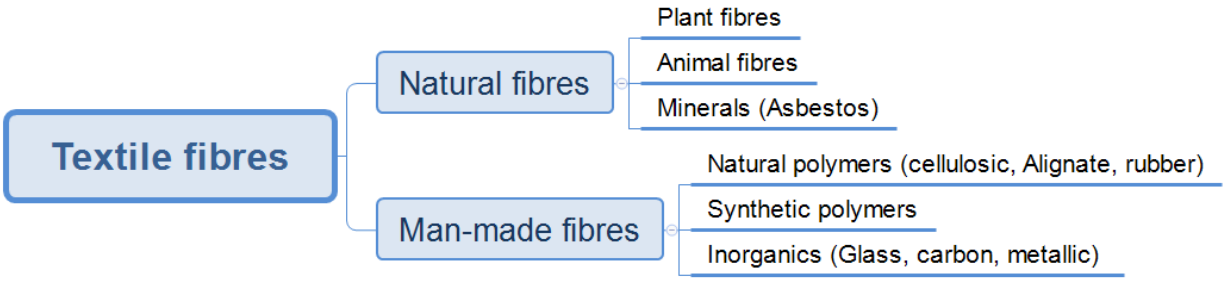
Fibre technology

Contents

Source of textile fibres

Textile fibre is a material mainly made from natural or synthetic sources.



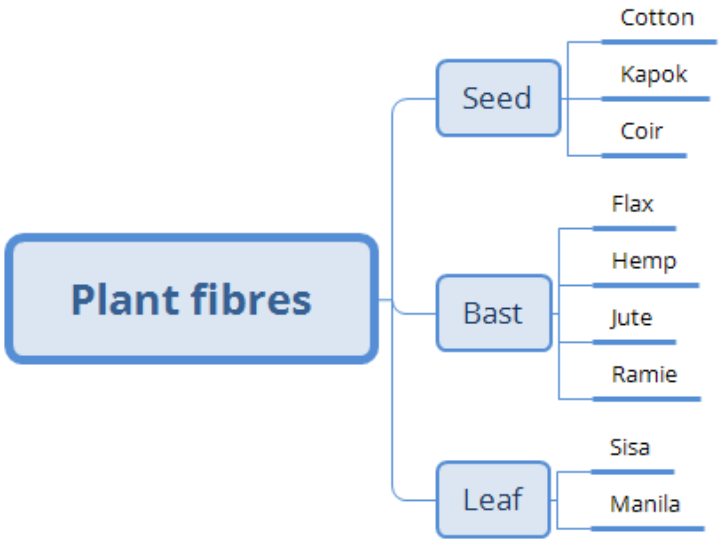
Natural fibres

Natural fibres generally can be classified based on their origin, either plants, animals or minerals.

- **Cotton**
- **Wool**
- **Flax**

Plant-based fibres

The precise composition of plant fibres, cellulose, hemicellulose, lignin, wax, etc. depends on several factors such as the method of analysing, the growth environment and geographical location of the plant and the level of maturity of the plant, etc. The plant-based fibres can be classified according to the part of the plant they are recovered from.

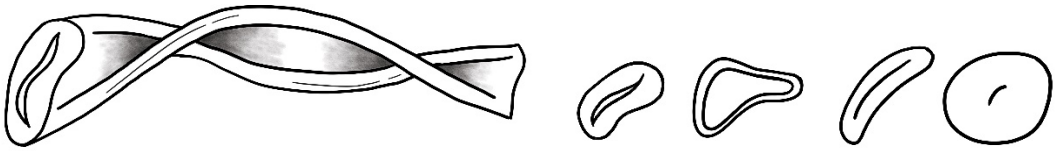


Plant based fibres

Seed fibres

Cotton

- 1/3 of all fibre use
- Cotton plant 1 - 1.5 m
- Cultivated around equator (The most important producers of are China, India, USA, Pakistan, Brazil, Uzbekistan, turkey, Australia, Gree



Maturity

Cultivation: Cultivated around equator (The most important producers of are China, India, USA, Pakistan, Brazil, Uzbekistan, turkey, Australia, Greece and Syria)

Harvesting : Harvesting is either by hand or by picking machines

Ginning: Separation of the fibres from seeds

Grading: Grading will be done based on length of fibres, maturity, colour and impurities.

Length

- Facilitates spinning
    - Softer, thiner, stronger fibre, more expensive
    - Short 18-22mm, Normal 23-27 mm, Long 28-34mm, Very long 35-40

Maturity

- Immature cotton affects strength, evenness, dyeing properties
- High class cotton (65% mature fibre and maximum 10% immature)

Colour

- Different colours: white, grey, blue, brown, yellow

- White facilitates bleaching and dyeing
- Sally Fox – Natural colour cotton

Utilisation: Fibres are made into spun yarns either by OE rotor spinning or ring spinning

Chemical modification: Mercerisation, Flame retardant treatment, Water repellent treatment, Improve resilience

Applications: Apparel fabrics, Accessories, Household textile, Technical textiles

Kapok – Java Cotton fibre

- Seed fibre from Kapok tree
- Light, high flammability
- Moisture resistant
- Dries quickly
- Smooth
- Not possible to spun into yarns
- Used for stuffing and insulation

Coir fibre

- So Seed fibre from the coconut palm
- Stiff and Strong
- Stuffing in upholstery
- Ropes
- Door mats

Bast fibres

A family of vegetable fibres which run the length of the plant stem.

Flax fibres

- Linum plant 0,5-1,25 m

Cultivation: Cultivated in temperate climates: France, Belgium, Netherlands, Ireland, Russia, Poland, New Zeeland, Australia

Harvesting and fibre extraction: Pulling, Rippling (Remove reeds) , Retting (Biological- Dew reeting, Biological-Tank or water retting, Chemical retting) , Drying (by warm air ovens) , Breaking and scotching, Hackling

Processing: The fibres are spun into yarn using the linen process

- **Applications:** Apparel fabrics, Accessories, Household textile, Technical textiles

Jute fibre

- Second natural fibres after cotton
- Retting and Crutching
- Heavy fibres
- Light sensitive

Hemp fibre

- Origin: Soviet, Italia, Hungary, Spain, India
- Flax process
- Length 15-50mm
- High strength, coarser than flax
- Sensitive to light
- Applications: Ropes, curtain and upholstery
- Environmental friendly cultivation

Rami fibre

- Origin: China, Japan, Philippines, India, USA
- High strength
- Low elasticity
- Length of fibre 10-25 cm
- Properties and use close to flax

Leaf fibres

Sisal fibres

- Origin: Brazil, Indonesia, Mexico, East Africa
- High strength and abrasion resistance
- Applications: Ropes, carpets, nets and matting

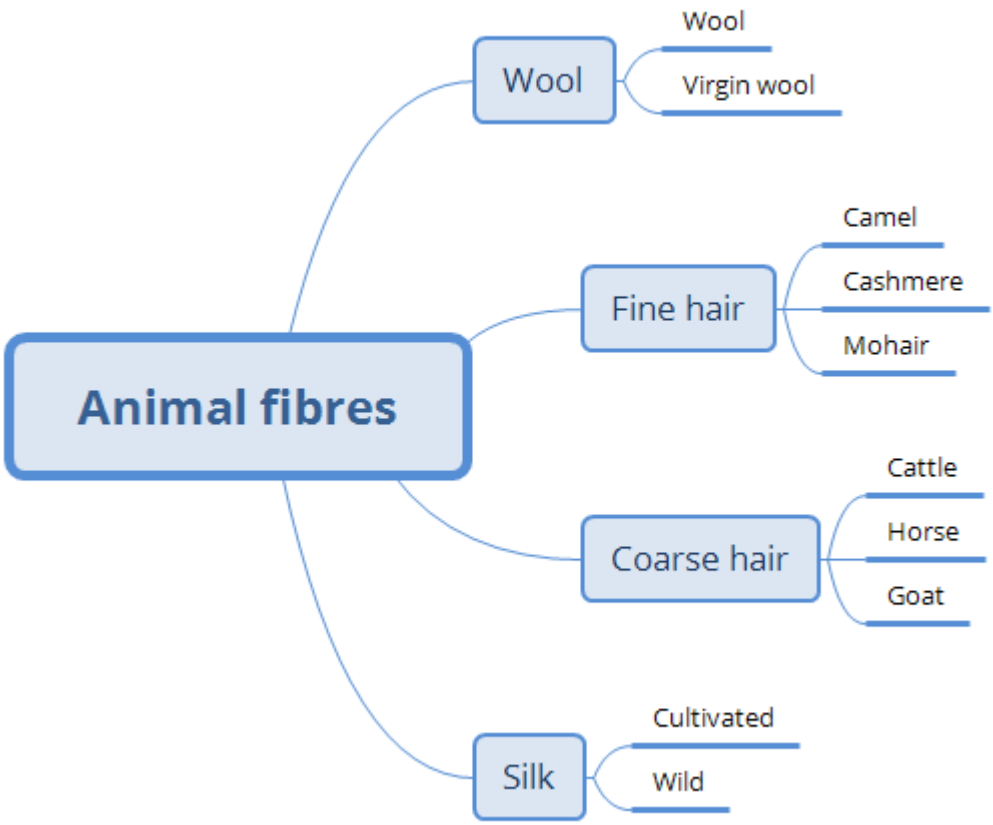
Manila fibres

- Origin: China, Japan, Philippines, India, USA
- High strength

- Low elasticity
- Length of fibre 10-25 cm
- Properties and use close to flax

Animal fibres

Animal fibres consist largely of particular proteins.



Animal based fibres

Wool fibres

- Major hair fibre
- 5% of Fibre market
- Origin: Australia, New Zeeland, China, Eastern Europe, turkey, UK, Argentina, Uruguay, South Africa, USA
- Merino 90% of all Sheep wool

The structure of wool fibres

The wool fibre is made of keratin (protein molecules). The long chain protein molecules are formed into fibrils.

Wool production

Shearing: The sheep are shorn using electric shears.

Classing: 1 = best, 4 = worst. The grader classifies the wool according to: finess, crimp, length, impurities and colour

Scouring

- Remove nonwool containers such as dirt and most of the grease (lanolin)
- 40% of weight is removed
- Washing in hot water and detergent

Carbonising

- Removes burrs and other vegetables
- Acid impregnation
- Sulfuric acid (svavelsyra) degrades cellulosic impurities
- Baking in order to excess acid
- Mechanical rollers to crush residues
- Neutralisation and rinsing of acid

Processing

Wool fibre spun into yarn by Worsted or Woolen process:

- Worsted
    - Fine Smooth Yarn
    - Long staple fibres
    - Gilling: parallelising fibres
    - Combing: Comb fibres to remove short fibres
- Woolen
    - Coarser more bulky yarn
    - Spun from shorter fibres
    - No combing

Silk fibre

- Origin: China, India, Uzbekistan, Brazil, Iran, Thailand, Vietnam, Korea, Romania
- Larva of silkworm
- **Cultivated silk (Mulberry)**: The best-known silk is obtained from the cocoons of the larva of the mulberry silkworm.
- **Wild silk fibre**: Beside the mulberry silkworm, there are many wild spices. Wild silk comes from insects that live in wild or semi-domesticated conditions.
    - Tussah Silk, Coarser, stronger, Different colours
    - Heavier than cultivated silk, Not so uniform, Cheaper

Processing

Egg

Caterpillar – Mulberry leaves

Chrysalis – Cocoons

Chrysalis is killed with steam or dry heat

Cocoons are grades and sorted

Silk reeling

The cocoons are placed in hot water to soften the gum and then the filaments wound up onto a reel (opposite).

Improvement of properties by finishing

1. Degumming:
    - Boiling of yarn/fabric in soap solution
    - Finer fibres – double no of fibres
    - Weight reduction 20-30%
2. Weighted Silk:
    - Lead and tin
    - More rigid
    - Sustainability, elasticity and resistance to light is reduces

Goat fibres

Cashmere fibre

- Cashmere goat
- Very fine
- Soft
- Rather dull

Mohair fibre

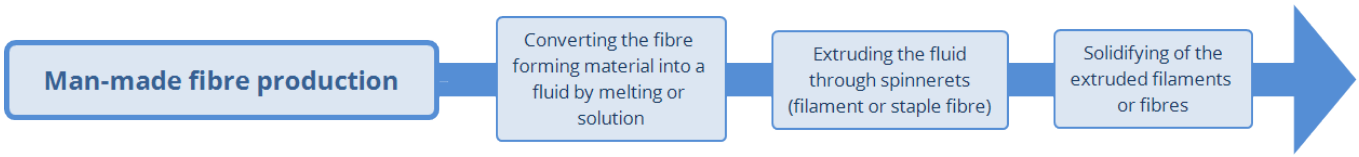
- Angora goat
- Long fibre
- Fine fibre
- Strong
- Lustrous

Alpaca fibre

- Various natural shades
- Long
- Lustrous
- Soft

Man-made fibres

Man-made fibre manufacturing comprises three basic steps:



Cellulosic man-made fibres:

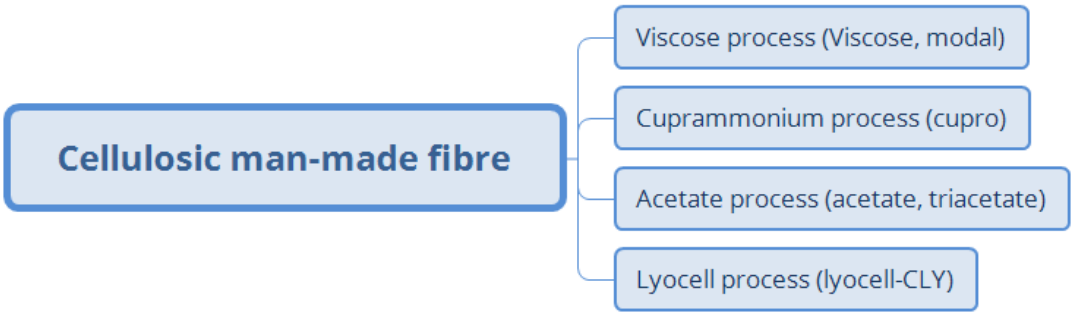
- These fibres are made from cellulose (natural polymer), extracted from plants.

Synthetic man-made fibres:

- These fibres are made from synthetic polymers or inorganic materials.

Cellulosic man-made fibres

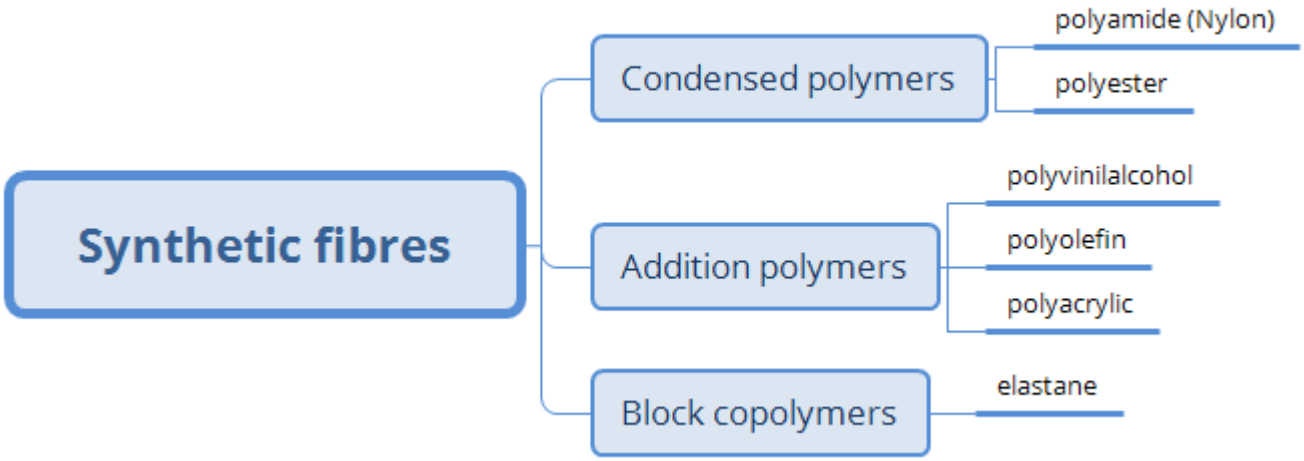
Cellulosic man-made can be categorised based on the solvent system being applied to convert the cellulose raw material to a spinnable solution.



Synthetic polymer fibres

Introduction

Synthetic polymer fibres can be classified based on the general chemical mechanism used for building the linear polymers.



Fibre type	Fibre composition	Cross-section appearance
Polyester	Poly(ethylene-terephthalate)	Depends on spinneret
Nylon	polyamide	Depends on spinneret
Acrylic	Poly-acrylonitrile	Depends on spinning conditions

Polypropylene	polypropylene	Depends on spinneret
Elastane	polyurethane	fibrillar

Synthetic polymer fibres

Polyester-PES

- Variants – PET most common
- Methylene groups, Carboxyl groups, ester link, benzen rings
- DP 115-140
- 65% Crystalline 35% amorphous
- Highly oriented in amorphous areas
- Very useful – most used synthetic fibre

Polyamide-PA

- First synthetic fibre 1939, DuPont
- Parachutes, shirts, underwear, carpets, outdoor clothing
- Today substituted by PES/Cotton in shirts, underwear etc.
    - Nylon
    - Amide groups
    - Degree of polymerisation (DP): 50-80
    - Zig-zag molecule chain, high crystalline and orientation
    - 65-85% crystalline 15-35% amorphous
    - Nylon 6 (PA6) and Nylon 6.6 (PA6.6)

Acrylic – PAN

- 1950 DuPont
- Homo-polymer – Compact structure – Bikryl®
- Co-Polymer open structure – Acrilan®
- DP ~ 1000
- Wet or Dry spinning, no melt spinning

Polypropylene-PP

- Methyl groups
- Crystalline 50-65%
- Cheap process

Elastane - EL

- 1959 – DuPont
- Elastomeric fibre
- Hard and soft segments

- Stretched repeatedly return to original length
- Blended with other fibres
- Spandex® Lycra®

Questions

Please complete these questions in the online version of this resource.

Fibre identification

A number of technical methods are available for fibre identification including:

1. Microscopy
    - Identifying the fibres with the help of a good microscope
    - The test can easily distinguish between fibres.
2. Solubility test
    - Immersing the fibres in various chemicals for some hours
    - Used mainly to identify fibre blends
3. Burning test:
    - Recognizing the composition of fibres by moving them slowly towards a small frame and observing the reaction to heat, how they burn, burning odour and the residue
4. Dry tearing test:
    - Tearing the fabric and observing the length of the broken fibre end
5. Wet tearing test
    - Applying a drop of water on the fabric and observing the behaviour of wet place during tearing

View the Fibre identification table in the online version of this resource.

Questions

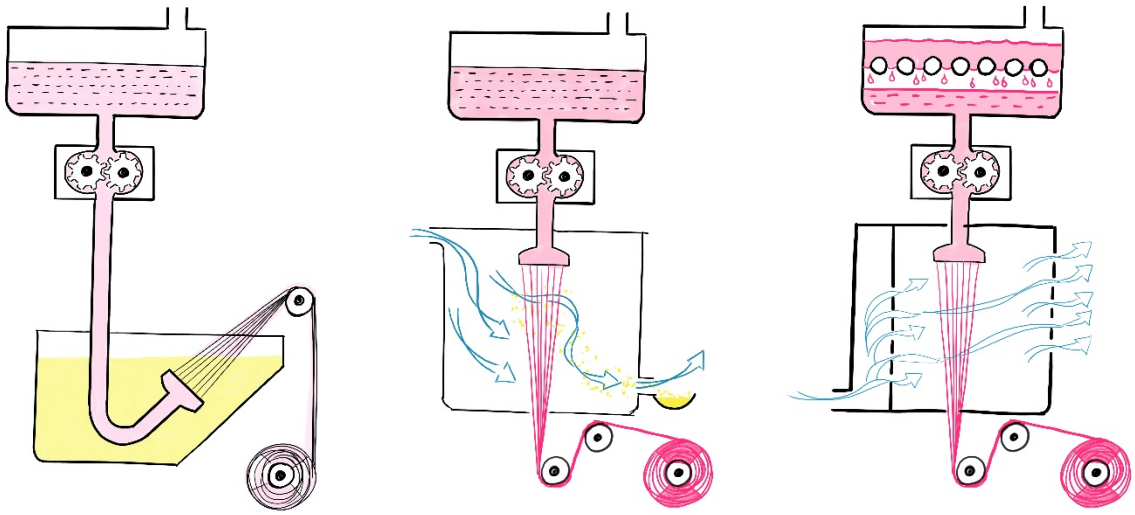
Please complete these questions in the online version of this resource.

Man-made fibre spinning process

There are three major types of process for spinning man-made fibres (filament yarns):

	Wet spinning	**Dry spinning**	**Melt spinning**
	Spinning from polymer solution		Spinning from polymer melt
Spin-solution	Polymer + solvent agent	Polymer + solvent agent	Melted polymer
Spinning medium	Chemical bath	Hot air	Cold air
Examples	Acrylic, Modal, Viscose	Acrylic, Acetate, triacetate	Polyamid, Polyester, Polypropylene

Chemical bath **Hot air** **Cold air**



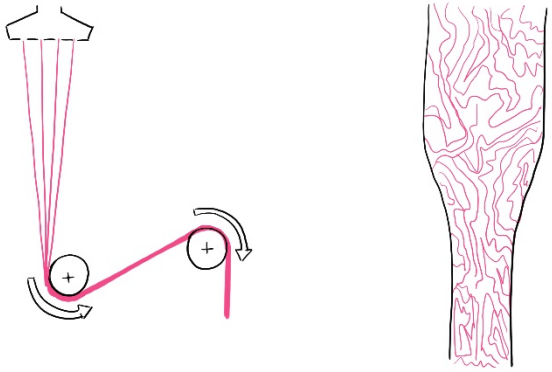
Melt spinning – Please watch this video content in the online version of this resource

Drawing

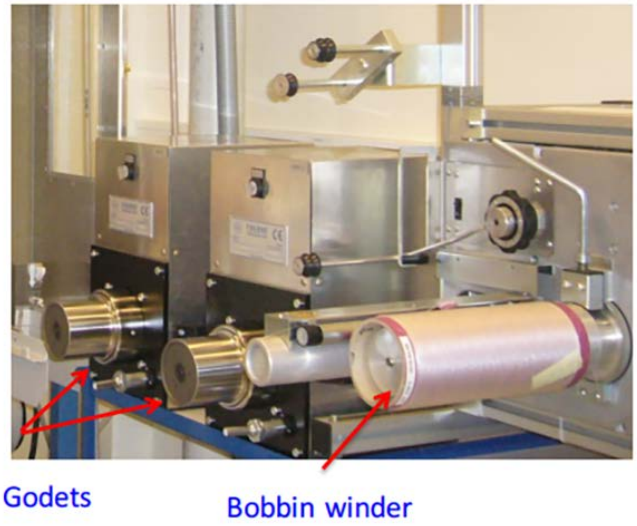
The spinning fluid solidifies when it emerges from the spinnerets. There are some microfibrils in side of filament which are not very well ordered. By drawing the filament, these disordered microfibrils will become more oriented in the direction of the filament axis. The filament's strength comes from the formation of crystalline regions within the microfibrils and their orientation along filament axis.

- Drawing of fibres : higher orientation, more crystalline

- Higher tenacity – Low elasticity
-



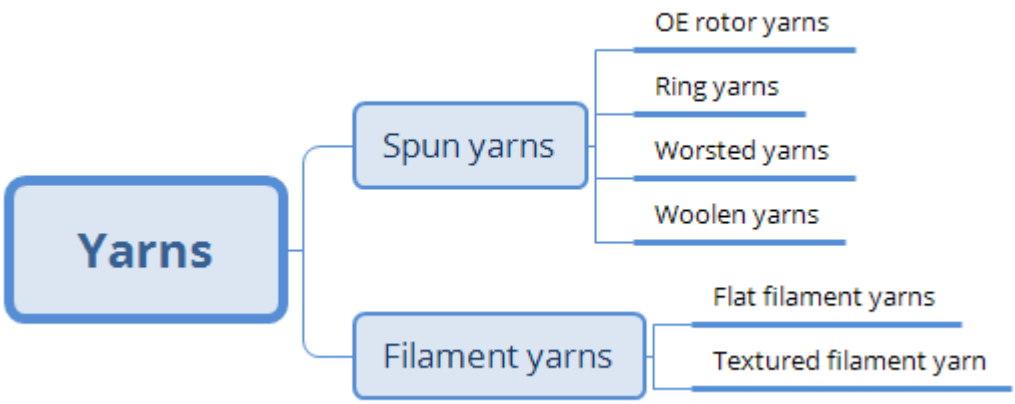
orientation of microfibrils
© University of Borås



Filament drawing in a separate subsequent process
© University of Borås

Yarns

Yarns are classified as in two main categories: Spun yarns and filament yarns.



For the following, choose the correct statement:

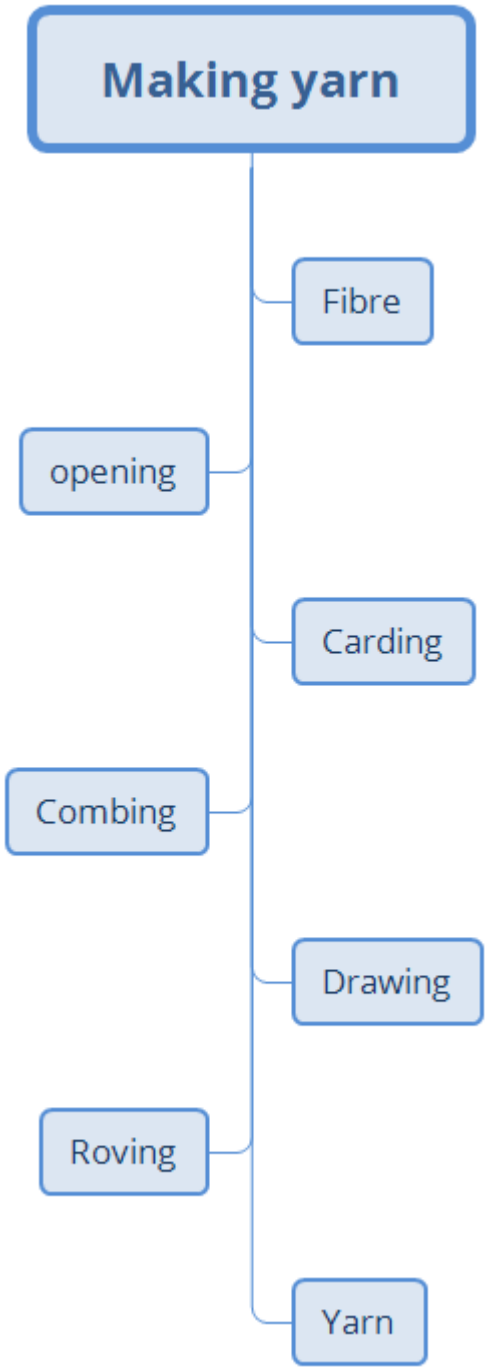
What is a filament fibre by definition, and, a fibre that is born (not converted into one), as a filament fibre...

- A filament fibre is endless in width, Silk is born as a filament fibre...
- A filament fibre is endless in length, Lyocell is born as a filament fibre...
- A filament fibre is measurable in length, Polyester is born as a filament fibre...

Feedback: **Filament fibres are continuous in length, not measurable lengths of fibres. All man-made fibres plus silk are examples of fibres that are "born" as filament fibres. Filament fibres can be cut into defined lengths and thus converted into staple fibres.**

Spun yarn production

Yarn spinning is a process of converting fibres from the compressed bale into a yarn. In textile industry, the size of yarns is determined by unit of Denier, Tex, Worsted and Woolen.



Spinning process

True or False? Mark true or false for each of the following statements:

Spun yarns are generally smoother, stronger and more lustrous then filament yarns?

True False

Some fibres are only available in staple form?

True False

Natural fibres grow or develop in fibre form and come from plant, animal or mineral sources?

True False

Microscopy works well to identify all fibres?

True False

A fibre with a denier of 1 would be softer and more flexible then a fibre with a denier of 10?

True False

Textured yarns

Texturing is the process which is used for filament from thermoplastic materials to make them permanently bulky via various methods:

1. Flat-twist texturing
2. Air-jet texturing
3. Stuffer-box texturing
4. Knit-deknit texturing

Choose all relevant answers. Texturized filament yarns may have?

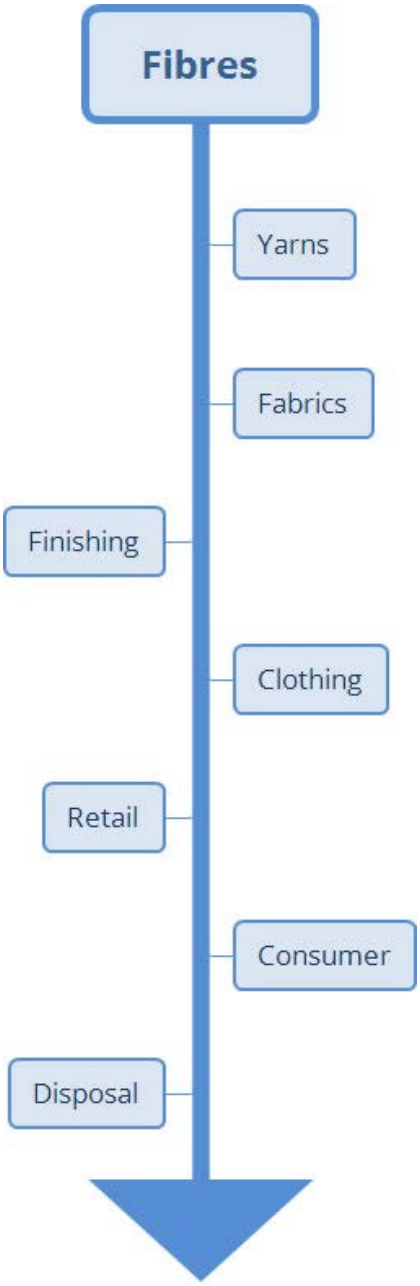
- More covering power
- Lower price
- Are heavier than non-texturized fabrics
- Better insulation properties
- More elasticity and stretchability
- Spun-yarn appearance

Most texturized yarns are produced from fibres which are:

- Thermoplastic
- Staple in length
- Protein
- Cellulosic

Textile chain

Textile chain: from fibre to disposal



Summary

You should now be able to:

- Describe the fibre composition
- Production, classification, designation, morphology, mechanical and chemical properties of textile fibres.
- Define the difference between natural and man-made fibres
- Describe the process of spun yarn production, including the main operations.
- Identify an unknown textile material on structure, yarn and fibre level

Further reading

- Eberle, H., & Ring, W. (2014). *Clothing technology : ...from fibre to fashion*. Haan-Gruiten: Haan-Gruiten : Europa Lehrmittel (page 1-70).