Chapter - 3

TEXTILE - FIBRE TO FABRIC PROCESSING

1. INTRODUCTION:

Textile industry is one of the few basic industries that have always been a necessary component of human life. One may classify it as a more glamorous industry, but whatever it is, it provides with the basic requirement called clothes. This chapter is about textiles. The researcher has given in this chapter all possible terms and concepts involved in textile production process. Most of these terms are technical. This chapter is an attempt to understand clear cut ideas about research topic. It gives an insight about terms that are used all around the world in context of textile industry. There are numerous kinds of fibres and other raw materials, which are used to produce a cloth. But most of them are unheard of. This chapter is designed in such a way that it is easy to understand the basics of textiles.

In any study of textile fabrics the meaning of the word textile must be made clear. The dictionary states that the word is derived from the Latin word 'texere' [1] to weave, but a wider meaning than simply that of weaving must be accepted since that is only one of various ways of making textile fabrics.

2. STAGES OF TEXTILE MANUFACTURING:

The initial stage of textile manufacturing involves the production of the raw material either by farmers who raise cotton, sheep, silkworms, or flax or by chemists who produce fibre from various basic substances by chemical processes. The fibre is spun into yarn, which is then converted into fabric in a weaving or knitting mill. After dyeing and finishing, the woven material is ready for delivery either directly to manufacturer of textile products where they are finally stitched into clothes that we wear. The flow diagram of the fibre to fabric process is given below.
3. **FLOW DIAGRAM OF FIBRE TO FABRIC PROCESS:**

Polymers are the resource for man-made fibers. Polymers are derived mostly from oil. Plant fibers and animal fibers constitute the natural fibers. After the fabric is formed, it is generally subjected to finishing and/or dyeing process, in which the raw fabric properties are modified for the end use.

4. **METHODS OF FABRIC FORMING:**

The most commonly used fabric forming methods are weaving, braiding, knitting, felting, tufting and nonwoven manufacturing. However, major method of fabric construction is weaving. Some of terms and definitions are given below.

4.1 **Weaving:**

Weaving is the interlacing of warp and filling yarns perpendicular to each other. There are practically an endless number of ways of interlacing warp and filling yarns. Each different way results in a different fabric structure. Approximately 70% of the fabrics made in the world are woven fabrics.
4.2 Braiding:
Braiding is probably the simplest way of fabric formation. A braided fabric is formed by diagonal interlacing of yarns. Although there are two sets of yarns involved in the process, these are not called warps and fillings as in the case of woven fabrics. Each set of yarns moves in an opposite direction. Braiding does not require shedding, filling insertion, and beat up.

4.3 Knitting:
Knitting is interlooping of one yarn system into vertical columns and horizontal rows of loops called wales and courses, respectively. There are two main types of knitting: weft knitting and warp knitting.

4.4 Weft Knitting:
In weft knitting, the yarns flow along the horizontal direction in the structure (filling or course direction).
4.5 **Warp Knitting:**

In warp knitting, they flow along the vertical direction (warp or wale direction).

Special needles are used to form the yarn loops. The basis of knit fabric structure is the continuing intersection of loops. Knit fabrics are widely used in apparel and home furnishings. They are also used in technical textiles, such as artificial arteries, bandages, casts, composites, sporting equipment, etc.

4.6 **Tufting:**

Tufting is the process of manufacturing some carpets and similar structures. A surface yarn system of loops is "sewn" or "stitched" through a primary backing fabric, usually a woven or nonwoven fabric. The loops are arranged in vertical columns (rows) and horizontal lines (stitches). Loops can be in the form of cut or uncut loops (piles) or a combination of thereof. The fabric is usually back-coated in a later process to secure tufted loops.
4.7 **Bonding:**

Bonding is the method of manufacturing nonwovens using textile, paper, extrusion, or some combination of these technologies, to form and bond polymers, fibers, filaments, yarns or combination sheets into a flexible, porous structure. In fact, some nonwoven products are claimed by both the textile industry and paper industry.

**Fibre:** A Unit of matter characterized by Flexibility, Fineness and a High Length to Width Ratio [3].

5. **FIBRES:**

Fibres are the basic raw material for any textile industry. Technically a fibre is defined as a Unit of matter characterized by flexibility, fineness and a high length to width ratio. The textile industry uses many different kinds of fibres as its raw materials. Some of these fibres were known and used in earlier years of civilization.
as well as even today, while some other fibres have acquired importance in recent years. The factors affecting the development and utilization of these fibres include their ability to be spun, their availability in sufficient quantity, the cost or economy of production and their desirability of their properties to consumers.

The detailed classification of fibres is as given below.

**CLASSIFICATION OF FIBRES**[^4]

**FIBRE TYPE**

- **ORGANICS**
  - **NATURAL**
    - *VEGETABLE* (Cellulosic)
      - e.g. Cotton (Seed hair), Flax (bast), Hemp (bast), Ramie (bast), Sisal (leaf), Coir (coconut)
    - *PROTEIN* (Animal)
      - e.g. Wool (Seed hair), Silk, Angora, Mohair, Camel
  - **MANUFACTURED**

- **INORGANICS**
  - **NATURAL**
    - e.g. Asbestos
  - **MANUFACTURED**
    - e.g. Glass

**NATURAL POLYMER**
- e.g. Viscose Rayon, Cuprammonium Rayon, Cellulose acetate, Cellulose diacetate, Polynosic Rayon, Casein.

**MAN-MADE POLYMER**
- e.g. Nylon, Polyester, Polypropylene, Polyethylene, Acrylic, Kevlar, Nomex.
6. **FORMATION OF YARN:**

Primitive people discovered that a succession of short fibers could be twisted into a continuous yarn. This was probably accomplished slowly and laboriously at first, but the greater strength thus produced and the many uses soon found for articles made from continuous yarns led to the invention of hand implements to aid and improve the process of twisting and spinning. Many such implements and methods are still used by people in various underdeveloped parts of the world as well as by persons interested in reviving artistic handicraft. At the same time, it was necessary to invent simple methods of disentangling, separating, and arranging the fibres according to their length, other than by just using the fingers. Thus, crude methods of carding were invented to separate the fibres according to their length of staple. Eventually, techniques were refined. In time, long filament strands unwounded from silk cocoons, and still later, filaments formed by chemical synthesis were made into yarns. Now yarns are also made by integrating the staple and filament fibres.

6.1 **Yarn Types:** [5]

A textile yarn is an assembly of substantial length and relatively small cross section of fibres and or filaments with or without twist.

**CLASSIFICATION OF YARNS** [6]

<table>
<thead>
<tr>
<th>Group</th>
<th>Sub Group</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Continuous</td>
<td>Flat CFY</td>
<td>Tape</td>
</tr>
<tr>
<td>Filament Yarns (CFY)</td>
<td>(untextured)</td>
<td>Twisted.</td>
</tr>
<tr>
<td>Textured yarns</td>
<td></td>
<td>False Twisted</td>
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<td></td>
<td></td>
<td>Stuffer Box</td>
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<td></td>
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<td>Air Jet.</td>
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<td>2) Staple Spun Yarns</td>
<td></td>
<td>Carded Ring Yarn</td>
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<td></td>
<td></td>
<td>Combed Ring Yarn</td>
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<tr>
<td></td>
<td></td>
<td>Worsted</td>
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<tr>
<td></td>
<td></td>
<td>Woolen</td>
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<tr>
<td></td>
<td></td>
<td>Rotor Spun</td>
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<tr>
<td></td>
<td></td>
<td>Compact Ring Yarn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air-Jet Spun, Friction Spun.</td>
</tr>
</tbody>
</table>
6.2 **Continuous Filament Yarns:**

Filament yarns are basically unbroken lengths of filaments, which include natural silk and filaments extruded from synthetic polymers (e.g. Polyester, Nylon) and from modified natural polymers (e.g. viscose rayon). Such a continuous filaments are twisted to produce a continuous filament yarn. Continuous Filament Yarn can be subdivided into untextured or flat continuous filament and textured continuous filament.

(a) Flat continuous filament yarns:

Man-Made continuous filament yarns may be produced in either

Mono Filaments: Yarns with one filament

Multi Filaments: Those with more than one filament standard filament yarns are known as flat filament yarns.

(b) Continuous filament textured yarns:

There are man-made continuous filament yarns that have been modified by subsequent processing to introduce durable crimps, coils, loops or other distortions into the filaments.

6.3 **Staple Spun Yarns:**

A staple spun yarn is a linear assembly of fibres, held together, usually by the insertion of twist, to form a continuous stand, small in cross section but of any specified length.
6.4 Combed Ring Yarn: [9]

COTTON HARVESTING [Large Containers]

[Containers] GINNING [Bales]

[Bales] BLOW ROOM [Laps Or Tufts]
[Mixing, Blending, Opening, Cleaning, Dedusting]

CARDING [Sliver]

Breaker DRAW FRAME [Sliver]

[Sliver] UNILAP [Lap]

[Lap] COMBING [Sliver]

[Sliver] Finisher DRAW FRAME [Sliver]

[Sliver] SPEED FRAME [Roving]

[Roving] RING FRAME [Yarns in Bobbin]

[Yarns in Bobbin] WINDING [Cones/Cheeses]
6.5 Carded Ring Yarn: [10]

COTTON HARVESTING

GINNING

BLOWROOM
[Mixing, Blending, Opening, Cleaning, Dedusting]

CARDING

DRAWING

DRAWING

SPEED FRAME

RING FRAME

WINDING
6.6 Rotor Yarn: \[^{11}\]

- COTTON HARVESTING
- GINNING
- BLOWROOM
  - [Laps Or Tufts]
  - [Mixing, Blending, Opening, Cleaning, Deducting]
- CARDING [Sliver]
- DRAWING [Sliver]
- DRAWING [Sliver]
- [Sliver] ROTOR M/C. [Yarn but in Cones]
7. **WORSTED AND WOOLEN PREPARATION:**

These are the processes to produce the worsted and woolen yarns from the wool.

```
SHEARING

GRADING AND SORTING

WASHING AND SCOURING

CARBONIZING

WORSTED

PREPARING

BLACK WASHING

GILLING

COMBING

DRAWING

CARDING

COMBING

SPINNING, WINDING.

WOOLEN

WILLOWING

BLENDING

OILING

TEASING

CARDING

SPINNING

WINDING.
```

7.1 **Woolen Vs Worsted Yarns:**

Apparel fabrics are woven from two types of yarn-woolen and worsted and each is made from a different type of wool.

i) **Woolen yarns:** (carded)

Woolen yarns are made from shorter fibers of 1 to 3 inches, which sticks out in all directions, giving the yarn its characteristic fuzziness. They are almost always singles, yarns and are thicker and more loosely twisted than worsted yarns. Fabrics made from woolen yarns are warm and fuzzy, such as flannels, tweeds and meltons and are usually associated with fall and winter garments.
ii) **Worsted yarns**: (combed & carded)

Worsted yarns are made from longer fibers of 3 - 6 inches, which are combed, to lie parallel to each other, producing a smooth, clean look. They are usually ply (double) yarns, and are finer and more tightly twisted than woolen yarns. Fabrics made from worsted yarn are smooth, such as gabardines, crepes, tropicals and suitings, and can be worn comfortably in moderately warm weather and climates.

### 8. COMBED RING YARN: [14]

**Harvesting:**

Cotton is one of the oldest fibres known to man. The cotton fibres belong to the botanical genus "Gossypium". Cotton is a cellulose fibre is a seed hair. The flower appears in cotton plant. This lasts only for a day or so. After disappearance of the flower, the seeds become gradually surrounded by a soft fibrous substance. By this time flower pod appears and it grows to the full size. In between this time, the fibre growth is continuous until they mature. The enlargement of the seeds cause the pod to burst and a ball of whitish fibre is brought to light.

**Ginning:**

Harvested cotton is accumulated in large containers, which are sent to a gin for cleaning. In ginning, reeds, twigs, seeds, leaves and other foreign objects (trash) are removed mechanically from the cotton fibre. The cleaned cotton is then compressed into standard weight bales [170 kg] wrapped, and labeled ready for dispatch.

**Blowroom:** [15]

The blowroom contributes only about 5 - 10% to the production cost.

**Objects of Blowroom:**

1. OPENING
2. CLEANING
3. DUST REMOVAL
4. BLENDING
5. MIXING
6. UNIFORM FEED TO THE CARD.
**TRUTZCHLER: [Blowroom line]**

1. Automatic Bale Opener (BO-A)
   - Multi-Function Separator (SP-MF)
   - Integrated Mixer (MXI-6)
   - CLEANOMAT CLEANER (CL-C4)
   - Foreign Part Separation (SP-F)

**RIETER: [Blowroom unit line]**

- UNIFLOC (A11)
  - UNICLEANC (B11)
  - UNIMIX (B70)
  - UNIFLEX (B60)

**Opening:**
Opening is the first operation required carried out to the stage of flocks in the blowroom and to the stage of individual fibres in the card.

Opening to flocks in the blowing room.

* Opening Out: In which the volume of the flock is increased while the no. of fibres remains constant i.e. specific density of the material is reduced.
* Breaking Apart: In which two or more flocks are formed from one flock without changing the specific density.

**Cleaning:**
The blowroom cannot eliminate all, or even almost all of the foreign matter in the raw material. A blowroom installation removes 40% - 70% of the impurities.

\[
CE\% = \frac{WT_1 - WT_2}{WT_1} \times 100 \quad [13]
\]
CE% = Cleaning Efficiency.

WT₁ = Weight of Trash in Raw Fiber (%)

WT₂ = Weight of Trash in Processed Fibre (%).

(3) Dust Removal:
Almost all manufactures of blowroom machinery are equipped with dust removing attachment in addition to opening and cleaning.

(4) Blending:
Blending of fibre material is an essential preliminary in the production of yarn.

(5) Even feed of material to the cards:
Finally, the blowroom must ensure that raw material is evenly delivered to the cards.

Previously, it was carried out by means of laps from the scutcher. (Lapping M/c.)

But now, automatic flock feeding installations are increasingly being used.

Carding:[16]

Two Proverbs:
(a) The card is the heart of Spinning.
(b) Well Carded is half spun.

Objects:
(1) Opening to individual fibres.
(2) Elimination of Impurities.
(3) Elimination of Dust.
(4) Disentangling of Nepes.
(5) Elimination of short fibre.
(6) Fibre Orientation.
(7) Sliver Formation.

Machinery Manufacturers:

TRUTZSCHLER CARD RIETER CARD
(TC03) (C60)

Production upto 150 kg./hr.
(1) Opening to individual fibre:
Whereas the blowroom only opens the raw material to flocks, the card must open to the stage of individual fibres. Thus is essential to enable elimination of impurities.

(2) Elimination of Impurities:
Elimination of foreign matter occurs mainly in the region of the taker in. The degree of cleaning achieved by modern card is very high in the range of 85 - 95%.

(3) Elimination of Dust:
The card also removes a large proportion of the micro particles that are bound to fibres. Significant Fibre/Metal or Fibre/Fibre friction is needed in order to loosen such particles.

(4) Disentanglements of Neps: (Neps are small entanglements or knots of fibre):
While the number of neps increases from Machine to Machine in the blowroom, the card reduces the remaining number to a small fraction. Neps are mostly opened out in carding.

Production Formulae:
\[
\text{Delivered Speed (m/min) } \times 60 \times 8 \times 1.0937 \times (\text{Efficiency}) \% = \frac{\text{840 } \times \text{ Hank of Sliver } \times 2.204}{\text{Kg / Shift / M/c.}}
\]
\[
\text{Kg = Kilogram, Shift = 8 Hours, M/c = Machine.}
\]

\[
\frac{(\text{m/min}) \times (\text{m /hr}) \times \text{m / shift} \times \text{yd / shift}}{840 \times \text{Hank of sliver} \times 2.204}
\]
\[
\text{HK / Shift, lb / Shift x Kg / Shift.}
\]
HK = Hank, lb = Pound, Kg = Kilogram, Shift = 8 Hours, m/min = Metre Per Minute.
yd / shift = Yard per Shift, m/hr = Metre Per Hour, m/shift = Metre Per Shift.
Disadvantages of Carding:

1) Formation of hooks:
   - 50% Trailing hook
   - 15% Leading hook
   - 18% Double hook
   - 20% of the fibres have no hooks.

2) Fibre Arrangement in Card Sliver is Criss Cross

Breaker Drawframe:

Objects:

(i) To straighten out the fibres and improve the fibre extent.
(ii) To parallelize them to their neighbours and to the sliver axis so that in the final stage of spinning they can contribute maximum towards yarn strength.
(iii) To improve the uniformity and evenness so that the final slivers produced becomes more regular by doubling.

Machinery Manufacturers:

TRUTZSCHLER (DRAW FRAME)  RIETER (DRAW FRAME)
TD(03)  RSB-D-30
L DO/6

Production Speed upto 1000 m/min.

Production Formulae:

Delivered Speed (m/min) x 60 x 8 x 1.0937 x (Eff.) %
=  

840 x Hank of Sliver x 2.204

Unilap:\[17\]

Objects:

(i) No. of card sliver put side by side to form a lap.
(ii) Small amount of draft to straighten and parallelize to reduce entanglement in it.
(iii) To form compact uniform lap which unroll easily on comber.
Machinery Manufacturers:

RIETER:

**E32** → Production 350 kg/hr.

- Lap Weight = 25 kg.
- Lap Width = 300 mm.
- Lap Dia = 650 mm.
- Delivery Speed = 70 - 120 m/min.

**Production Formulae:**

\[
\text{Delivered Speed (m/min)} \times 60 \times 8 \times 1.0937 \times (\text{Efficiency} \%) \times \frac{840 \times \text{Hank of Lap} \times 2.204}{1000 
\]

**Comber:**

**Objects:**

(i) To remove fibers which are shorter than predetermined lengths.

(ii) To remove neps and microdust.

(iii) To improve general appearance.

Machinery Manufacturers:

RIETER:

**E65** → 66 KG/HR.

**Production Formulae:**

\[
\frac{\text{Nips/minute} \times \text{Amount of (mm) Feed} \times (100 - \text{noil} \%) \times \text{Batt Wt. (gm./mtr.)} \times 60 \times 1.094 \times (\text{Efficiency}\%)}{100} \times \text{No.of Heads} \times 1000 \times 1000 
\]

noil % = Waste, gm./mtr = Gram Per Metre,

**Finisher Drawframe:**

**Objects:**

(i) Improve irregularity by doubling no. of slivers.

(ii) To parallelize the fibres criss crossed, with one another and align them to the sliver axis.
Machinery Manufacturers:
RIETER:
RSB D-30 → 400 m/min.

Production Formulae:

\[
\text{Delivered Speed (m/min) \times 60 \times 8 \times 1.094 \times (\text{Eff.}) \%} = \frac{840 \times \text{Hank of Slivers} \times 2.204}{\text{Kg./Shift.}}
\]

Speed Frame or Roving Frame or Intermediate Frame: \[\text{[20]}\]

Objects:

(i) To reduce thickness of draw frame sliver to form fine fibrous strand of material known as roving by drafting [DRAFTING].

(ii) To insert certain amount of twist into roving in order to bind parallelized fibre together. It gives strength to roving [TWISTING].

(iii) To wind delivered roving into bobbin [WINDING].

Machinery Manufacturers:
RIETER → F11

Max. Flyer Speed = 1500 rpm.
Or
Max. Spindle Delivery = 50 m/min.

Production:

\[
\text{Kg./Spindle/Shift.} = \frac{\text{Spindle Speed (rpm)} \times 60 \times 8 \times (\eta\%) \times 36 \times 840 \times 2.204 \times \text{Count}}{\text{Twist Per Inch}}
\]

Ring Frame: \[\text{[21]}\]

Objects:

(i) To draw the roving to the desired degree of fineness [DRAFTING].

(ii) To impart sufficient twist to emerging strand of fibres and from a continuous yarn [TWISTING].

(iii) To wind up the spun yarn onto convenient package [WINDING].
Machinery Manufacturers:
RIETER → G33
    Spindle Speed  =  25000 [Max.]
    No. of Spindles = 1000.

Production:
    Spindle Speed (rpm) 60 x 8 x \( \eta \% \times 1000 \)
    \[ \frac{\text{gm./Spindle/Shift}}{= \frac{\text{Spindle Speed}}{x}} \times \text{gm./Spindle/Shift} \]
    Twist Per Inch 36 x 840 x Count x 2.204

Winding:
Objects:
(i) To form a uniform package that contains sufficient long length (km) of yarn. [CONE OR CHEESE].
(ii) To remove objectionable faults like slub, knot, snarl etc., of improve yarn quality.

Machinery Manufacturers:
SCHALOFHORST → AUTOCORO 238
                      AUTOCORO 338
    Delivery Speed = 1400 m/min.

Production Formulae:
    Delivered Speed (metre per minute) x 60 x 8 x (Efficiency) \% \times 1.094
    \[ = \frac{840 \times \text{Hank of Slivers} \times 2.204}{\text{Kg./Shift}} \]

Rotor yarn:
Direct Sliver - Yarn [In Cones]

Makers:
RIETER → R40
    Rotor Speed = 150,000 rpm.
    Delivery Speed = 235 metres per minute
9. **WEAVING PREPARATION:**

The technique of fabric forming probably became known to mankind before spinning. Primitive people may have observed the interlaced grasses and twigs in the nests of birds, thus discovered how they could make clothing for themselves, baskets and nets, thatch like huts and fences using such materials as grass, leaves, twig, branches etc. Or they may have seen rushes naturally interlacing as they grew. Spinning developed later when people discovered that the raw material could be improved before they were woven. In the course of time, rude looms were made, which were crudely simple and hand operated. The modern looms used in the textile industry today essentially performs the same operations as the simple hand operated loom. (but in much sophisticated manner).

9.1 **Process Sequence in Weaving:**

Cone/Cheese WARPING [Warper's Beam]

↓

[Warper's Beam] SIZING [Weaver's Beam]

↓

[Weaver's Beam] WEAVING [Cloth Roller Beam]

**Warping:**

This process is also known as beaming. To produce a beam which contains a large number of individual threads parallel to each other. The resulting package is a warper's beam.

**Sizing:**

It is the heart of Weaving. In the sizing process, coating of a starch based adhesive is applied to the sheet of yarn to improve its weavability. Sizing increases yarn strength, reduces hairiness, which minimize the abrasion that occur between the warp thread and various parts of the loom.
Weaving

A woven cloth consists of two sets of yarns namely warp and weft. The yarns that are placed lengthwise or parallel to the selvedge of the cloth are called warp yarn. Each thread in the warp is called an end. The yarns that run crosswise are called weft yarns and each thread in the weft is called a pick.

9.2 Basic Motions in Weaving:

Every loom requires three primary motions to produce woven fabric.

Shedding:
To separate the warp threads into two layers. One layer is raised and other lowered.

Picking:
To insert a weft thread across the warp ends through the shed.

Beat-up:
To push the weft thread that has been inserted across the warp ends upto the cloth fell.

Besides the three main basic motions there are other two subsidiary motions necessary for weaving continuously a cloth on a weaving motion. They can be termed as secondary motion.

Take-up:
To pull the cloth forward after the beat-up of weft, maintaining the same pick density and spacing throughout weaving of a cloth and winding the woven cloth on to a roller.

Let-off:
To allow the warp to unwind from the warp beam during weaving and also to maintain an average constant tension of warp as it weaves down.

In order to produce a good quality of cloth and to prevent damages it is necessary to have some stop motions provided on the loom. They can be termed as auxiliary motions.

Warp Protector:
To protect the warp threads by stopping the loom when the shuttle fails to reach, and box properly into either the shuttle box during picking.
**Warp Stop:**
To stop the loom when a warp thread breaks or excessively loose.

**Weft Stop:**
To stop the loom when a weft breaks or the weft runs out of the pirn (weft package).

**Temple:**
To hold the cloth firmly at the fell to assist in the formation of a uniform width cloth.

### 9.3 Types of loom:
Weaving of yarn into a fabric is performed on a Weaving Machine which has also been called a loom. Two Classes.

1. **Shuttle loom**
2. **Shuttleless loom**

1. **Shuttle loom:**
   (a) Hand Loom,  
   (b) Non-Automatic Power Looms,  
   (c) Automatic Power Loom,  
   (d) Circular Loom.

In shuttle looms, winding of weft yarn on pirns and picking and checking of shuttle, which carries the pirns, are common feature, which limits the speed of the looms.

**Disadvantages of Shuttle Loom:**
(i) Smaller weft package, requiring frequent replenishment.
(ii) Limited scope for increase in speed and performance.
(iii) Noise and performance.
(iv) Space and Workers required for Weft Pirn Winding.
(v) Complicated Mechanism on Multi-Colour Loom.
(2) Shuttleless Loom:

CLASSIFICATION OF SHUTTLELESS LOOM

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**Projectile Rapier Fluid Multi Phase Circular Triaxial**

---

**Water Air-Jet**

---

**Single Jet Multi-Jet (Relay)**

---

**Projectile:**

A bullet like shuttle, 90 mm long and weighs 40 g technically named as gripper projectile draws the weft thread into the warp shed from a large, stationary cross-wound package always from the same side.

**Features of Projectile Weaving Machine:**

Gripper Projectile made fine steel 90 mm long 14 mm wide and 6 mm thickness weighs 40 g.

The weft is drawn directly from a large, stationary cross wound package.

There is no weft winding.

During its flights through the shed the projectile runs in a rake like steel guide, so that warp threads are touched neither by the projectile nor weft threads.

Weft insertion rate upto 900 - 1500 m/min.

Sulzer Projectile Weaving Machine available in Two-Four Colour Versions with working Width of 190 - 390 cm.

P7200 is upgraded version of P7100 with Central Microprocessor Control.

On P7200 Weft Insertion Rate is 1500 mpm (3.92 m x 400 rpm.)
Rapier Machine:[27]
Rapier Weaving Machine which produces a versatile range of fabrics from outerwear fabrics to sophisticated label weaves; carpets are manufactured by a no. of companies such as Dornier, Picanol, Somet, Sulzer-Ruti, Trudakoma etc. At a top speed of 550 rpm, maximum Weft Insertion Rate = 1350 mpm has been achieved by Vamatex. 8 Colour weft capability is standard, however dornier claimed even for 16 colours.

CLASSIFICATION OF RAPIER LOOMS

<table>
<thead>
<tr>
<th>NUMBER OF RAPIER</th>
<th>WEFT INSERTION PRINCIPLE</th>
<th>RIGIDITY OF RAPIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Double</td>
<td>Twin</td>
</tr>
<tr>
<td>Gabler</td>
<td>Dewas</td>
<td>Rigid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flexible</td>
</tr>
</tbody>
</table>

Single Rapier:
The weft is inserted during rapier insertion. Weft put in the shed during rapier insertion.

Advantage:
(1) Problem of weft transfer does not arise and normal range of fabric can be woven.

Disadvantage:
(1) One movement of rapier is wasted.
(2) Loom speed is very slow. Maximum Weft Insertion Rate - 400 m/min.

Double Rapier:
(i) These looms work on bilateral principle of rapier insertion. Two rapiers are used for insertion of a full pick in each shed. Both the rapiers enter simultaneously in the same shed from opposite ends-one the giver with a weft thread and other the taker empty.

(ii) The weft is transferred from the giver to the taker.
Loop Transfer: (Gabler System):
The weft is taken by the giver rapier from supply package in loop form.

Tip Transfer: [Dewas System]
The end of weft is directly transferred from the rapier to the other rapier.

Air-jet Weaving Machine: [28]
Weft Insertion by means of airjet has made a major break through in the early 70s and its importance is increasing further being of its ability to weave a wide range of fabrics at a very high Weft Insertion Rate of about 2000 metres per minute. The width restriction of about 150 cm for a single jet with confuser is overcome by a relay jet principle.

Some of the weaving machine manufacturers like Dornier, Somet, Trudakoma and Picanol etc.

Different System of Air-jet Weaving:
(a) Single nozzle with confuser type guide.
(b) Multiple nozzle with guide.
(c) Multiple nozzle with profile reed.

Today type C is most popularly used.

Water Jet Weaving Machine: [29]
Water Jet Weaving Machine has limited versality since only hydrophobic (Water-Insensitive) yarns can be woven. But these machines have been successful in the filament area because of the following characteristic Features:
(a) Low Cost Machine.
(b) Low Energy Consumption.
(c) Simple Maintenance.

Multi-Phase Weaving: [30]
Within the last decade, [31] Sulzer Textile has developed a new Multi-Phase Weaving Machine called M8300 Multi Linear Shed. Weaving Machine M8300 is a multiphase air-jet weaving machine in which 4 picks are inserted simultaneously. It has a filling insertion rate of over 5000 m/min.
For Example:
Single Phase Air-jet Loom having width 190 cm. typically weaves 23 metres of fabric per hour. However, M8300 multi-phase loom produces 69 metres of fabric for the same width during the same time.

9.4 Triaxial Weaving:\[32\]
Two warp and one weft yarn systems are interwoven at an angle of 60°. The two warp yarn systems are taken from series of (six) rotating warp beam located above the weaving machine. The result is interlacing of warp yarn an angle of 60°. After leaving the warp beams, the warp ends are separated into two layers and brought vertically down into interlacing zone. The weft is inserted by two rigid rapiers with tip transfer in the center of shed. Development of equipment to produce biaxially woven fabric is done by Barbar Colman Company of USA.

9.5 Circular Weaving Machine:
Circular weaving machines are not frequent in the Textile Industry. The main reason is the lack of flexibility in the fabric width and narrow range of options. Only sacks and tubes are woven on Circular Weaving Machines. In this Machine, the warp is circular and there are continuously circulating shuttle running around the periphery in a ripple shed.

10. CLASSIFICATION OF WEAVES:
The manner in which groups of warp yarns are raised by the harnesses to permit the insertion of the filling yarn determines the pattern of the weave, and in large measure the kind of fabric produced. Weave patterns can create varying degrees of durability in fabrics, adding to their usefulness and also to their appearance. In a simple weave construction, consisting of the filling going under one warp and over the next, two harnesses are needed: one to lift the odd-numbered warp yarns, and a second to lift the even-numbered warp yarns. More than two harnesses are required for advanced weaves, and as many as forty for figured weaves.
The three basic weaves in common use for the majority of fabrics are plain, twill, and satin, with some variations. Important constructions are also obtained from the following weaves: pile, double cloth, gauze, swivel, lappet, dobby, and Jacquard.

### Table – 3.1

**WEAVES AND THEIR CHARACTERISTICS**

<table>
<thead>
<tr>
<th>WEAVE</th>
<th>STRUCTURE</th>
<th>APPEARANCE</th>
<th>PROPERTIES</th>
<th>TYPICAL FABRICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>Each filling passes alternately over and under each warp in a square pattern.</td>
<td>Flat; no distinct design unless yarns have contrasting colors or thicknesses.</td>
<td>Easily produced; maximum yardage; inexpensive; relative durability depends on yarn count and balance; adaptable for printing and other finishing processes.</td>
<td>Batiste; cheesecloth; cretonne; gingham; percale; voile.</td>
</tr>
<tr>
<td>Basket</td>
<td>Two or more warps simultaneously interlaced with one or more fillings giving balanced structure.</td>
<td>Variation of plain weave; basket or checkerboard pattern; contrasting colors often used; attractive.</td>
<td>Inexpensive; drapable; somewhat flexible and resilient; absorbent; less durable than plain weave; soils more easily.</td>
<td>Monk’s cloth; oxford.</td>
</tr>
<tr>
<td>WEAVE</td>
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<tr>
<td>Ribbed</td>
<td>Plain weave with wales or cords in warp or filling.</td>
<td>Variation of plain weave; ribs or cords provide texture and design.</td>
<td>Drapes well; durability affected by pronounced ribs; possible yarn slippage from tension.</td>
<td>Bengaline; broadcloth; dimity; faille; poplin; rep; taffeta.</td>
</tr>
<tr>
<td>Twill</td>
<td>Three (or more) shaft; warp or filling floats over two or more counterpart yarns in progressively stepped up right or left direction.</td>
<td>Left- or righthand diagonal; variations provide chevron (herringbone), cork-screw, houndstooth, or other designs; enhanced by colored yarns.</td>
<td>Strong, firm texture; increased drapability and resilience; interesting designs; may develop shine.</td>
<td>Cheviot; covert; denim; drill; foulard; gabardine; serge; surah; tweed; whipcord.</td>
</tr>
<tr>
<td>Satin</td>
<td>Three (or more) shaft with warp floats in interrupted diagonal.</td>
<td>Compact; smooth; interrupted diagonal discernible with magnifying glass.</td>
<td>Lustrous; excellent drapability; floats subject to snagging.</td>
<td>Satin; slipper satin; crepe-back satin.</td>
</tr>
<tr>
<td>Sateen</td>
<td>Four (or more) shaft with filling floats in interrupted diagonal.</td>
<td>Variation of satin weave; compact, smooth.</td>
<td>Similar to satin; may be of staple yarns and Schreinerized.</td>
<td>Sateen.</td>
</tr>
<tr>
<td>WEAVE</td>
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<tr>
<td>Crepe</td>
<td>Combination of plain and satin or sateen weave.</td>
<td>Irregular, indistinct pattern with pebbly, textured surface.</td>
<td>Interesting hand; could have good strength, resilience, drapability, and serviceability depending upon fiber, yarn twist, compactness, structure.</td>
<td>Granite; moss crepe; sand crepe; wool crepe.</td>
</tr>
<tr>
<td>Pile</td>
<td>Extra set of warps or fillings woven over ground yarns of plain or twill weave to form loops.</td>
<td>Three-dimensional effect formed by yarns, entering perpendicularly into the ground weave.</td>
<td>Soft, warm, resilient, absorbent; interesting surface effects.</td>
<td>Cut and uncut pile fabrics ranging from toweling to rungs.</td>
</tr>
<tr>
<td>Cut Pile</td>
<td>Pile loops cut.</td>
<td>Soft, brush like surface; may have rows of cut pile</td>
<td>As above.</td>
<td>Corduroy; velvet; velveteen.</td>
</tr>
<tr>
<td>Uncut Pile</td>
<td>Pile loops intact.</td>
<td>Soft, though rougher than cut pile; loops apparent and close together, covering ground weave; loops may be on both sides.</td>
<td>As above. Softness and absorbency depend upon compactness of loops and twist of pile yarn.</td>
<td>Frieze; terry.</td>
</tr>
<tr>
<td>WEAVE</td>
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<tr>
<td>Double-Cloth</td>
<td>Two fabrics of independent weaves woven together with extra set of yarns.</td>
<td>Two different surfaces, sometimes reversible; thick; heavy.</td>
<td>Strong; warm; may be bulky.</td>
<td>Blanket cloth;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>coatings; upholstery.</td>
</tr>
<tr>
<td>Gauze (Leno)</td>
<td>Pairs of warps twisted over each other with each passing of filling.</td>
<td>Open-mesh with yarns securely held; variations produce corded effects.</td>
<td>Sheer but durable for its weight.</td>
<td>Grenadine; marquisette.</td>
</tr>
<tr>
<td>Swivel</td>
<td>Small designs interwoven on surface of fabric with extra filling yarn insertion mechanism.</td>
<td>Decorative designs, sometimes multi-colored; extra yarns forming design are cut on reverse side.</td>
<td>Attractive; design yarns tend to roughen on back and may pull out.</td>
<td>Dotted swiss; madras.</td>
</tr>
<tr>
<td>Lappet</td>
<td>Small designs stitched into fabric during weaving.</td>
<td>Decorative designs limited to one color; extra yarns of design are cut on reverse side but held firmly.</td>
<td>Attractive; design more durable than swivel.</td>
<td>Grenadine; madras.</td>
</tr>
<tr>
<td>Dobby</td>
<td>Small, geometric designs composed of short floats created by dobby loom attachment.</td>
<td>Decorative designs, often with corded effect which may give textured surface.</td>
<td>Attractive; generally good body.</td>
<td>Huckaback; granite cloth; pique.</td>
</tr>
</tbody>
</table>


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</thead>
<tbody>
<tr>
<td>Jacquard</td>
<td>Any combination of weaves and patterns possible since each warp is individually controlled with each pick passage.</td>
<td>Unlimited range of intricate designs on all types of backgrounds; multicolor effects.</td>
<td>Attractive; drapes well; serviceable but durability dependent upon weave and yarn.</td>
<td>Brocade; brocatelle; damask; matelasse; tapestry.</td>
</tr>
<tr>
<td>Triaxial</td>
<td>Three yarn construction at various angles.</td>
<td>Porous, cane like patterns.</td>
<td>Strong; stable; minimum stretch.</td>
<td>Industrial uses and home furnishings.</td>
</tr>
</tbody>
</table>
11. **PROCESSING:**

The wet processing is a term that involves the mechanical and chemical treatment to improve the aesthetic value of the fabric, yarn, fibre.

The wet processing sector can be divided into 3 distinct sections.
1) Preparation process or preparatory process.
2) Colouration process.
3) Finishing process.

The general process sequence followed for the fabric wet processing is as follows:

**Preparation processes**
- Grey cloth inspection & stitching
  - Shearing & cropping
    - Singeing
      - Desizing
        - Scouring
          - Bleaching
            - Mercerisation
              - Dyeing
                - Printing
                  - Finishing
                    - Folding
                      - Packing.
1) **Grey Stitching:**
Stitching of cloth another is carried out to make required length depending upon the same sorts.

2) **Shearing & Cropping:**
This process is employed to remove the etc. threads which are present on the surface of the fabric so as to attain even surface for further processing.

3) **Singeing:**
The process of singeing is carried out for the purpose of removing the loose hairy fibres protruding from the surface of the cloth as well as fibres from the interstices of yarn are burnt away with the help of gas flame directly impinging on the fabric resulting in giving smooth, even and clean looking face.

There are three types of singeing machines uses:
1. Plate Singeing Machine.
2. Roller.

The gas singeing machine is the most widely accepted now-a-days.

**Advantages:**
1. To provide smooth and even surface for fine prints.
2. To reduce the pilling tendency.
3. To reduce the fuzzy appearance of the fabric.

4) **Desizing:**
Sizes are applied to the warp yarns of the woven fabrics to assist in the weaving process but must be removed prior to dyeing or printing. This process of removing the starch from the fabric is called desiring. Cellulosic and Synthetic fabrics contain sizes to some extent. But sizes will not be found on the knitted fabric.

As we know sizing is a necessary operation in which the cotton warps are sized and so as to withstand the stress and strains during weaving. The size is applied depending upon the type of yarn i.e. coarse or fine or the type of twist S or Z.
To make the wet processing more efficient desizing treatment is given which removes the size content from the fabric. Starches and waxes present in the size paste forms a hydrophobic film on the surface of the fabric which winders the further processing such as dyeing, printing. The methods available for desizing are classified as follows:

**DESIZING METHODS**

- Hydrolytic
- Oxidative
- Rot Sleeping
- Chlorine
- Enzymatic
- Chlorite
- Acid.
- Bromide.

Mostly accepted in textile industry are enzymatic desizing because it is very safe and does not cause any damage to the fabric.

5) **Scouring:**

Scouring is the next process after desizing in which the water soluble impurities the natural fats and waxes present in the fabric are removed. This provides a greater cleaning or detergency action to remove the soiling and staining developed during transportation or storage of the goods.

Due to the removal of these impurities the absorbency of the fabric increases to the greater extent, which results in efficient further processing.

There are tow methods to carry out scouring:

1. Alkali Scouring.
2. Solvent Scouring.

Normally, alkali scouring is carried out and the alkali used is sodium hydroxide (NaOH).
6) **Bleaching:**

The scouring process of cotton removes waxes and other majority of impurities leaving behind the natural colouring matter. Bleaching completes the purification of fibre by ensuring the complete decolourisation of colouring matter. A general classification of bleaching agents is shown.

**BLEACHING AGENTS**

![Diagram showing classification of bleaching agents](image)

**Oxidation Bleaching Agents**
- Peroxide System
- Hydrogen Peroxide
- Pottassium Permanganate
- Peracetic Acid

**Reductive Bleaching Agents**
- Chlorine System
- Sulphur Dioxide

The bleaching process must ensure:
* A pure and permanent whiteness.
* Level dyeing properties (There should be no variation in bleaching).
* Three should not be any loss in tensile strength due to degradation of cellulose.
* Eco-Friendly bleaching should be preferred.

Hydrogen Peroxide is the most widely used bleaching agent.

7) **Mercerisation:**

The main purpose of mercerization is to alter the physical and chemical properties of fibre.

**Objectives:**
* To impart luster.
* To impart dimensional stability.
* To improve the strength.
* To increase the capability to accept dye.
* To make the fabric more absorbent.
* To give soft handle.

This process is named after John Mercer in 1884. A thought was given to study the effects of strong caustic dye on cotton. The process is carried out with 24% caustic soda at 18°C.

The mercerisation process is classified as:

1. Caustic Mercerisation:
   * Cold Mercerisation
   * Hot Mercerisation.

2. Liquor Amonia Mercerisation.

8) **Dyeing and Printing:**

Textiles are usually coloured to make them attractive and beautiful. They would appear extremely dull in the absence of colour. There are two ways of adding colour to a textile substrate i.e. printing and dyeing. Printing is a process in which a multicolours effect is produced on the textile at discrete places whereas dyeing completely covers the substrate with colour. The substances used to colour textiles can be classified as dyes or pigments.

11.1 **Methods of Dyeing:**

a) Batchwise processes:

    Machine used - Jigger, Jet Dyeing Machine.

b) Continuous processes:

    Continuous dyeing range.

    The basic units are: Padding
    Steaming
    Dry heat treatment
    Soaping.
11.2 Quality of Dyeing:

The major requirements for dyed goods are evenness of dyeing, desired fastness value and brightness of colours. Process controls are necessary to achieve these objectives.

Any scheme of process has three aims:
(i) To keep the cost of production to a minimum.
(ii) To maintain the quality of production at the required level.
(iii) To keep the damage to a minimum level.

11.3 Printing:

Printing can be defined as the localized application of dye or pigment in a thickened form to a substrate to generate a pattern or design.

Printed patterns may vary from simple geometric designs in a single colour to very complex designs up to 20 or more colours. The printing pastes are utilized to ensure the colour adheres precisely to the spot it has been applied to and does not spread over the textile to destroy the definition of the printed object.

Textile materials can be printed in any of the following way:

1. Flat bed screen printing.
2. Rotary screen printing.
3. Heat transfer printing.

Various styles of printings.
1. Direct style.
2. Discharge style.
3. Resist style.

11.4 Finishing:

Textile Finishing covers an extremely wide range of activities which are performed on textiles before they reach the final customer. The term finishing includes all the mechanical and chemical processes employed commercially to improve the acceptability of the product.
Mechanical finishes:

1. **Calendering:**
   Compression of fabric between two heavy rollers to give a smooth appearance to the surface of the fabric.

2. **Napping and Shearing:**
   They are applied to raise a velocity or soft surface. Shearing cuts the raised naps to a uniform height.

Chemical finishes: (involve application of chemicals)

1. Water Repellency.
2. Flame retardancy.
3. Resin Finishing (Anticrease, Wash-n-wear, durable press (permanent pleating)).
4. Softening (handle modification).
5. Oil and soil repellancy.
6. Antistatic finishes.
7. Anti-microbial finish.
8. Moth proofing and insect damage.

12. **QUALITY ASSURANCE LABORATORY:**

    The textile industry has a grave concern for maintaining high quality standards so it establishes rigid systems of inspection before the fabric gets finally packed. It is extremely essential to maintain a reputation of supplying fault free goods. Hence, the fabric undergoes test for product quality at every major stage of processing.

    The textile material is tested in an equipped laboratory and skilled technicians to maintain product quality. The fabric is instantly rejected if it is not within the specification limits. Modern quality control has been assisted by development of techniques and machines for assessing fabric properties. The automatic testing devices has greatly reduced testing time and cost.

13. **EFFLUENT TREATMENT PLANT:**

    The textile industry generates a lot of toxic effluent during the processing of the fabric which has to be treated before its disposal the strict norms issued by the pollution control boards of respective states to the textile processing industry has helped to curb pollution and combat the menace quite effectively.

    The effluent process is divided into following process.
1. Physical.
2. Chemical.
3. Biological.
4. Tertiary.

14. **CONCLUSION:**

Textile materials are of interest to everyone for they play a most important part in civilized life, as we know it today. The result is that, today although we have available for our use a wide variety of textile materials, further improvements can be anticipated perhaps at a rate, greater than ever before.

**REFERENCES:**

1. Mr. P.V. Vidyasagar, Publisher: Mittal Publication, New Delhi-110 059 (India), Handbook of Textiles, Page No.: 67.
2. Mr. Sabit Adanur, Publisher: Technomic Publishing Co.Inc., Lancaster-Basel, 'Fabric Formation by Weaving', Published in Handbook of Weaving, Page No.: 01 - 05.
3. Mr. Carl A. Lawrence, Publisher: CRC Press, Fundamentals of Spun Yarn Technology, Motivate Series, Page No.: 02, 03, 04, 05, 06, 07, 08, 09, 10, Page No.: 19, 11, Page No.: 19, 12, Page No.: 19.
5. Mr. S.P. Mishra Publisher: New Age International (P) Limited, New Delhi, 'Cotton', Published in A Textile Book of Fibre Science & Technology, Page No.: 71-73.
6. Mr. W. Klein [Volume 2], Publisher: The Textile Institute, 'The Blowroom' Published in A Practical Guide to Opening and Carding, Page No.: 1 - 3.
7. Prof. A.R. Khare, Publisher: Sai Book Centre, Bhandup, Mumbai-400 078, Elements of Carding and Drawing, Page No.: 116 - 119.
9. Dr. M.K. Talukdar, Publisher: Mahajan Publishers Private Limited, Stiper Market Basement, Near Natraj Cinema, Ashram Road, Ahmedabad-380 009, GS-India, Weaving Machines, Mechanism, Management, Page No.: 04, 05, 06, Page No.: 344.
10. NCUTE Pilot Programme, Weaving II Shuttleless Looms, October 7-9, 1999, Page No.: 16.


32. NCUTE Pilot Programme, Weaving II Shuttleless Looms, October 7-9, 1999, Page No.: 7.

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