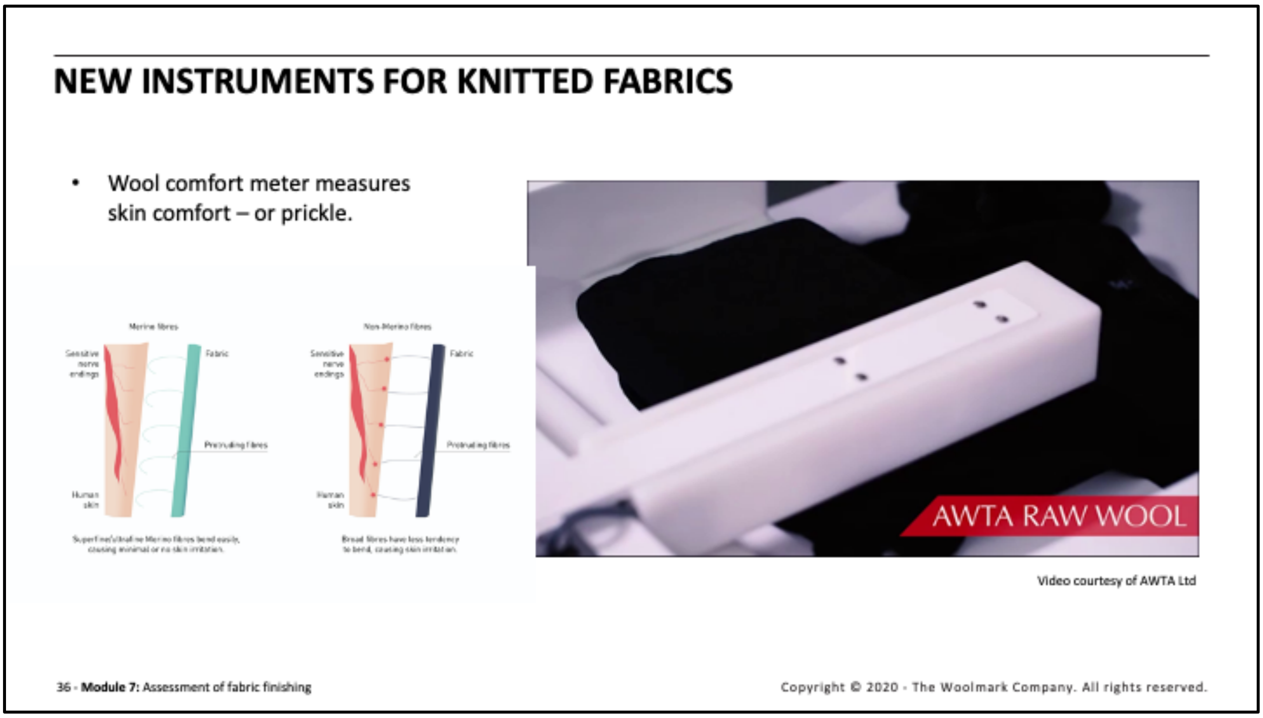
INDICATE THAT during 2012, two new instruments were released for measuring the aesthetic properties of knitted fabric
- wool handle meter
- wool comfort meter.

Wool handle meter

EXPLAIN THAT the wool handle meter measures a number of aspects of handle, based on the measurement of the force required to force a fabric through a circular orifice.
- Rough – smooth
- Hard – soft
- Loose – tight
- Light – heavy
- Clean – hairy
- Warm – cool
- Greasy – dry
- Overall handle.

NOTE THAT this instrument is designed for light-weight knitted fabrics, which are difficult or impossible to measure using KES-F, SiroFAST or other simple instruments.

EMPHASISE THAT the instrument uses a principle similar to that of the Phabrometer, but includes extra weights on the test specimen.



Wool comfort meter
INDICATE THAT the wool comfort meter measures skin comfort or prickle.

EXPLAIN THAT prickle is an unpleasant feeling caused when coarse wool fibres stick into the skin and stimulate pain sensors. The instrument counts the number of 'stiff' fibre ends protruding from the fabric.

NOTE THAT the results have been correlated with extensive wearer trials carried out in Australia and have demonstrated that, while the result of the comfort measurement correlates with mean fibre diameter, there are other determinants of the result such as fabric structure.

HAND OUT *samples of coarse and fine wool fabrics to the participants.*

ASK *participants to lay each sample on their bare arm to determine the difference in feel and the relative 'prickliness'.*

ENCOURAGE *participants to share their responses with the group.*

INTERPRETATION

The key to the effective use of fabric objective measurement is correct interpretation of the data.

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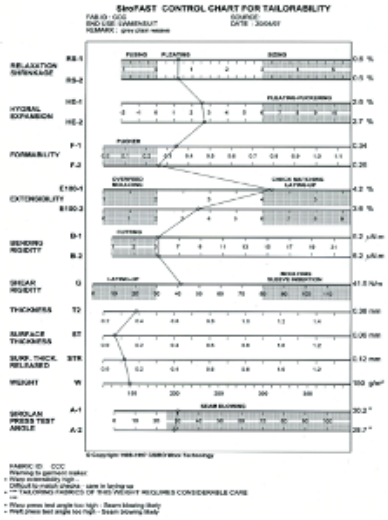
NOTE THAT the key to using fabric objective measurement is not in doing the tests but interpreting the data.

EXPLAIN THAT the effective use of fabric objective measurement requires both close analysis and correct interpretation of the data.

EMPHASISE THAT if an operator is trained on how to use a new instrument it is important they are also trained on how to interpret the results from the instrument(s).

INTERPRETING SIROFAST DATA

- The key is:
  - not in doing the tests
  - interpreting the data.
- SiroFAST data interpreted through the use of a chart or ‘fingerprint’.
- This chart can be used to:
  - evaluate finishing routes
  - identify re-finishing routes
  - identify fabric faults
  - predict the consequences of that fault.



Source: CSIRO, Geelong

38 - **Module 7:** Assessment of fabric finishing

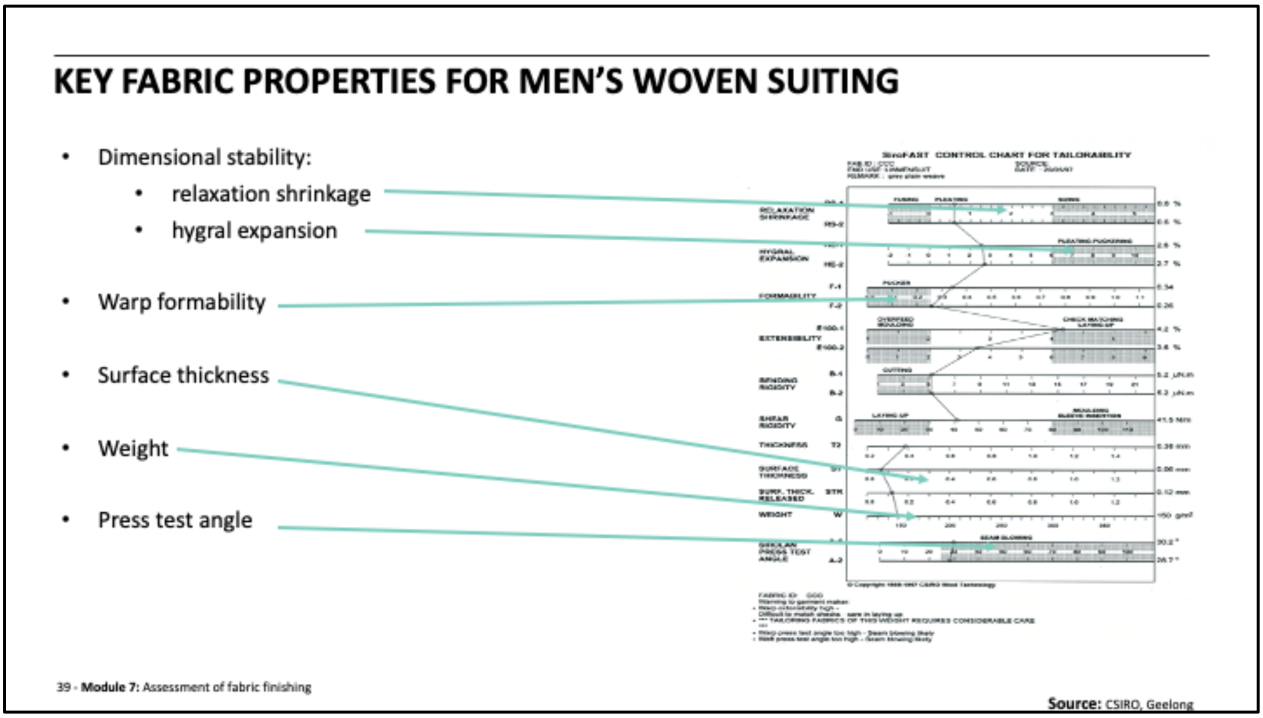
NOTE THAT SiroFAST data is interpreted through the use of a chart or ‘fingerprint’.

EXPLAIN THAT this chart is constructed by plotting the measured values on the chart shown on the slide and joining the dots. The line created is called the ‘fingerprint’ of the fabric.

INDICATE THAT this chart can be used to:

- evaluate finishing routes
- identify re-finishing routes
- identify fabric faults
- predict the consequences of that fault.

***NOTE TO FACILITATOR:** The diagram is explained in more detail on the next slide.*

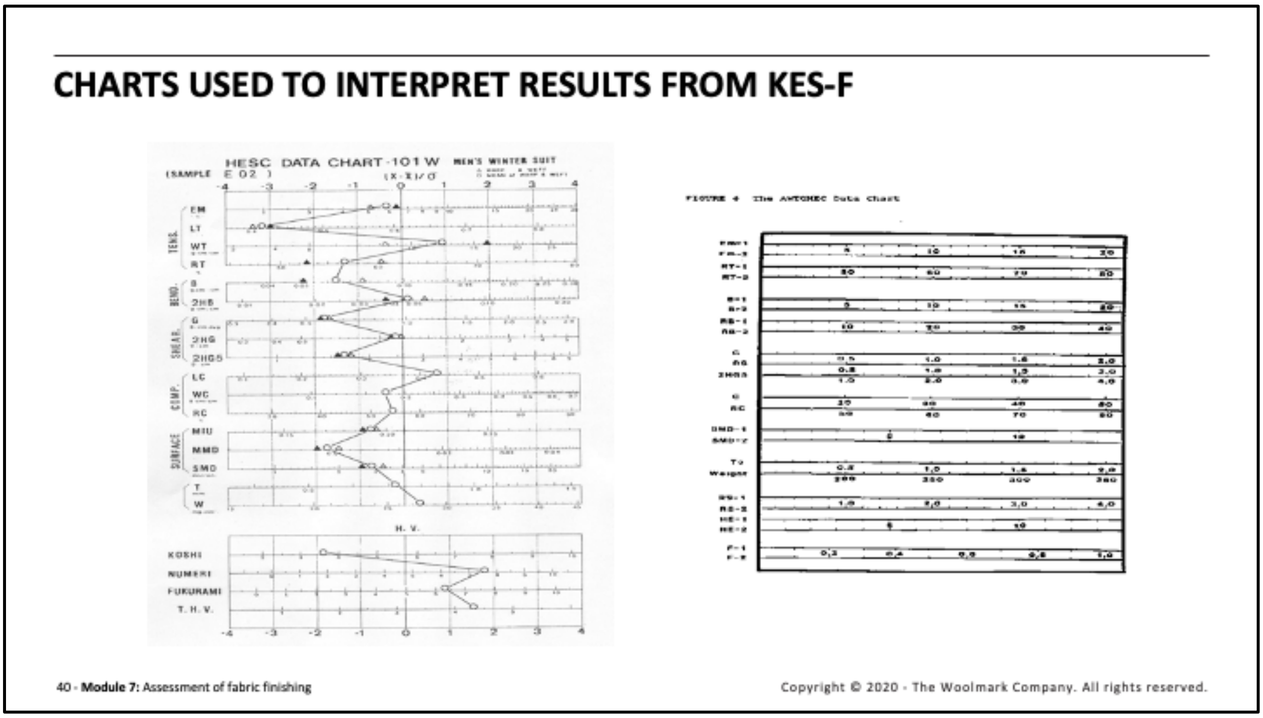


EXPLAIN THAT it is possible to interpret the 'SiroFAST Control Chart for Tailorability', for men's suiting fabric by making reference to the following:

- dimensional stability:
    - relaxation shrinkage – predicting dimensional changes
    - hygral expansion – predicting garment distortion
- warp formability – predicting seam pucker
- surface thickness – predicting finish stability
- weight - predicting ease of manufacture
- press test angle – predicting seam blowing.

NOTE THAT if the fingerprint goes into the shaded zones on this chart then a problem can be predicted in the manufacture of men's suiting and trousers.

MENTION THAT for other product types, different shaded zones are used.



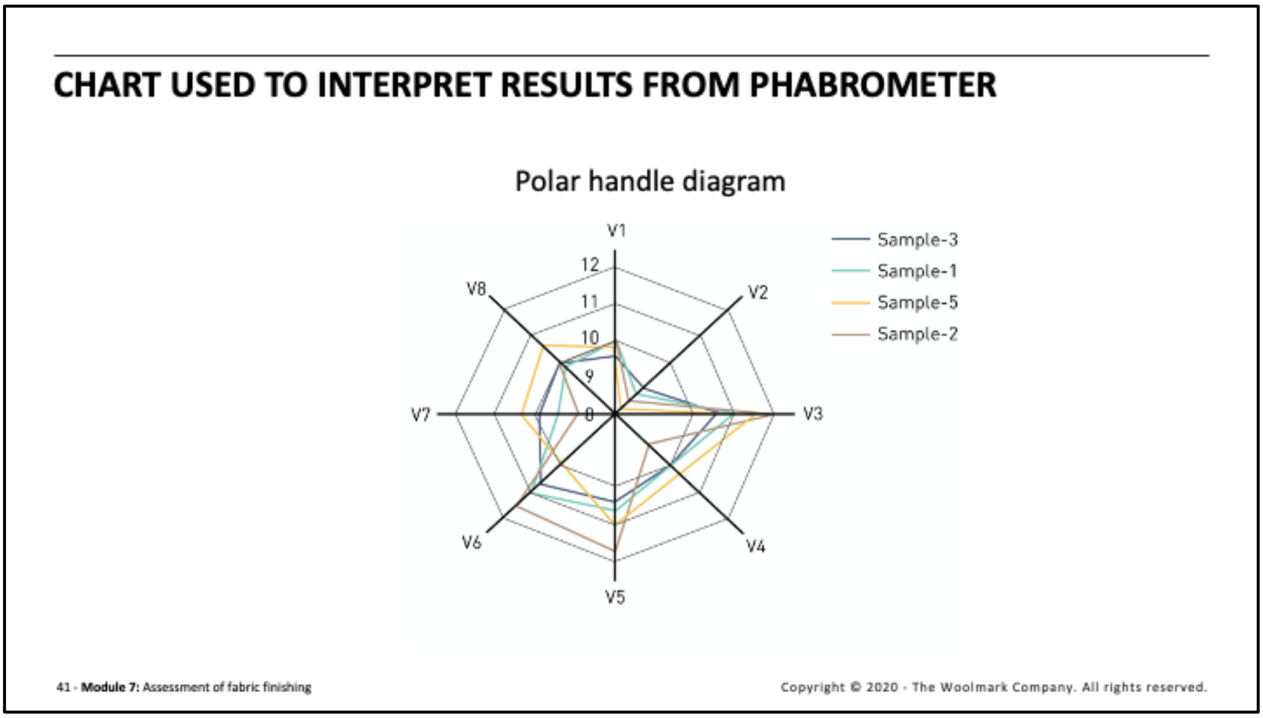
EXPLAIN THAT charts and fingerprints are also used to interpret the results from KES-F.

Different charts have been used to interpret the KES-F data. Two of the most well known are:

- KESF chart used in Japan
- AWTOMEC chart used in Australia

NOTE THAT there are other charts used by individual companies.

INDICATE THAT the shape of the fingerprints must be interpreted to give information on the properties of the fabric and the impact of finishing operations.



INDICATE THAT the chart shown on the slide is used to interpret the results from a Phabrometer (woven and knitted fabric).

NOTE THAT the shape of the fingerprints must be interpreted to give information on the properties of the fabric and the impact of finishing operations.

SUMMARY — MODULE 7

- Functional properties of fabrics are measured using a wide range of standard methods.
- Specialised instruments are available to measure fabric properties related to the aesthetics characteristics:
  - SiroFAST
  - KES-F
  - alternative instruments
  - machine designed for knitted fabrics.
- Interpretation of the results can be complex and is aided by the use of charts and statistical analysis.

42 - **Module 7:** Assessment of fabric finishing

SUMMARISE the module by explaining that functional properties of fabrics are measured using a wide range of standard methods

REMIND participants that specialised instruments are available to measure those properties related to the aesthetics characteristics of fabrics:

- SiroFAST
- KES-F
- Simple and more complex instruments that can be used as alternatives to the SiroFAST and KES-F systems
- Instruments designed for knitted (and some woven) fabrics.

REITERATE THAT ring or cone instruments measure the force required to push or pull the fabric through a ring. These instruments are best suited for knitted fabrics that tend to curl.

REVIEW the fact that interpretation of the results can be complex but is the key to effective use of fabric objective measurement. Interpretation is aided by the use of charts and statistical analysis.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 8 Fabric mechanics* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

BEFORE participants leave ensure you have collected all materials distributed during the lecture.

FABRIC MECHANICS

RESOURCES — MODULE 8: FABRIC MECHANICS

No additional resources are required to deliver **Module 8: Fabric mechanics**

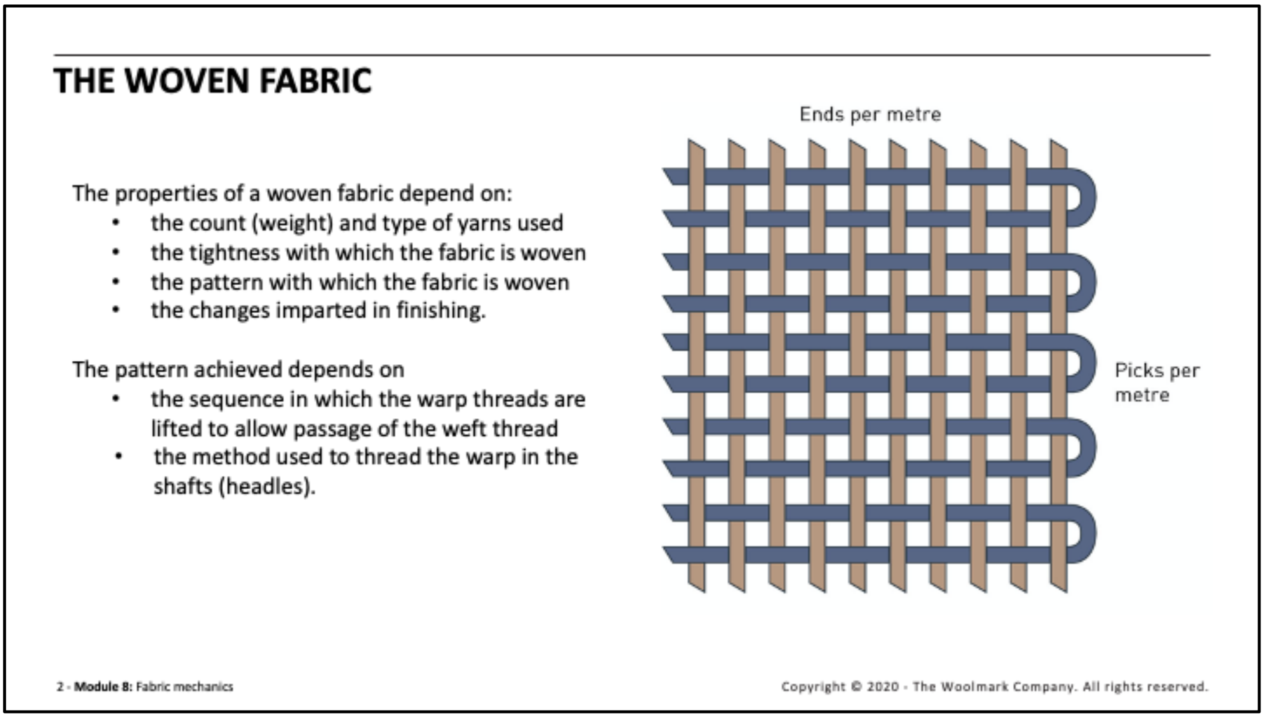
WELCOME participants to Module 8 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Fabric mechanics*.

EXPLAIN THAT this module provides a simple description of the mechanics of fabrics.

INFORM participants that by the end of this module, they should be able to describe:

- a simple model for the description of a fabric to explain its dimensional stability and extensibility
- the application of the simple model to describe the engineering of the dimensions of a fabric and the impact on fabric properties.

NO RESOURCES REQUIRED



INDICATE THAT the settings used in the loom (weaving machine) greatly affect the properties of the fabric; both before and after finishing.

EXPLAIN THAT the structure and properties of the woven fabric depend on:

- the yarn used (type and count)
- the settings in the weaving machine, which determine the tightness of the fabric
    - warp sett (number of warp threads per course width)
    - weft sett (number of weft threads per course length)
    - weave pattern
- the pattern with which the fabric is woven
- the changes to the fabric imparted during finishing.

INDICATE THAT the weave pattern is determined by the sequence in which the warp threads are raised or lowered. This is determined by two factors:

1. The sequence of raising and lowering the shafts or headle frames which, in modern looms, are controlled by a microprocessor.

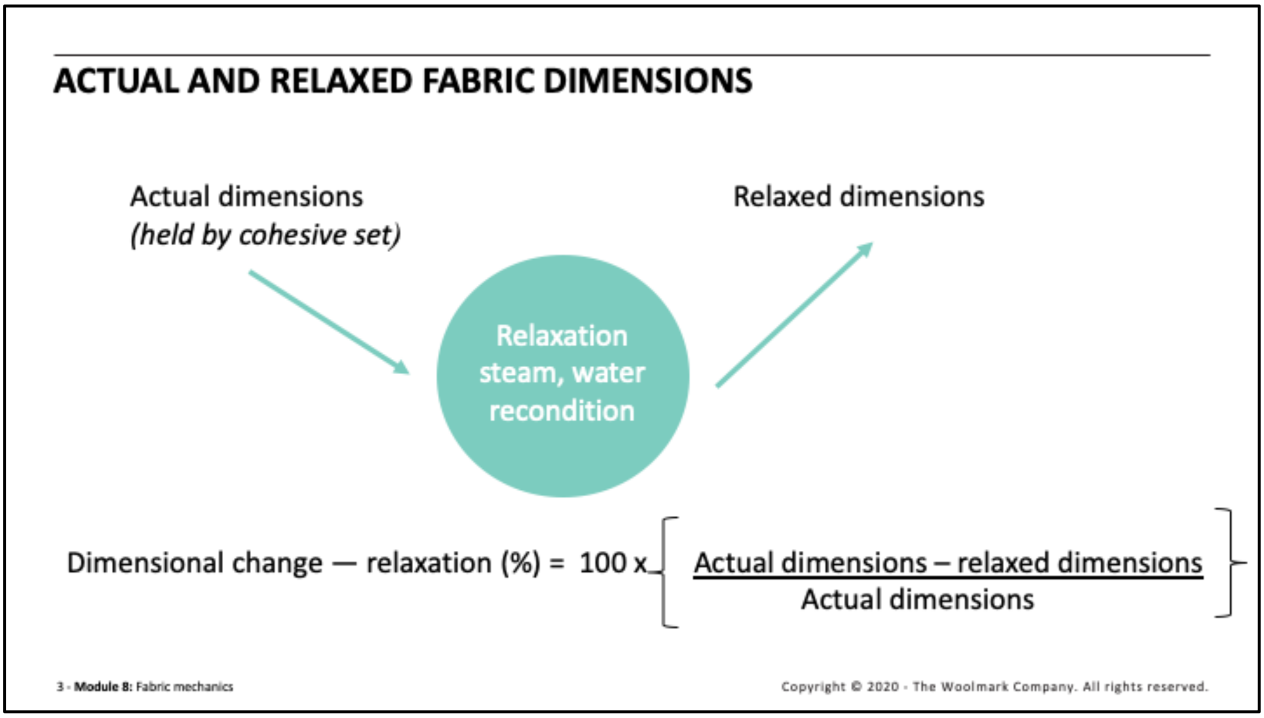
2. The system used to thread the warp yarns though the headles. Normally for a four-shaft loom, the warp would be threaded in the order 1,2,3,4,1,2,3,4,1,2,3,4…. and so on. A range of alternative threading sequences can be used can be used, such as 1,2,3,4,3,2,1,2,3,4,3,2,1…. This can be used to expand the patterning capacity of the four shafts.

EXPLAIN THAT alternatively, a programmable jacquard may be used to control the individual or a large number of small groups of warp threads. Modern jacquards can control every end in the warp individually allowing full width patterning capacity.

In some systems, it is possible to feed in a picture of the desired fabric and the jacquard will organise colours and weave.

NOTE THAT the following measurements are important:

- sett – number of threads per course length (metre)
- ends – warp threads
- picks – weft threads.



EXPLAIN THAT wool fabric can have two dimensions:

Actual dimensions:
These are the dimensions of the cohesively set fabric, as presented in the absence of relaxation.

Relaxed dimensions:
These are the dimensions adopted by the fabric when the fibres are relaxed:

- by immersing in water then drying and reconditioning the fabric without any stress imposed
- by steaming then drying and reconditioning the fabric without any stress imposed.

NOTE THAT the dimensions of wool fibre, yarn and fabric depend on the moisture content of the fibres. All measurements made for wool should only be made after the fibres have been 'reconditioned' in a standard atmosphere (20^{o}C at 65% relative humidity).

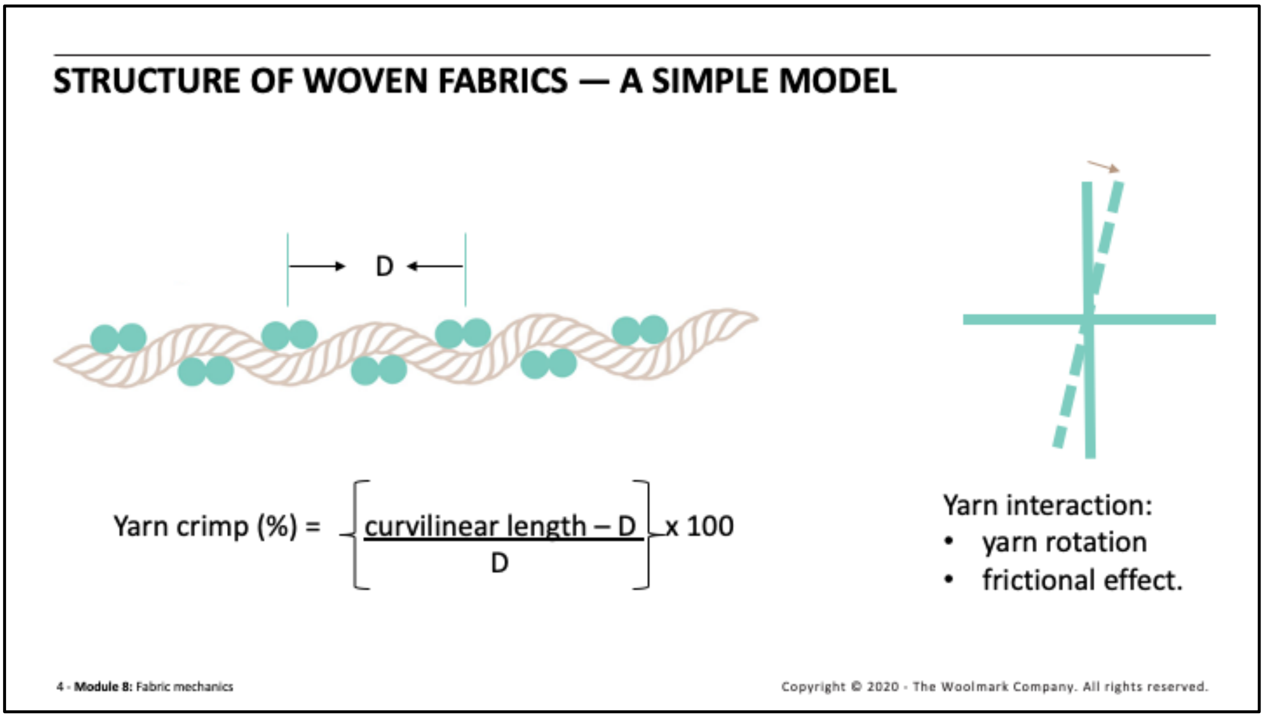
EXPLAIN THAT if the actual dimensions of a fabric are different from the relaxed dimensions of that fabric it can be taken that:

- the yarns are distorted (yarn crimp has changed)
- the yarns and fibres have been cohesively set in their new position.

INDICATE THAT when the fibres are relaxed (wet out or steamed and conditioned) the fabric tends to return to its relaxed dimensions. In some tightly-woven fabrics, friction between fibres and yarns can inhibit full recovery of a distorted fabric.

Dimensional change — relaxation
Dimensional change — relaxation (DCR) (often called relaxation shrinkage) is a measure of the difference between the actual and relaxed dimensions and is calculated by:

$$\text{DCR\%} = 100 \times \frac{\text{actual} - \text{relaxed dimensions}}{\text{actual dimensions}}$$



EXPLAIN THAT when fabrics are woven, the warp and weft yarns are interlaced. Each set of yarns adopts a curved shape as shown in on the slide. The shape depends on the yarn count and the weave adopted.

EMPHASISE THAT the physical behaviour of the woven fabric also depends on the following three parameters:

- the crimp in the yarns
- the interaction (friction) between the yarns at crossover points, for both the actual and relaxed fabric states
- the interaction (friction) between fibres within adjacent yarns.

Yarn crimp

Yarn crimp measures the amount of curvature in the yarn as a percentage and it is the difference between the curvilinear length of the yarn and the thread spacing. Crimp is determined by

- the weave pattern used
- the relative tension in the warp and weft yarns.

As outlined on the slide, yarn crimp can be calculated using the following equation:

- yarn crimp (%) = (YCL-D/D) x 100, where:
    - YCL is yarn curvilinear length (mm)
    - D = yarn spacing (mm)

Typical values for crimp are 0 – 10 per cent.

force required to distort the fabric by extending the fabric in the bias direction (rotating the fabric).

Friction between fibres in adjacent yarns

Friction between fibres in adjacent yarns is more difficult to measure

EXPLAIN THAT when a fabric is extended or bent:

- the shape of the yarns change
- there is relative movement of warp and weft yarns at crossovers
- there is relative movement of adjacent fibres within yarns.

REITERATE THAT all three factors contribute to the force required to distort the fabric and its recovery.

NOTE THAT the finisher can have relatively small effect on yarn crimp, by inducing or allowing changes in the dimensions of the fabric. However, finishing operations can reduce or increase the frictional interaction between yarns at crossover points and the frictional interaction between fibres.

EXPLAIN THAT setting operations reduce this frictional interaction. Pressing and felting operations increase the frictional interaction between yarns.

USING THE SIMPLE MODEL

Aims of finishing:
- to control yarn crimp
- to minimise yarn interaction.

Yarn crimp can be controlled by:
- cover factor (to a large degree)
- weave type (to a large degree)
- finishing route (to a smaller degree).

Yarn interaction is controlled by:
- cover factor(to a large degree)
- weave type (to a large degree)
- fabric setting (to a large degree):
    - low interaction in a well-finished wool fabric
    - high interaction in an unset fabric.

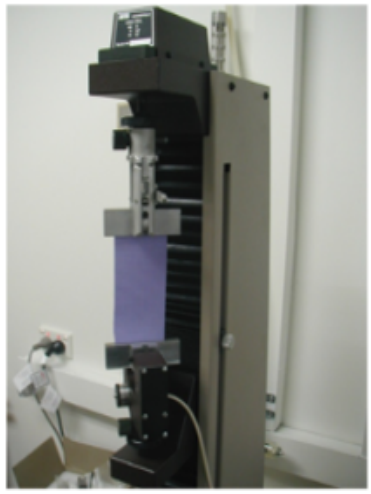


Image courtesy of CSIRO, Geelong

5 - **Module 8:** Fabric mechanics

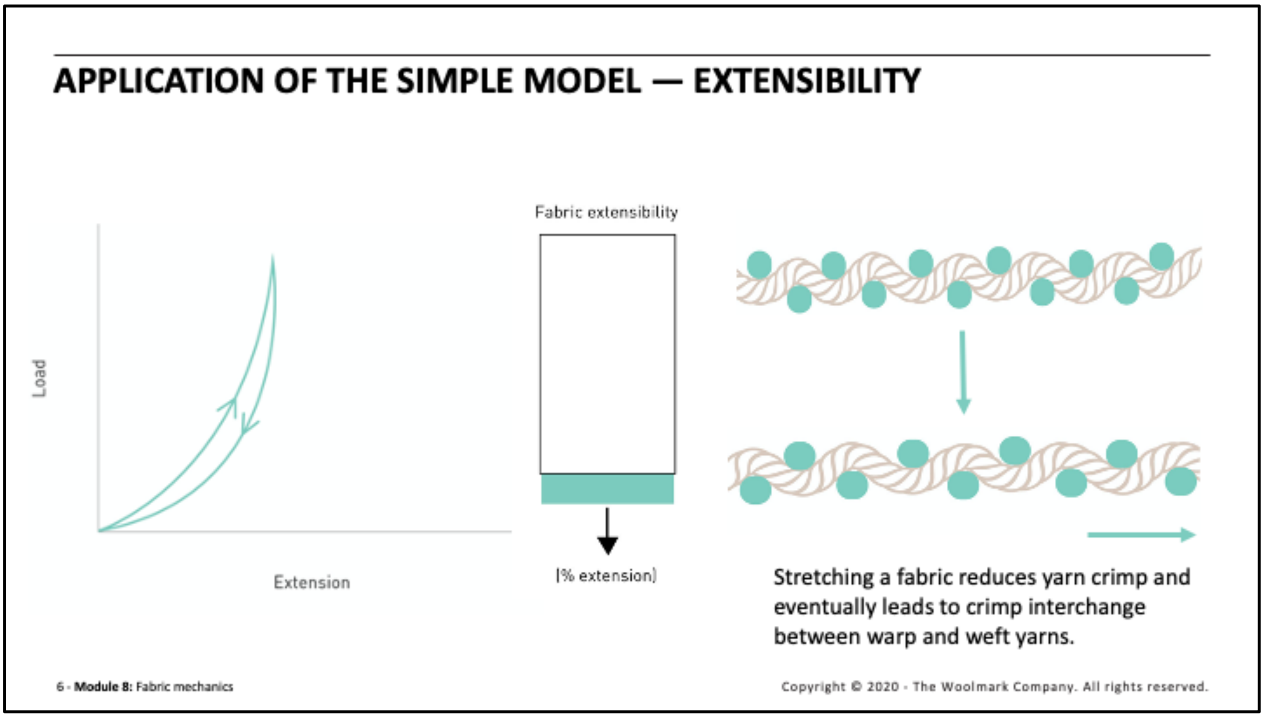
EXPLAIN THAT this simple model can be used to predict or engineer some of the key properties of wool fabrics.

INDICATE THAT by controlling yarn crimp and yarn interaction during fabric finishing, the properties may be engineered – within limits.

EXPLAIN THAT yarn crimp is determined by the:
- cover factor of the fabric — a large effect
- weave type – a large effect
- dimensional control during finishing – a smaller effect.

EXPLAIN THAT yarn interaction is controlled by:
- cover factor — a large effect
- weave type — a large effect
- fabric setting – a large effect.

EMPHASISE THAT to successfully engineer fabric properties the finisher must control both yarn crimp and yarn interaction.



EXPLAIN THAT all fabrics are extensible to some degree in:

- the weft direction
- the warp direction
- the bias direction.

NOTE THAT warp and weft extensibility depend on:

- yarn crimp
- yarn interaction.

POINT OUT that bias extensibility depends on yarn interaction.

EXPLAIN THAT the greater the yarn crimp, the more extensible and formable the fabric. In a well-set fabric, yarn interaction is small.

At low extensions the yarns uncrimp in the direction of extension. This involves the yarns bending, which requires relatively small loads.

The force required depends on the twist in the yarn and the cover factor in the direction of extension.

EXPLAIN THAT as extension increases, the crimp in the yarns in the direction of extension is reduced, and the interaction between warp and weft yarns increases.

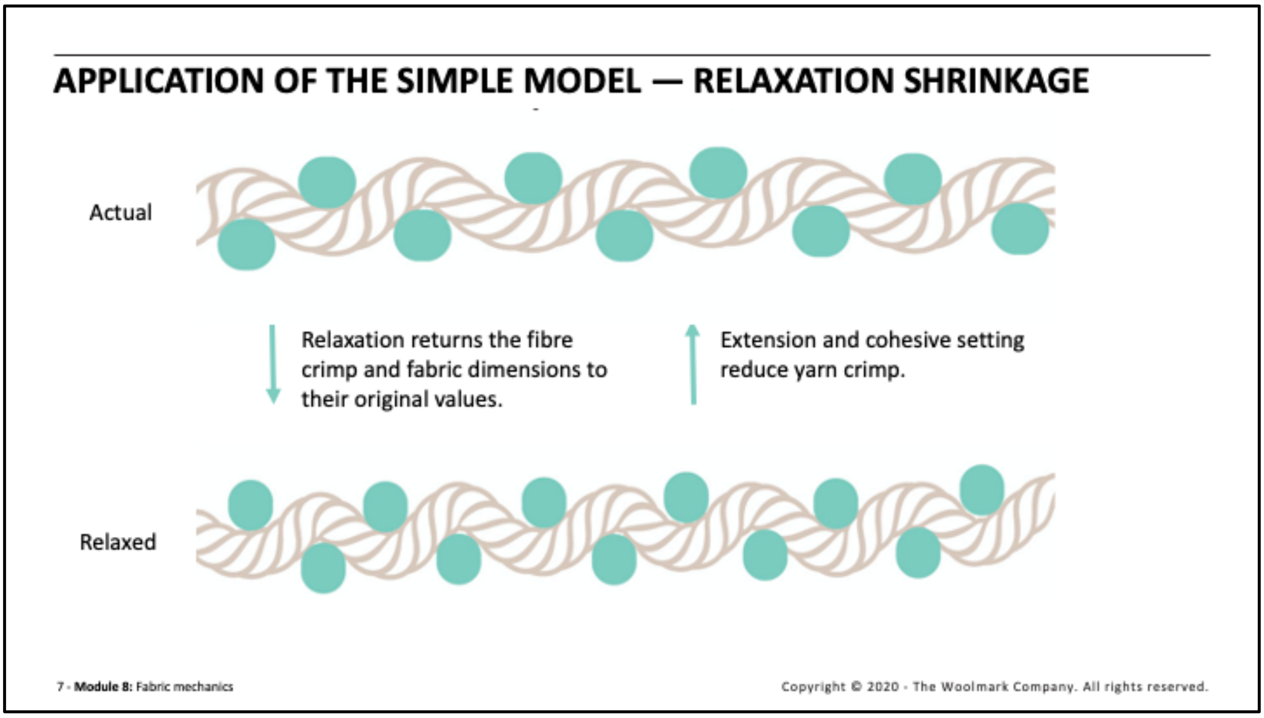
As the extension increases further, the shape of the cross-threads also changes, increasing the crimp in the cross-threads. This is called 'crimp interchange'.

NOTE THAT this simple model assumes a relatively inextensible yarn, which is true for most wool and wool-blend fabrics, although some modern fabrics have highly extensible yarns derived from blends of wool and elastane. In such fabric the extensibility also depends on the extensibility of the individual yarns.

REINFORCE THAT with these principles in mind, the extensibility of the fabric depends on:

- the initial crimp in the yarns in the direction of extension (high crimp makes for highly extensible fabric)
- the initial interaction between warp and weft yarns at crossover points (permanent setting reduces the interaction between warp and weft yarns and increases fabric extensibility)
- the extensibility of the yarns, which is high in elastane blends.

Note that the bias extensibility of fabric involves rotation of the yarns at the crossover points and depends primarily on yarn interaction at crossovers. As the yarn interaction changes during finishing, the bias extensibility of the fabric also changes.



REITERATE THAT when a fabric is extended (or forced to contract) and cohesively set at new dimensions, a difference is created between the actual (set) and relaxed dimensions.

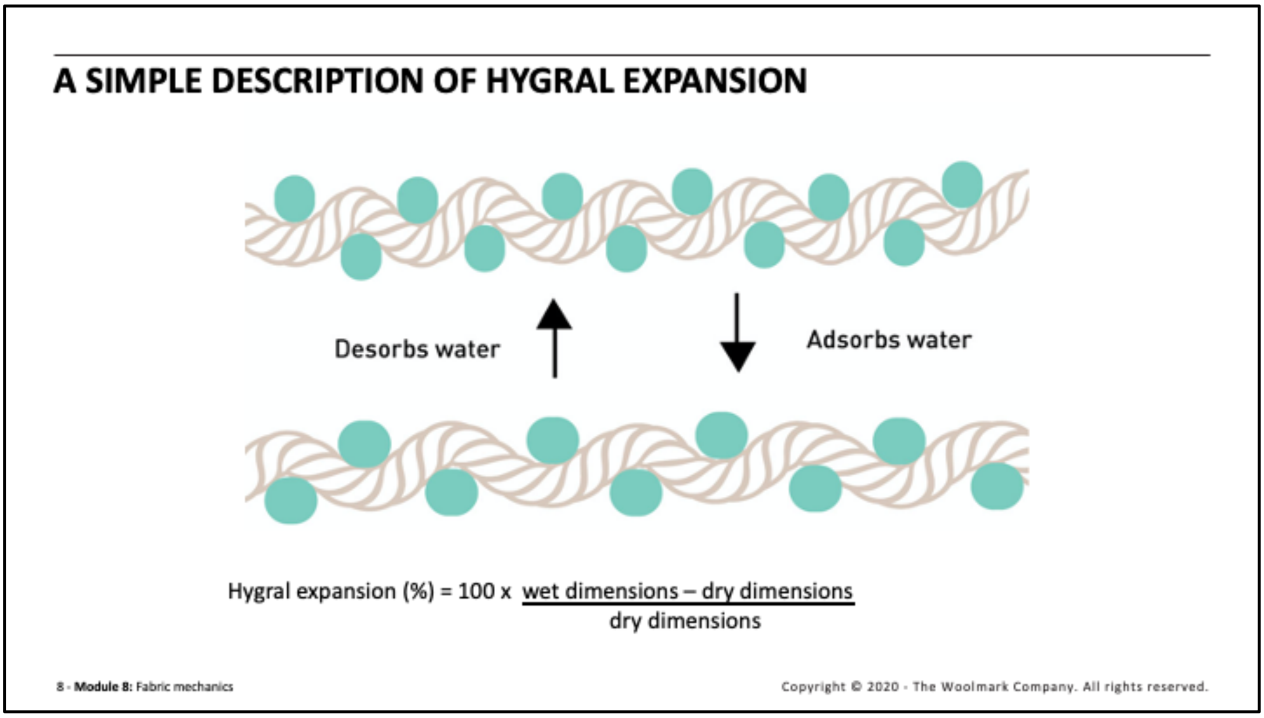
REINFORCE THAT when the cohesively set fabric is subsequently 'relaxed' in water or steam (i.e. fibres are taken above the glass transition temperature), the cohesive set is lost and the fabric reverts to its previous (relaxed) dimensions. This change in dimensions is called 'relaxation shrinkage' or 'dimensional change — relaxation'.

NOTE THAT the extent of warp and weft relaxation shrinkage depend on the difference in yarn crimp in the actual and relaxed fabric. The greater the difference in yarn crimp between the fabric states, the greater the extent of relaxation shrinkage.

EXPLAIN THAT the yarn crimp in the newly extended and set fabric is changed. As a result, the warp and weft extensibility of the cohesively set fabric is also changed. Extension and cohesive setting of the warp or weft reduce yarn crimp, but have little effect on yarn interaction (unless the extension is large, bringing the yarns into strong contact at crossover points).

INDICATE THAT the greater the extension before fabric is cohesively set, the greater the relaxation shrinkage will be. On the other hand, at low extensions, the bias extensibility of the fabric, which involves rotation of the yarns at crossover points, is relatively unaffected.

As stated, when the cohesively set fabric is subsequently 'relaxed' in water or steam, the fabric adopts its relaxed dimensions and pre-stretch properties.



REINFORCE THAT the term 'hygral expansion' describes the spontaneous dimensional change in fabric when the moisture content of the fibres increases.

EXPLAIN THAT the mechanism of hygral expansion is as follows:

- Fibres in the yarn swell as they adsorb water, causing the yarn to straighten (reducing crimp) and, consequently, the fabric to extend.
- The effect is reversible and the fabric contracts as the fibres lose moisture and de-swell.

NOTE THAT The term 'hygral behaviour' is also used to describe this effect.

EXPLAIN THAT as described in an earlier module hygral expansion is expressed as a percentage change and is calculated as follows:

$$100 \times \frac{\text{wet dimensions} - \text{dry dimensions}}{\text{dry dimensions}}$$

NOITE THAT the extent of the dimensional change depends on:

- the level of change in the moisture content of the fibres
- the blend content of the fabric
- the construction and finishing of the fabric.

EMPHASISE THAT hygral expansion must always be measured on fully-relaxed fabric to avoid the possibility of relaxation effects interfering with the measurement of dimensional changes. In most tests for hygral expansion:

- the fabric is relaxed using a static soak in water and the wet dimensions are measured
- the fabric is oven dried and the dimensions re-measured.

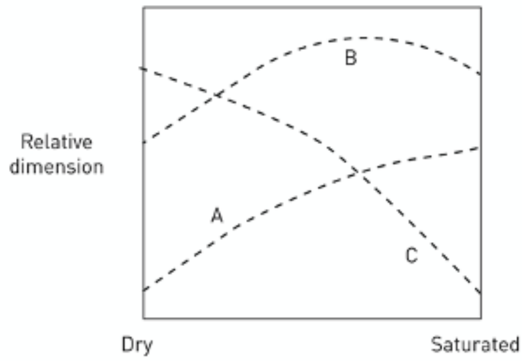
EXPLAIN THAT hygral expansion (dry to wet) in pure wool fabrics depends on:

- the crimp in the yarns of the relaxed fabric (the higher the crimp the higher the hygral expansion dry to wet)
- the interaction between yarns (higher interaction reduces hygral expansion dry to wet).

APPLICATION OF THE SIMPLE MODEL — HYGRAL EXPANSION

The impact of finishing on hygral behaviour:

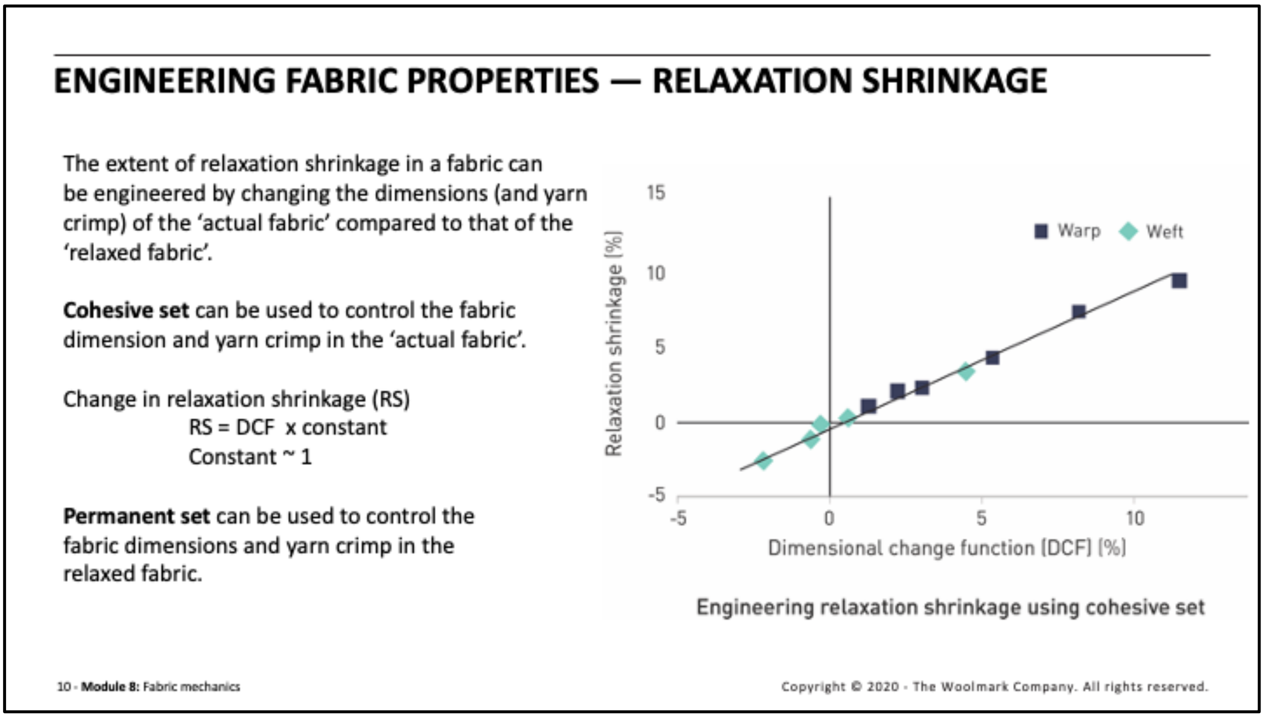
A. well set fabric — small yarn interaction
B. lightly set – intermediate yarn interaction
C. unset fabric – large yarn interaction.



9 - **Module 8:** Fabric mechanics

NOTE THAT as illustrated in this simple model, the hygral behaviour of fabrics varies depending on the method used to finish of the fabric:

A. This is a well-set fabric in which frictional interaction is low and yarn crimp is high (e.g. piece-dyed gabardine). As the moisture content of the fibres increases the fabric continues to expand.
B. This lightly set fabric has more frictional interaction between yarns (e.g. yarn-dyed plain-weave fabric). This fabric expands initially as the moisture content of the fibres rises until the interaction between yarns, caused by the swelling wool fibres, becomes sufficiently high that the fabric shrinks to accommodate the swollen fibres.
C. This unset fabric has high yarn interaction (e.g. loom-state fabric). The swelling of the wool fibres increases fibre interaction and the fabric shrinks to accommodate the swollen fibres.



EXPLAIN THAT the final dimensions of wool fabric and the extensibility and dimensional stability of the fabric are important during garment manufacture and wear. By engineering these properties, a finisher can improve the performance of the fabric.

NOTE THAT to 'engineer' the relaxation shrinkage of a wool fabric it is only necessary to change the difference in the dimensions (and yarn crimp) of the actual and relaxed fabric. This can be achieved using:

- cohesive setting
- permanent setting.

Cohesive setting

To engineer the relaxation shrinkage of a wool fabric using cohesive set, it is only necessary to adjust the dimensions of the initially relaxed fabric and cohesively set it at the required new dimensions. This can be done using a stenter or steam frame, which only imparts cohesive set (rather than permanent set) to the wool fibres. The expected relaxation shrinkage can be easily determined from the change in fabric dimension or the change in yarn crimp.

The graph on the slide shows the effect of controlling the dimensions of wool fabric using cohesive set on relaxation shrinkage.

The term 'dimensional change function' (DCF), which is numerically similar to the actual dimensional change, is used to allow for the different forms of calculation of dimensional change (as a ratio) and relaxation shrinkage (as a percentage).

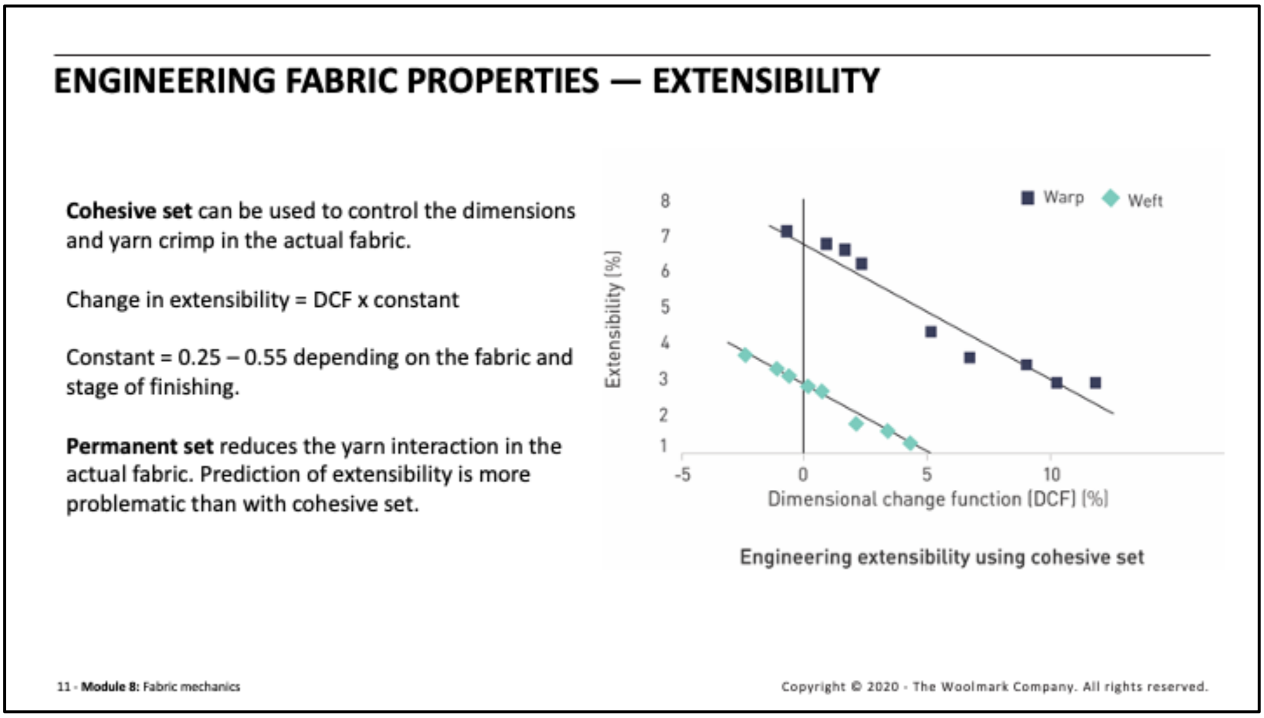
$$\text{DCF (\%)} = \frac{(\text{dimensional change} \times 100)}{(\text{dimensional change} + 100)}$$

Permanent setting

If the fabric is permanently set it will change the relaxed dimensions of the fabric – unless the fabric is already in its relaxed state before permanent setting.

The change in the relaxed dimensions will depend on the amount of permanent setting that occurs. If the permanent set is very high, the dimensions during permanent setting will become the new relaxed dimensions so there is no residual relaxation shrinkage.

At lower levels of permanent set, the extent of the change in the relaxed dimensions (and thus the relaxation shrinkage) is much more difficult to predict.

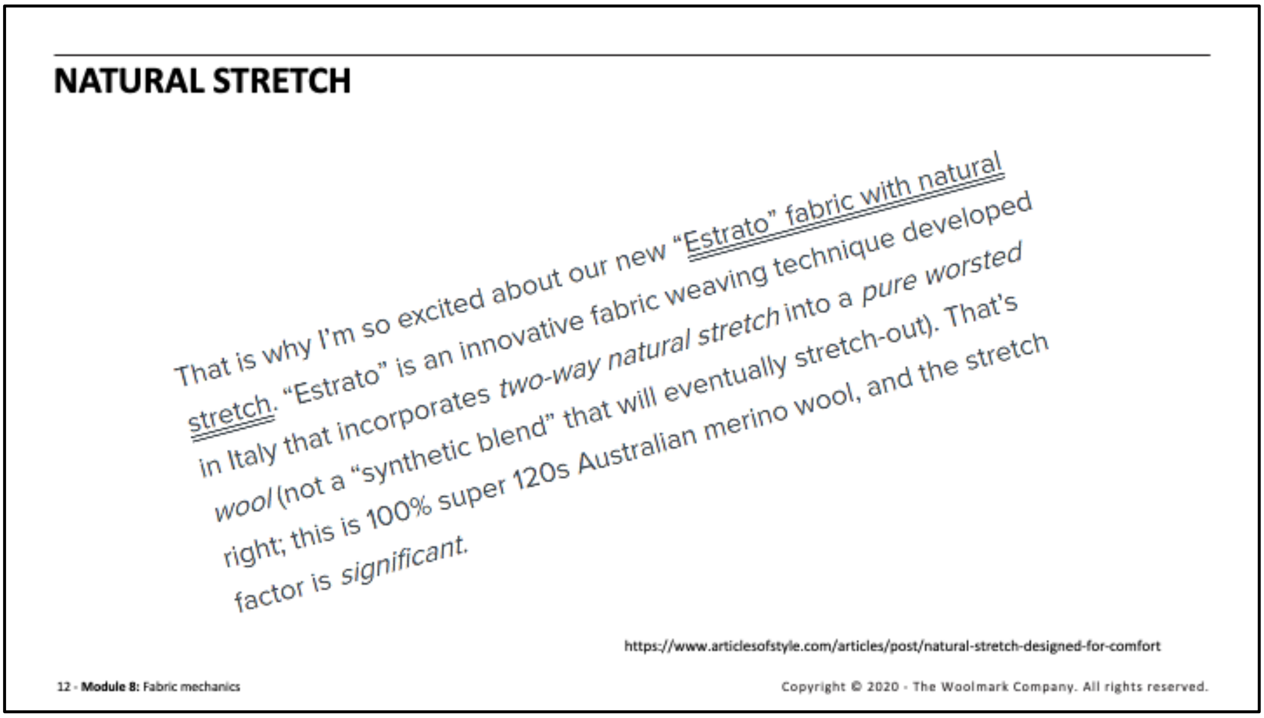


EXPLAIN THAT to engineer the extensibility of fabric it is necessary to control the yarn crimp in the actual (not relaxed) fabric by controlling the fabric dimensions. This can be achieved by cohesive setting or by permanent setting the fabric at the required new dimensions.

Cohesive setting has little effect on yarn interaction so the change in extensibility depends only on the change in yarn crimp and the change in the actual dimensions. This is illustrated on the slide for a gabardine fabric, where the change in extensibility can be predicted from the change in dimensions using: change in extensibility = DCF x constant

Permanent setting can modify the yarn interaction in the fabric, which will affect extensibility in addition to any changes in yarn crimp that occur during the process. As with the engineering of relaxation shrinkage using permanent setting, prediction is more problematic.

Engineering fabric dimensions with cohesive set
The use of the steam frame in the final stages of finishing gives finishers an opportunity to engineer the final dimensions of wool fabric and thereby the extensibility and dimensional stability of the fabric.



EXPLAIN THAT natural stretch is achieved in wool fabrics by the manipulation of yarn crimp.

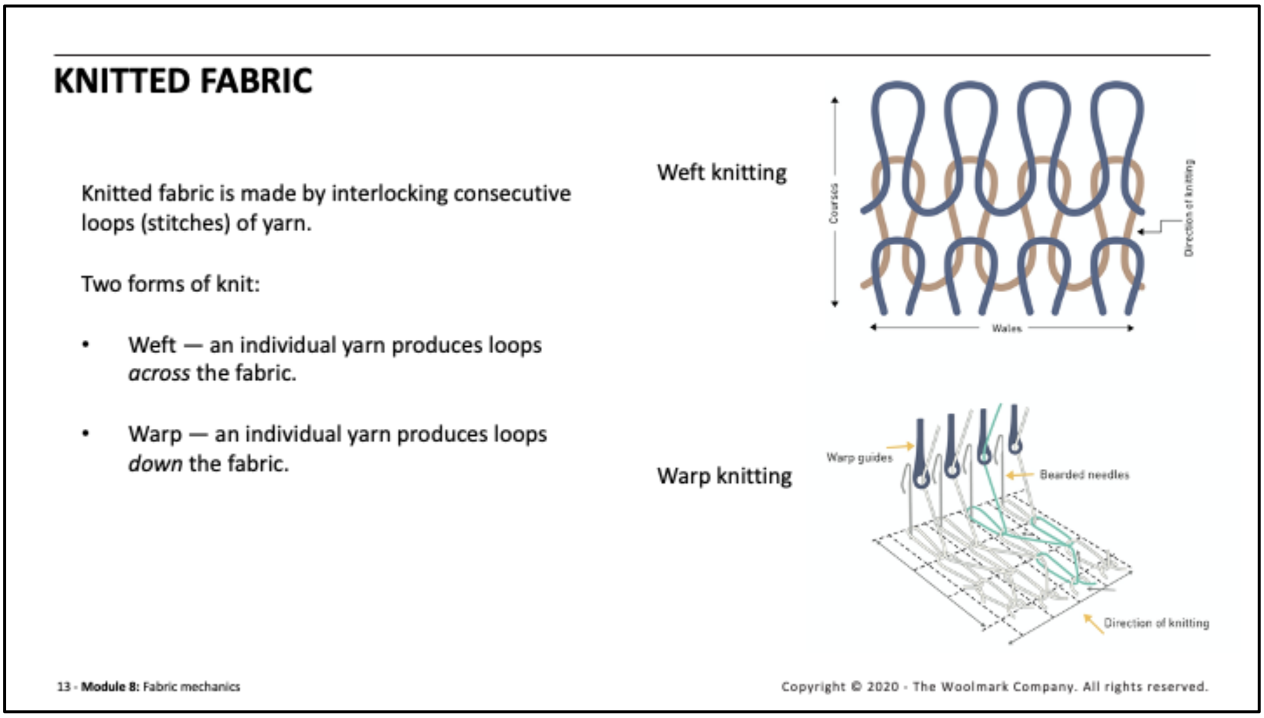
NOTE THAT stretch in pure wool fabrics (no elastane) is induced by creating high crimp in the yarns:

- One-way stretch is achieved with high crimp in warp or weft.
- Two-way stretch is achieved by high crimp in both directions.

EXPLAIN THAT weft stretch is normally achieved by fabric design and wet setting with high tension.

EXPLAIN THAT Warp stretch is achieved by fabric design and intensive overfeed and permanent final setting.

EMPHASISE THAT in all cases relaxation shrinkage must be controlled by sponging after the setting operations or by steam framing.



EXPLAIN THAT knitted fabric consists of a large number of consecutive rows of interlocking loops of yarn formed across and along the fabric. The loops of yarn are called stitches.

INDICATE THAT to build a fabric, each new loop (stitch) is pulled through an existing loop to create the new 'front edge' of the fabric.

NOTE THAT there are two forms of knitting — warp and weft, which are illustrated on the slide:

- Weft knitting — the continuous yarn loops across the fabric.
- Warp knitting — the continuous yarn loops down the fabric.

MENTION THAT knitting by hand is a form of weft knitting.

INDICATE THAT like woven fabrics, the mechanical properties of knitted fabrics depend on:

- the properties of the yarn
- the length and shape of the knitted loop — this is analogous to yarn crimp in a woven fabric.

The cover factor of the fabric.
NOTE THAT the cover factor measurement for knitted fabric is analogous to the woven cover factor. Like woven fabrics, the cover factor for knitted fabrics can be calculated from.

- yarn count
- stitches per centimetre.

POINT OUT that in knitted fabrics the relaxed dimensions of the fabrics, as well as the number of wales and courses (stitch density), can be related directly to the loop length.

The friction or interaction between yarns at crossover points.
EXPLAIN THAT yarn interaction depends on the frictional properties of yarns and any permanent setting or relaxation process during finishing.

Like woven fabrics, knitted fabrics have:

- actual dimensions
- relaxed dimensions.

MENTION THAT knitted fabrics can be stretched and cohesively set to impart relaxation shrinkage. Often relaxation shrinkage can be much higher than in woven fabric, as the fabrics are more easily distorted.

NOTE THAT knitted fabrics are much more extensible than woven fabrics. The loops are longer than crimped yarns and more easily distorted.

The simple model of knitted fabric relates the mechanical properties of the fabric to:

- loop length
- yarn interaction.

SUMMARY — MODULE 8

The mechanical properties of woven fabrics change during finishing due to changes in the:
- crimp in yarns
- interaction between warp and weft yarns at crossovers.

The mechanical properties of knitted fabrics change during finishing due to change in the:
- loop length and shape
- interaction between yarns in successive loops at crossovers.

Any fabric can have two distinct dimensions
- actual dimension (held by cohesive set)
- relaxed dimensions.

The difference is dimensional change — relaxation (DCR).

- Generally the impact of yarn extension properties yarns is relatively small, except in wool/elastane blends.

- Cohesive set control is used to relaxation dimensional change.
- Permanent set controls relaxed dimensions.

15 - **Module 8:** Fabric mechanics

SUMMARISE the module by reinforcing that the mechanical properties of woven fabrics depend on a number of key features in the structure of the fabric, which can change during fabric finishing, including the:
- crimp in yarns — determined in weaving and finishing,
- interaction between warp and weft yarns at crossovers — determined by cover factor and finishing route.

REMIND participants that the mechanical properties of knitted fabrics depend on:
- loop length and shape,
- interaction between yarns in successive loops at crossovers.

REITERATE THAT all wool fabrics have two distinct dimensions:
- actual dimension (held by cohesive set)
- relaxed dimensions.

The difference between these dimensions is the dimensional change — relaxation (DCR) or relaxation shrinkage.

REVIEW the fact that generally the impact of yarn extension properties of wool yarns is relatively small, except when blended with elastane filaments.
REMIND participants that controlling fabric dimensions using cohesive set has little effect on the relaxed dimensions of the fabric.

Cohesive setting can be used to control
- yarn crimp
- relaxation shrinkage
- extensibility.

REVIEW the fact that permanent setting is required to control relaxed dimensions and relaxed yarn crimp and, as a result, hygral expansion.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 9 Faults in finishing* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

MODULE 9

FAULTS IN FINISHING

RESOURCES — MODULE 9: FAULTS IN FINISHING

No additional resources are required to deliver **Module 9: Faults in finishing**.

WELCOME participants to Module 9 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Faults in finishing.*

EXPLAIN THAT this module will review some typical faults in finishing and outline the corrective procedures for each.

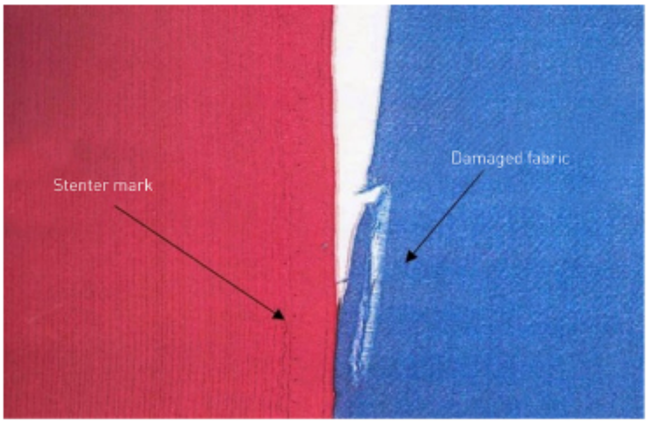
INFORM participants that by the end of this module they will be able to:

- describe some of the faults that can occur due to errors in finishing
- list some of the faults that are immediately visible and those which final product (latent faults)
- recognise how latent faults can be detected using objective measurements, such as SiroFAST
- describe how faults can be prevented
- describe how to correct the named faults, if correction is possible.

NO RESOURCES REQUIRED

FAULTS IN FINISHING

- Immediately visible and found during inspection:
  - holes
  - milling scuff marks
  - uneven raising
  - running marks (felted).
- Latent faults (emerge in final product):
  - running marks (set)
  - poor finish stability
  - excessive relaxation shrinkage
  - excessive hygral expansion
  - poor formability
  - poor pressing performance.



http://textilelearner.blogspot.com.au/2013/07/defects-in-woven-fabric-with-image.html

2 - **Module 9:** Faults in finishing

INDICATE THERE are many types of faults that can occur in fabric. They can be caused in yarn spinning (a yarn fault) in weaving or knitting (a weaving or knitting) fault or during finishing (a finishing fault). This module will describe finishing faults.

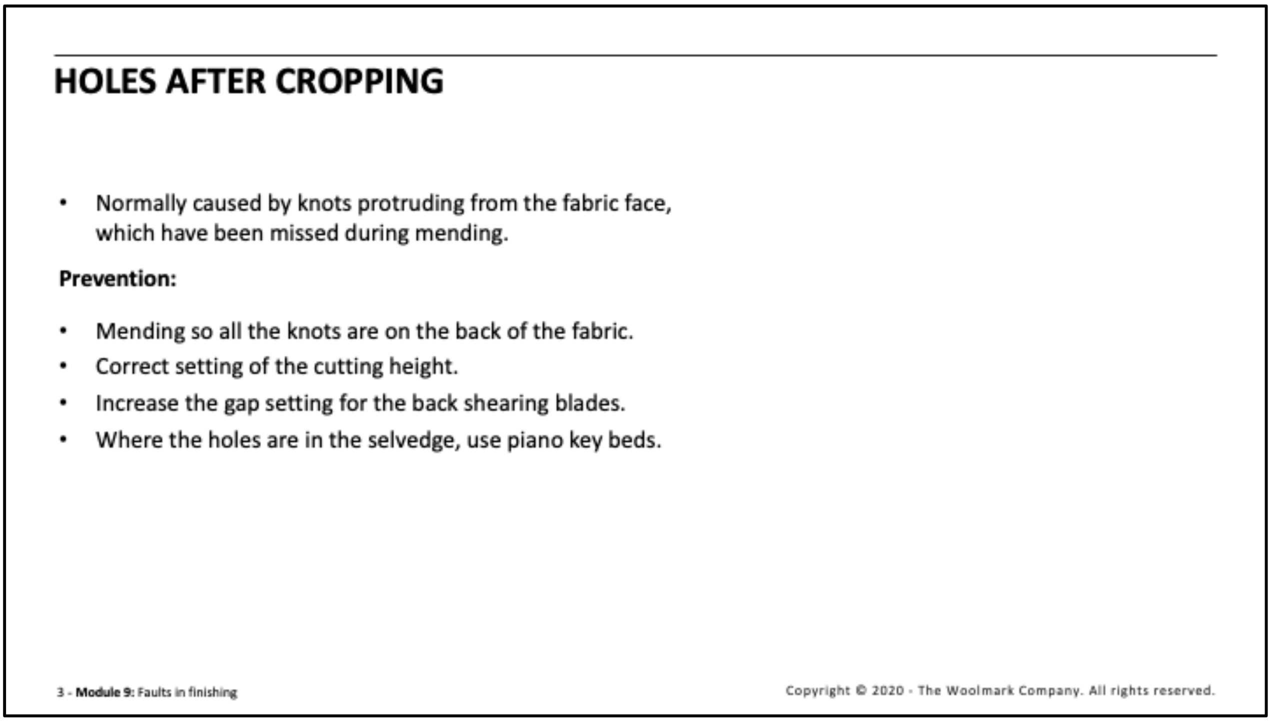
NOTE THAT the finishing faults immediately visible and found during inspection are:

- holes
- milling scuff marks
- uneven raising
- running marks (felted).

POINT OUT that the latent faults that re-emerge in the final product are:

- running marks (set)
- poor finish stability
- excessive relaxation shrinkage
- excessive hygral expansion
- poor formability
- poor pressing performance.

EXPLAIN THAT latent faults tend to be expensive, because after the fabric has been cut for garment manufacture it cannot be corrected. After the faulty garment is made the full costs of the fabric and garment manufacture are lost.



NOTE THAT holes are normally caused by knots protruding from the fabric face, which have been missed during the mending process.

EXPLAIN THAT it is possible to avoid these holes by one or more of the following actions:

- Mend so all the knots are on the back of the fabric.
- Correct setting of the cutting height in the shearing machine.
- Increasing the gap setting for the back shearing blades of the shearing machine.
- Where the holes are in the selvedge, use piano key beds.

MILLING FAULTS

Formed when fabric slips in the rollers of the milling machine.

Prevention:

- Adequate moisture in the fabric.
- Correct amount of milling aid.
- Correct pressure on rollers.

Correction:

- Almost impossible.
- If minor, appearance may improve with continued milling.

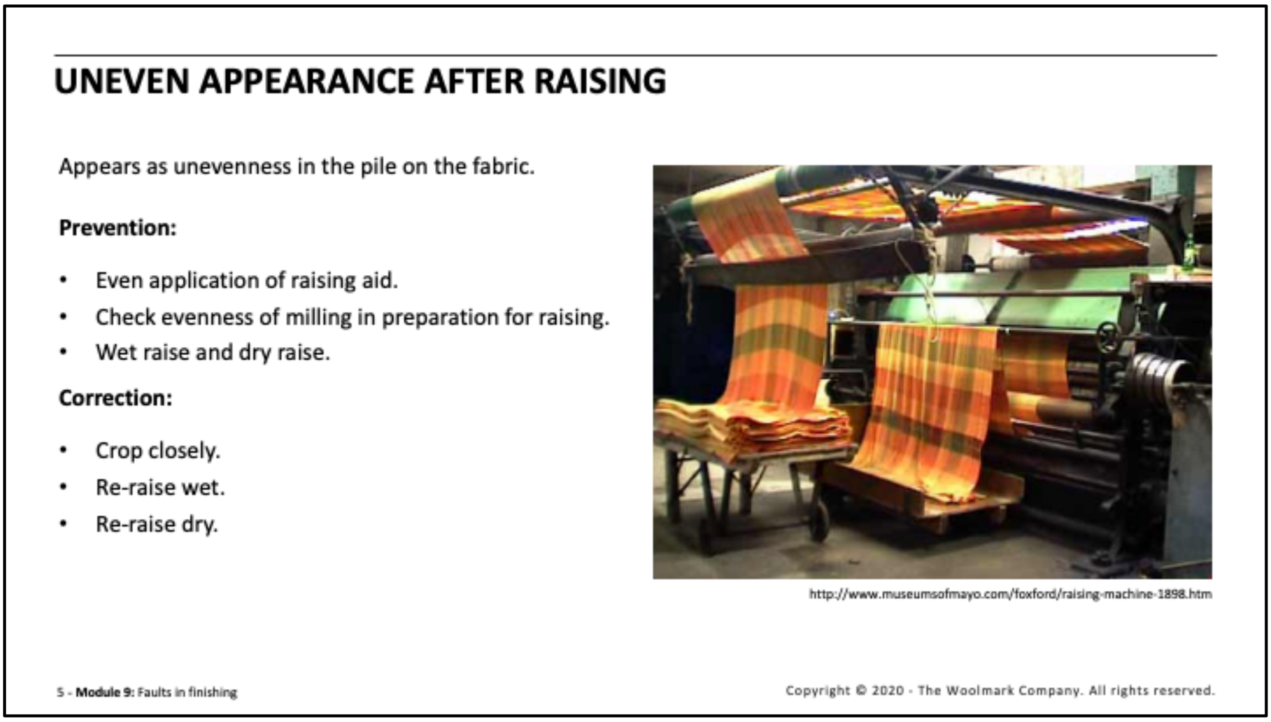
4 - **Module 9:** Faults in finishing

EXPLAIN THAT milling faults are evident as holes or scuff marks (also called 'bruising') and are formed when the fabric slips in the rollers of the milling machine.

NOTE THAT milling holes and scuff marks can be prevented by ensuring there is:

- adequate moisture in the fabric
- the correct amount of milling aid
- the correct pressure on the milling rollers.

MENTION THAT it is almost impossible to correct milling holes. If minor, their appearance may improve with continued milling.



NOTE THAT uneven raising appears as unevenness in the pile on the fabric.

EXPLAIN THAT uneven raising can be prevented by one or more of the following:

- Make sure there is an even application of raising aid on the fabric. This can be achieved using a pad application rather than a spray.
- Check the evenness of milling in preparation for raising.
- Raise the fabric in two stages: wet raise as well as dry raise.

INDICATE THAT uneven raising can be corrected by the following sequence of steps:

- closely cropping the fabric
- re-raising wet
- then re-raising dry.

FINISHING TO PREVENT RUNNING MARKS

Prevention:

- Avoid rope processing.
- Bag fabrics.
- Use effective wet setting.
- Ensure appropriate moisture content during milling.

Correction (set running marks):

- Wet out, re-dry wider than normal.
- Contidecatise.
- Add moisture.
- Pressure decatise (125°C, 3 minutes).
- Sponge.

Correction (felted running marks):

- Re-mill (and hope).

ASK *participants to describe the two types of running marks that can occur during finishing.*

ALLOW *participants sufficient time to respond before continuing the lecture.*

NOTE THAT two types of running marks can form during finishing: set running marks and felted running marks.

Set running marks
Set running marks occur during scouring or piece dyeing, because the folds in the fabric are not re-arranged from time to time in the process. This fault may be latent and not visible until the fabric is relaxed after dry finishing.

Felted running marks
Felted running marks are formed in any wet process but normally during high-speed scouring and milling. This fault is normally easy to see during inspection after wet finishing.

EXPLAIN THAT the formation of running marks during finishing can be prevented by one or more of the following:

- avoiding rope processing
- bagging fabrics for rope processing
- using effective wet setting before and after rope processes
- ensuring appropriate moisture content during milling.

INDICATE THAT bagging is the term used to describe the process where the selvedges of the fabric are sewn together to form a tube.
Air is trapped in the tube, causing the fabric to balloon. This 'ballooning' redistributes the folds in the fabric so the folds are not reinforced.

Set running marks can be corrected by:

- wetting out and re-drying the fabric wider than normal
- treating in a continuous decatiser
- adding moisture
- pressure decatising (125°C for three minutes)
- sponging.

Felted running marks can sometimes be corrected by:

- re-milling the fabric, but often the marks cannot be removed.

EMPHASISE THAT prevention is better than cure.

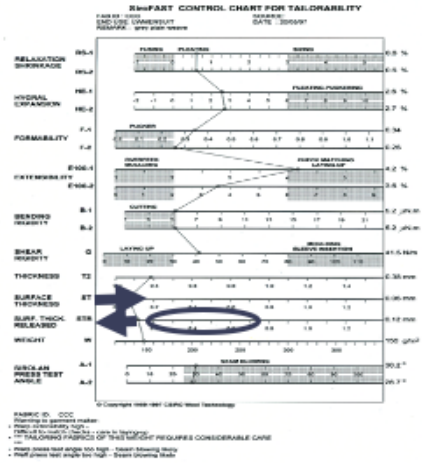
FINISHING TO ENSURE GOOD FINISH STABILITY

Preventing poor stability:

- Adequate permanent set during pressure decatising.
- Adequate moisture in the fabric before pressure decatising.

Correcting poor stability:

- Sponging.
- Pressure decatise (again) with appropriate conditions.



Source: CSIRO, Geelong

7 - **Module 9:** Faults in finishing

***ASK** participants if they can explain what is meant by the term 'finish stability'*

***ALLOW** participants sufficient time to respond before continuing the lecture.*

EXPLAIN THAT finish stability is the ability of a fabric to maintain its finish when it is relaxed in water or steam. Finish stability is measured as a change in thickness when the fabric is relaxed in steam. In a fabric with good finish stability, the relaxed surface thickness (shown in the slide as measured using the SiroFAST system) is only slightly greater than the 'initial' surface thickness. In a fabric with poor finish stability, the relaxed surface thickness is considerably greater than the 'initial' surface thickness

INDICATE THAT poor finish stability of fabric can be prevented by:

- ensuring adequate permanent set during pressure decatising by:
    - increasing the time
    - increasing the temperature,
    - adjusting the pH of the fabric (~7)
- ensuring adequate moisture in the fabric before pressure decatising.

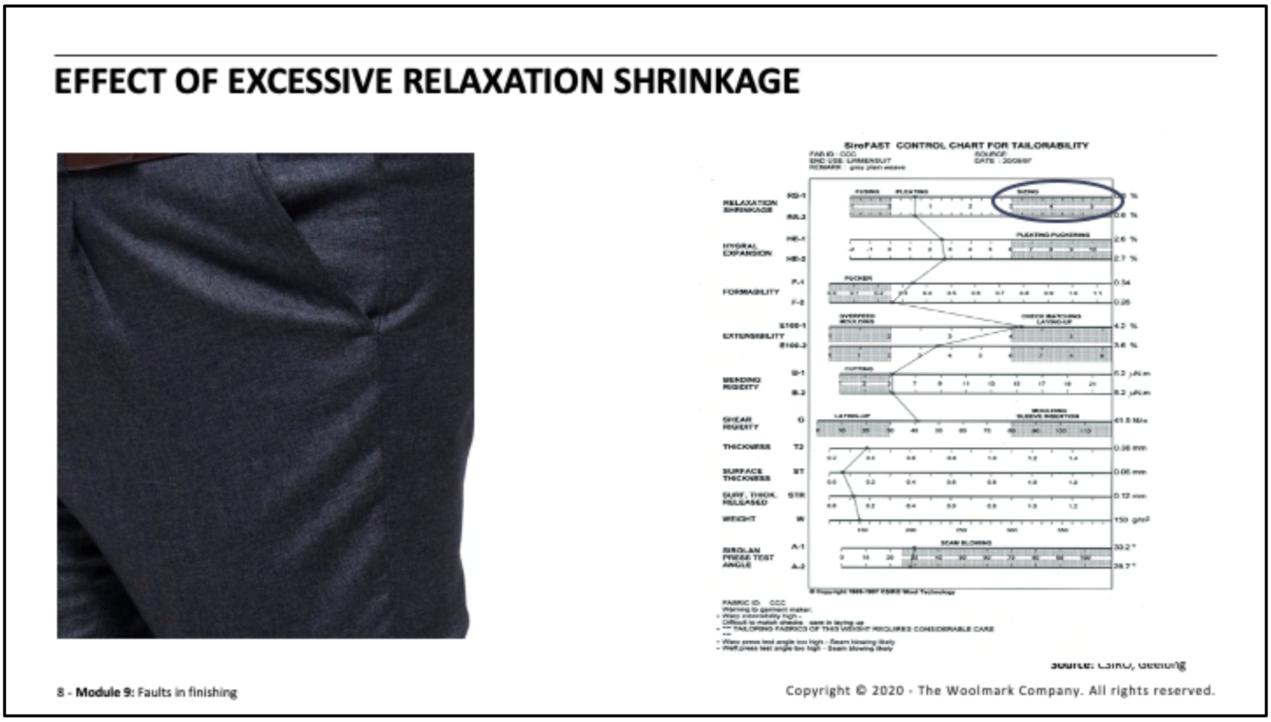
NOTE THAT poor finish stability of fabric can be corrected by:

- sponging to ensure the final finish is achieved before the fabric leaves the mill and any distortions are visible
- pressure decatising (again) with appropriate conditions.

***ASK** participants if they can explain why sponging ensures the final finish is achieved before any distortions are visible.*

***ALLOW** participants sufficient time to respond before continuing the lecture.*

MENTION THAT sponging ensures any latent distortions in the fabric held by cohesive set are normally visible during final inspection.



EXPLAIN THAT excessive relaxation shrinkage (shown by the red ring in the diagram) can be detected based on the measurements taken from SiroFAST-4 test or a relaxation test included with testing using the KES-F instruments. Alternatively there are numerous test procedures that can be used to measure relaxation shrinkage.

INDICATE THAT excessive relaxation shrinkage can cause

- a change in the garment size (dimensions)
- puckering of seams (which are not free to relax)
- puckering of seams joining garment panels with different amounts of relaxation shrinkage, as shown on the slide.

MENTION THAT ideally relaxation shrinkage should be between 0.5% and 2% depending on the application.

POINT OUT that relaxation shrinkage is normally 'excessive' when it exceeds 3%.

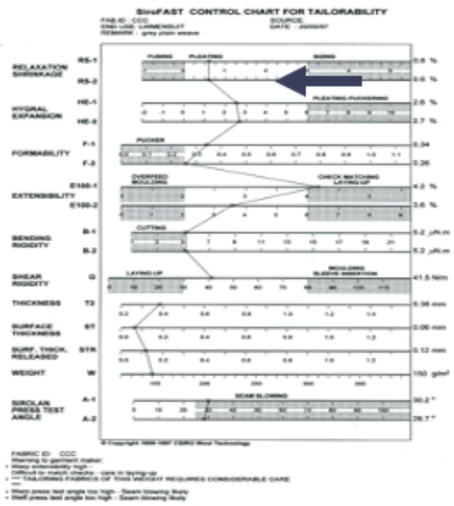
FINISHING TO ENSURE APPROPRIATE RELAXATION SHRINKAGE

Prevention of excessive relaxation:

- Dry narrower and/or more overfeed.
- Better tension control in dry finishing.
- More effective permanent setting.

Correction of excessive relaxation:

- Steam relaxing (sponging).
- Steam frame to reset dimensions.
- Wet out and re-dry in stenter with appropriate width and more overfeed.
- Light decatise.



Source: CSIRO, Geelong

9 - **Module 9:** Faults in finishing

EXPLAIN THAT excessive relaxation shrinkage of fabric (shown by the red arrow in the SiroFAST fingerprint) can be prevented by one or more of the following:

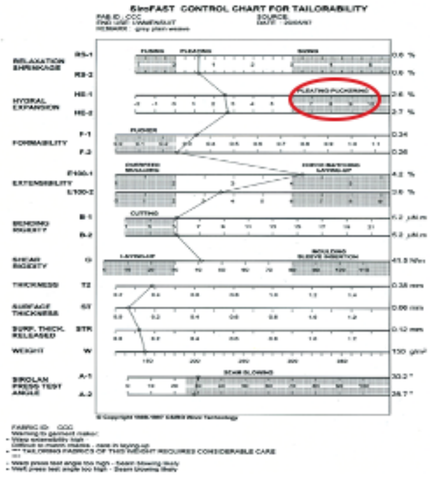
- dry narrower and/or with more overfeed
- better tension control during dry finishing
- more effective permanent setting.

INDICATE THAT excessive relaxation shrinkage of fabric can be corrected by:

- steam relaxing (sponging)
- steam framing to reset dimensions of the fabric
- wetting out and re-drying the fabric in a stenter with an appropriate width and more overfeed followed by a light decatise.

MENTION THAT inadequate relaxation shrinkage <0% can also be a problem in garment making. It is corrected by similar methods (e.g. dry wider).

EFFECT OF EXCESSIVE HYGRAL EXPANSION



Source: CSIRO, Geelong

10 - **Module 9:** Faults in finishing

REITERATE THAT as discussed in previous modules, hygral expansion is the spontaneous change in the dimensions of wool fabric that occurs when the moisture content of the fibres increases.

REINFORCE THAT the fibres swell as they adsorb water and this causes the yarn to straighten (reducing crimp) and, consequently, the fabric to extend.
The effect is reversible and the fabric contracts as the fibres lose moisture and de-swell.

INDICATE THAT the impact of excessive hygral expansion on garment appearance is shown on the slide. The seams in the jacket cannot accommodate the increase in panel size as the fabric expands and the garment develops an unsightly appearance.

NOTE THAT hygral expansion also causes:

- the distortion of garment panels when the garment is worn in high humidity
- the delamination of fusible interlinings.

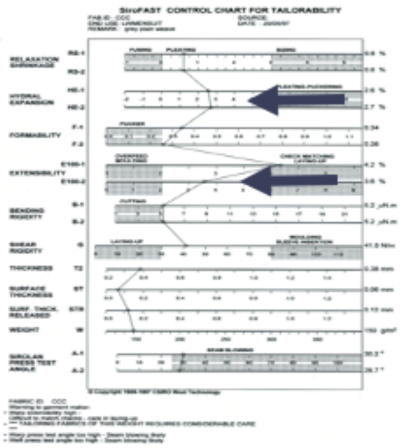
INDICATE THAT the image on the right-hand side of the slide indicates how this fault can be detected based on the measurements taken from SiroFAST-4 measurement.

MENTION THAT hygral expansion should remain below 6%.

FINISHING TO IMPROVE HYGRAL EXPANSION

Preventing excessive hygral expansion:
- Avoid piece-dyeing route.
- Use anti-setting agents in piece dyeing.
- Light mill after piece dyeing.
- Stenter dry wide and/or with little underfeed, pressure decatise using severe conditions, sponge to release excessive relaxation shrinkage.

Correcting excessive hygral expansion:
- Wet out and re-dry wide and/or with little underfeed, pressure decatise using severe conditions, sponge to release excessive relaxation shrinkage.
- Wet out, give light mill and refinish.

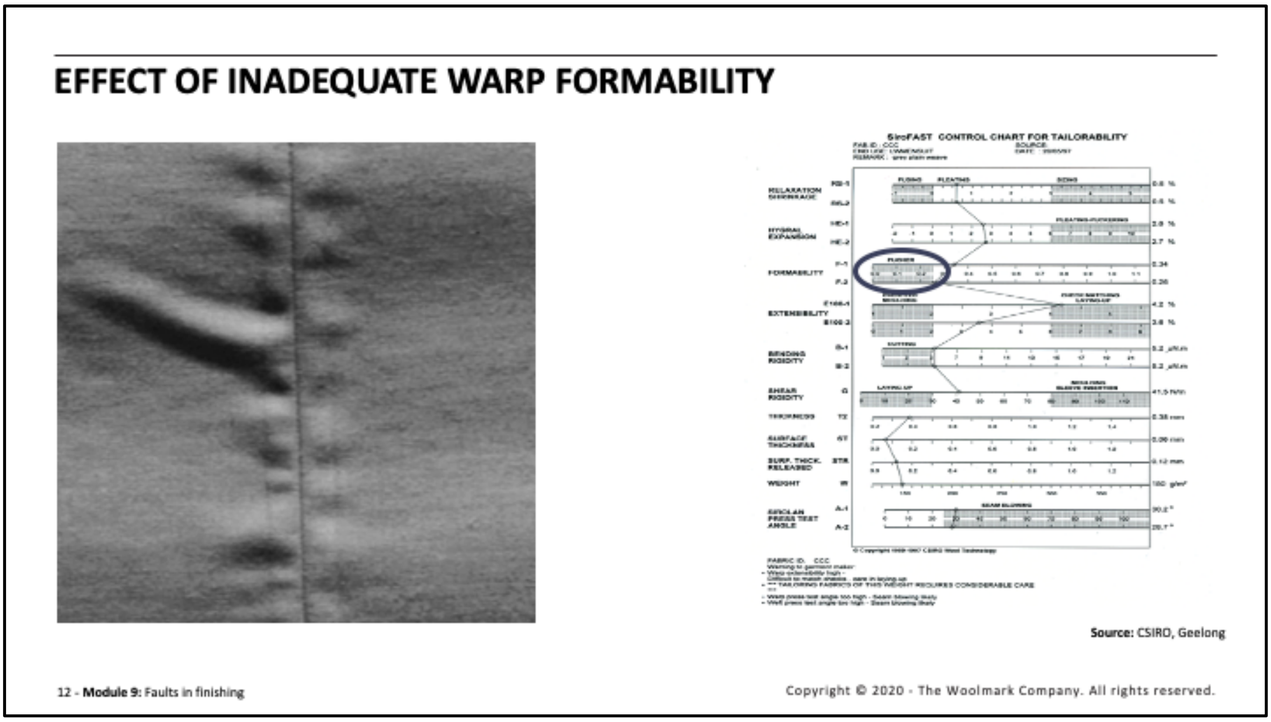


Source: CSIRO, Geelong

11 - **Module 9:** Faults in finishing

EXPLAIN THAT hygral expansion of fabric can be prevented by one or more of the following:
- avoiding piece dyeing route by using a colour-woven route
- using anti-setting agents during piece dyeing
- giving the fabric a light mill after piece dyeing
- stenter drying the fabric wide and/or with little underfeed, pressure decatising using severe conditions and sponging to release excessive relaxation shrinkage.

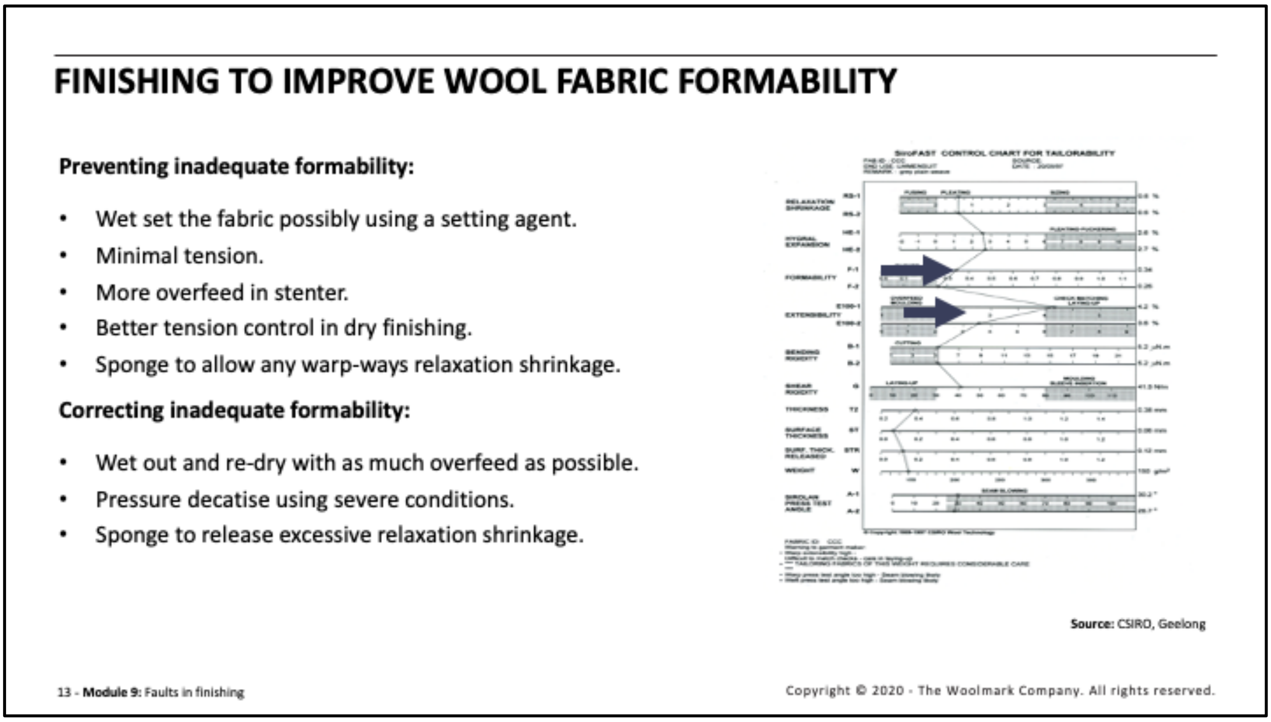
INDICATE THAT hygral expansion of fabric can be corrected by:
- wetting out and re-drying wide and/or with little underfeed, pressure decatising using severe conditions, sponging to release excessive relaxation shrinkage
- wetting out, giving the fabric a light mill and refinishing.



INDICATE THAT warp formability is the ability of the fabric to resist puckering when compressed in the plane of the fabric. If formability is inadequate, puckering will occur on the seams of a garment.

NOTE THAT the image on the right-hand side of the slide indicates how this fault can be detected based on the measurements taken from SiroFAST instruments.

MENTION THAT ideally, formability should be more than 0.25. If it is below 0.25 it means the formability is inadequate.



EXPLAIN THAT inadequate fabric formability can be prevented by increasing the extensibility of the fabric through the following actions:

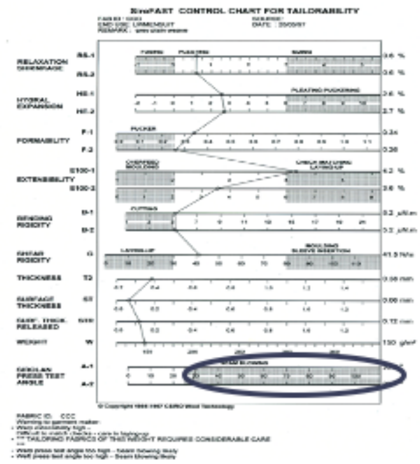
- Wet setting (continuous crab) the fabric possibly using a setting agent.
- Minimal tension in processing.
- More overfeeding in the stenter (warp formability).
- Better tension control in dry finishing.
- Sponging to allow any warp-ways relaxation shrinkage.

NOTE THAT the diagram on the slide illustrates the property that must be changed to improve formability (namely extensibility).

MENTION THAT inadequate formability can be corrected by:

- wetting out and re-drying with as much overfeed as possible
- pressure decatising using severe conditions
- sponging to release excessive relaxation shrinkage.

EFFECT OF POOR PRESSING PERFORMANCE



Source: CSIRO, Geelong

14 - **Module 9:** Faults in finishing

REFER participants to the image to observe the effect of poor pressing performance on finished fabric. Note the rounded seams on the trousers.

NOTE THAT if the pressing performance is poor, the seams do not remain flat, but become rounded (or blown).

INDICATE THAT this fault can be detected based on the measurements taken from Sirolan PressTest as shown on the slide. The Sirolan PressTest Angle should be less than 25 degrees.

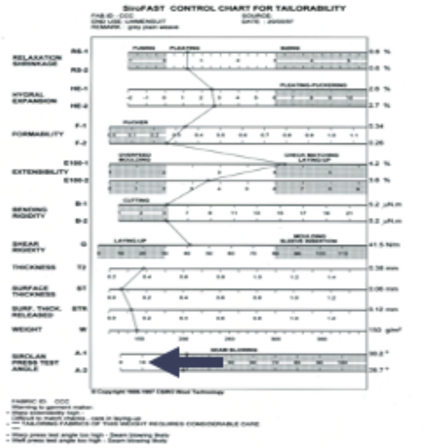
FINISHING TO IMPROVE PRESSING PERFORMANCE

Preventing poor pressing performance:

- Ensure adequate regain in pressure decatising.

Correcting poor pressing performance:

- Wet out the fabric, re-dry at correct dimensions, light decatise.
- Sponge and re-decatise.



Source: CSIRO, Geelong

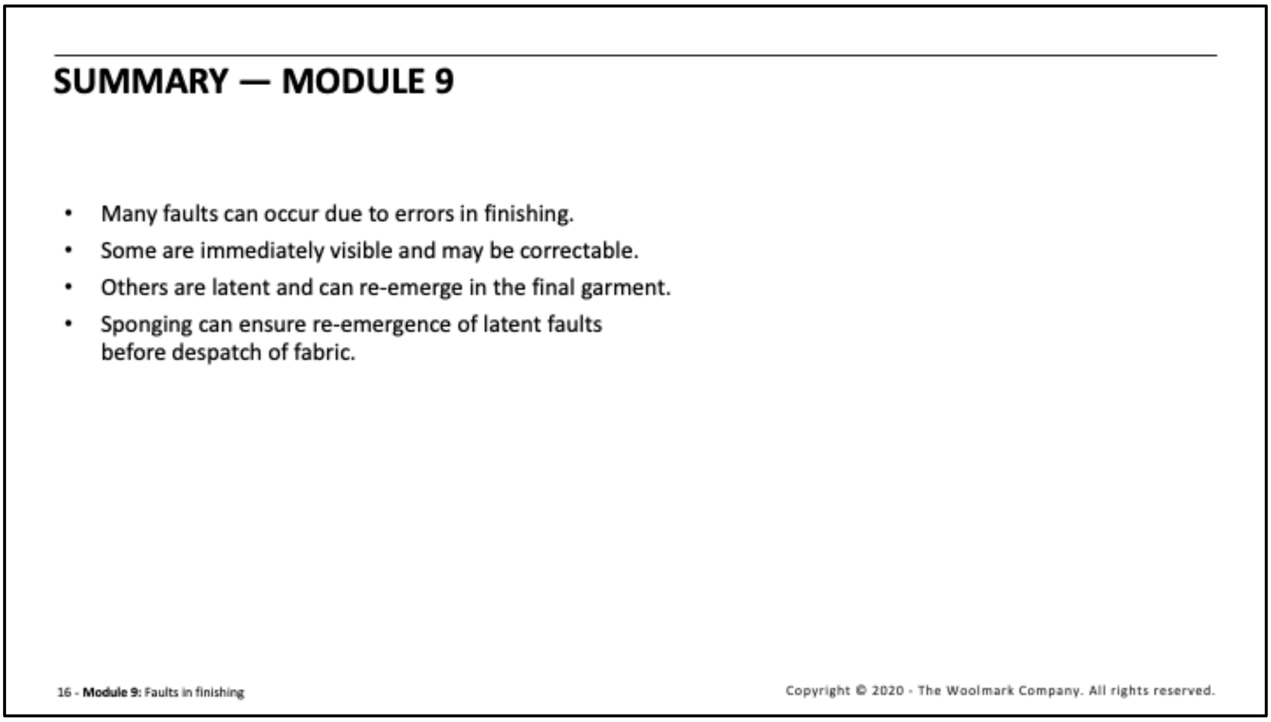
15 - **Module 9:** Faults in finishing

INDICATE THAT poor pressing performance can be prevented by ensuring there is adequate moisture content in the wool fibres during pressure decatising.

EXPLAIN THAT poor pressing performance can be corrected by the following sequence of operations:

- wetting out the fabric, re-drying at correct dimensions
- decatising the fabric under mild conditions
- ensuring the fabric moisture content is relatively high (>15%) before decatising again.

REFER participants to the diagram to note which measures must be affected to improve pressing performance (namely Sirolan Press Test Angle).



SUMMARISE the module by explaining that there are many faults that can occur as a result of errors in finishing.

REITERATE that some are immediately visible and may be correctable.

REVIEW the fact that others are latent and can re-emerge in the final garment.

REMIND participants that sponging can ensure re-emergence of latent faults before despatch of fabric.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 10 Performance standards* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here: www.woolmarklearningcentre.com

MODULE 10

THE WOOLMARK COMPANY

PERFORMANCE STANDARDS

RESOURCES — MODULE 10: PERFORMANCE STANDARDS

No additional resources are required to deliver **Module 10: Performance standards**.

THE WOOLMARK COMPANY

WOOL FABRIC FINISHING

MODULE 10
Performance standards

WELCOME participants to Module 10 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Performance standards*.

EXPLAIN THAT this module will cover:

- the functional tests used for determining whether the fabric meets the required performance standard
- the different types of performance standard fabrics have to meet
- the functional properties of wool represented by the Woolmark Standard
- the performance standards required for Woolmark's sub-brands.

INFORM participants that by the end of this module they will be able to:

- briefly describe the different standards of performance all wool fabrics have to meet
- explain the difference between test methods and specifications
- list the different properties of wool that are covered by the Woolmark Standards, for both woven and knitted fabrics
- describe additional claims that are associated with the Woolmark Standard
- identify key differences between Woolmark sub-brands.
- describe some of the functional tests used.

NO RESOURCES REQUIRED

NOTE TO FACILITATOR: *If time allows, Module 10 and Module 11 can be run as a single lecture, as both modules are short in length (less than 30 minutes each).*

PERFORMANCE STANDARDS

- Functional tests measure fabric against standards.
- There are various types of performance standard.
- The Woolmark Company uses:
  - standards
  - sub-brands
  - testing methods.

2 - **Module 10:** Performance standards

NOTE THAT there are a number of different types of performance standards used on wool textiles.

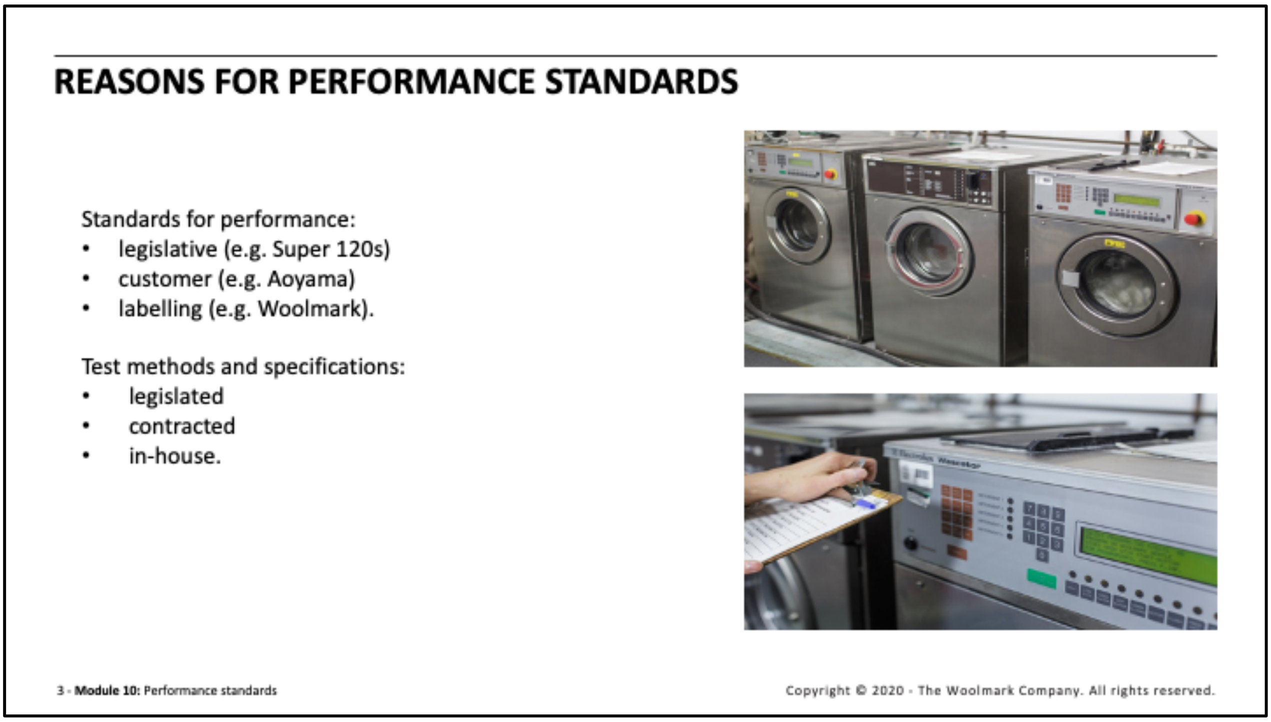
Functional tests are used to determine whether a fabric meets the required performance standard.

INDICATE THAT as described earlier, low-strain tests also are used to ascertain the impact of finishing on the aesthetic characteristics of wool fabric.

In addition there are different types of performance standards certain fabrics have to meet.

EXPLAIN THAT Woolmark will be used as an example of a system of performance standards used to certify wool products for the use of brands and sub-brands.

POINT OUT that the Woolmark logos or trademarks are not just brands; they reassure consumers the products they buy meet relevant quality standards set by The Woolmark Company. The Woolmark Company has a system of performance standards used to certify wool products for the use of brands and sub-brands.



INDICATE THAT all fabrics have to meet some form of standards for performance. these can be:

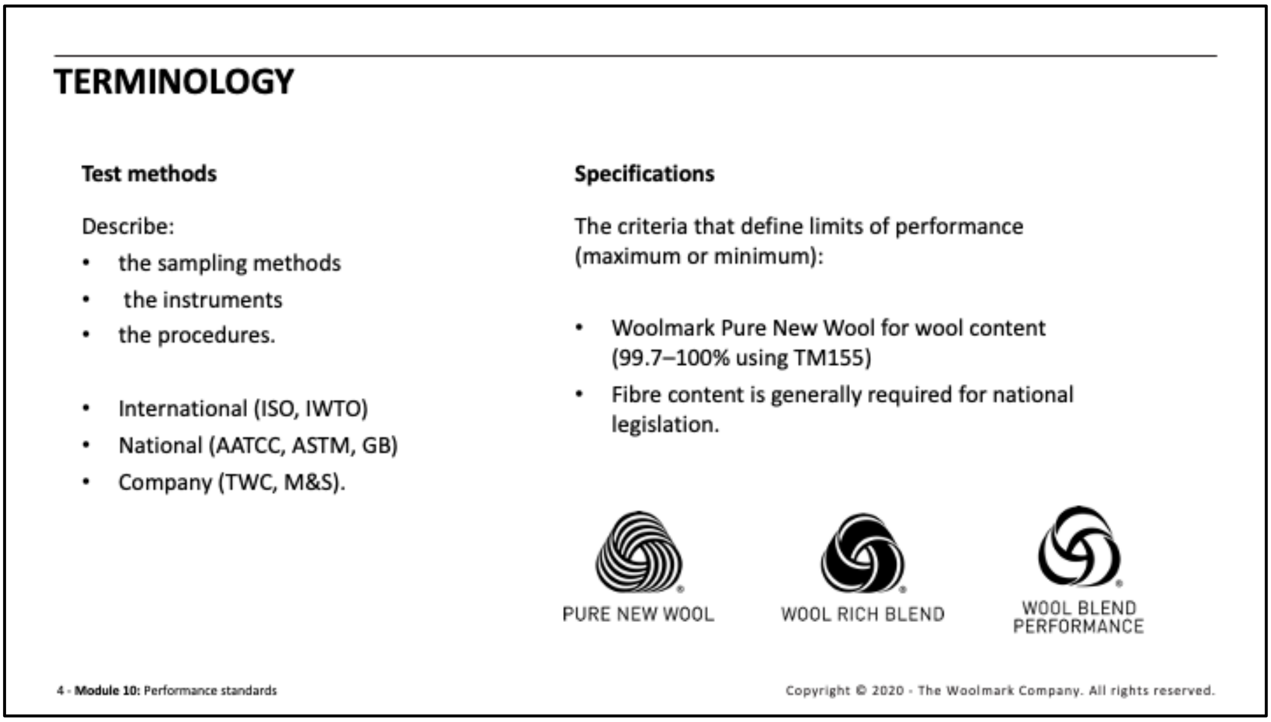
- legislative (e.g. super 120s as included in US labelling regulations)
- customer requirements (e.g. Aoyama)
- labelling rules (e.g. Woolmark).

EXPLAIN THAT virtually all standards for wool fabrics relate to functional properties. Performance is determined by:

- properties of the fibre
- yarn characteristics
- fabric construction and finishing
- finishing methods used.

NOTE THAT the test methods and specifications required to meet each of these standards can be:

- legislated
- contracted
- in-house.



EXPLAIN THAT the difference between test methods and specifications is as follows:

Test methods
Test methods describe the procedure required to make the measurement that will predict performance. They describe the sampling methods, the instruments and the procedures that must be used to test a particular property, or group of properties, on a fabric or product.

NOTE THERE are large number of different test methods, including:

- international (ISO, IWTO)
- national (AATCC, ASTM, GB)
- company (Woolmark, Marks & Spencer (UK)).

Specifications
Specifications are the criteria that define the limits of performance (maximum or minimum), which must be met to satisfy the customer requirements. For example:

- The limits on fibre content for Woolmark Pure New Wool labelling (99.7–100% using TWC TM155), or for local labelling laws.
- The minimum abrasion resistance (using an ISO method) that is acceptable for a worsted fabric for an individual customer.

MENTION THAT fibre content measurement is commonly required to meet national labelling legislation.

FUNCTIONAL TESTS
WOVEN RELAXATION AND FELTING DURING LAUNDERING

Woolmark – TM31:

- Wascator (Electrolux).
- Gentle (7A) cycle for relaxation shrinkage.
- Severe (5A) cycle for felting shrinkage.

AATCC TM135:

- Kenmore-Whirpool top-loading machine.
- Total shrinkage measured.

ISO 6330:

- Wascator.
- Total shrinkage measured.

5 - **Module 10:** Performance standards

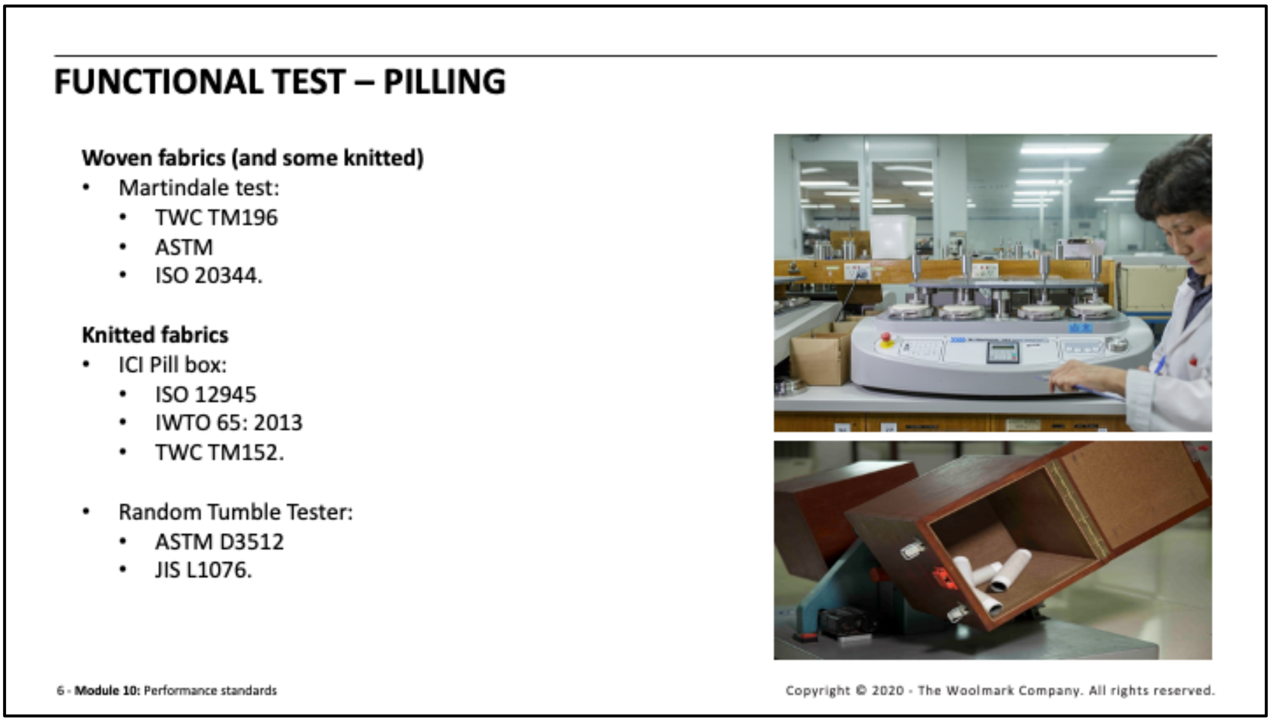
EXPLAIN THAT most of the standard tests deal with functional aspects of fabric performance. An example of a functional test is that carried out to test shrinkage.

However, there are also numerous international tests for aesthetic characteristics (e.g. IWTO 51 Finish Stability).

INDICATE THAT there are numerous tests for relaxation and felting of wool fabric during laundering:

- Woolmark–TM31 1.
    - Wascator (Electrolux)
    - Gentle (7A) cycle for relaxation shrinkage
    - Severe (5A) cycle for felting shrinkage.
- AATCC TM135 2.
    - Kenmore–Whirlpool top loading machine, total shrinkage measured.
- ISO 6330 3.
    - Wascator, total shrinkage measured.

NOTE THAT many international tests do not distinguish between relaxation shrinkage (an aesthetic characteristic) and felting shrinkage (a functional characteristic) of the fabric.



INDICATE THAT here are several standard tests for pilling.

NOTE THAT the Martindale Test is used to test pilling in woven fabrics, as well as some knitted fabrics:

- TWC TM196
- ASTM
- ISO 20344.

POINT OUT that the ICI Pill box and Random Tumble Tester are two standard tests used to test pilling in knitted fabrics:

- ICI Pill box
  - TWC TM152
  - ISO 12945
- Random Tumble Tester
  - ASTM D3512
  - JIS L1076.

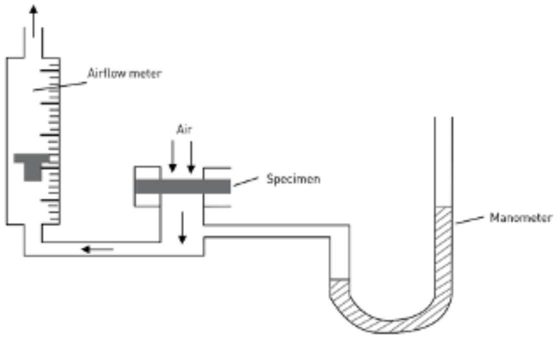
FUNCTIONAL TEST – AIR PERMEABILITY

Air permeability is the extent to which a fabric allows air to pass:

- An important test for outdoor and activewear.
- Measures airflow through a standard area of fabric under a standard pressure.

Tests available:

- ISO 7321 (international)
- ASTM D737 (national)
- BS 5636 (national)
- GB T 5453 (national)



Schematic of air permeability meter

https://www.quora.com/Whats-the-principle-of-the-air-permeability-tester

7 - **Module 10:** Performance standards

INDICATE THAT air permeability is a measure of the extent to which a fabric allows air to pass.

EXPLAIN THAT the air permeability test is used on a wide range of textiles as diverse as canvas, parachute material and outdoor apparel. It is an important test for outdoor and activewear as well as industrial textiles.

NOTE THAT the air permeability test is another test for which there are international test methods:

- ISO 7321 (international)
- ASTM D737 (national)
- BS 5636 (national)
- GB T 5453 (national).

The air permeability test measures the rate of flow of air through a standard area of fabric (often 100 mm^2) under a standard pressure drop.

POINT OUT that alternatively, the resistance of the fabric can be measured. The test determines the pressure required to get a given airflow which is the reciprocal of the permeability.

MENTION THAT instrumentation is available to carry out these standardised tests methods.

EXPLAIN THAT the Woolmark standards are examples of **contracted standards.** The contract is between the Woolmark Company and the company licensed to the Woolmark brand or sub brand.

INDICATE THAT the licence requires all new products for which a Woolmark label is required to be tested by an independent laboratory and approved by The Woolmark Company.

NOTE THAT the tests used are discussed later in this module.

EXPLAIN THAT this Woolmark company video explains the use of Woolmark specifications and test methods and the general context of the Woolmark certification and labelling program.

***PLAY** video (1 minute 37 seconds)*

***ASK** participants if they have any questions or comments regarding the video content.*

***ALLOW** sufficient time for participants to respond before proceeding with the lecture.*

WOOLMARK SPECIFICATIONS

Woven fabric

- Wool content
- Non-wool fibres
- Weight (g/m^2)
- Tensile strength
- Abrasion
- Seam slippage
- Pilling
- Colour fastness
  - Light, rubbing, washing.
- Dimensional stability
  - Relaxation shrinkage
  - Felting shrinkage.
- Surface pile weight

Knitted fabric

- Wool content
- Non-wool fibres
- Weight (g/m^2)
- Cover factor
- Burst strength
- Spirality
- DCM extractables
- Pilling
- Colour fastness
  - Light, rubbing, washing
- Dimensional stability
  - Relaxation shrinkage
  - Felting shrinkage
- Surface pile weight

10 - **Module 10:** Performance standards

INDICATE THAT the Woolmark Standards cover the properties of wool fabrics and garments listed in the slide.

NOTE THAT the tests are similar for both knitted and woven fabrics. The tests are for both functional and aesthetic properties.

WOOLMARK SUB-BRANDS

Cool Wool

- Worsted yarn
- Clean finish
- Fabric weight < 190g/m2
- MFD* < 22.5um

*MFD=Mean fibre diameter

11 - **Module 10:** Performance standards

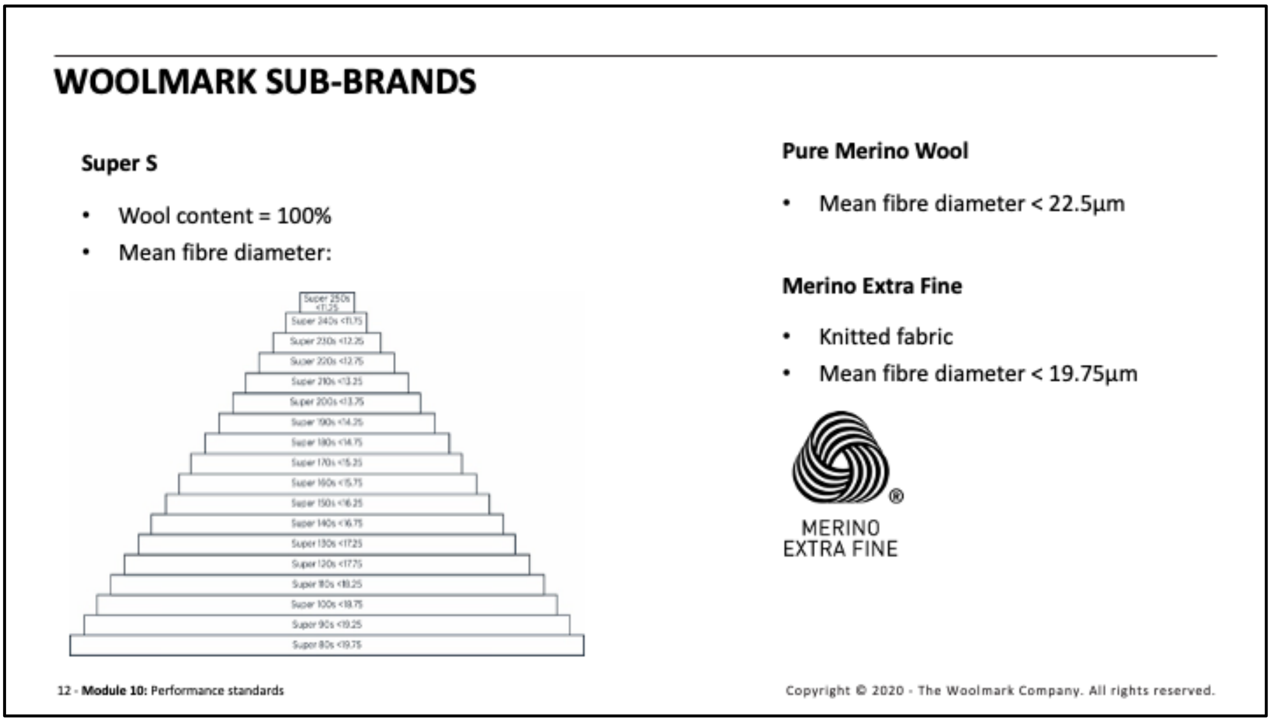
NOTE THAT Woolmark also has a series of sub-brands. A sub-brand is an 'extra' brand that can be used in addition to Woolmark Brands for products that meet the extra requirements of the sub-brand. Examples include:

- Cool Wool
- Merino Gold.

EXPLAIN THAT Cool Wool is a sub-brand applicable to fabric woven from worsted yarn, with a clean finish.

- It is designed to be used in clothing that is suitable for wearing in warmer months, taking advantage of the fact that wool it regulates temperature better than any other material.
- In addition to the normal specifications for the product, Cool Wool must weigh less than 190g per square metre, with the mean fibre diameter no greater than 22.5µm.

Although Cool Wool is lighter, it doesn't mean that garments don't hang and retain their shape as well as a classic, slightly weightier Merino.



INDICATE THAT Woolmark has three sub-brands defined by fibre diameter:

- Super S
- Pure Merino Wool
- Merino Extrafine

Super S fabric is:

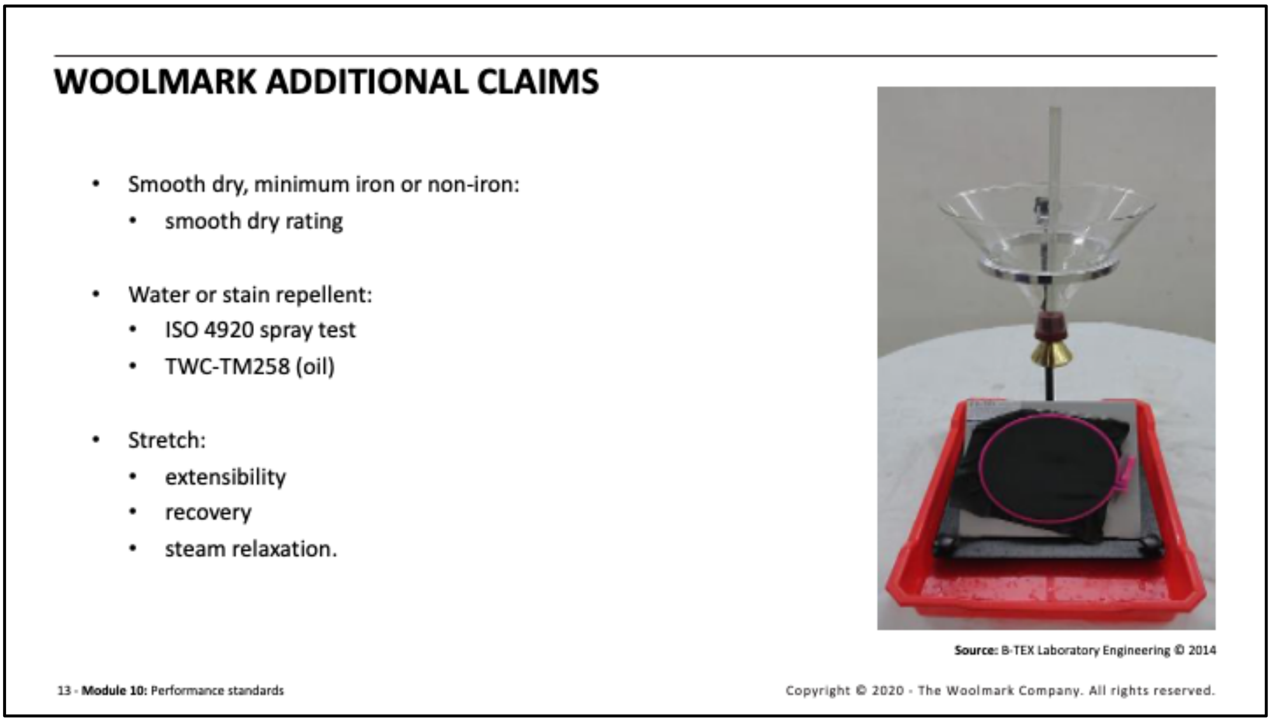
- made of 100% wool
- graded according to the mean diameter of the fibre (MFD), as shown on the pyramid.

Pure Merino Wool:

- products must be made up of 100% wool with a mean fibre diameter of less than 22.5µm.

Merino Extrafine:

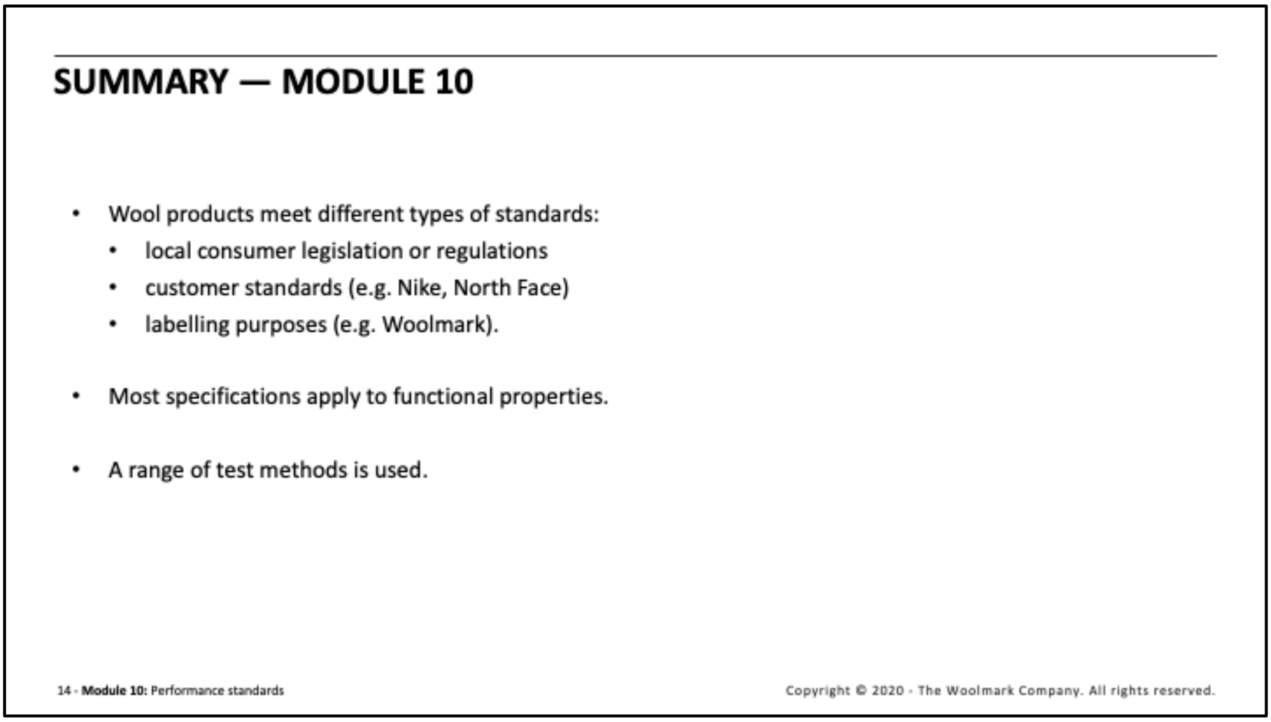
- refers to a product where the wool fibre has a mean fibre diameter of less than 19.75µm.



INDICATE THAT the Woolmark Standard also offers some additional functional and aesthetic claims.

These are as follows:

- Smooth dry, minimum iron or non-iron
    - Smooth dry rating using subjective standards
- Water or stain repellent
    - ISO 4920 spray test
    - TWC-TM258 (oil)
- Stretch
    - extensibility
    - recovery
    - steam relaxation.



SUMMARISE the module by explaining wool products and the fabrics from which they are made usually have to meet different types of standards:

- to comply with local consumer legislation or regulations (e.g. China, USA)
- to meet customer standards (e.g. Nike, North Face) — will normally include functional and aesthetic properties
- for labelling purposes (e.g. Woolmark).

REITERATE THAT most international standards apply to functional properties but not all.

REVIEW the fact that a range of test methods is usually available, which must be agreed between the supplier and customer.

REMIND participants that the ability of wool fabrics to meet most functional and aesthetic standards depends on:

- the properties of the fibre
- the characteristics of the yarn
- the construction and finishing of the fabric
- the finishing methods used.

REVIEW the fact that the finishing method used depends on the finisher.

ASK *participants if they have any questions about the content covered in this module.*

ALLOW *time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants of the time and location for the next lecture — *Module 11 Environmental issues* — and encourage them to read through the relevant notes in their Participant Guides before attending the lecture.

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

Participants can register with and explore the Woolmark Learning Centre here:
www.woolmarklearningcentre.com

THE WOOLMARK COMPANY

MODULE 11

ENVIRONMENTAL ISSUES

RESOURCES — MODULE 11: ENVIRONMENTAL ISSUES

No additional resources are required to deliver **Module 11: Environmental issues**.

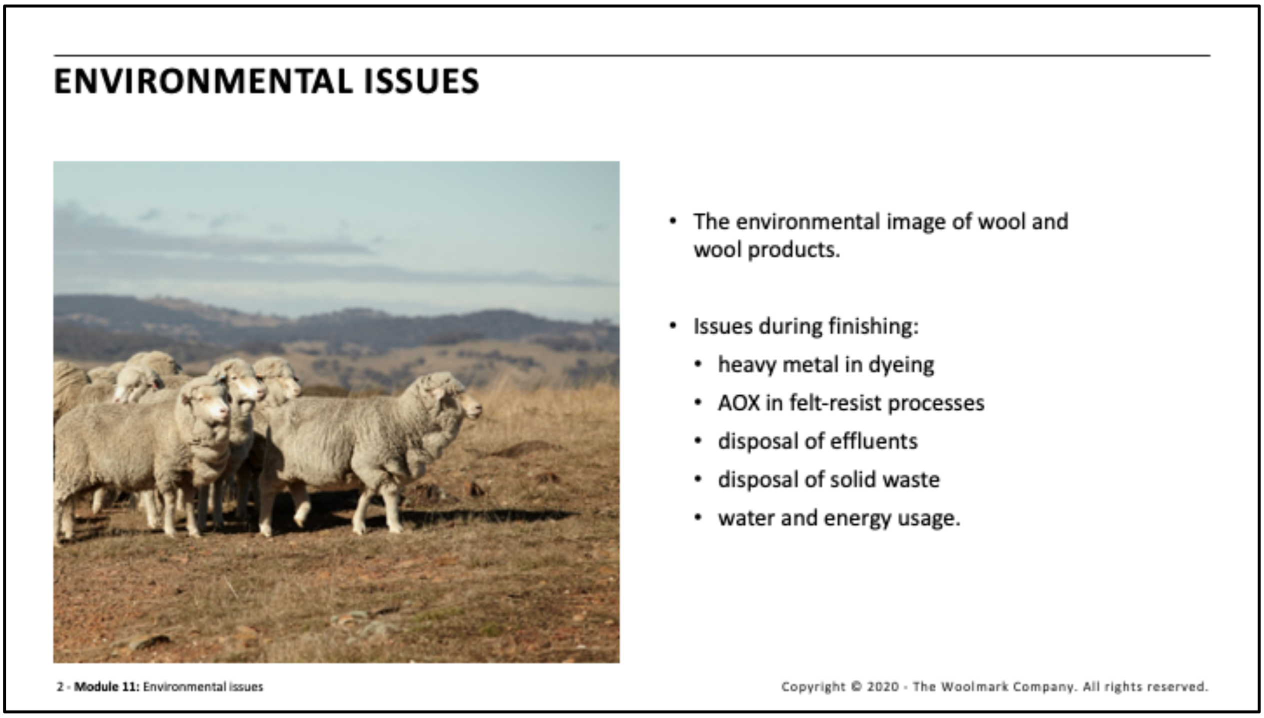
WELCOME participants to Module 11 of the Woolmark Wool Science, Technology and Design Education Program — *Wool fabric finishing — Environmental issues.*

INDICATE THAT the image of wool and wool products and the issues of environmental responsibility are important to all sectors of the processing chain from woolgrowers to retailers of wool products.

EXPLAIN THAT this module looks at the environmental impacts associated with wool fabric finishing.

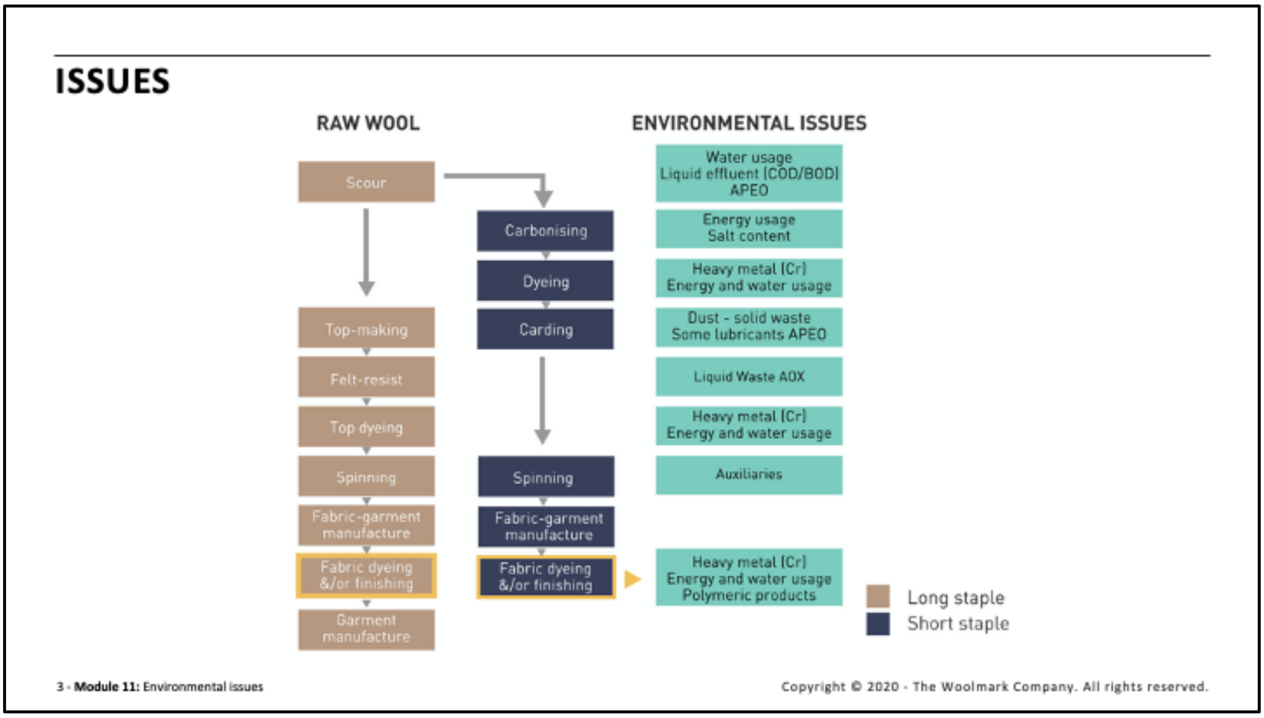
INFORM participants that by the end of this module they will be able to:

- describe how the 'environmentally friendly' image of wool products can be challenged
- describe the positive and negative environmental aspects of wool products
- describe how the limits for indirect discharge of chemicals in wool finishing are changing
- describe some of the common environmental issues related to wool finishing processes and how these can be effectively managed
- recognise the benefits associated with pro-actively changing finishing processes to more environmentally responsible options.



EXPLAIN THAT there are a number of issues associated with wool finishing that can impact on the environment, such as:

- disposal of effluents
- disposal of solid waste
- AOX in felt-resist processes
- heavy metal in dyeing
- water and energy usage.



INDICATE THAT the environmental issues listed on the right-hand side of the slide relate to each stage in the dyeing and finishing of wool.

POINT OUT that many governments have introduced new regulations, which cover each of these processes.

EXPLAIN THAT the slide shows a shortened version of the processes to which wool is subjected in its journey to become a product.

Processing of worsted product is highlighted on the left, processing for woollen product is represented in the middle of the diagram.

The routes represented on the slide are those primarily used for fine wool. The slide does not include routes for non-apparel products (such as carpets).

Each box represents a number of processes, both wet and dry.

EMPHASISE THAT every time wool is wet there is potential for environmental impact.

NOTE THAT many of the potential pollutants were not on the wool when it was grown – they are added or formed in processing.

INDICATE THAT since this course is about finishing, some of the common environmental challenges associated with finishing will be discussed and how these can be minimised through appropriate management.

AOX IN FELT-RESIST PROCESSES

Adsorbable Organic Halides (AOX) are an environmental hazard. Their release in mill effluent is now regulated.

The Chlorine-Hercosett process:

- is cheap, robust and effective
- contains AOX in effluent.

This process is used mostly on loose wool and top.

Non-chlorine processes are available for the treatment of:

- woven fabrics
- some knitted fabrics.
- knitwear.

4 - **Module 11:** Environmental issues

Adsorbable Organic Halide (AOX)

EXPLAIN THAT the term AOX represents a series of products created when chlorine reacts with proteins, such as wool. AOX is considered an environmental hazard and the release of AOX in mill effluent is now regulated by many governments.

INDICATE THAT the Chlorine-Hercosett felt-resist process is used mostly on loose wool and top. It is also widely used on knitted fabric. It is:

- cheap
- robust
- effective.

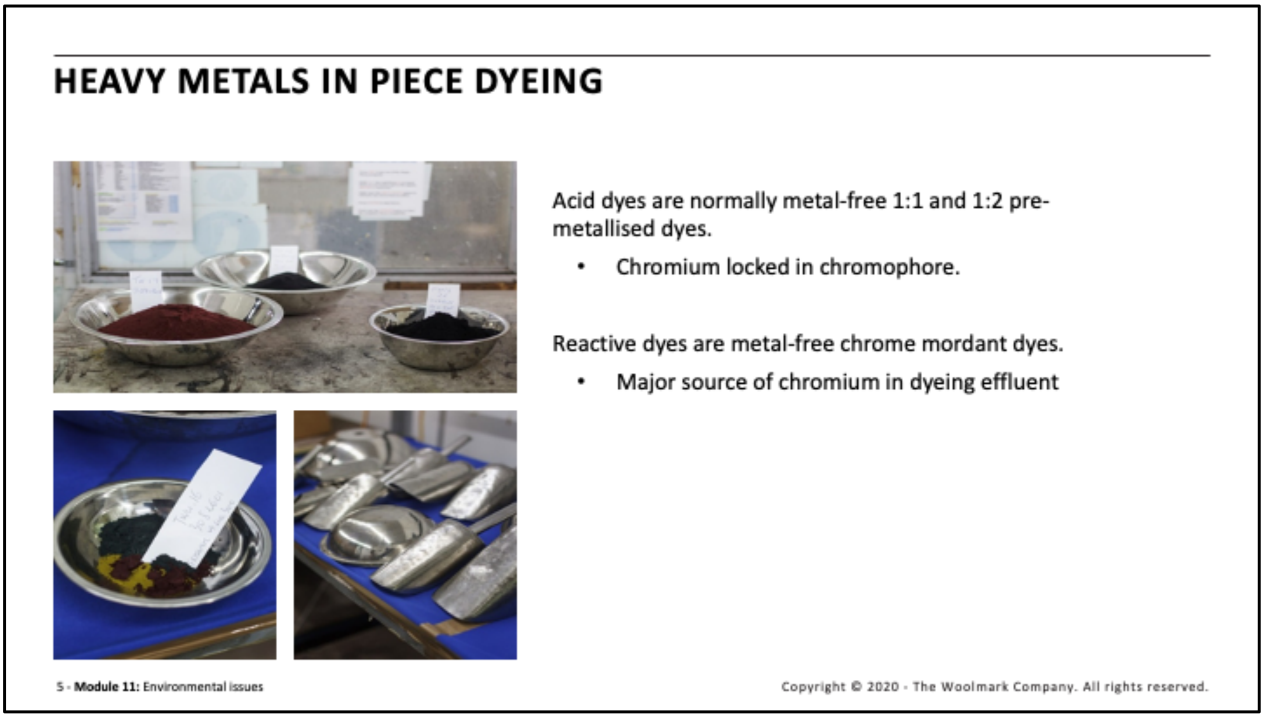
However, it releases AOX (a by-product from the process) into the processing effluent.

POINT OUT that if the waste from the Chlorine-Hercosett process is not managed properly, this can result in AOX being indirectly discharged in amounts much higher than the government limit.

NOTE THAT there are several processes available for the felt-resist treatment of fabric that do not require the use of chlorine. The non-chlorine treatments available for woven fabrics are cheap, robust and widely used. The range of options for knitted fabrics is smaller.

EXPLAIN THAT AOX is not as big an issue for the wool finishing industry as it is for top-makers, where most of the chlorine-based processes are used, but must be monitored.

EMPHASISE THAT it is important all the waste from finishing treatments is effectively managed so the chemicals indirectly discharged into the environment are within the government limitations.



INDICATE THAT a range of dyes is used in piece dyeing of wool fabrics, with varying environmental impacts.

The most common are:

Acid levelling dyes:

- Acid dyes do not contain heavy metals, but often lack the wet fastness required for many applications.

1:1 pre-metallised dyes:

- The chromium is locked in the chromophore and can only enter the effluent if the dye does not exhaust.
- Used in piece dyeing but must be applied under strongly acid conditions.

1:2 pre-metallised dyes:

- Not used in piece dyeing, but widely used in yarns and fibre dyeing.
- The chromium is locked in the chromophore and can only enter the effluent if the dye does not exhaust.

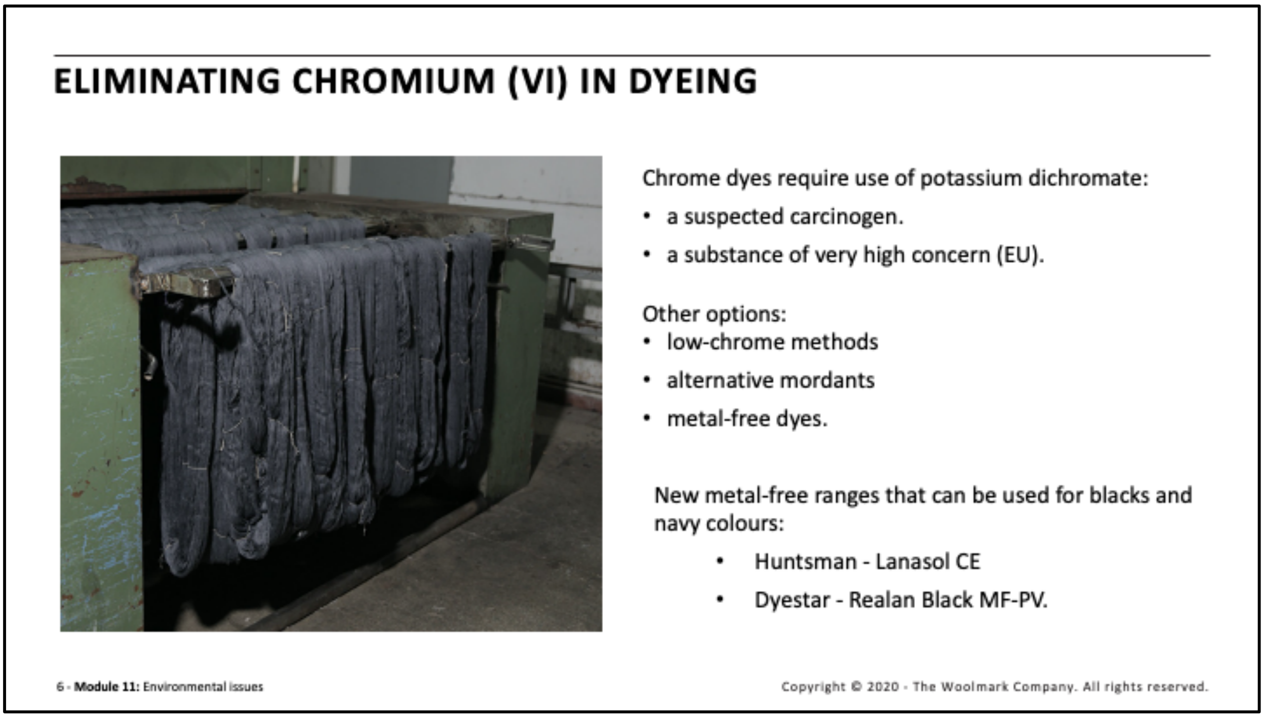
Reactive dyes

- These dyes do not contain heavy metal.

Chrome mordant dyes:

- Major source of chromium in dyeing effluent.
- Inexpensive, with good exhaustion and excellent wet fastness.
- Approximately 25% of all dyes used on wool—mostly black and navy.

EMPHASISE THAT for all dye systems, achieving a high level of exhaustion, so there is little or no dye remaining in the effluent, is a key requirement.



Chrome mordanting

EXPLAIN THAT chrome mordant dyes require the use of potassium dichromate (Cr{VI]), which is a suspected carcinogen and a substance of high concern in the European Union (EU).

INDICATE THAT other options are:

Low-chrome methods designed to minimise the use of dichromate while maintaining the dye properties.

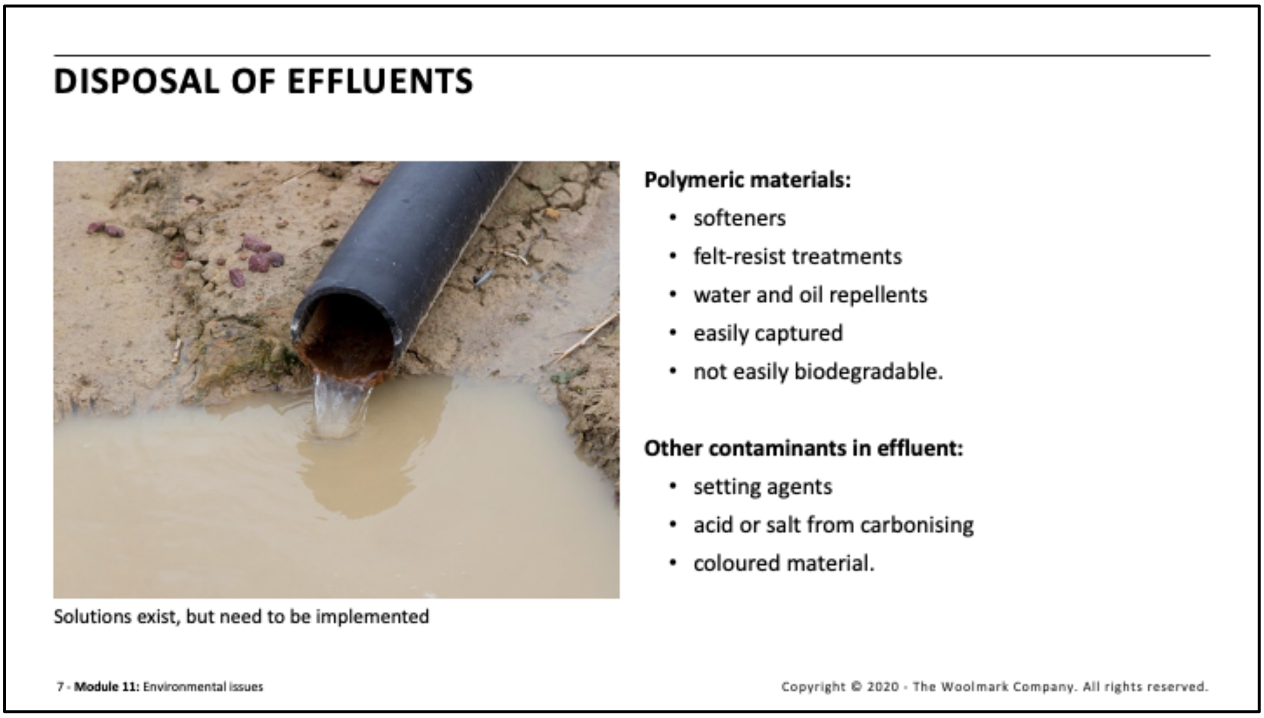
Alternative mordants that do not contain chromium (VI).

Metal-free dyes.

MENTION THAT new ranges of metal-free dyes are available, which are designed to replace chrome mordant dyes, especially in blacks and navy colours. Brands include:

- Lanasol CE dyes from Huntsman
- Realan dyes from Dyestar.

NOTE THAT these issues are fully covered in course of The Woolmark Wool Science, Technology and Design Education Program *The dyeing of wool*.



INDICATE THAT there are other products used in finishing that must be removed from any effluent before it can be discharged to the environment.

Polymeric materials
Finishing processes release a number of polymeric materials into the effluent. For example:
- softeners, such as silicone dispersions
- felt-resist treatments, such as silicones, urethanes
- water and oil repellents such as fluorocarbon emulsions.

EXPLAIN THAT all these polymeric materials are easily captured, but none are easily biodegradable. As a consequence, the more they are used, the more this unwanted waste must be managed.

Other contaminants
MENTION THAT other contaminants commonly found in finishing effluent include:
- setting agents
- acid from carbonising
- coloured material from dyeing (not exhausted).

EMPHASISE THAT solutions for these problems exist, but they need to be implemented.

LIMITS ON WATER USAGE

Products	Limit
Yarns, knitwear fabric	85
Worsted wool fabric	500
Woollen wool fabric	575

Standard displacement of course products
(m^3/t product = litres/kg)

High water and energy usage processes in wool finishing:

- wet setting — chemical assistants are a viable option
- fabric scouring — open-width continuous scouring generally uses less water than rope scouring
- dyeing — solutions can be found in:
  - machinery design
  - enhanced recycling
  - low-temperature dyeing
  - short-time dyeing.

Use of recycled water is critical, although there are additional requirements for management of the waste stream.

8 - **Module 11:** Environmental issues

INDICATE THAT the finishing of wool fabrics and garments generally requires a lot of water. In today's environmentally-conscious society, there is pressure to reduce the amount of water used.

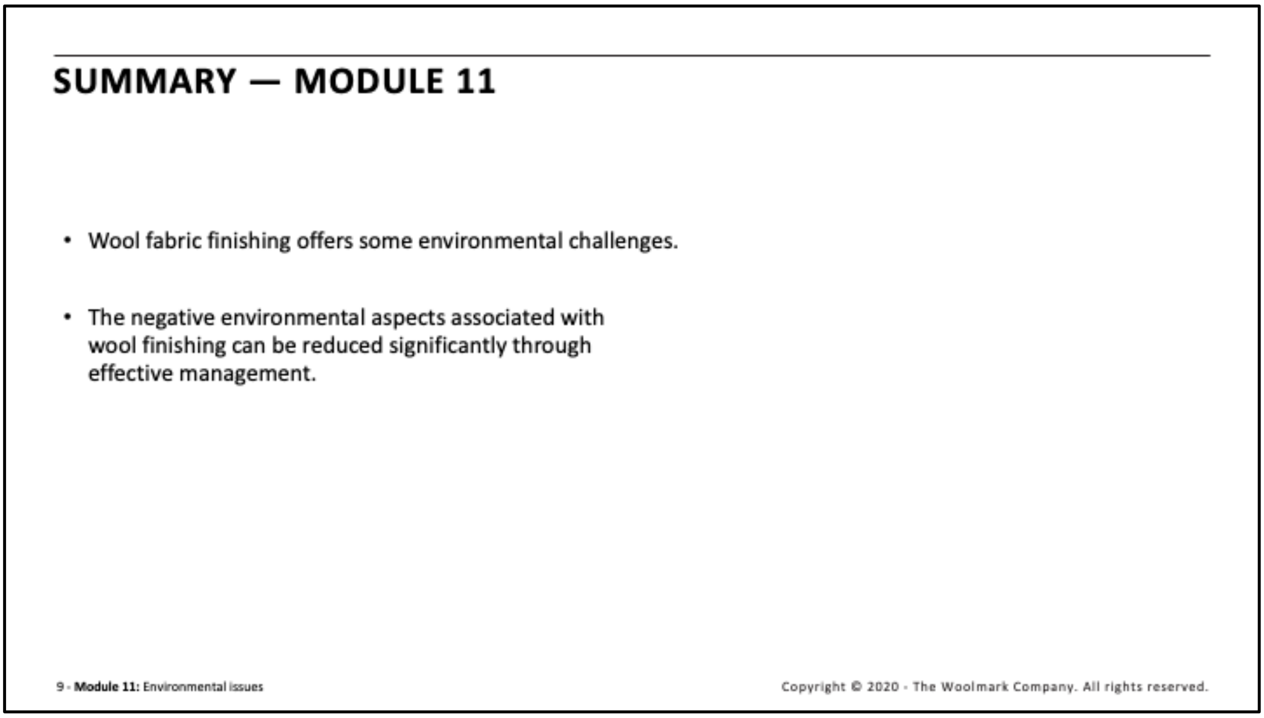
POINT OUT that many governments or local authorities set new limits on the amount of water that can be used in the finishing of fabric. As an example, the limits required in China are shown in the slide in the form of standard water usage per course product (m^3/t product = litres/kg).

EXPLAIN THAT the wool finishing processes that require the most amount of water and energy are:

- wet setting — chemical assistants pose a viable option to help resolve this
- fabric scouring — this can be addressed by using open-width continuous scouring, wherever possible, as this generally uses less water
- dyeing — challenges can be addressed by:
  - improved machinery design
  - enhanced recycling
  - low-temperature dyeing
  - short-time dyeing.

NOTE THAT based on surveys, the water consumption and wastewater discharge by the finishing industry has been considerably reduced during recent years. The wool processing industry has invested a lot on low-liquor dyeing at all stages in the pipeline and continuous treatment equipment in finishing.

EMPHASISE THAT water recycling is critical to reducing water usage rates, with all the additional requirements for management of the waste stream. The increased use of recycled water is the goal of all organisations.
Water use reduction is itself a two-edged sword because reducing water and energy usage can increase the concentration of pollutants in the effluent. This can make the effluent treatment more difficult.



SUMMARISE the module by explaining that wool fabric finishing offers some unique environmental challenges.

REITERATE THAT the negative environmental aspects associated with wool finishing can be reduced significantly through effective management.

REMIND participants that examples have been given of methods for:

- reducing chromium in the effluent from piece dyeing
- reducing AOX in fabric felt-resist treatments.

***ASK** participants if they have any questions about the content covered in this module.*

***ALLOW** time for questions and discussion before proceeding to the final slide and closing the lecture.*

INFORM participants that this module completes the Wool Science,Technology and Design Education Program course *Wool fabric finishing.*

ENCOURAGE participants to explore the Woolmark Learning Centre to reinforce and build on what they have covered in today's lecture.

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