SPINNING OF FILAMENT YARNS
# HISTORY OF MANUFACTURED FIBRES

<table>
<thead>
<tr>
<th>Year</th>
<th>Fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>Rayon</td>
</tr>
<tr>
<td>1924</td>
<td>Acetate</td>
</tr>
<tr>
<td>1930</td>
<td>Rubber</td>
</tr>
<tr>
<td>1936</td>
<td>Glass</td>
</tr>
<tr>
<td>1939</td>
<td>Nylon</td>
</tr>
<tr>
<td>1939</td>
<td>Vinyon</td>
</tr>
<tr>
<td>1941</td>
<td>Saran</td>
</tr>
<tr>
<td>1946</td>
<td>Metallic</td>
</tr>
<tr>
<td>1949</td>
<td>Modacrylic</td>
</tr>
<tr>
<td>1949</td>
<td>Olefin</td>
</tr>
<tr>
<td>1950</td>
<td>Acrylic</td>
</tr>
<tr>
<td>1953</td>
<td>Polyester</td>
</tr>
<tr>
<td>1959</td>
<td>Spandex</td>
</tr>
<tr>
<td>1961</td>
<td>Aramid</td>
</tr>
<tr>
<td>1983</td>
<td>PBI</td>
</tr>
<tr>
<td>1983</td>
<td>Sulfar</td>
</tr>
<tr>
<td>1986</td>
<td>Microfiber</td>
</tr>
<tr>
<td>1992</td>
<td>Lyocell</td>
</tr>
</tbody>
</table>
KING OF FIBERS?

Worldwide Demand by Major Fiber Type

During 2000, Polyester replaced Cotton as “King”.

Sources: Fiber Organon; PCI World Synthetic Fibres S/D 2003
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FILAMENT YARNS
FILAMENT YARN

- Untwisted filament yarn
- Twisted filament yarn
- High bulk filament yarn
- Stretch filament yarn
FILAMENT YARN

- Composed of continuous filament yarns
- Includes all man-made fibres and silk
- Slight twist or no twist at all
- Types of filament yarns:
  - Monofilament
  - Multifilament
  - Flat filament
  - Bulk filament
    - textured
    - bulky
    - stretch.
Filament yarn spinning

- In spinning, polymers are forced to extrude through spinneret holes.
- The holes can be in different cross-section such as round, trilobal, oval, dogbone, etc.
- The fibres formed after extrusion can be made into continuous filaments or cut into staple forms.
Filament yarn spinning

- SPINNERET HOLEs

Consists of tiny micro holes in which the polymeric materials are forced through to form filaments, which are then combined into continuous filament yarns or cut into staple fibres.
Types of Spinning

- Melt Spinning
  - Nylon, polyester, olefins

- Dry Spinning
  - Acetate, acrylic, modacrylic, spandex

- Wet Spinning
  - Acrylic, rayon, spandex

- Others:
  - Solvent spinning (Lyocell)
  - Dry-jet wet spinning (aramids)
  - Gel spinning (HMPE)
Dry-jet Wet Spinning
Both Nylon and Polyester are melt spun into filament and staple fibres.

Important aspect is the degree of orientation in the filament which depends on spinning speed:
- Low oriented yarn (LOY)
- Partially oriented yarn (POY)
- Highly oriented yarn (HOY)
- Fully oriented yarn (FOY)
<table>
<thead>
<tr>
<th>FORM</th>
<th>SPINNING SPEED (m/min)</th>
<th>PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOY</td>
<td>&lt;2,500</td>
<td>Staple fibre</td>
</tr>
<tr>
<td>POY</td>
<td>2,500 – 4,000</td>
<td>Textured yarn</td>
</tr>
<tr>
<td>HOY</td>
<td>4,000 – 6,500</td>
<td>Flat filament</td>
</tr>
<tr>
<td>FOY</td>
<td>&gt;6,500</td>
<td>Flat filament</td>
</tr>
</tbody>
</table>

The higher the spinning speed, the higher is the degree of orientation
Polyamide

1. Crude oil
2. Aromatics
3. Production of polyamide 6.6
4. Production of polyamide 6
5. Adipic acid
6. Hexamethylene diamine
7. Caprolactam
8. Polyamide 6 or polyamide 6.6 polymer
9. Melt
10. Production of polyamide filament yarn, one-step
11. Production of polyamide filament yarn, multi-step
12. Production of polyamide staple fibres
13. Melt spinning
14. Drawing
15. Flat polyamide filament yarn
16. Spinning bobbin
17. Tow
18. Drawing
19. Crimping
20. Polyamide tow
21. Polyamide staple fibres

Source: IVC, Frankfurt
MICROFIBRES
Introduction

- A microfiber is by definition a material in which the yarn’s thickness is equal to or less than $\frac{1}{60}$th the thickness of an average human hair.

- Comparatively, microfibers are:
  - two times finer than silk
  - three times finer than cotton
  - eight times finer than wool, and
  - one hundred times finer than a human hair.

- Ultra-microfibers on the market are even finer – some having thickness of just $\frac{1}{200}$th the thickness of human hair!
Based on the specific weight of the fiber material (1.32), the graph above demonstrates nicely how small in diameter micro fibers really are.

Most commercially available wool fabrics are made from medium to fine wool.

Today, any fiber less than 1 dpf (denier {or dtex} per filament) is called a micro fiber.
There are two ways to produce microfibers:

- Direct spinning of POY with high number of filaments
- Bicomponent spinning of yarns, where each filament will split into a multitude of smaller filaments after a chemical treatment during the finishing of the fabric.

Both ways are being practiced today. The first one being the more economical method because of a much lower investment cost for such yarns and the latter one being a method, which allows the production of very specialized yarns with interesting cross sections.
<table>
<thead>
<tr>
<th>Method</th>
<th>Composition</th>
<th>Manufacturer</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Direct spinning</td>
<td>PES</td>
<td>Montefibre</td>
<td>Terital Zero 4</td>
</tr>
<tr>
<td>2. Split/separation radial</td>
<td>PES/PA 6</td>
<td>Kanebo</td>
<td>Belleseime,* Savina DP,↑</td>
</tr>
<tr>
<td>Radial hollow</td>
<td>PES/PA 6</td>
<td>Teijin</td>
<td>Savina Mini-Max;↑</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hilake,* HilakeElettes,↑</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MicroStar↑</td>
</tr>
<tr>
<td>Side by side</td>
<td>PES/PA 6</td>
<td>Kuraray</td>
<td>Tactel Micro</td>
</tr>
<tr>
<td></td>
<td>PA</td>
<td>Du Pont</td>
<td>Leacril Micro/Myoliss</td>
</tr>
<tr>
<td></td>
<td>PAN</td>
<td>Montefibre</td>
<td></td>
</tr>
<tr>
<td>3. Dissolution</td>
<td>PES</td>
<td>Unitika</td>
<td>FSY</td>
</tr>
<tr>
<td>Islands in the sea</td>
<td>PES/PSY</td>
<td>Toray</td>
<td>Ecsaine,* Youest,§ Toraysee↑</td>
</tr>
<tr>
<td>Polymer blend</td>
<td>PES/PSY</td>
<td>Kuraray</td>
<td>Amara,* Sofrina,§ Clarino-F§</td>
</tr>
</tbody>
</table>

* Artificial suede.
† High-density fabric.
‡ Cleaning cloth.
§ Artificial leather.
Advantages of Microfibres

- Example: Polyester microfibres for outerwear
  - Light
  - Comfortable
  - Wind barrier
  - Breathable
  - Repels water
Currently, there are four types of synthetic microfibers being produced:
- acrylic,
- nylon,
- polyester and
- rayon

The most common blend of microfiber material used in automotive detailing applications is nylon and polyester.
Main products for which microfiber are ideally suited:

- Microfiber Glass Cloth
- Duster/Multi-purpose Microfiber Cleaning Cloth
- Kitchen Cloth
- Optical & CD Cloth
- Mops
- Cleaning Sponge
- Cleaning Cloths
Other products for which microfiber is being used:

- Bags
- Bath towels
- Beachwear, beach wear
- Bedspreads & bed sheets
- Boxer shorts
- Bras & women’s inner wear
- Bikinis
- Carpet
- Casual clothing – high-end
- Coats / Overcoats
- Curtains
- Cushions
- Cloths
- Dresses
- Garments
- Gloves
- Handkerchiefs
- Hats & headscarves
- Leggings
- Mats – high-end
- Menswear
- Miniskirts
- Pants
- Panties
- Pantsuits
- Panty hose
- Pull overs
- Swimsuits
- Sweatshirts
- Shirts
- Stockings
- Skirts
- Socks
- Table linen/ tablecloth
- Trousers
- T-shirts
- Tracksuits
- Tight/Tights
- Underwear - Underpants, Undershirts
- Vests
Global Manufacturers

- Meryl Microfiber is made by Nylstar, an Italian company which is one of the largest manufacturers of Nylon 6.6. It finds application in sports where it is used for swimming, sailing & athletics.

- Kanebo, a Japanese company, manufactures a high-density polyester, polyamide woven fabric. Called Belseta and made from the microfiber Belima-X, it is used in fashion and sportswear.

- The European company Akzo Nobel is another company that has been producing microfibers. This company has been producing microfibres since 1983.

- The German company Hoechst High Chem launched its polyester microfiber for high-performance clothing, called Trevira Finesse in 1987. A variation of Trevira Finesse is Trevira Micronesse.
Kuraray, the Japanese company, produces ultra-fine synthetic fibers as alternatives to leather. Their products are called Clarino and Sofrina, and they are used to produce fabrics used in sportswear, fashion and luggage.

Kolon Fibers produces an ultra-microfiber fabric called Rojel. The warp-knitted fabric from this fibre has the look and feel of leather.

The Italian textile company Montefibre/Enimont produces Terital Zero.4. Originally used for sportswear, this polyester filament microfiber now finds application in fashion and lingerie. Montefibre / Enimont also produces an acrylic microfiber called Myoliss, and another Microfibre Leacril.
DuPont are the leading worldwide producers of polyamide microfiber. Their best known microfibre brand is Tactel. Tactel, a registered trademark, describes a wide range of polyamide 6.6 yarns which can be altered during the finishing processes to create many effects.

- Tactel HT is an extremely strong grade that has been used for parachutes.
- Tactel texturals are used mainly for active sportswear.
- Tactel acquator can be pure or blended with other fibers.
- Tactel Ispira has a cross section resembling a spring which makes it elastic while being strong.
- Tactel diabolo with its luster and good draping qualities is marketed for swimwear, underwear and fashion knitwear. The super-soft, lightweight, strong and lustrous
- Tactel multisoft is used in hosiery and underwear.
- Tactel ispira has a cross section resembling a spring, which gives it its strength and elasticity. The ultra-luxurious Tactel micro is water-repellant and breathable and can be used in hosiery and rainwear.
BICOMPONENT FIBRES

A bicomponent fibre (speciality fibre) consists of two polymers that are chemically and/or physically different.
- Concentric Sheath/Core
- Eccentric Sheath/Core
- Side by side
- Pie wedge
- Hollow pie wedge
- Islands/Sea
- Three islands
Different cross sections of fibers

- Single fiber of "orange-type"
- Core/sheath
- 7-hole hollow fiber
- 4-hole hollow fiber
- Side-by-side
- Side-by-side hollow (eccentrically)
Texturing
(Texturizing)
Texturing

- Texturing or texturizing is a process in which permanent distortion (such as zig-zag, loop, coil, entangled) is introduced to the continuous filament yarn.

- Main fibres used in texturing are normally Nylon, Polyester and Polypropylene.
Texturing

The purposes of texturing are to improve:
- bulkiness
- hairiness
- warmth
- comfort
- dimensional stability
- handle aspects

Texturing produces two types of yarn: stretch and bulky
Types of texturing methods

- False twist (DTY) (90%)
  - Pin, friction (belt, discs)
- Air-jet texturing (ATY)
- Stuffer box texturing
- Knit-de-knit texturing
- Gear crimp texturing
<table>
<thead>
<tr>
<th>curled</th>
<th>peaked crimp effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>high bulk (stretched and relaxed principle)</td>
<td>rounded crimp effect</td>
</tr>
<tr>
<td>lofted effect from use of air jet</td>
<td>heated gears provide the crimp</td>
</tr>
<tr>
<td>stretch core (retains good elasticity)</td>
<td>&quot;stuffing box&quot; method (imparts crimp)</td>
</tr>
<tr>
<td>synfoam (twist and untwist method)</td>
<td>high twist not highly elastic</td>
</tr>
<tr>
<td>coiled</td>
<td></td>
</tr>
</tbody>
</table>
Principle of False-Twist Texturing

- Give a very high twist (2500tpm – 6000tpm) to the filaments
- Heat the filaments
- Cool the filaments
- Untwist the filaments
In practice:

– Single heater machine:
  – Twist - Heat – Cool – Untwist
    ◆ Stretch yarns
    ◆ Nylon

– Double heater machine:
    ◆ Bulky yarns
    ◆ Always polyester and polypropylene
    ◆ The filaments are heat-set again with 15-20% relaxation from the extended state.
Textured Nylon

Schematic of the False Twist Friction Texturing Process

- Shaft 1
- POY
- Friction Disks
- Shaft 2
- Textured Yarn
DTY - Polyester

SCHEMATIC OF THE DOUBLE HEATER SET-YARN PROCESS

- Shaft 1
- Shaft 2
- Shaft 3

POY
Heater
Cooling
Friction Disks
Second Heater
Typical Layout for 2 heater false twist machine
Friction Disc Principle
Air-Jet Texturing (ATY)
Principle

Overfeed

Drawing

Lubrication

Air-jet

ATY yarn
Core/Effect Yarns – for high bulk and volume yarns
Core/Effect Yarns – for high bulk and volume yarns

Increase stability and shrink the loops to smaller size
Difference between DTY and ATY

- ATY is a yarn with zillions of small loops, which give it a distinct feeling and look. The loops in ATY contribute to the bulk and loft of a fabric.

- DTY is a yarn with preferably no loops at all. The even crimp in every filament creates the bulk and volume of a fabric.
FILAMENT YARN

Examples of end-uses:

– Sutures, fishing line, webbing for lightweight beach and casual furniture, openwork knits

– Seatbelts, tents, backpacks, parachute fabrics, airbags

– Socks, carpet piles, knitting yarns, apparel items, hosiery, stretch fabrics
Other examples:

- Hosiery
- Automotive Car Seat Fabric
- Home textiles, upholstery
- Technical Fabrics for Awnings, Tarpaulins, Marina, umbrella and outdoor fabric
- Sportswear
- Leisure wear
- Men's- and ladies wear
- Rainwear
- Automotive fabrics
- Coating fabrics
- Decorating fabrics
- Industrial yarns
- Soft luggage
- Sewing thread
FAREEDA
Aisya
Fenomena Termasyhur!

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