Wool Fibre Innovation

OPTIM Technology

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Drivers for Wool Fibre Innovation

- Changing consumer and market needs
  - Finer, lighter yarns and fabrics
  - Softness and low prickle required
  - Reduced demand for >21 µm wools
  - Product Innovation

- Challenge: How to make wool finer?
  - Solution (1): Breed finer wools (5 years breeding for 1 µm)
  - Solution (2): Drought conditions
  - Solution (3): Fibre modification/transformation

Fibre transformation provides major scope for product innovation. Fibre transformation is the most radical form of innovation.

Watteau

What is Innovation? “Make the strange familiar or make the familiar strange.” G.K. Chesterton
The supportive CSIRO R&D environment in the 1980s

- Radical innovation encouraged
  - 'Fibre modification underpins fundamental innovation.'
- Broad skill base at Geelong:
  - wool physics and chemistry know-how
  - machine design and building skills
  - fibre-to-fabric facilities
  - fibre-to-fabric know-how.
- Strong support from wool R&D funding body.
Wool fibre is extensible

- Data for 18.7 µm wool fibres (3.5 dTex)
Fibre diameter decreases with extension
Wool fibre is extensible

- Extensibility depends on:
  - moisture content of fibre
  - temperature
  - level of broken disulphide bonds (thiols)
    - needs reducing agents.
Wool fibres can be set

- Setting chemistry is well-known.
  - Wool fibres can be set in bending, extension or when twisted

- Two separate setting processes can apply:
  - glass transition temperature (cohesive)
  - thiol-disulphide interchange
Setting of wool

- **Glass transition temperature**
  - Cohesive (released in cold water)
    - e.g., wrinkles in trousers.

- **Thiol-disulphide interchange**
  - Temporary (released in hot water at 70°C)
    - stability of a wool fabric surface after pressing using mild steaming conditions (e.g. 87°C)
    - treat a freshly spun yarn in steam at 87°C for several minutes.

- **Permanent (stable to hot water at 95°C)**
  - stability of a wool fabric surface after pressure decatising at 110°C
  - bend and hold a fabric in boiling water for one hour
  - extend and hold a fibre in boiling water for one hour
The Challenge

- How to extend and set fibres in practice?
- What were the consequences?
- What were/are the opportunities?
Stretching of fibres

- Too difficult to stretch fibres separately.
- Stretch against twist provides fibre cohesion and control.
- Stretching of slivers using false twist developed.
Stretching of fibres

- Too difficult to stretch fibres separately.
- Stretch against twist provides fibre cohesion and control.
- Stretching of slivers using false twist developed.
Commercial Optim plant

Woolmark/Andar commercial plant

Productivity: ~ 30-40 kg/hr

6 machines globally (including 5 Andar machines)
Setting of extended wool fibres

Temporary or permanent set possible.

- Stress relaxation occurs in stretched fibres.
- Reducing agent generates thiols.
- Thiols aid the relaxation process by thiol-disulphide interchange.
- Oxidation step rebuilds disulphides.
- Time and temperature parameters important.

- Choice of conditions produces temporary or permanent set.
Commercial Optim plant

- heating
- stretch
- set
Optim™ fibres

- At present, two fibre types allow product innovation:
  - OPTIM™fine – permanent set
  - OPTIM™max – temporary set.
The OPTIM™ fine process

WOOL SLIVER (e.g., 19 µm)

TWIST

STRETCH

PERMANENTLY SET

OPTIM™ fine FIBRE (e.g., 15.5 µm)
Cross-sectional shape of OPTIM™ fine

Parent Wool

OPTIM™ fine fibres
Fibre structure

Wool

Alpha keratin diffraction pattern

OPTIM™fine

Beta keratin diffraction pattern (silk-like)
Optim™ Fine Fibres

- Benefits
  - Lustrous, silk-like, glitter
  - Longer
  - Stronger
  - Prickle reduced
  - Applies to all wools (and all animal fibres)

![Fibre Stretch Chart](image)

![Fibre Diameter Chart](image)

![Fibre Length Distribution Chart](image)

![Microscopic Image of Fibres](image)
Optim™ fine properties

Disadvantages
- Low wet modulus
  - affects top and package dyeing
  - more care needed in finishing
  - poor wrinkling behaviour
## OPTIM™ fine fibre properties

<table>
<thead>
<tr>
<th></th>
<th>Optim™ Fine</th>
<th>Wool</th>
<th>Viscose</th>
<th>Silk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear density (dTex)</td>
<td>2.3</td>
<td>3.7</td>
<td>1.7</td>
<td>1.2</td>
</tr>
<tr>
<td>Tenacity (cN/Tex)</td>
<td>14.5</td>
<td>11.5</td>
<td>22-26</td>
<td>39</td>
</tr>
<tr>
<td>Extensibility (%)</td>
<td>19</td>
<td>38</td>
<td>20-25</td>
<td>18</td>
</tr>
<tr>
<td>Wet modulus (cN/Tex)</td>
<td>51</td>
<td>95-100</td>
<td>40-50</td>
<td>220</td>
</tr>
</tbody>
</table>
The OPTIM\textsuperscript{TM}max process

WOOL SLIVER

TWIST

STRETCH

TEMPORARY SET

OPTIM\textsuperscript{TM} max FIBRE

Retractable wool fibre ~ 25\%
Bulk generation in yarn

OPTIM\textsuperscript{TM} \textit{max} fibre

Blend as top

Spin

Wool

Release yarn in hot water
Yarn bulk

Wool with Optim Max

Normal wool yarn
# Yarn and fabric bulk (wool with Optim™ max)

<table>
<thead>
<tr>
<th></th>
<th>Yarn count (Tex)</th>
<th>Yarn bulk (cm³/g)</th>
<th>Fabric bulk (cm³/g)</th>
<th>Fabric weight (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>R75/2</td>
<td>12</td>
<td>3.5</td>
<td>287</td>
</tr>
<tr>
<td>Wool with Optim™ max(40%)</td>
<td>R74/2</td>
<td>17</td>
<td>6.3</td>
<td>225</td>
</tr>
<tr>
<td>Wool</td>
<td>R478/3/3</td>
<td>6</td>
<td>7.8</td>
<td></td>
</tr>
<tr>
<td>Wool with Optim™ max(40%)</td>
<td>R435/3/3</td>
<td>12</td>
<td>10.5</td>
<td></td>
</tr>
</tbody>
</table>
Optim™max properties

Benefits:
- Retractable
- Generates bulk when blended
- Good for ‘warm without weight’ products
- Basis for further product innovation.

Disadvantages:
- Extra relaxation process required in yarn processing.
Commercial position

- Process patented
- Woolmark was sole licensee for manufacture and sale of Optim machines now part of AWI merger.
- Detailed technology transfer packages provided to Woolmark from CSIRO
  - Fibre to fabric processing advice available
- Optim™ machines are operating in China and Japan.
- Arcana machine operating in Australia.
Further developments of Optim

Currently Optim demand is limited by supply, fibre cost and performance issues.

The following will enhance the opportunity for Optim products:

- reduce cost of production
- improve wet fibre and fabric properties
- develop new fibre products
Black box approach to fibre modification

- Modify process to engineer wool fibres for unique product applications.
- Optim example:
  - fibre tenacity
  - elongation to break
  - crimp
  - range of fibre types possible.
Ancient thoughts on problem solving

‘By always thinking unto them, I keep the subject constantly before me and wait till the first dawning open little by little into the full light.’

Sir Isaac Newton (1642-1727)
Final word on innovation

Product innovation is largely a process of problem solving combined with passion and persistence, but, above all, arises from the need to think and rethink about needs, problems and opportunities.

David Phillips, 2007
Next

- Questions
- Visit to Optim™ prototype plant
- Show of Optim™ products