Textile Fibres Production

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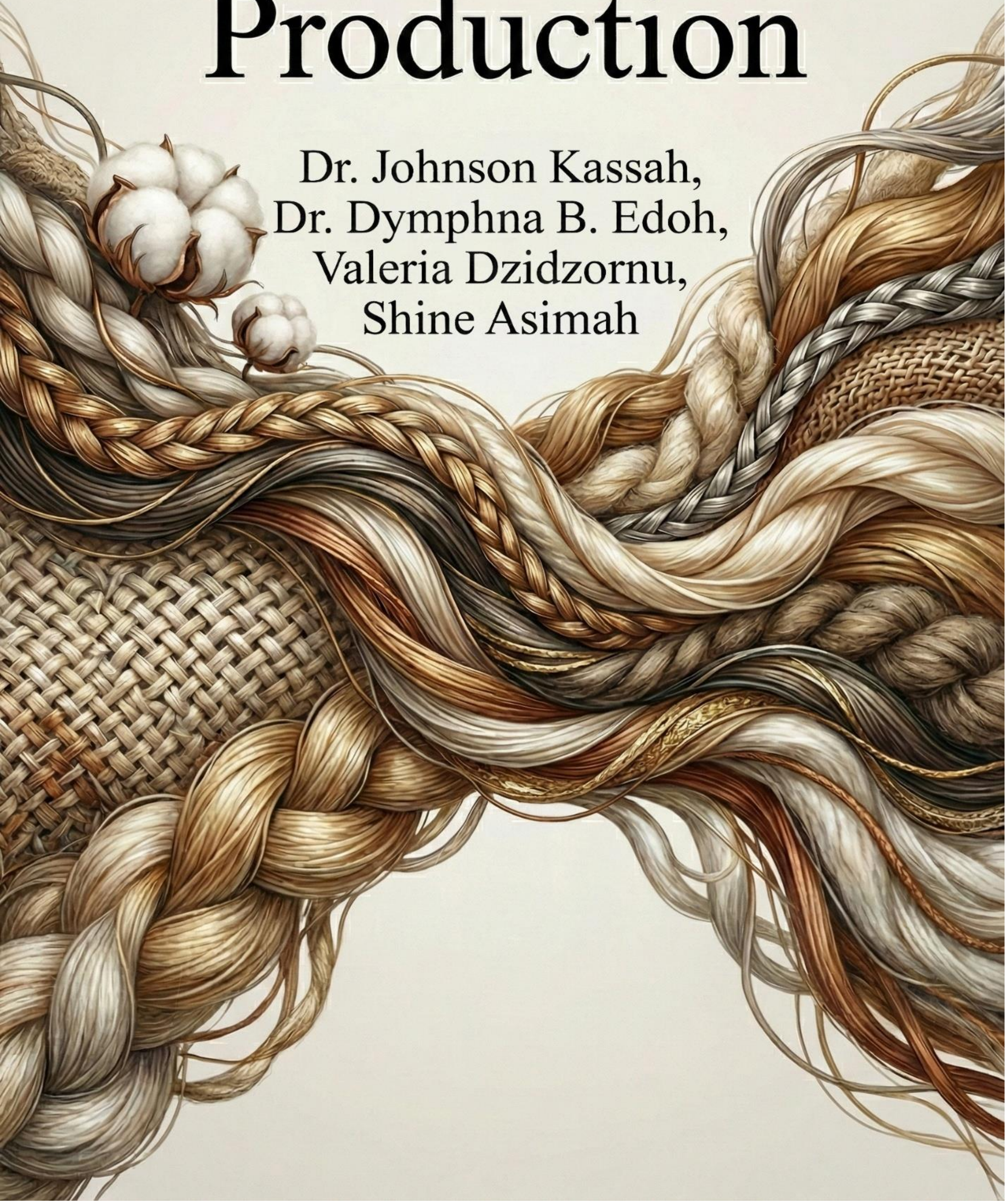

Textile Fibres Production

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FOREWORD

This book is intended to serve as a comprehensive reference for students of textiles and fashion design in senior high schools, technical and vocational institutes, colleges of education, and universities. It covers information obtained from reliable and highly regarded sources. Republished materials in this book are quoted with permission, and sources are referenced. Several efforts have been made to publish reliable information. However, the authors and the publishers cannot assume responsibility for the validity of all the materials.

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PREFACE

Goods made from textile fibres have become an integral part of our everyday lives. Unlike the past, when the goods produced from textile fibres were merely used for wearing, textile fibres are now used in numerous applications, including very high-end applications. The use of textile fibres depends on the necessities of the final product. Currently, the intensive research in textiles has unlocked new prospects that require very high technical specifications. The textile fibres, being the rudimentary building block, have great importance.

The characteristics of a textile product do not only depend on the intrinsic features of the designated raw material but also on the subsequent processes involved in its production. The demand for textile fibres for industrial use is now very high. Consequently, it is impossible to select the right textile fibres for a certain application without adequate knowledge of the properties of the textile fibres. This book will guide readers through every step of product development, helping them make the right choice of textile fibres. Chapter one of this book aims to define textiles, fibres, the history of textile fibres, the properties of textile fibres, and the classification of textile fibres into their generic groups. Chapter two is about the production processes and properties of individual plants or cellulosic fibres. Chapter three is about the production processes and properties of individual animals/protein fibres. Chapter four discusses the production processes and properties of popular mineral fibres. Chapter five deals with the production processes and properties of regenerated fibres. Chapter six writes on the production processes and properties of synthetic fibres. Chapter seven talks about fibre or fabric identification tests. Chapter eight is about textile yarns.

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ABOUT THE AUTHORS

Dr. Johnson Kofi Kassah is a senior lecturer in the Department of Fashion Design and Textile, Ho Technical University, Volta Region, Ghana. His area of specialization is fashion and textiles design. Dr. Kassah is from Dzodze, a town in the Ketu North Municipality of the Volta Region of Ghana. He completed his basic education at Dzodze Central R. C. Junior Secondary School in the year 1997. He then proceeded to Dzodze-Penyi Secondary School and completed it in the year 2000. After his secondary education, Dr. Kassah went to Takoradi Polytechnic to read HND Textiles and completed it in the year 2005. After his National Service, Dr. Kassah went back to Takoradi Polytechnic to do a top-up and graduated in the year 2009. He then proceeded to the University of Education, Winneba, Kumasi campus to pursue a Master of Technology Education in Fashion Design and Textiles Technology and completed in the year 2013. In 2016, Dr. Kassah was admitted to Kenyatta University, Nairobi, Kenya, to pursue a PhD in Art and Fashion Design Education. He completed his PhD programme successfully in the year 2019. Dr. Kassah taught vocational skills at St. Francis College of Education, Hohoe, Ghana, for seven (7) years. He also taught Textiles and General Knowledge in Arts in Zion College of West Africa, Anloga, and Adidome Senior High School, all in the Volta Region of Ghana. Dr. Kassah has published over twenty (20) scholarly works in credible journals.

Dr. (Mrs.) Dymphna Bakker-Edoh is a Senior Lecturer in the Department of Fashion Design and Textiles at Koforidua Technical University, Eastern Region, Ghana. Her area of specialization includes Fashion Marketing, Sustainable Fashion, Apparel Technology, Millinery and Accessories.

She is an academician with a PhD in Fashion Design and Marketing from Kenyatta University, Nairobi, Kenya. She also holds a Master of Technology in Fashion and Textile Design and Technology and a Bachelor of Education from the University of Education, Winneba, Ghana. Dr. Bakker-Edoh continued her fashion training at Ho Polytechnic, Ho, Ghana, after her secondary education at St. Anne's Secondary/Technical School, Nuaso, Ghana where the beginning of her fashion carrier started.

Dr. Bakker-Edoh began her professional career as the Headmistress of St. George's Vocational Institute, Koforidua, where she served from 1989 to 2007. With over twenty-eight (28) years of experience in higher education, she has facilitated numerous training programs at the National Vocational Training Institute (NVTI), Ghana, as well as at Koforidua Technical University, where she has trained hundreds of practitioners in the fashion design and textiles industry.

Her research interests span across Fashion Marketing, Apparel Technology, Beauty Culture, Millinery and Accessories, Sustainable Fashion, and Textile Innovation. She has contributed significantly to knowledge sharing in these areas through teaching, research, training, and mentorship.

Dr. Bakker-Edoh is also a member of several professional organizations. She serves as a member of the Ghana National Tailors and Dressmakers Association, Eastern Regional Secretariat, Koforidua, I Believe Global, and the International Conference on Gender Equality (ICGE). She is equally affiliated with the International Textile and Fashion Professionals (ITFP), the Institute of Textiles and Fashion

Professionals – Ghana, and the International Textiles and Apparel Association (ITAA).

Valeria Makafui Dzidzornu is a lecturer in the Department of Fashion Design and Textile, Ho Technical University, Volta Region, Ghana. She has specialization in the areas of Textile Design and Technology. Valeria Makafui Dzidzornu is a Ghanaian and hails from Asadame in the Keta Municipality of the Volta Region of Ghana. She had her primary education from Amazing Love Schools, Denu, and completed in the year 1998; through Mawuli School in 1999, where she completed her Secondary School education in 2001. Miss Dzidzornu proceeded to train as a Teacher at Akatsi College of Education in 2005. After practicing for four years, she proceeded to Kwame Nkrumah University of Science and Technology to read Industrial Art – Textiles in 2009 and successfully completed in 2013. She had her National Service and posting after successful completion to the Sovie Technical and Vocational Institute in Sovie. To further formalize her love for education, Miss Dzidzornu gained admission in the year 2015 to study Textile Ecology in the Department of Textile, Merchandising, and Fashion Design at Seoul National University, Seoul, South Korea, and successfully completed in 2018. Miss Dzidzornu is currently pursuing her PhD education at the Kwame Nkrumah University of Science and Technology, Kumasi in Textiles Design and Technology, which started in the 2023/2024 academic year. Miss Dzidzornu tested fabrics at the Fashion Textiles Center in South Korea usong the Kawabata System for two (2) years and taught Textiles at Sovie Vocational/ Technical Institute, Sovie in Ghana for two years. In Asadame A.M.E Zion Schools, Asadame in the Volta Region of Ghana, Miss Dzidzornu taught Vocational Skills at the Junior Secondary School level.

Miss Dzidzornu published three (3) scholarly works in credible journals.

Shine Adzo Asimah is a lecturer in the Department of Fashion Design and Textile, Ho Technical University, Volta Region, Ghana. Her area of specialization is Art Education (Textiles Design and Millinery and Accessories). She is from Ho in the Ho Municipality of the Volta Region of Ghana. She had her Basic School Education at St. Cecilia R. C. School, Ho in the Volta Region from 1993 to 2001. She then proceeded to OLA Secondary School, Ho and completed in the year 2004. After her secondary education, she went to Takoradi Polytechnic to pursue HND Commercial Arts, Textiles option (2005-2008). After her National Service, Miss Asimah went to University of Education, Winneba for a top up Bachelor of Art in Art Education, Textiles option and graduated in the year 2012.

She then proceeded to Kwame Nkrumah University of Science and Technology, Kumasi to pursue Master of Philosophy in Art Education with research focus on Textiles and completed in the year 2018. In 2022, She was again admitted to Kwame Nkrumah University of Science and Technology in Kumasi to pursue a PhD in Art Education (Textiles Technology), which she is still pursuing. Miss Asimah taught textiles design, history of fashion, millinery and accessories, beauty culture, history of art and interior decoration in the Fashion and Graphic design Department of Koforidua Technical University in the Eastern Region of Ghana for seven years. She has published two scholarly works in credible journals.

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CHAPTER 1
INTRODUCTION TO TEXTILES

Concept of Textiles

The word "textile" was originally used to describe fabric produced by weaving and the processes involved in weaving. Over the years, the term has taken on broad connotations which involve the production of fibres, yarns made from natural or man-made fibers, fabrics, and other products made from fibres or from yarns, decoration of fabrics, and production of apparel.

This broad description of textiles covers all the products produced by the textile industry. Textiles are mainly produced in factories called mills. The mills are either vertical or horizontal. Vertical mills are large textile companies that produce several goods such as fibres, yarns, fabrics, and garments. Horizontal mills are small or medium-sized textile companies that are involved in the production of one particular product on a commission basis.

Textile production is the process of manufacturing textile goods. There are two types of textile production, which are structural textile production and surface textile production. The structural textile production involves the production of fibres, yarn, fabrics, and other products made from fibers or from yarns. Surface textile production involves the decoration of fabrics by dyeing, printing, appliqué, and embroidery, etc.

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Textile Fibres

There are many fibres, but not every fibre is qualified to be called a textile fibre. A textile fibre is a fine, flexible, hair-like unit of matter that has its length a hundred times longer than its diameter and can be spun into yarn or made into fabrics.

History of Textile Fibres

In the 6th and 7th centuries BC, the oldest recorded indication of using fiber comes with the invention of flax and wool fabric at the excavation of Swiss Lake inhabitants. In India, the culture of silk was introduced in 400AD, while the spinning of cotton dates back to 3000BC.

In China, the discovery and consequent development of sericulture and spinning silk methods were initiated at 2640 BC, while in Egypt, the art of spinning linen and weaving developed at 3400 BC. The discovery of machines and their widespread application in processing natural fibers was a direct outcome of the industrial revolution of the 18th and 19th centuries.

The discoveries of various synthetic fibers, like nylon, created a wider market for textile products and gradually led to the invention of new and improved sources of natural fiber. The development of transportation and communication facilities facilitated the path of the transaction of localized skills and textile art among various countries.

Properties of Textile Fibres

The properties are the characteristics or the behaviour of the fibres in the fabric produced. There are two properties of textile fibres. These are primary and secondary properties.

Primary Properties of Textile Fibres

The primary properties are prerequisites or mandatory properties that a fibre must possess for it to be considered a textile fibre.

High length-to-width ratio

For a fibre to qualify as a textile fibre, the length of the fibre must be a hundred times longer than its diameter.

Elasticity

This is the ability of the fibre to stretch and immediately return to its original size.

Tenacity/tensile strength

The ability of fibre to withstand stress and strain, such as pulling and tearing, encountered during yarn manufacturing processes.

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Flexibility or pliability

The ability of the fibre to bend without breaking during yarn manufacturing or during the regular wear and tear of the fabric in its end use.

Cohesiveness

The ability of fibres to adhere to each other or fit into another fibre during yarn manufacturing.

Elongation

The ability of a fibre to extend or expand when a force is applied to it.

Uniformity

Uniformity is the evenness of the individual fibre in its length and diameter. Natural fibres are irregular in length; hence, they need to be sorted and graded for yarn making. Irregular fibres are weak, rough, and unsuitable for textile use.

Secondary Properties of Textile Fibres

The secondary properties are the properties that individual fibres possess. They are desirable properties that influence the appearance, durability, comfort, and maintenance of the fabric manufactured.

Moisture regains

The ability of a textile fibre to absorb water from the atmosphere. This property influences the comfort. For instance, fibres with high moisture absorption properties are preferred in hot climates.

Resiliency

It is the ability of the fibre to return to its original shape after bending or creasing.

Abrasion

It is the ability of a textile fibre to sustain wear and tear without damage.

Dimensional Stability

It is the ability of the fibre to keep its shape and size in the presence of moisture, with changing temperature.

Thermal properties

The ability of a textile fibre to react to heat and flame.

Lustre

This is the ability of a textile fibre to reflect light from its surface. It is also called gloss, sheen, or shine that fibres naturally possess. It is seen when light is reflected from the

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surface. The fabrics made with filament fibres are more lustrous than those made from staple fibres.

Effect of acids

Concentrated, cold, or dilute hot mineral acids like sulphuric acid destroy both cellulosic and wool fibres. However, wool remains safe from the effects of other acids.

Effect of alkali

Alkali does not harm cellulosic fibres but damages protein fibres. This property is important while selecting the detergents for different fibres.

Effect of sunlight

Some fibres are adversely affected by strong and prolonged exposure to sunlight, resulting in yellowing and damage to the fibre.

Classification of Textile Fibres

Generally, there are two types of textile fibres. These are natural fibres and man-made or artificial fibres. The natural fibres are fibres derived from plants, animals, and mineral sources. Natural fibres are in three categories, which are:

- Natural fibres of plant or cellulosic origin.
- Natural fibres of animal origin.
- Natural fibres of mineral origin.

The plant or cellulosic fibres are in five categories, namely:

- Seed fibres. Examples: cotton and kapok.
- Bast or stem fibres. Examples: flax/linen, jute, kenaf, ramie, and bamboo.
- Leaf fibres. Examples: sisal, abaca, and raffia.
- Grass/reed fibres. Examples: totora, corn, etc.
- Fruit fibres. Examples: coir, luffa, and oil palm empty fruit bunch.

When we come to animal or protein fibres, we have wool and silk. Wool is obtained from the hair of animals such as sheep, mohair, Llama, alpaca, cashmere, rabbit, camel, goose etc. Silk is obtained from the secretion of the Bombyx mori and the spider web of animals. An example of a mineral fibre is asbestos, glass fibres, etc.

The man-made fibres are in two groups, which are:

- regenerated fibres.
- purely synthetic fibres.

Regenerated fibres are in two groups, which are regenerated fibres from:

- cellulosic origin. Examples: viscose rayon, acetate rayon, cuprammonium rayon, corn starch fibre, artificial silk, soy protein fibre, collagen fibre, etc.
- protein origin. Examples, casein and ardil.

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Examples of purely synthetic fibres include polyester, nylon, acrylic, and olefin. Figure 1 shows the classification of textile fibres into their generic groups.

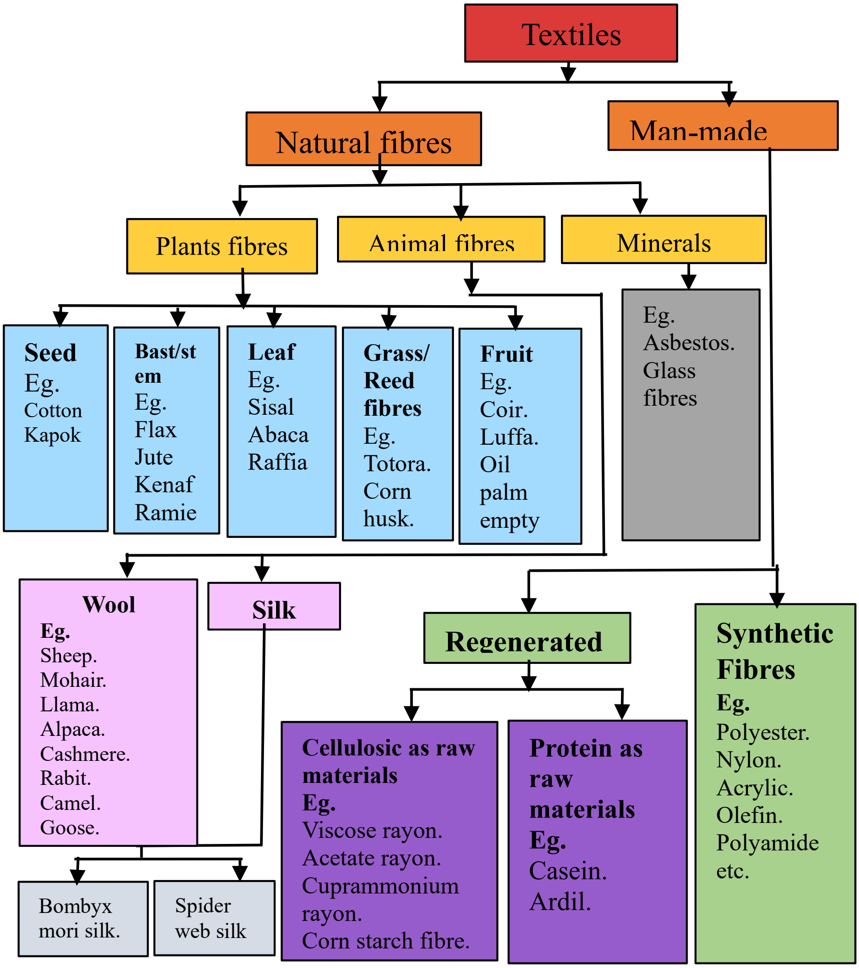

Figure 1: Classification of textile fibres

CHAPTER 2
PRODUCTION OF NATURAL CELLULOSE OR PLANT FIBRES

SEED FIBRES PRODUCTION

Cotton

Cotton is a natural plant or cellulose fibre derived from the boll of the cotton plant. Cotton is an industrial crop, grown mainly for the textile, food, and cosmetics sectors. It is one of the mainstays of cropping systems in tropical and subtropical regions, which also include food crops.

Cotton fibre is one of the most prevalent natural fibres in the textile industry. The cotton production processes are harvesting, ginning, baling, opening and cleaning, scutching, carding, combing, drawing, roving, and spinning.

Harvesting

The process of cotton harvesting is known as picking. There are two types of picking, which are hand picking and mechanical picking. In hand-picking, the farmers pick the cotton from the open bolls by hand.

Mechanical picking involves using machines known as cotton pickers or strippers to harvest the cotton. These machines pluck the cotton bolls from the plants and harvest them in large quantities. Figures 2 and 3 indicate the manual and Mechanical harvesting of cotton fibres.

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Figure 2: **Manual harvesting of cotton fibre**

Figure 3: Mechanical harvesting of cotton fibre

Ginning

After harvesting the cotton, the next process is ginning. Ginning is the process of separating fluffy cotton fibres from the seeds. The ginning process also cleans the cotton to remove impurities such as seedpods, soil, leaves, dust, and other debris. Ginning is usually done using a machine called a cotton gin. Figures 4 and 5 show the ginning.

Figure 4: Manual ginning of cotton

Figure 5: Mechanical ginning of cotton

Baling

Cotton baling is the process of compressing and packaging cotton fluff or lint into bundles for easy storage and transportation. The cotton bales are characteristically enfolded in protective material to preserve their quality during transportation. Figure 6 shows the baling of cotton.

Figure 6: Bale of cotton fibres

Opening and Cleaning

Opening is the process of loosening, separating, and breaking the bale into smaller tufts for easy mixing and blending. Cleaning, on the other hand, involves removing impurities from the fibres after opening. It is done to ensure smoother processing in subsequent steps.

The opening process involves feeding the cotton bales into an opening machine or bale opener. The machine rollers separate the cotton, generating smaller tufts of fibres. The fibres then move to the airflow chamber to help loosen the fibres. Figure 7 indicates the opening and cleaning of cotton.

Figure 7: Opening process

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Scutching

This process further loosens the cotton fibres to remove any impurities and packs the loose cotton fibres into a roll called a LAP. The main purpose of scutching is to prepare the fibres for a problem-free spinning process. The process is done by feeding the raw cotton into the scutching machine. The fibres are passed through the rotating beaters of the machine, which loosen the fibres to remove the impurities. The fibres then move to the air blowing chamber, which removes tiny impurities. The cleaned fibres are then collected and formed into a roll known as a lap or layer. Figure 8 shows scutching of cotton fibres.

Figure 8: Scutching process

Carding

The carding process separates individual fibres using a series of dividing and redividing steps, which causes many of the fibres to lie parallel to one another for the easy spinning process. The process also removes most of the remaining impurities, improves the degree of blending, and finally turns the lap into a thick, untwisted rope-like form called **card sliver**. Figure 9 shows the carding process of cotton fibres.

Figure 9: Carding process

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Combing

This process removes the short fibres, refines the cotton by removing any other impurities, and aligns long fibers into parallel rows. The combing process is optional. If fine cotton fibres are needed, combing is done. The combing increases luster and strength. Figure 10 indicates the combing of cotton fibres.

Figure 10: Combing process

Drawing

Drawing in cotton production comprises the straightening, paralleling, and condensing of fibers to ensure uniformity in the resultant yarn. The drawing process uses a machine referred to as a draw frame. The product of this drawing process is called a drawn sliver. Figure 11 shows the drawing process of cotton fibres.

Figure 11: Drawing process

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Roving

This is a process in which the drawn cotton fibres are pulled to approximately one-fourth of their original diameter, and a slight twist is added. The roving process reduces the drawn cotton fibres to a size suitable for spinning. Figure 12 indicates the roving process of cotton fibres.

Figure 12: Roving process

Spinning

This is the process of twisting roved cotton fibres into yarns. This final twist is inserted by turning the roving rapidly around its own axis between a fixed entering point and a rotating point at the other end of the spinning system. The twisted yarn is then taken up by a bobbin attached to and rotating with the spindle. Figure 13 indicates the spinning process.

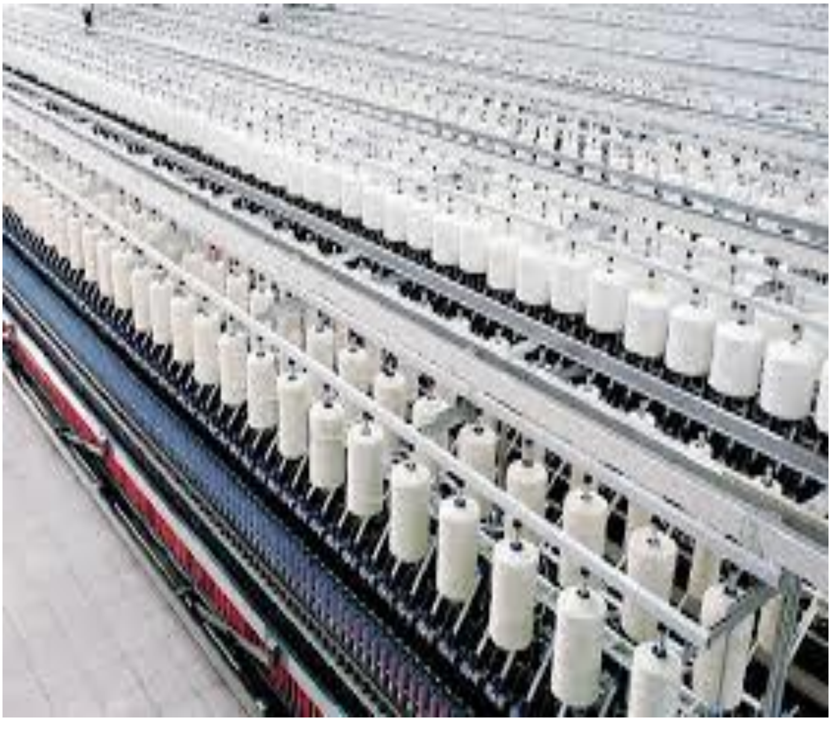

Figure 13: Spinning process

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Properties of Cotton Fibre

1. Cotton fibres are comfortable and cool to wear.
2. They are absorbent.
3. They dry slowly.
4. They crease badly.
5. They do not itch the skin nor abstract hair from the skin.

Samples of Cotton Fabrics

Figure 14: Samples of cotton fabric

Kapok

Kapok is a seed fibre obtained from the fruits of Ceiba pentandra, a tree surgeon in tropical countries. The processes involved in kapok production are harvesting, pod opening, removing the fibres, separation of seeds from the fibres, cleaning, baling and packing.

Harvesting

There are two ways of harvesting kapok fibres. Firstly, the pod is collected directly from the kapok trees when the kapok is mature by using simple tools. Secondly, the mature pods that have fallen on the ground themselves may be collected**.** Figure 15 indicates the harvesting of kapok.

Figure 15: Harvesting of kapok

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Pod Opening and Removing of the Fibres

After harvesting the kapok, the pods that did not open on their own are opened by hand or using simple tools. This is followed by removing the fibres from the pods. Figure 16 shows the pod opening and removal of the kapok fibres.

Figure 16: Pod opening

Separation

After opening the pod and removing the fibres, the seeds are separated from the fibres by stirring the mixture in baskets or sieve-like devices resembling drums. This causes the seeds and impurities, such as pod debris or dry leaves, to settle at the bottom of the container, making them easy to collect. Figure 17 shows the separation of seeds from the fibres.

Figure 17: Separation of the seed from the fibres

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Cleaning of Fibres

Cleaning of the kapok fibres can be done mechanically by beating or blowing air into the fibres to remove any impurities. Sometimes, the washing and drying process is carried out to additionally clean the fibres. Figure 18 shows the cleaning of the kapok fibres.

Figure 18: Cleaning of the kapok fibres

Baling and Packing

The dried kapok fibres after cleaning are compressed into bales for packaging. These packages are sold to producers who integrate kapok into products such as cushions, mattresses, or insulating materials. Figure 19 shows baling and packing of the kapok fibres.

Figure 19: Bale of kapok fibres

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Properties of Kapok Fibre

1. They are light in weight.
2. They are excellent at absorbing fluids like fuel, machine oil, or coconut oil.
3. They dry quickly.
4. They do not absorb water.
5. They are warm to wear.

Sample of Kapok Fabric

Figure 20: Kapok fabric

BAST OR STEM FIBRES PRODUCTION

Flax/Linen

Harvesting

The harvesting of flax is known as pulling. When the flax turns yellowish, it shows that it is ready to be harvested immediately. Any delay in pulling can make the flax fibres lose their luster and soft texture. The pulling of the flax can be done mechanically or manually. The flax stalks are tied in bundles called **beets.** The flax is then dried in the sun. Figure 21 shows the harvesting of flax.

Figure 21: Manual harvesting of flax

Figure 22: Mechanical harvesting of flax

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Rippling or Threshing

Rippling or threshing is the process of removing seeds and leaves from the stem of the flax by drawing the upper part of the bundle of flax through a comb. Figure 23 shows the rippling of the flax.

Figure 23: Rippling or Threshing

Retting

Retting is the process of removing the flax fibers from the flax stalks. The retting is done by steeping bundles of flax stalks in water. This allows the tissue or woody bark surrounding the fibre to decompose and loosen the gum that binds the fibre to the stem.

Types of Retting

- **Dew Retting**

The flax straw is spread on the grass to expose it to the atmosphere for three to four weeks. This method gives uneven results but produces flax that is strong and dark gray in colour. Figure 24 shows the dew retting of the flax.

Figure 24: Dew retting

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- **Pool retting**

This is done by putting the flax stalks in a pool of water. It requires less time than dew retting, from ten to fifteen days. This method sometimes causes over-retting as stagnant water is used, and it may result in brittle and weak flax fibres. The fibres obtained are bluish gray in colour. Figure 25 shows the pool retting of the flax.

Figure 25: Pool retting

- **Tank retting**

Bundles of flax are placed in huge concrete tanks with river water. The temperature of the water is 750°F and increases to 900°F, requiring 24 to 25 days, and produces strong, lustrous, highest quality flax fibres. Figure 26 shows the tank retting of the flax.

Figure 26: Tank retting

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- **Wooden vat or mechanical retting**

The flax is immersed in wooden vats containing warm water at a temperature ranging from 750°F to 900°F. This method shortens the retting process. The flax is removed from the vats and passed between rollers to crush the decomposed bark as clean water flushes away the gum and other impurities. Linen produced by this method is more susceptible to mildew. Figure 27 shows the mechanical retting of the flax.

Figure 27: Wooden vat or mechanical

- **Chemical retting**

The flax is stacked in tanks containing water and chemicals such as Sodium Hydroxide or Sodium Carbonate. Flax is sometimes boiled in a dilute solution of Sulfuric acid. It can shorten the process considerably, but it may affect the strength of the fibres if it is not carefully controlled.

Breaking

Breaking is the process of separating the bast from the exterior fibers. It is done by passing the bundle of stalks between fluted rollers. The process breaks the outer woody covering into small particles called shives. Figure 28 shows the breaking process of the flax.

Figure 28: The breaking process of flax

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Scutching

Scutching is the removal of non-fibrous material from retted stalks to extract the bast fibres. The scutching is done using a scutching machine. The machinery consists of a breaker, which has around six pairs of comparatively small fluted rollers to break the stem into small pieces. Dried flax straws are passed through the fluted rollers of the machine, which crushes the straw and breaks up the woody stem into small pieces.

Broken woody pieces are separated from the fibres by the stroke against the horizontal metal bar of the scutching machine. Thoroughly retted and dried stems are easily separated from the fibre by the stroke of a beater. The flax straws are again passed through the fluted rollers, and the process is repeated three times to separate the fibres from woody stems. Figure 29 shows the scutching process of the flax.

Figure 29: Scutching process of flax

Hackling or Combing

The hackling or combing process straightens the flax fibre and separates short fibers known as ‘tow’ from the long fibers called ‘lines. This process arranges longer fibres in parallel formation. To obtain fine linen, the hackling is repeatedly done by hand, while coarse linen is hackled by machine. Figure 30 shows hackling process of the flax.

Figure 30: The hackling or combing process of flax

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Spinning

The flax fibres are drawn out into yarn, and twist is imparted. Although flax is one of the strongest fibres, it is inelastic and requires a carefully controlled, warm, moist atmosphere while spinning. Flax fibres are spun by either dry or wet spinning methods. Wet spinning gives the best quality yarn from 18-22 inches. The average length of fibres after processing is 10-15 inches. Tow fibres (short linen fibers) are less than 12 inches in length and can be as short as a fraction of an inch. Figures 31 and 32 show the spinning process of the flax.

Figure 31: Manual spinning process of flax

Figure 32: Mechanical spinning process of flax

Properties of Flax Fibre

1. Linen fibres are the oldest textile material in the world.
2. They are strong fibres.
3. They are absorbent.
4. They are easy to dye and print.
5. They crease badly.

Sample of Flax Fabric

Figure 33: Flax fabric

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Jute

Harvesting

Jute is harvested by cutting the plants to the ground, after which the stalks are bundled together. The plants are harvested when they are flowering. After harvesting, the plants are left in the field for 2-3 days to allow the leaves to shed naturally. Figure 34 shows the harvesting of the jute plants.

Figure 34: Harvesting of jute

Retting

Jute retting, also known as soaking, is done to separate the fibres from the stalk of the jute plant. The retting is done by soaking the bundles of jute stalk in a pond, well, dam, river, or tank, for a period of 10 to 30 days, depending on the water temperature and flow. During retting, bacteria break down the pectin that holds the fibres together, making it easier to extract them. Figure 35 shows the retting of the jute

.

Figure 35: Retting process of jute

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Denudation

After the retting process, the jute is denudated. This process involves stripping or separating the jute fibres from the stalk, after which the fibres are extracted, washed, and cleaned. Figure 36 shows the denudation of the jute.

Figure 36: Denudation

Drying

The next process of denudation is drying. The fibres are hung in the sun for 2-3 days to dry. The drying gives the fibres strength and also helps to avoid fungal attacks. Figure 37 shows the drying process of the jute.

Figure 37: Drying process of jute fibres

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Grading and Sorting

The grading and sorting are done to classify jute fibres based on their quality. The fibres are graded and sorted based on their strength, fineness, length, and colour. High-quality jute fibres are used to manufacture fabrics, whilst low-quality ones are used for ropes, mats, and bags. Figure 38 shows the grading of the jute fibres.

Figure 38: Jute grading

Baling

Baling is the process of compressing jute fibres into bundles for easy handling, storage, and transportation. After grading and sorting, jute fibres are compressed into bales and transported to mills for further processing into yarns, fabrics, and other textile or fashion products. Figure 39 shows the baling of the jute fibres.

Figure 39: Bale of jute fibres

Properties of Jute fibre

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1. Jute fibres are long, which makes them spin into yarn.
2. They are soft and comfortable to handle.
3. They are strong and durable.
4. They are elastic.
5. They are flexible.

Sample of Jute Fabric

Figure 40: Jute fabric

Kenaf

Harvesting

The harvesting of the kenaf is done at the time leaves begin to appear yellow, normally between 4-6 months. The harvesting can be done manually or mechanically. Figure 41 shows the harvesting of the kenaf.

Figure 41: Harvesting of kenaf

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Retting

Extracting the kenaf fibres from the stalk is known as retting. The outer bark layer of the kenaf stalk has long and strong fibres, while the inner woody part of the kenaf stalk has short and coarse fibres. There are three ways of kenaf retting. These are water retting, chemical retting, and mechanical decortication. The water retting is done by soaking the kenaf stalks in water for microorganisms to decompose the stalk.

The chemical retting involves treating the stalks of the kenaf with chemicals like sodium hydroxide (NaOH) to break down the stalk so that the fibres can be easily extracted from the stalk. The mechanical decortication is carried out by using machines to strip the fibres directly from stalks. Figure 42 shows the retting of the kenaf.

Figure 42: Retting of kenaf

Washing and Drying

After retting, the extracted kenaf fibres are washed to remove impurities and then dried in the sun. Figure 43 shows the drying of the kenaf fibres.

Figure 43: Washing and drying of kenaf fibres

Baling

The dried kenaf fibres are then baled and transported to textile mills for conversion into yarns and fabrics. Figure 44 shows the baling of the kenaf fibres.

Figure 44: Bale of kenaf fibres

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Properties of Kenaf fibre

1. Kenaf fibres are strong.
2. They are soft.
3. They break easily.
4. They are not elastic.
5. They are easily chemically degraded.
6. They are hydrophobic.

Sample of Kenaf Fabric

Figure 45: Kenaf fabric

Ramie

Harvesting

Ramie stalks are cut when the lower portion turns brown and new stalks appear. The harvesting is done by hand or a mechanical harvester. After harvesting, the stalks are tied in bundles for further processing. Figures 46 and 47 show the harvesting of ramie.

Figure 46: Manual harvesting of Ramie

Figure 47: Mechanical harvesting of ramie

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Retting

After harvesting, the ramie stalks are subjected to retting to separate the fibres from the woody stalk. The best retting ramie requires is chemical retting, since it does not respond well to water retting. Sodium hydroxide solutions are used to break down the gummy substances. Figure 48 shows the retting of ramie.

Figure 48: Retting of ramie

Decortication

Ramie decortication involves mechanically or manually removing the outer bark and some of the central woody core and gums from the ramie plant stalks to extract the fibres. Figure 49 shows the decertification of ramie.

Figure 49: Decortication of ramie

Degumming

This is a process of removing the natural gums and pectins from the ramie fibres. Degumming is done by boiling the ramie fibres in sodium carbonate solution to soften and purify them. Figure 50 shows the degumming of ramie.

Figure 50: Degumming of ramie

Washing and Drying

After degumming, the fibres are washed and dried in the sun. The fibres are thoroughly washed and sun-dried. Figure 51 shows the drying of the ramie.

Figure 51: Washing and drying of ramie

Baling

The dried ramie fibres are combed, carded, baled, and transported to textile mills for spinning into yarns. Figure 52 shows the baling of the ramie.

Figure 52: Bale of ramie fibres

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Properties of Ramie fibre

1. Ramie fibres are absorbent.
2. They are cool to wear, especially in hot climates.
3. Ramie fibres are stronger than cotton and flax.
4. They have low abrasion resistance.
5. Ramie fibres are not easily damaged by acids and alkalis.

Sample of Ramie Fabric

Figure 53: Sample of ramie fabric

Bamboo Fibre

Bamboo fibres are stem fibres obtained from the bamboo plant in a sustainable manner. They are used to make garments, rugs, and upholstery, among other things. Bamboo fibre garments are breathable and comfortable to wear in both hot and cold temperatures.

Harvesting

The harvesting of bamboo for textile fibre production involves cutting mature bamboo stems when they are 3-4 years old. The cutting is done close to the base of the bamboo plant. Figure 54 shows the harvesting of bamboo.

Figure 54: Bamboo harvesting

Fibre Extraction

Bamboo fibres can be produced by mechanical or chemical means.

Mechanical Process of Bamboo Fibre Extraction

There are two processes of mechanical bamboo fibre extraction. These are decortication and breaking. In the breaking method of bamboo fibre extraction, longer sections of bamboo are cut into shorter pieces using water pressure or high-speed steel blades; cutting blades made from tungsten carbide or other hard metals may also be used in larger plants. Other equipment, such as shredders and separators, helps produce specific grades of pulp.

In decortication, a large machine takes harvested bamboo stems as input and produces compressed fibers as output. This process uses less energy than mechanical breaking but generates some waste that must be disposed of or recycled.

Chemical Method of Bamboo Fibre Extraction

Chemical bamboo fibre extraction involves crushing bamboo and treating it with an alkaline solution, such as sodium hydroxide (NaOH), to dissolve lignin, hemicellulose, and other non-cellulosic components, separating the cellulose fibers. This process can also involve carbon for regeneration, and the resulting fibres are then washed, bleached to a bright white, and dried.

LEAF FIBRES PRODUCTION

Sisal Fibre

Harvesting

The sisal plant is normally harvested for the first time in 3 to 4 years after planting. Sisal is usually harvested by hand because the rosette pattern of growth makes it difficult to harvest mechanically. The harvesting is done by cutting the leaves close to the base of the plant using a sharp blade. Figure 55 shows the harvesting of sisal.

Figure 55: Harvesting of sisal

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Decortication

This is a process of extracting the fibres from the leaves of sisal plants. Decortication is done by feeding the harvested sisal leaves into a machine called a **decorticator,** which crushes the leaves and scrapes away the tissue to expose the fibres. Figure 56 shows the decortication of sisal fibres.

Figure 56: Decortication of sisal fibres

Washing and Drying

After decortication, the fibres extracted are then washed to remove unwanted leaves. The washed fibres are then dried in the sun for 1–2 days, depending on climate conditions. The drying is done to ensure that the fibres remain strong and do not develop fungus. Figure 57 shows the drying of the sisal fibres.

Figure 57: Washing and Drying

Brushing and Sorting

The next process after drying of the sisal fibres is brushing. The fibres are brushed to remove impurities and to improve their feel. The fibres are also sorted after brushing based on their quality, length, and colour before being bundled for sale. Figure 58 shows the brushing and sorting of the sisal fibres.

Figure 58: Brushing and sorting

Baling and Exporting

After brushing and sorting, the sisal fibre is compressed into bales for easy transportation and storage. Figure 59 shows the baling of the sisal fibres.

Figure 59: Bale of sisal fibres

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Properties of Sisal Fibre

1. Sisal fibres are coarse and inflexible.
2. Sisal fibres do not attract dust.
3. They do not absorb moisture or water easily.
4. They are strong and durable.
5. Sisal fibres are both biodegradable and recyclable.

Sample of Sisal Fabric

Figure 60: Sample of sisal fabric

Abaca Fibre

Abaca, also known as Manila hemp (Musa textilis), is a natural plant leaf fibre obtained from the leaf stalks of the abaca plant, a close relative of the banana plant.

Harvesting

Abaca is harvested between 18 and 24 months after planting. Subsequent harvests are done at 3 to 4-month intervals. The harvesting process of abaca involves topping and tumbling. The topping is done by cutting the leaf stalk at the base of the leaf stalk with a knife or a sickle. The topping makes harvesting easier and minimizes the damage to nearby plants. The tumbling involves cutting the trunk down at the ground above the roots using a sharp bolo knife. Figures 61and 62 show the harvesting of abaca.

Figure 61: Topping

Figure 62: Tumbling

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Tuxying

This is the process of separating the outer layer of leaf coverings from the inner layer. The outer layers produce primary fibres, which are coarser, while the inner layers produce secondary fibres, which are finer. Tuxying is typically done by inserting a specially-made knife between the two layers at one end (the base) and then peeling off the outer layer. The separated outer covering layer is called a **tuxy**. Figure 63 shows the tuxying of the abaca.

Figure 63: Tuxying

Stripping

This is a process of manually or mechanically extracting the fibres from the leaf coverings using a stripping knife or a machine. There are three methods of abaca stripping. These are hands, spindle, and decortication.

The hand strip, which is labor-intensive, is done by extracting the fibres using an improvised structure that is made up of a knife, a block, and a foot pedal. The block is usually fixed, the knife is movable, and controlled by the pedal, which applies pressure on it towards the block. The tuxies are placed between the block and the knife, pressure is applied on the knife, and then the tuxies are pulled away from the knife with force, which removes the pulpy materials. Figures 64 and 65 show the stripping of the abaca fibres.

Figure 64: Hand stripping

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Spindle-stripping is a semi-mechanized improvement on the hand-stripping process. This involves winding the tuxes around a tapered-shaped spindle, which is kept in motion by an electric motor. This speeds up the extraction process, and in a short amount of time, many more fibers can be extracted compared to hand striping.

Figure 65: Spindle-stripping

Decortication

Decortication is a mechanized fibre extraction method where leaf coverings are crushed and scraped by a machine with revolving wheels with knives. Unlike the two methods above that extract fibre from tuxies, this method uses the whole leaf sheath, recovering both the primary and the secondary fibres at the same time. The position of the leaf sheath determines its color and the strength and texture of the fibers it produces. The outer sheaths are the darkest and the inner sheaths the lightest. Figure 66 shows the decortication of the abaca fibres.

Figure 66: Decortication of abaca

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Drying

After the stripping process, the extracted fibres are washed and left to dry in the sun for several hours to reduce their moisture content and improve their strength and durability. Figure 67 shows the drying of abaca fibres.

Figure 67: Drying of abaca fibres

Grading and Sorting

Once dried, the fibres are graded based on their colour, texture, length, strength, and cleaning. The best grades of Abaca are fine, lustrous, light beige in colour, and very strong. Figure 68 shows the grading and sorting of the abaca fibres.

Figure 68: Grading and sorting of abaca

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Baling

The graded fibers are then bundled and baled in bales of 125 kg for storage, export, and transportation to various industries. Figure 69 shows the baling of the abaca fibres.

Figure 69: Bale of abaca fibres

Properties of Abaca Fibre

1. Abaca fibres are resistant to saltwater damage.
2. They are flexible.
3. They are durable.
4. They are the strongest natural fibre.
5. The best grades of Abaca are fine and lustrous.

Sample of abaca Fabric

Figure 70: Abaca fabric

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Raffia Fibre

Raffia is a natural plant fibre that is obtained from the leaves of the raffia palm tree (genus *Raphia*). Raffia fibres are extensively used for producing textile articles, baskets, ropes, mats, and other ornaments.

Harvesting

During the harvesting process, the raffia leaves are cut and torn by hand in lines parallel to each other with respect to the trunk of the tree. Only a young branch of the tree is cut; the entire tree remains intact, not chopped. The leaves are judiciously cut from the raffia to avoid damage to the plants. Figure 71 shows the harvesting of the raffia fibre.

Figure 71: Harvesting of raffia

Stripping of the Raffia Fibre

After harvesting the raffia, the leaflets are removed from the main leaf stalk. The outer part of the leaflet peels away and dried to get the raffia fibres. Figures 72 and 73 show the stripping and drying of the raffia fibres.

Figure 72: Stripping of Raffia

Figure 73: Drying of Raffia

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Dyeing (Optional)

Raffia naturally has a creamy-white pale yellowish color. Raffia can be dyed with natural or synthetic dyes before being woven into textile articles. Figure 77 shows the dyeing of the raffia fibres.

Figure 74: Dyed raffia

Properties of Raffia Fibres

1. Raffia fibres are strong.
2. They are durable.
3. They are flexible.
4. They are light in weight.
5. They decompose easily.

Sample of raffia fabric

Figure 75: Raffia fabric

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GRASS OR REED FIBRES PRODUCTION

Totora Fibre

Totora is a reed that grows in swampy areas, particularly around lakes, lagoons, and rivers. Totora is harvested by uprooting or cutting the stem.

Harvesting

Harvesting is done during the dry season when the plant is mature and has a strong fibre structure. Figure 76 shows the harvesting of totora.

Figure 76: Harvesting of totora

Drying

The harvested totora is dried under the sun for several days. The drying is done to reduce moisture, strengthen the fibres, and make processing easier. Figure 77 shows the drying of the totora.

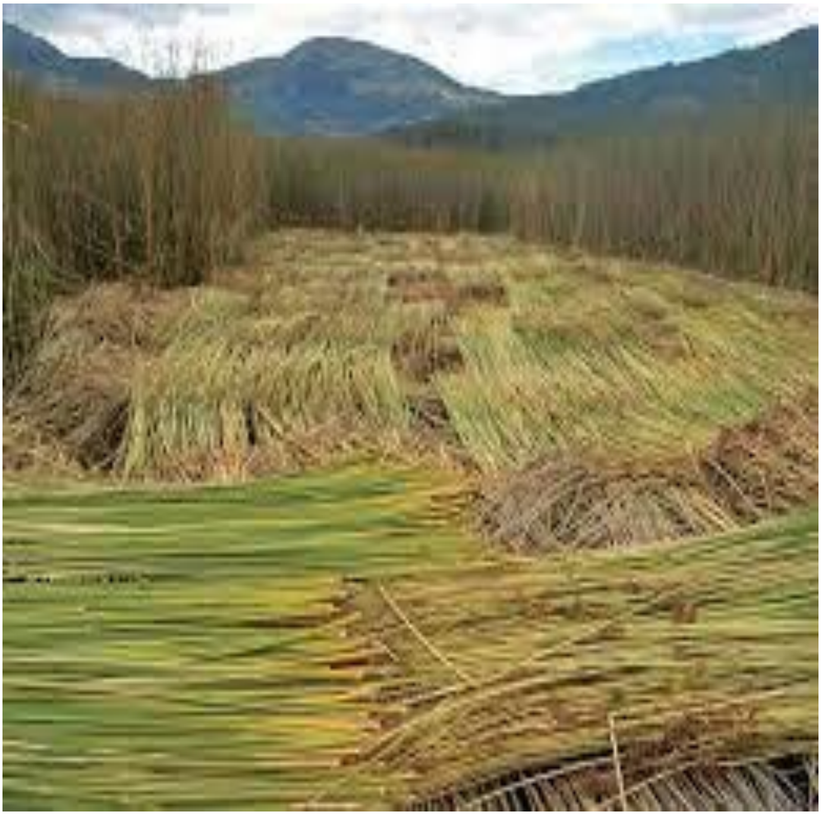

Figure 77: Drying of totora

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Extraction of the fibres

After drying, the outer layers of the reeds are peeled off to extract the finer fibres. sometimes the reeds are split into thinner strips based on the use of the fibres. The fibres are sometimes soaked in water to soften them before they are used for manufacturing textiles and other products. Figure 78 shows the extraction of the totora fibres.

Figure 78: Extraction of totora fibre

Characteristics of Totora Fibres

1. Totora fibres are flexible and fresh to the touch.
2. They are durable.
3. They are absorbent.
4. They are strong.

Sample of Totora Fabric

Figure 79: Sample of totora fabric

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PRODUCTION OF FRUIT FIBRES

Coir Fibre

Coir fibre is a natural plant fibre obtained from the husk of coconuts. The processes of coir fibre production are harvesting, retting, decorticating, washing, drying, sieving or screening, and compressing and packaging.

Harvesting

First of all, the mature coconuts are harvested, and the outer shell or husk is removed from the fruits. The husk is then dried for a few days. Figure 80 shows the harvesting of the coir.

Figure 80: Harvesting of the coir

Retting

The retting process is done by soaking the dried coconut husks in water, either in ponds, dams, or lagoons, for a period of 3-6 months or even longer to soften the fibres for easy separation from the woody parts of the husk. Figure 81 shows the retting of the coir.

Figure 81: The retting process of the coir

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Decorticating

The separation of the fibres from the coconut husks can be done manually or mechanically. The manual method involves beating the husks with a club to extract the fibres, while the mechanical decorticating is done using a machine to separate the fibres from the retted coconut husks. Figures 82 and 83 show the decertification of the coir.

Figure 82: Manual decorticating of coir

Figure 83: Mechanical decorticating of coir

Washing and Drying

After extracting the fibres from the husks, the fibres are thoroughly washed to remove impurities such as dust, dirt, and debris. The fibres are then dried under shade or using mechanical dryers to reduce moisture. Figure 84 and 85 show the washing and drying of the coir.

Figure 84: Washing coir

Figure 85: Drying of coir

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Sieving or Screening

Sieving or screening is done to separate the coconut husk into different lengths and qualities and to remove impurities such as dirt, small particles, and other debris. Figure 86 shows the sieving of the coir.

Figure 86: Sieving, or screening coir

Compressing and Packaging

The sieved or screened fibres are compressed into bales or blocks for storage and transportation.

Figure 87: Compressing and packaging of coir

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Properties of Coir Fibre

1. They have high tensile strength.
2. They are durable.
3. They are elastic.
4. They are absorbent.
5. They have good resistance to saltwater damage.

Sample of coir fabric

Figure 88: Coir fabric

Luffa Fibre

Luffa fibre is a natural plant fibre derived from the luffa plant. Luffa fibre is also known as loofah or sponge gourd. The production processes of luffa are harvesting, drying, retting and washing, and bleaching.

Harvesting

The fruits of the luffa plant are harvested when they are mature and turn yellow-brown, and feel light in weight. The harvesting is done by cutting the fruits from the vine. Figure 89 shows the harvesting of luffa.

Figure 89: Harvesting of luffa

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Drying

After harvesting, the fruits are dried in the sun to permit the fibrous vascular network to form a sponge-like structure. Figure 90 shows the drying of the luffa.

Figure 90: Drying of luffa

Retting

Water resting is carried out by soaking the dried fruits to soften the husks.

Removal of husk and seeds

The outer skin is then removed, after which the fruits are shaken manually to remove the seeds. Figures 91 and 92 show the removal of the seeds and husk.

Figure 91: Removal of husk

Figure 92: Removal of seeds

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Washing and Bleaching

After removing the seeds, the fruit is washed thoroughly to remove fluid and residue. Bleaching is then carried out using sunlight or mild chemicals to improve the aesthetic and hygiene of the fibre. The fibres are converted into yarns after bleaching.

Properties of luffa fibres

1. They are highly absorbent.
2. They are strong.
3. They are durable.
4. They are soft when wet and rigid when dry.
5. They are not elastic.

Sample of luffa fabric

Figure 93: Luffa fabrics

CHAPTER 3: PRODUCTION OF ANIMAL OR PROTEIN FIBRES

Animal fibres are fibres obtained from the hair or secretion of animals. These fibres are also known as protein fibres. The examples of these fibres are wool, which is obtained from the hair of animals, and silk, which is derived from the secretion of animals.

Wool Fibre

Wool is a natural fibre obtained from the hair of animals such as sheep, mohair, llama, alpaca, cashmere, rabbit, camel, goose, etc. The processes involved in wool fibre production are shearing, scouring, carding, dyeing, grading, and spinning.

Shearing

This is a process of removing the fleece (hair) of the animals that gives us wool fibres. The shearing is normally done once a year, usually at the end of winter, using electric shears. Figure 94 shows how the shearing of animals is done.

Figure 94: Shearing

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Scouring

This is a process of washing the raw fleece after shearing to remove dirt, grease, and any other impurities. The scouring process is done by feeding the raw wool into a machine where it passes through a series of bowls containing detergent, warm water, or alkaline solution. Figure 95 indicates the scouring process.

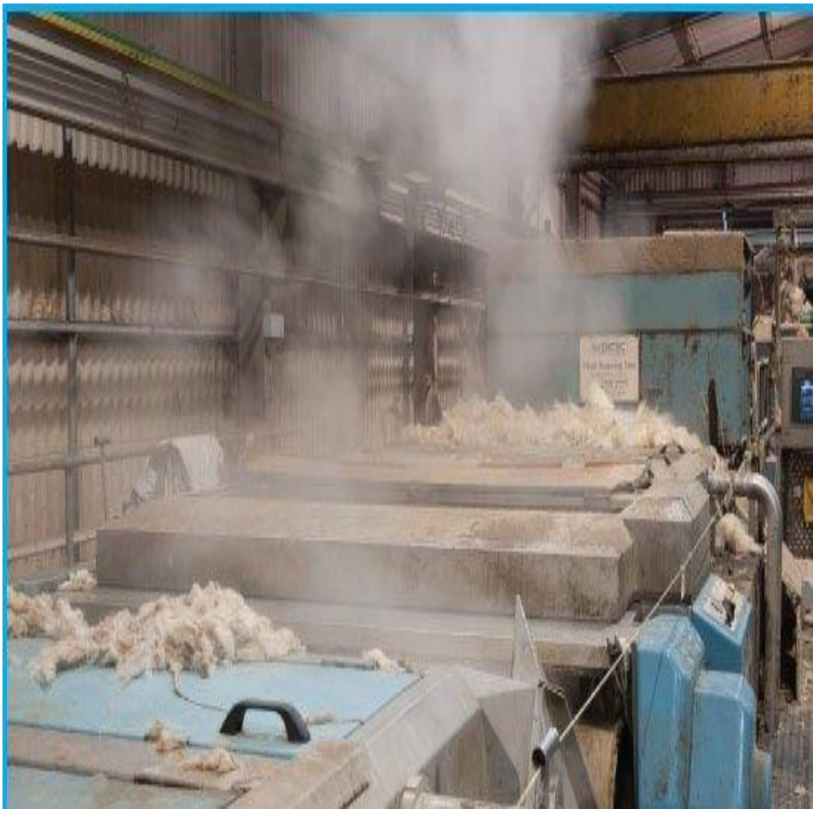

Figure 95: Scouring

Grading

Grading is sorting the wool fibres based on their length, strength, colour, and texture. The sorting is essential to determine the suitability of the wool fibre for diverse uses such as clothing, carpets, and industrial uses. Figure 96 shows the grading of wool fibres.

Figure 96: Grading

Dyeing

After the carding process, the fibres are dyed to colour them. Wool is destroyed by alkaline, so the best dyes for dyeing wool fibres is acid dyes. Figure 97 shows the dyeing of wool fibres.

Figure 97: Dyeing of wool fibres

Carding

Carding is a process of separating the wool fibres after dyeing to prepare them for spinning. The carding process also removes impurities and aligns the fibres into a continuous strand called a **sliver.** The process involves using specialised machines which has rollers or drums covered in fine wire teeth to brush and comb the wool fibres. figure 98 shows how the wool carding process is carried out.

Figure 98: Wool carding process

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Spinning

Spinning is the process of converting the carded wool into yarn by twisting and pulling it together to create a continuous thread. Spinning can be done mechanically or manually using a drop spindle or with a spinning wheel. Figures 99 and 100 show the spinning process of wool fibres.

Figure 99: Manual wool spinning

Figure 100: Mechanical wool spinning

Properties of wool

1. They do not burn easily.
2. They are absorbent.
3. They are flexible.
4. They are elastic.
5. They are warm to wear.
6. They are soft.
7. They are resistant to high temperatures.
8. They resist dirt.

Sample of wool fabric

Figure 101: Wool fabric

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Bombyx Mori Silk Fibre

Silk is a natural protein fibre obtained from silkworms. Silk production is known as sericulture. Sericulture is the process of cultivating silkworms and extracting silk from them. There are two categories of silkworms. We have Bombyx mori silkworms, which are cultivated, and wild silkworms. The production processes of Bombyx mori silk fibre are the cultivation of silkworms, harvesting, reeling, and spinning.

Cultivation of Bombyx Mori Silkworms

- The female silk moth lays tiny eggs on mulberry leaf surfaces, which are covered with a protective coating called sericin, which helps keep them safe. They hatch into larvae (silkworms). A female moth can lay more than 350 eggs at a time. The incubation period for the eggs lasts about 10 to 14 days, depending on the temperature and humidity.
- When the eggs hatch, tiny larvae (silkworms), also known as caterpillars, appear. These larvae have a small head, soft body, and numerous tiny hairs covering their skin. The larvae, which have a strong appetite, are fed with mulberry leaves day and night for 40 days until they grow.
- After the larva stage, the silkworms enter the pupa stage. This stage is the resting or motionless, or transitional stage of development. During this stage, the silkworm starts weaving a protective cocoon around itself using

the secretion produced from special glands in its head. This secretion quickly hardens upon contact with air, forming a continuous thread that wraps around the body of the pupa. The pupa continuously moves and weaves while secreting the silk threads. The cocoon serves as a protection and provides a safe environment for the pupa to undergo its transformation into a butterfly.

In this stage, the pupa completes the weaving of the cocoon around itself. The cocoon has the size of a small cotton ball. The cocoon is oval-shaped and consists of a single continuous silk filament, which can measure up to 900 meters long. The silk filament is made up of two proteins: fibroin, which gives the thread its strength, and sericin, a gummy substance that holds the fibers together. Figure 102 shows the cultivation of Bombyx mori silkworms.

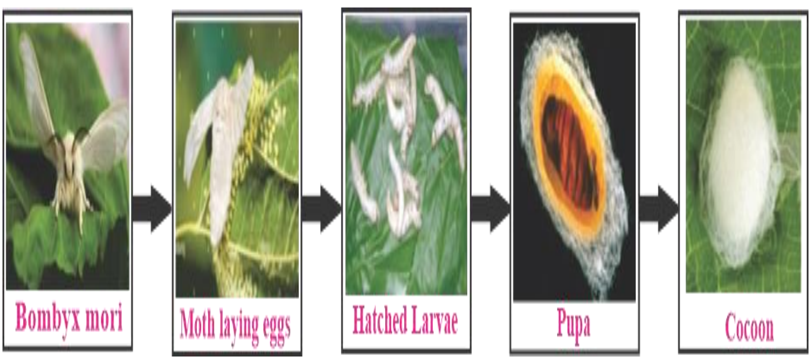

Figure 102: Cultivation Process of Bombyx Mori Silkworms

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Harvesting of the Cocoons

Once the pupa completes the formation of their cocoons, it is time to harvest them successfully. The harvesting of the cocoons is a delicate process. The harvesting process includes carefully examining and sorting the cocoons that are in optimal condition.

The sorting of the cocoons is based on their quality and size. Generally, larger and more uniform cocoons produce better quality and longer silk threads. Figure 103 shows the harvesting of the cocoons.

Figure 103: Harvesting and sorting of the cocoons

After harvesting and sorting, the pupa are killed by plunging the cocoon into boiling water and unwinding the silk thread. Figure 104 shows the killing process of the pupa.

Figure 104: Boiling of the cocoons

Reeling

Reeling is the process of unwinding the silk filaments from several cocoons and combining them into a single, thicker yarn. The reeling process is done by boiling the cocoons in hot water to remove the sericin or gum holding them together and then unwinding the filaments. This process is essential in silk production because individual silk filaments are too thin to be used directly. Figure 105 shows the reeling process.

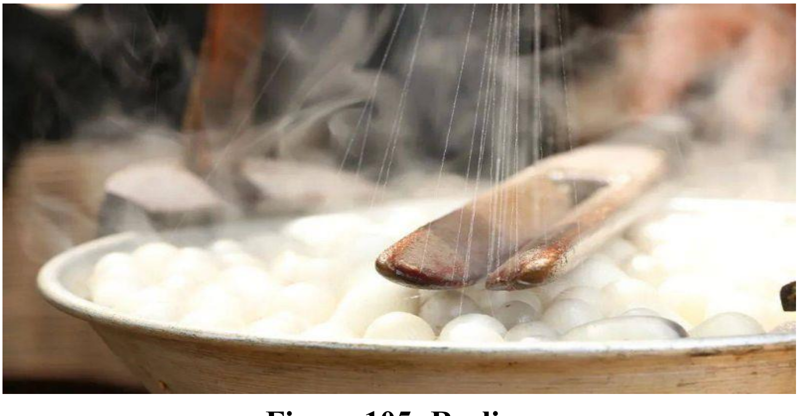

Figure 105: Reeling

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Throwing

Throwing is the process of twisting silk filaments into yarn to make them sufficiently strong for weaving or knitting. This process involves several steps, including cleaning, twisting, and winding silk threads onto bobbins. Throwing is conducted in a throwing mill, and the workers engaged in throwing are called **throwsters.** Figure 106 and 107 shows the throwing process.

Figure 106: Manual silk throwing

Figure 107: Mechanical silk throwing

Spider Web Silk Production

Spider silk fibre is an animal fibre produced by the glands of spiders. The spiders normally build their web in stages. They start by making a beam bridge between two supports. They then spin their web with the help of the excretion from their ampullary gland. Figure 108 shows a spider building its web.

Figure 108: A spider producing its web.

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Harvesting

The web (spider silk fibres) is obtained by pulling the web from the spider at a controlled speed. Figure 109 shows how spider fibres are harvested.

Figure 109: harvesting of the spider web fibres

Properties of silk

1. Silk fibres are strong threads.
2. They are elastic.
3. They are warm to wear.
4. They are lustrous.
5. They are expensive.
6. They are damaged by heat.
7. They are damaged by alkaline.

Sample of silk fabric

Figure 110: Silk fabric

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CHAPTER 4

PRODUCTION OF MINERAL FIBRES

Mineral fibres are fibres obtained from natural non-organic materials like rock, ores, slag, carbon, and glass. These fibres are generally used for insulation, fireproofing, and other applications. Examples include asbestos, carbon fibre, fiberglass, and rock wool.

Asbestos Fibre

Asbestos is a natural mineral fibre obtained from a group of long and thin silicate minerals formed in rock. There are six minerals used for asbestos fibre production. These are chrysotile (white asbestos), amosite (brown asbestos), crocidolite (blue asbestos), tremolite (appears colourless, light green, milky white, dark green, brown & grey asbestos), actinolite (green or yellow-green asbestos), and anthophyllite (gray or green, sometimes brown asbestos). The production processes of asbestos are mining, crushing, milling, and grading

Mining

Asbestos deposits are found underground, and the ore is brought to the surface for processing using conventional mining practices. There are two ways of mining asbestos. These are underground mining and open-pit mining. The brown and blue asbestos are mined underground. The white asbestos usually found near the surface can be mined from open pits. Figure 111shows the mining of asbestos minerals.

Figure 111: Mining of asbestos

Crushing

After the rock is mined, it is crushed and dried before being transported to a mill. The mined rock is dried by exposing it to air and sun or by using furnaces. It is then broken mechanically in a mill, and the fibre is separated from the rock on a series of screens. Figure 112 indicates the crushing process of the mined asbestos rocks.

Figure 112: Crushing of asbestos

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Milling or Fiberisation

The process of separating the fibres from the crushed rock is known as milling or fiberisation. Fiberisation can be done by using a machine (Hammer mills) that uses a wet or dry method to crush and spread asbestos fibres. Air pressure systems or vibrating screens are used to collect or lift the fibres depending on their weight and structure. Figure 113 shows the fiberisation process.

Figure 113: Milling or Fiberisation of asbestos fibres

Screening and Grading

After fiberisation, the separated fibres are passed through a screening machine to grade them by length, colour, purity, and fineness. The grading is done to help determine the application of the fibres. usually, long fibres are used for textile production, while shorter ones are used for cement and insulation production. Figure 114 shows the grading of asbestos fibres.

Figure 114: Screening and Grading

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Carding

As screening and grading, the fibre is fed to a carding machine, which uses a series of rollers and blades to further separate asbestos fibres while aligning them in parallel rows, to produce a uniform sheet or lap. The carding process also removes impurities such as rock fragments, soil, dust, and dirt from the fibres. Figure 115 shows the asbestos carding process.

Figure 115: Carding of asbestos

Roving

During carding, the fibre is continuously refined through the removal of impurities before the material is formed into web-shaped sheets or laps. From these sheets, ribbon-like strips are cut and then bundled into fibrous strands that are known as roving. Cotton, rayon, or other material may be added at this stage to strengthen the roving. Figure 116 indicates the roving process.

Figure 116: Roving of asbestos

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Spinning

The purpose of the spinning process is to impart a greater twist to the roving. Roving, which has been mechanically twisted and spun to give it greater tensile strength, forms a single yarn. The spinning process is typically facilitated by either a ring frame or flyer frame spinning machine, both of which serve to provide the roving with a specified diameter and tensile strength in a finished yarn suitable for weaving into cloth. Figure 117 shows the spinning process of the asbestos fibre.

Figure 117: Spinning of asbestos

Properties of Asbestos Fibres

1. Asbestos fibres are flexible.
2. They withstand the fiercest heat.
3. They are resistant to alkaline.
4. They are strong fibres.
5. They have good tensile strength.

Sample of Asbestos Fabric

Figure 118: Asbestos fabric

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CHAPTER 5
PRODUCTION OF REGENERATED FIBRES

Regenerated fibres are man-made fibres produced by chemically modifying natural materials derived from plants or animal origins. Examples of regenerated fibres of plant or cellulosic origin are viscose rayon, acetate rayon, cuprammonium rayon, corn starch fibre, etc., while the examples of regenerated fibres of protein origin are casein (milk fibre), ardil, corn starch fibre (zein fibre), artificial silk, soy protein fibre, collagen fibre, etc.

PRODUCTION OF REGENERATED FIBRES OF CELLULOSIC OR PLANT ORIGIN

Viscose Rayon

Viscose rayon is a cellulose regenerated fibre produced from natural cellulose obtained from wood pulp. The manufacturing processes of viscose rayon are raw material preparation, steeping, pressing, shredding, aging, xanthation, dissolving, ripening, filtration and deaeration, degassing, spinning, drawing, washing, cutting, drying, and packaging.

Raw Material Purification

In this process, wood pulps are purified to eliminate non-cellulosic components such as lignin and hemicellulose. Figure 119 shows the raw material purification process.

Figure 119: Wood pulp preparation

Steeping

This process is carried out by soaking the purified wood pulp in caustic soda solution to produce alkali cellulose that is more reactive. The operation is carried out in a long rectangular tank in which a hydraulic ram is incorporated.

Pressing

This involves pressing the swollen alkali cellulose to squeeze out excess caustic soda solution. This step is crucial to obtaining the correct ratio of alkali to cellulose and ensuring a uniform product for subsequent stages.

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Shredding

Shredding is the process of mechanically breaking the alkali cellulose sheets into smaller, fluffy particles called "crumbs". This step is vital as it increases the surface area of the cellulose, facilitating subsequent chemical reactions needed to create the viscose solution**.**

Aging

This process involves storing the shredded alkali crumbs for a controlled number of days at a specific temperature to reduce the molecular weight of the cellulose to make it more manageable during the next step of production.

Xanthation

This process is also called sulphidising. The xanthation process involves converting the aged alkali cellulose into cellulose xanthate, which is orange-yellow in colour, by reacting it with carbon disulfide (CS2).

Dissolving

In this process, the cellulose xanthate is dissolved in sodium hydroxide solution to form a thick, viscous liquid called viscose dope.

Ripening

This process involves storing the viscose dope for a period of 4-5 days at a temperature range of 10-18°C to allow the viscose dope to mature (ripen) to improve spinning properties.

Filtration

Filtration is a process where the viscose solution, which is a mixture of dissolved cellulose and chemicals, is cleaned to remove undissolved particles and impurities. This process ensures a reliable and high-quality solution that is ready for the spinning stage.

Deaeration

After the filtration of the viscose solution, the deaeration process is done by removing tiny air bubbles trapped in the viscose solution before it is extruded to form rayon fibres. This step is essential for ensuring the quality and uniformity of the resulting viscose fibres.

Degassing

The degassing process removes dissolved gases and volatile impurities such as low-boiling solvents or unwanted volatile by-products before extrusion. The degassing process is done to remove impurities that would cause voids or weak spots in the fine rayon filaments.

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Spinning

Viscose rayon spinning is a wet-spinning process where a viscose solution is extruded through spinnerets (fine nozzles) into a clotting bath containing chemicals like sulfuric acid, sodium sulfate, and zinc sulfate, which cause the viscose to clot and form the filaments. These filaments are then drawn out and solidified to create the viscose rayon fibres.

Drawing

The drawing process involves stretching the newly formed rayon filaments while the cellulose chains are still relatively mobile to improve their strength and alignment. This stretching process enhances the fibre properties, making it more suitable for use as a textile fibre.

Washing

Several different washings of the freshly viscose rayon are done to remove residual chemicals.

Cutting

The cutting process occurs after the filaments have been spun and drawn. The fibres are cut into various lengths using a rotary cutter, to create staple fibers for use in weaving and knitting.

Drying and Baling

The cut fibres (staple fibres) are dried to an ideal moisture content and balled for shipping and storage. Figure 120 indicates the manufacturing process of the viscose rayon.

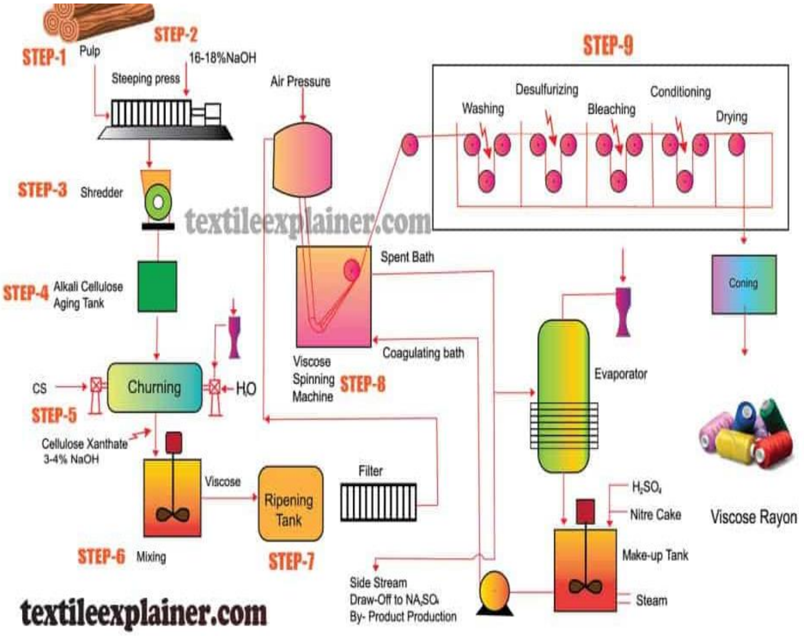

Figure 120: Production process of viscose rayon fibres

Properties of Viscose Rayon Fibres

1. They are absorbent.
2. They do not shrink.
3. They drape well.
4. They are weaker in water.
5. It is damaged by acid.
6. They are soft and comfortable.

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Sample of Viscose Rayon Fabric

Figure 121: Viscose rayon fabric

Acetate Rayon

Acetate rayon is a cellulose regenerated fibre obtained from cotton linters or wood pulp. The manufacturing process of acetate rayon involves the preparation of raw materials, the acetylation process, hydrolysis, the preparation of a dope solution, and spinning.

Raw Material Purification

This process involves cleaning the cotton linters by kier boiling for 4-10 hours with an alkali solution of sodium carbonate ($Na2CO3$) to remove any non-cellulosic materials, followed by bleaching with sodium hypochlorite (NaOCl).

Acetylation process

In this process, the cleaned cotton linters are soaked in acetic acid and acetic anhydride. A small amount of sulfuric acid is added as a catalyst to chemically modify the cellulose by replacing some hydroxyl (-OH) groups with acetyl groups(-$OCOCH_3$) to form a high acetyl content, which is the primary cellulose acetate known as triacetate.

Hydrolysis

This is the secondary acetate stage. At this stage, acetic acid, water, and sulphuric acid are added to the primary acetate (triacetate) and allowed to stand for 10-20 hours. During this period, partial conversion of acetate groups to hydroxyl groups takes place.

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Precipitation

After the hydrolysis process, dilute aqueous acetic acid is added to the acetate to destroy the catalytic sulfuric acid (H_2SO_4) added during the hydrolysis process.

Washing and Drying

During this stage, thorough rinsing of the acetate is done to remove excess acid and impurities, which can cause damage during drying. After washing, the acetate is dried into flakes (solid acetate).

Dope Preparation

In this process, the dried flakes are dissolved in a solvent (acetone) to form a thick, viscous liquid called **dope**.

Spinning

This is the process of forcing the dope through the spinneret into warm air to form the acetate filaments.

Drawing

At this stage, the filaments are stretched to align molecular chains to improve strength and elasticity.

Finishing

This process involves crumpling, cutting into staple fibres, and finishing with lubricants or antistatic agents, depending on their intended use.

Winding or Cutting

Finally, fibres are wound onto spools (for filament use) or cut into staple form for spinning into yarn.

Properties of Acetate Rayon

1. They are not absorbent.
2. They are prone to wrinkling and creasing.
3. They are damaged by heat.
4. They are damaged acids.
5. They drape well.

Sample of Acetate Rayon Fabric

Figure 122: Acetate rayon fabric

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Cuprammonium Rayon

Cuprammonium rayon is a regenerated cellulose fibre obtained from cotton linter or wood pulp, dissolved in a solution of copper salts and ammonia.

Raw Material Purification

Here, mechanical and chemical purifications of the raw material are done. The mechanical purification is done by loosening the cotton bales to remove impurities such as dust, sand particles, and seed residues.

The chemical purification is done by boiling the loosened-up cotton linters in diluted soda ash and caustic soda solution to convert the natural oily matter present in the cotton linters into a soluble substance.

Dissolution

This process makes the insoluble cellulose soluble by dissolving it in Schweitzer solution, made of copper, ammonia, and sodium hydroxide forms a viscous solution known as cuprammonium solution.

Spinning preparation

This process involves mixing cuprammonium cellulose solution with chemical compounds like glycerine, glucose, tartaric acid, citric acid, oxalic acid, and can sugar to make the cuprammonium cellulose solution more suitable for spinning.

Spinning process

In the spinning process, the cuprammonium cellulose solution is passed through a spinneret, which is subsequently pulled and stretched to make it into very fine filaments.

Hardening process

This is the last step of cuprammonium fibre creation. This process involves passing the extruded fibres through sulphuric acid and other baths to harden them.

Drawing & Washing

At this stage, the fibres are stretched (drawn) to align cellulose molecules and improve strength. The fibres are then washed to remove remaining copper and ammonia.

Drying

The cleaned fibres are dried and collected as filament.

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Properties of Cuprammonium Rayon

1. They are fine fibres.
2. They are soft like silk.
3. They burn rapidly.
4. They are not durable.
5. They are cool to wear.
6. They drape well.

Sample of Cuprammonium Rayon Fabric

Figure 123: Cuprammonium Rayon Fabric

Corn Fibre

Corn fibre is a cellulose regenerated fibre derived from the starch of corn. It is also known as polylactic acid (PLA) fibre. Corn fibre is an eco-friendly substitute for synthetic fibres. It is used for producing cloth, geotextiles, and home textiles. The production processes of corn starch fibre are harvesting, raw material purification, fermentation, polymerization, and spinning.

Harvesting

The corns are harvested from the farm. The husks are removed from the corns. The corns are then removed from the cobs. Figure 124 shows the harvesting of the corn.

Figure 124: Harvesting of corn

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Raw Material Purification

After harvesting, the corns are cleaned to remove dust, chaff, and any other impurities. The cleaning is normally done twice. Figure 125 shows the purification of the corn.

Figure 125: Purification of corn

Steeping

After cleaning the corn seeds, steeping is done by soaking the seeds in hot water containing a small amount of sulfur dioxide for 30–48 hours to soften the seeds and release the starch.

Polymerisation

The extracted starch is converted into dextrose (sugar). The sugar is fermented using microorganisms to produce lactic acid. The lactic acid is polymerized to form a polylactide polymer.

Spinning

The polymer is melted and extruded through spinnerets to produce the fine corn fibres. The hot fibres are allowed to cool before being drawn and cut to the required length. The corn starch fibres produced can be crimped, carded, and twisted into yarns. The fibres can also be blended with other textile fibres.

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Properties of Corn Starch Fibre

1. It is a natural flame-retardant fibre.
2. It has strength and provides comfort, softness, and drape.
3. It can be in spun and filament form and in a wide variety of counts.
4. It has moisture management properties and low odour retention.
5. Corn fibre filaments have a subtle lustre.

Sample of Corn Starch Fabric

Figure 126: Corn starch fabric

PRODUCTION OF REGENERATED FIBRES OF ANIMAL OR PROTEIN ORIGIN

Casein Fibre

Casein fibre is a regenerated fibre made from sour or spoiled milk. Sour or spoiled milk is milk that has an acidic taste, either because it has gone bad due to spoilage or because it has been intentionally turned through fermentation by lactic acid bacteria or by adding an acid like lemon juice or vinegar.

Casein Extraction

Casein is the main protein present in milk. Casein extraction is done by adding citric acid to a heated sour milk to separate the whey (liquid byproduct) from the protein used to produce the casein fibres. The heating makes the sour milk solidify. The hardened casein protein is then washed to remove acid, dried, and then ground into powder.

Dissolution, Ripening and Filtration

The grounded powder casein is dissolved in a caustic soda solution and allowed to ripen to achieve a suitable viscosity for spinning. The solution is filtered to remove impurities and degassed to remove air bubbles.

Spinning

The casein solution is pumped through a spinneret into a clotting bath containing a solution made of sulfuric acid, formaldehyde, and glucose, which causes the protein filaments to coagulate and solidify.

Drawing

The filaments are stretched (drawn) to align the protein molecules, which increases their strength and resistance to water.

Finishing

The hardened filaments are thoroughly washed to eradicate any remaining chemicals. They are then dried and mechanically crimped to give them a soft, springy texture similar to wool.

Staple Fibres Production

The crimped filaments are cut into short lengths, called staple fibres, ready for use in textiles

Properties of Casein Fibres

1. They are soft and have a smooth texture.
2. They are highly absorbent.
3. They are durable.
4. They are easily destroyed by acid.
5. They shrink and wrinkle when exposed to heat and moisture.

CHAPTER 6

PRODUCTION OF SYNTHETIC FIBRES

Man-made or artificial fibres are fibres made by man using chemicals. Examples are polyester, nylon, acrylic, olefin, etc.

Polyester

Monomer Formation

The polyester production process begins with reacting ethylene glycol with dimethyl terephthalate at high heat to form a monomer.

Polymer Formation

The monomer is then reacted again with dimethyl terephthalate to create a molten polymer.

Extruding

The molten polymer is extruded into long strips, which are cooled and dried, and then broken apart into small pieces.

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Spinning

The resulting small pieces/chips are then melted again to create a honey-like substance, which is extruded through a spinneret to create polyester fibres.

Finishing

The resulting fibres/filaments are either cut or reacted with other chemicals to achieve the desired type of result.

Properties of Polyester Fibres

1. They are comfortable to wear.
2. They drape well.
3. They are light in weight.
4. They are not absorbent.
5. They attract dirt.
6. They melt away from flame when burning.

Sample of Polyester Fabric

Figure 127: Polyester fabric

Nylon Fibre

Polymerisation

The first stage in nylon production is polymerisation. Polymarisation is the chemical process of joining smaller molecules (monomers) to procedure a larger molecule known as a polymer.

Nylon is manufactured by polymerisation of adipic acid and hexamethylene diamine to form long polymer chains.

The manufacturing process starts with the concentration of the hexamethylene diammonium adipate solution in an evaporator and adding the acetic acid to stabilize the chain length. After evaporation, the salt solution is heated and the remaining water removed. TiO2 dispersion is added and the polymerization takes place.

Solidification and Palletisation

The long polymer chains, which are in a molten state, are solidified. Air or water baths are used to solidify the polymer. The solidified nylon is then cut into pellets or chips, which facilitates handling and transportation.

Spinning

The nylon pellets are melted and extruded through a spinneret to form continuous nylon filaments. The filaments are then cooled and solidified.

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Drawing and Texturing

The nylon filaments are drawn to align the polymer molecules and enhance their strength. This process is followed by heat-setting to lock in the alignment and prevent shrinkage. Depending on the desired properties, the filaments may be textured to add crimp, curl, or other physical modifications.

Properties of Nylon Fibres

1. They are light in weight.
2. They are strong fibres.
3. They dry quickly.
4. They dye well.
5. They are cheap to buy.
6. They are damaged by heat.

Sample of Nylon Fabric

Figure 128: Nylon fabric

Acrylic Fibre

Polymerization

The first step in acrylic fibre manufacturing is the polymerisation of the acrylonitrile. Acrylonitrile is the primary monomer used in the production of acrylic fibre. Other monomers, often referred to as co-monomers, such as vinyl acetate and methyl acrylate, are also used in smaller quantities to modify the properties of the acrylic fibre.

For instance, vinyl acetate is often combined with acrylonitrile, a co-monomer to improve the acrylic fibre dyeability, while methyl acrylate is combined with acrylonitrile to improve the fibres softness and flexibility.

The polymarisation process typically involves heating the reactants in a reaction vessel under specific conditions of temperature, pressure, and time. The resulting polymer is a viscous liquid that can be further processed to create fibres.

Filtration

After the polymerization, the mixture is filtered to eliminate any impurities or unreacted chemicals. This step is critical to ensure the purity and quality of the final product, as any impurities or contaminants can affect the performance and properties of the acrylic fibres.

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Spinning

After filtration, the polymer is spun into fibres. The spinning is done by melting and extruding the polymer through a spinneret, which is a metal plate with many small holes, creating long, thin strands of acrylic fibre.

Drawing/Heat

Here, the spun fibres are then stretched or drawn to align the polymer chains and increase the strength and durability of the fibres. Drawing can be done either by mechanical means, such as using rollers or pulling devices, or by heating the fibres to a specific temperature and then stretching them. The heat also sets the fibres, locking in the molecular structure.

Crimping

The drawn fibres are then crimped to create a more natural, fluffy texture. Crimping is done by adding a twist to the fibres, which creates a series of waves or curls. This step gives the acrylic fibres a more voluminous and comfortable feel, making them ideal for use in clothing and other textiles.

Cutting

Finally, the crimped fibres are cut to the desired length, typically ranging from a few millimeters to several centimeters. The length of the fibres determines their end use, with longer fibres used for heavier textiles and shorter fibres used for lighter fabrics.

Olefin Fibre

Olefin fibre is produced by polymerization of monomers like ethylene and propylene into long chains of polymers.

Spinning

The olefin spinning is done by melting and extruding the polymer through a spinneret to produce long, thin strands of olefin fibres.

Drawing/Heat

At the drawing frame, the spun fibres are stretched or drawn to align the polymer chains and increase the strength and durability of the fibres.

Texturing

The stretched or drawn olefin filament is textured by crimping or curling it to make it bulk and improve its aesthetic and tactile characteristics.

Properties of Olefin Fibres

1. Olefin Fibres are strong.
2. They are elastic.
3. They are not absorbent.
4. Olefin fibres burn slowly and give off a waxy smoke.
5. They are damaged by heat.
6. Olefin fibres are highly resistant to alkaline.

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Sample of Olefin Fabric

Figure 129: Olefin fabric

CHAPTER 7

TEXTILE FIBRES AND FABRICS IDENTIFICATION TEST

The fibre identification test is a very important component since it plays a key role in quality control. This test is intended to identify the type of fibres used in producing a textile product. Identification of fibres or fabrics helps to determine the quality, durability, and suitability for specific uses. Understanding the basics of fibre and fabric identification tests is important for manufacturers, retailers, and consumers, as it provides valuable insights into the quality of the products they deal with.

There are many methods used for the identification of textile fibres. These include microscopic test, chemical test, and physical test, such as burning test, moisture regain test, feeling test, shrinkage test, etc.

Table 1: Microscopic Test

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Fibre	**Longitudinal view**	**Cross-sectional view**
Cotton	It appears as a flat tube with spiral twists or a twisted ribbon.	Kidney or bean-shaped, elliptical, very thin like a strip, nearly round or circular.
kapok	Smooth, cylindrical surfaces,	Wide open lumen with thin walls of about 2.5 m.
Flax	Smooth and Bamboo like with cross marking nodes, no lengthwise striations, narrow lumen.	Sharp polygonal shape with straight sides. Immature oval shape with a large lumen.
Jute	Cylindrical with uneven in diameter, a lumen is broad and varies greatly	Rounded polygonal with a central lumen
Kenaf	Long, cylindrical structures with visible cell lumens.	
Ramie	Irregular and broad	Oblong

Fibre	Longitudinal view	Cross-sectional view
	with cross marks Irregularly distributed, a conclusion may appear.	
Wool	Cylindrical, irregular, rough surface, scale-like structure, dark Medulla may appear on coarse wool fibres	Nearly round or circular, the medulla may appear
Silk	Smooth surface, Structureless, triangular-shaped transparent rod (Wild silk/Tussah silk – broader fibre with fine, longitudinal lines passing across filament).	Triangular shape with rounded corners (Tussah silk flat wedge or spindle-shaped

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Fibre	Longitudinal view	Cross-sectional view
Asbestos	Long and thin bundles.	Irregular, showing various "saw shapes".
Fibre glass	Smooth, transparent, and rod-like structures.	Round but sometimes elliptical, peanut, or oval, depending on the spinneret used during manufacturing.
Viscose rayon	Normal type has fairly dense longitudinal striations or fine lines. A special type may be smooth and structureless.	Irregular with a serrated outline, oval or round
Acetate rayon	Uniform in width with a few distinct longitudinal striations	Irregular with a serrated outline
Cuprammonium rayon	Smooth, uniform, and unmarked filaments, lacking the patterns.	Typically, round and smooth.

Fibre	Longitudinal view	Cross-sectional view
Casein fibre	Smooth, uniform, and sometimes with faint patterns and coarse surface.	Circular, but sometimes appears kidney or bean-shaped
Ardil fibre	Smooth, transparent, and somewhat cylindrical with patterns.	Circular
Polyester	Structureless, uniform diameter, rod-like appearance	Circular
Nylon	Structureless, uniform diameter, rod-like appearance	Circular
Acrylic	Smooth surface, uniform diameter, rod-like appearance, some types with irregularly spaced striations	Rounded or dumbbell-shaped

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Chemical Test

This test is carried out to determine the effects of chemicals such as acids, bases, oxidizing agents, reducing agents, and biological agents like molds and mildews on the fibres.

Table 2: Chemical test of textile fibres

Fibre	Acid	Alkaline
Cotton	Damaged by acid	Resistant to alkaline
kapok	Damaged by acid	Resistant to alkaline
Flax	Damaged by acid	Resistant to alkaline
Jute	Damaged by acid	Resistant to alkaline
Kenaf	Damaged by acid	Resistant to alkaline
Ramie	Damaged by acid	Resistant to alkaline
Wool	Damaged by alkaline	Resistant to acid
Silk		Resistant to acid

Fibre	Acid	Alkaline
Asbestos	Damaged by phosphoric and hydrochloric acids	Resistant to weak acids and weak alkalis
Fibre glass	Damaged by phosphoric, hydrochloric acids, and strong alkali metal hydroxides	Resistant to weak acids and weak alkalis.
Viscose rayon	Damaged by acid	Resistant to weak alkaline
Acetate rayon	Damaged by acid	Resistant to weak alkaline
Cuprammonium rayon	Damaged by acid	Resistant to weak alkaline
Casein fibre	Damaged by alkaline	Resistant to acid
Ardil fibre	Damaged by alkaline	Resistant to acid

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Table 3: Burning Test of Textile Fibres

Fibre	Approaching flame	In flame	Removed from flame	Odor	Ash
Grey cotton	Ignites quickly	Burns quickly; yellow flame	Continues to burn rapidly; has afterglow	Burning paper	Light and gray ash.
Mercerised cotton	Ignites quickly	Burns quickly; yellow flame	Continues to burn rapidly; has afterglow	Smells like bad fish	Black and skeletal
kapok	Ignites slowly	Burns slowly without a flame	It continues to burn	Burning paper	Soft powder ash similar to burning paper
Flax	Ignites quickly	Burns quickly with a yellow flame	Continues to burn	Burning paper	Light and gray ash

Fibre	Approaching flame	In flame	Removed from flame	Odor	Ash
Jute	Ignites quickly	Burns quickly with a yellow flame	Continues to burn	Wood/leaf	Light gray ashes
Kenaf	Ignites quickly	Burns quickly with a yellow flame	Continues to burn	Burning paper	light gray ashes that crumble to dust when touched
Ramie	Ignites quickly	Burns quickly with a yellow flame	Continues to burn	Burning paper	A soft, feathery, gray ash.

Wool	Burns and curls away from flame; ignites slowly	Burns slowly with small flickering flames; sizzles and curls	Ceases to flame	Burning hair; stronger odor than silk	Crisp, dark ash; round, irregular bead; easy to crush
Silk	Burns and curls away from flame	Burns slowly; sputters	Burns with difficulty; ceases to flame	Burning hair	Round, shiny black bead; easy to crush
Viscose rayon	Ignites quickly	Burns more quickly than cotton; bright yellow flame	Continues to burn rapidly; has no afterglow	Burning paper	Light and feathery gray ash

Acetate rayon	Fuses away from flame; turns black	Blazes and burns quickly; sputters, melts, and drips like burning tar	Continues to melt and burn	Vinegar	Hard, black ash; irregular bead; difficult to crush
Cuprammonium rayon	Ignites quickly	Burns with a steady, yellow flame	Continues to burn rapidly.	Burning paper/ wood	A fine, easily crushed, light gray, "feathery" ash
Casein fibre	Ignites slowly	Burns slowly	Burns with difficulty.	Burning hair or feathers.	Brittle, hard, dark ash that crumbles easily when touched.

Ardil fibre	Ignites slowly	Burns slowly	Burns with difficulty.	Burning hair	A black, brittle ash that turns to dust or crumbles easily.
Polyester	Fuses and shrinks away from flame	Melts and burns slowly	Burns with difficulty	Chemical	Round, hard, black bead; won't crush.
Nylon	Fuses (melts without burning) and shrinks away from flame	Melts, then burns slowly	Flame ceases and dies out	Celery	Round, hard, grayish bead; won't crush
Acrylic	Fuses and shrinks away from flame	Flames rapidly; sputters and melts	Continues to melt and burn	Chemical	Irregular, hard, black bead; won't crush

Why is Fibre or Fabric Identification Test Necessary

Quality Control

Fibre or fabric identification test helps to verify that fabrics are made from the intended fibres and identify any defects or impurities.

Conservation and Preservation

Fibre or fabric identification test helps in selecting appropriate cleaning and storage methods in order to prevent damage to the fabric.

Care Instructions

Identification of fibres or fabrics helps to know the selection of appropriate care instructions, such as ironing settings and washability of the fabrics.

Forensic Science

Fibre or fabric identification test helps in linking suspects to a crime scene by matching fibre evidence found at the crime scene with fibres found on a suspect.

Garment Construction

Fabric properties such as drape, stretch, and weight affect how a garment will drape and fit the figure. Identification of the fibre or fabric allows fashion designers to select suitable needles, stitching, and construction techniques.

CHAPTER 8

TEXTILE YARNS

Textile Yarns

A textile yarn is a continuous strand of short or long fibres arranged in a form appropriate for weaving, knitting, knotting, and other forms of fabric construction. Traditionally, yarns can be made from fibres of limited length known as staple fibres. The stable fibres are short. All the natural fibres are stable fibres except silk. Filament fibres are long, continuous fibres. All the man-made fibres are filament fibres. Yarns made from filament fibres tend to be smoother, more lustrous, more uniform, harsher, and less absorbent.

Yarns play an important role in the fabric construction process since the majority of textile products, such as sewing and embroidery thread, string, and rope, are constructed with yarns. Yarns are produced in various sizes and textures, and also vary in other characteristics. Performance, end use, and fabric care are affected by these yarn characteristics.

Types of Textile Yarn

We have types of yarn. These are staple or spun, and filament yarns.

Spun or Staple Yarns

Spun yarns are made of short fibres or filament fibres that have been cut into short fibres. Spun yarns may contain fibres of the same type or a blend of different fibres. The spinning method used to produce the yarn affects properties such as uniformity and strength. Finer, smoother, better quality cotton yarns, known as combed cotton yarns, are produced by combing the fibres before spinning. A similar process is used to manufacture fine-quality worsted wool yarns. Figure 130 shows the examples of spun yarns.

Figure 130: Spun yarns

Filament yarns

These are yarns made from long, continuous man-made fibres extruded through the spinneret. These yarns can be broadly divided into:

1. **Monofilament:** yarn made from a single, relatively thicker filament fibre. Transparent sewing thread, metallic yarns, bare elastic, and fishing lines are examples of monofilament yarns.
2. **Multifilament:** yarn made from multiple filament fibres. Continuous filament fibre length requires little or no twisting to hold the multifilament yarn together. Some filament yarns are produced by slitting or splitting yarns sheet or film of metallic-coated or polymer yarns. Some examples are: Metallic-coated yarn made by slitting a metallic foil laminated between plastic films. Tape yarns are made by slitting or splitting polymer films. Olefin is the most commonly used fibre for tape yarns. Figure 131 shows the examples of filament yarns.

Figure 131: Filament yarns

Classification of Yarns

Generally, we have three categories of yarns. These are simple yarns, novelty yarns, and textured yarns.

Simple yarns

Simple yarns are characterised by uniform size and a regular surface. Examples of single yarns are single, ply, cord, and rope yarns.

i. **Single yarn:** is the simplest type of yarn. It is commonly produced by twisting together staple or filament fibres. Figure 132 shows an example of a single yarn.

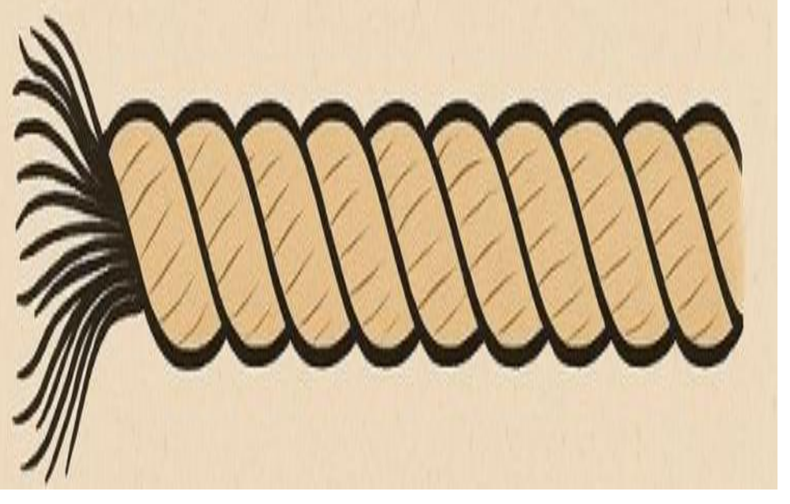

Figure 132: Single yarn

ii. **Ply yarns:** they are produced by twisting two or more single yarns. Each strand of single yarn is referred to as a ply. Thus, four single yarns twisted together would form a four-ply yarn. Figure 133 shows an example of a ply yarn.

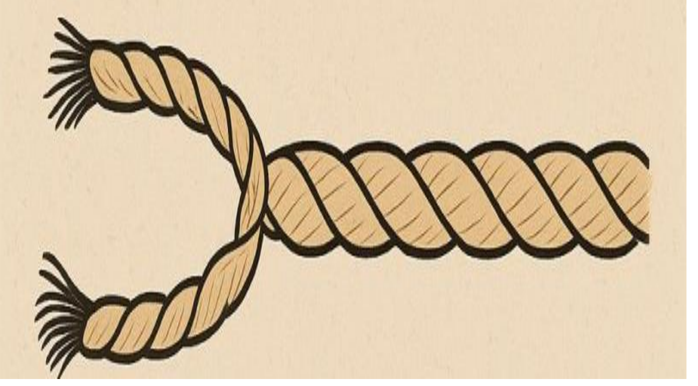

Figure 133: A ply Yarn

iii. **Cord yarns:** they are produced by twisting two or more ply yarns. Figure 134 shows an example of a cord yarn.

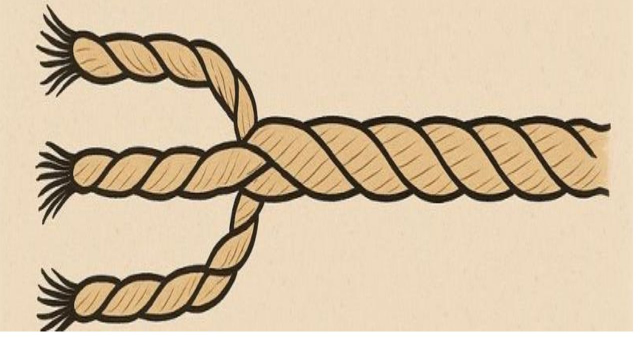

Figure 134: Cord yarn

iv. **Rope yarns:** they are produced by twisting two or more cord yarns. Figure 135 shows an example of a rope yarn.

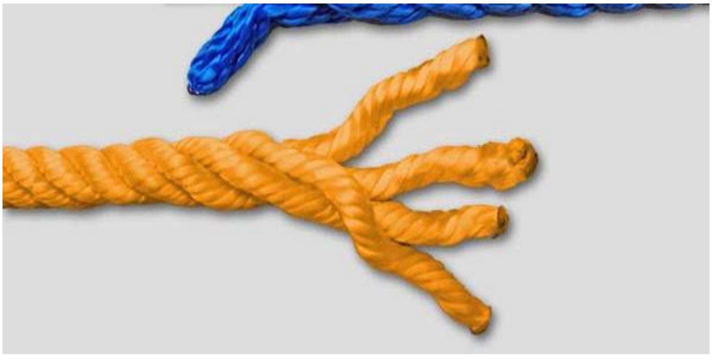

Figure 135: Rope yarn

Novelty Yarns

Novelty yarns, typically made of two or more stands, are produced to provide decorative surface effects. Based on the purpose, each strand is referred to as base/core, effect, or binder. - The base/core strand provides the structure and strength. - The effect strand creates decorative detail such as knots and loops. -The binder is used to tie the effect yarn to the base yarn if binding is necessary. There is a wide variety of novelty yarns that are produced using different techniques and types of fibres and strands.

Types of Novelty Yarns

- **Slub yarns:** They can be either single or ply yarns. These yarns are characterized by the soft, bulky area that is spun at regular or irregular intervals.

- **Flock/flake yarns:** These yarns have small tufts of different coloured fibres added at intervals. These tufts can be easily pulled out. Flock/flake yarns are generally single yarns.
- **Nub, knot, and spot yarns:** They are ply yarns in which the effect yarn is twisted around the base yarn to produce a thicker area or a bump.
- **Bouclé and loop yarns:** They are ply yarns that use three sets of yarns: base or core yarn, effect yarn, and tie yarn. The effect yarn is looped around the base or core yarn and tied with a binder yarn.
- **Spiral and corkscrew yarns**: They are ply yarns in which one ply is soft and thick, and the other is fine.
- **Chenille yarns**: They are pile yarns that are often made by slitting leno weave fabrics into narrow strips in the warp direction.

Textured yarns

Textured yarns are made of fully drawn filament fibres with a changed surface, shape, and texture developed by using the new spinning techniques. Nylon and polyester are two main fibres that are textured. Textured yarns provide many variations in fabric properties. There are two main types of textured yarns. These are stretch yarns and bulk yarns.

Stretch yarns

Stretch yarns are frequently continuous-filament synthetic yarns that are very tightly twisted, heat-set, and then untwisted, producing a spiral crimp giving an elastic character. Although bulk is imparted in the process, a very high amount of twist is required to produce a yarn that has not only bulk, but also stretch.

Bulk yarns

They are synthetic staple-fibre yarns containing a proportion of stretched fibre that will contract and crimp during wet finishing. They are used in knitted and woven fabrics for a full, well-covered appear

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