Textile – Fibre to Fabric Processing

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This paper is an attempt to provide all basic information related to textile Industry – in the field of manufacturing, purchasing, promoting, selling and so on. The study may also useful for intermediate level employees engaged in different aspect of textile technology, consumers and home economists who need sound guidance in the selection and care of textile products. This article covers comprehensive outline of fibres and steps involved in conversion of fibre to variety of yarns, fabric manufacturing and wet processing of fabric for value addition.

Keywords : Textile fibres; Combed yarns; Carded yarns; Rotor yarn; Warping; Sizing; Weaving; Colouringzation finishing

INTRODUCTION

Textile industry is one of the few basic industries, which is characterised as 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. There are numerous kinds of fibres and other raw materials, which are used to produce a cloth. This paper provides an insight about the basics of textiles and the terms that are used all around the world in context of textile industry.

Regarding study of textile fabrics, meaning of the word textile must be made quite clear. The dictionary states that the word is derived from the Latin word texere[1] to weave, but a wider meaning of weaving must be accepted since it is one of the various ways to produce textile fabrics. 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. The flow diagram of the fibre to fabric process is shown in Figure 1.

Polymers[2] are the resource for man-made fibres, which are derived mostly from oil. Plant fibres and animal fibres constitute the natural fibres. 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.

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.

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This paper (modified) was received on March 25, 2009. Written discussion on this paper will be entertained till October 31, 2009.

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 a different fabric structure. Approximately 70% of the fabrics made in the world are woven fabrics. Figure 2 shows the diagram of woven fabrics.

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 termed as 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

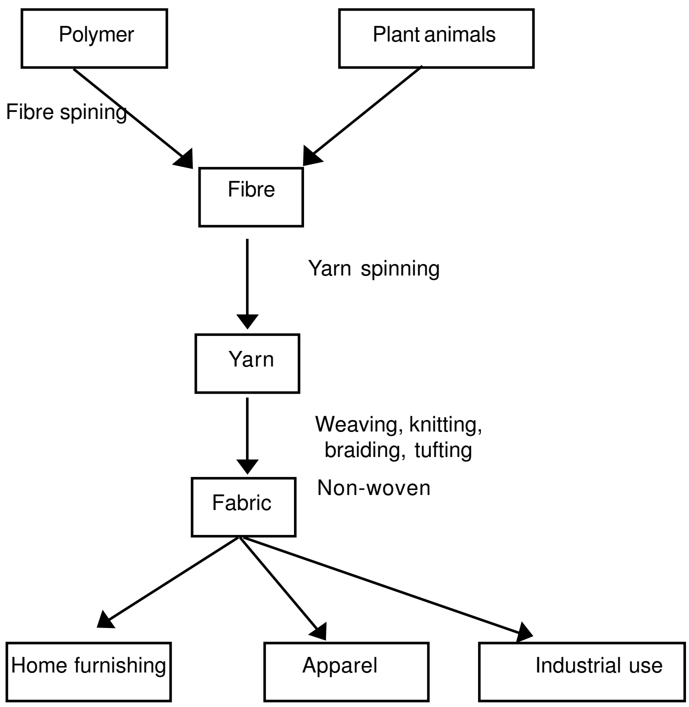

Figure 1 Material flow diagram for fibre to fabric process

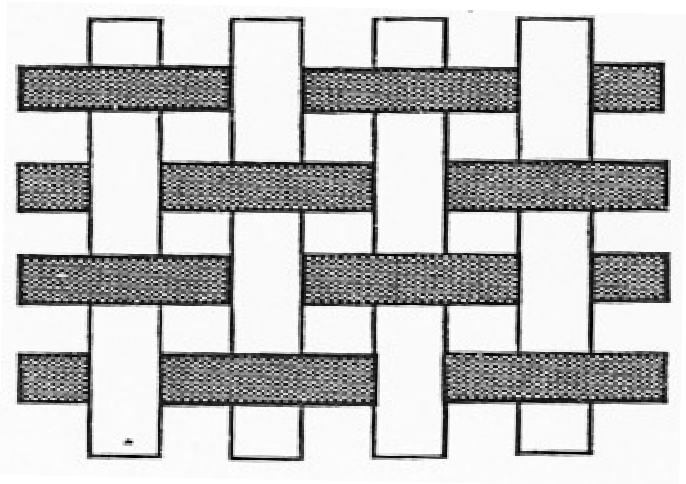

Figure 2 Woven fabrics

insertion, and beat up. Figure 3 shows the diagram of braded fabrics.

Knitting

Knitting refers to interloping 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.

Tufting

Tufting is the process of manufacturing some categories of carpets and similar structures. In this process 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. Orientation of tuffed loops is shown in Figure 4.

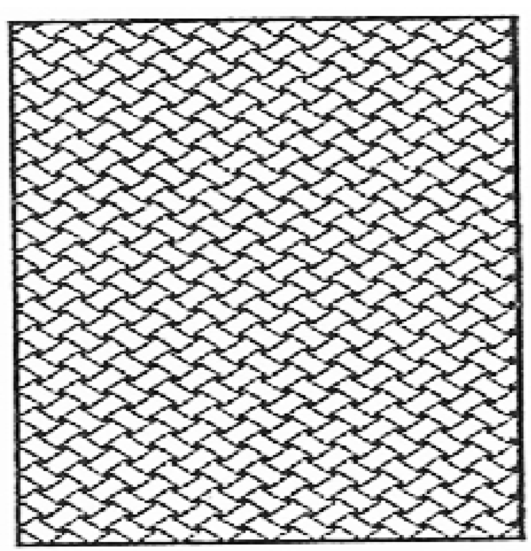

Figure 3 Braided fabrics

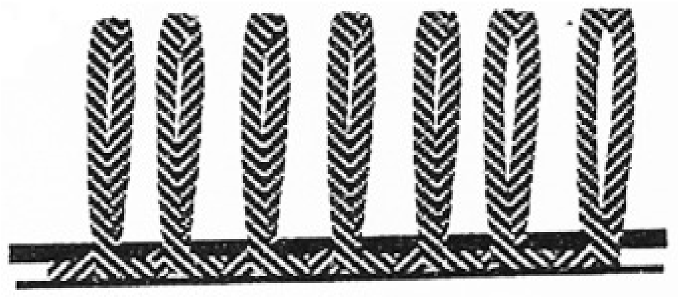

Figure 4 Tuffed loop

Bonding

Bonding is the method of manufacturing nonwovens using textile, paper, extrusion, or combination of these technologies, to form and bond polymers, fibres, filaments, yarns or combination sheets into a flexible, porous structure. In fact, some nonwoven products are subjected to both textile and paper industry. Figure 5 shows the bonding of nonoven fabric.

FIBRES

Fibres are the basic raw material for any textile industry, technically which is defined as a unit of matter, characterized by flexibility, fineness and a high length to width ratio. Different kinds of fibres are used in textile industry as raw material. Some of these fibres were well known and used earlier as well as even today, while some others 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 the desirability of their properties to consumers. The detailed classification of fibres is as shown in Figure 6.

INTRODUCTION TO YARNS

Primitive people discovered that a succession of short fibres could be twisted into a continuous yarn. This was probably accomplished slowly and laboriously at first, but due to greater strength for the articles produced from continuous yarns, it led to the development of better process of twisting and spinning. Different methods are till used 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,

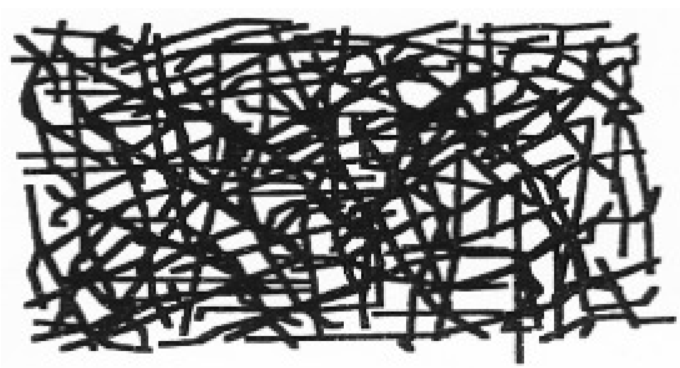

Figure 5 Bonding of nonwoven fabric

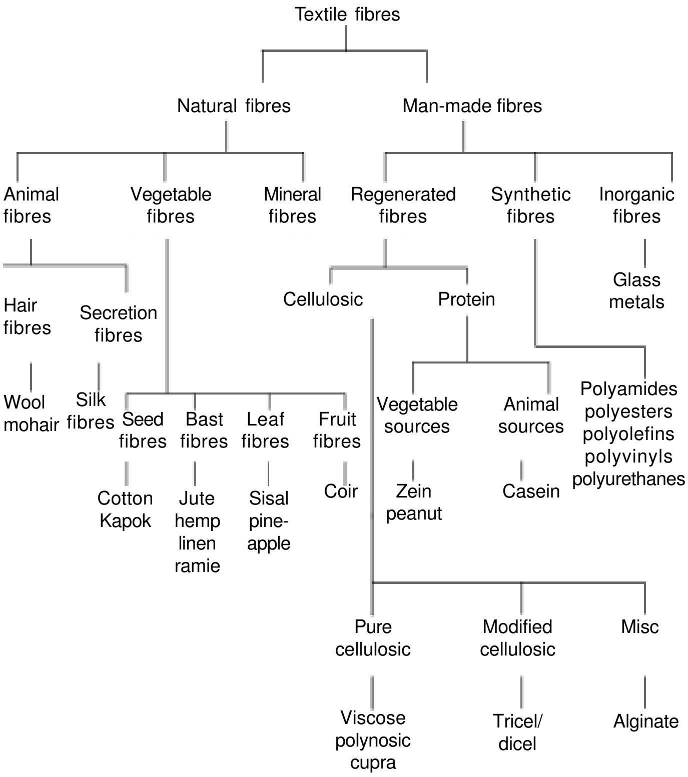

Figure 6 Detailed classification of fibre

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.

TYPE OF YARN

A textile yarn is an assembly of substantial length and relatively small cross section of fibres and or filaments with or without twist. Yarns can be classified in two major categories as shown in Table 1.

WEAVING PREPARATION

Introduction to Weaving

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 and thus discovered the way to make clothing for themselves, baskets and nets, thatch like huts and fences using such materials as grass, leaves, twig, branches etc. Spinning developed later when people discovered that the raw material could be improved before they were woven. In 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).

Table 1 Classification of yarns

Group	Sub Group	Example
Continuous filament yarns (CFY)	Flat CFY (untextured)	Tape twisted
	Textured yarns	False twisted
		Stuffer box
		Air jet
Staple spun yarns		Carded ring yarn
		Combed ring yarn
		worsted
		woolen
		Rotor spun
		Compact ring yarn
		Air-jet spun
		Friction spun

Process Sequence in Weaving

Weaving process contains these steps warping, sizing and final weaving. The flow diagram of weaving process is shown in Figure 7.

Warping

This process is also known as beaming. A beam contains 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 and the yarns that run crosswise are called weft yarns. Each thread in the weft is called a pick[3].

BASIC MOTIONS IN WEAVING

Every loom requires three primary motion to produce woven fabric.

Shedding

This process refers to separate the warp threads into two layers. One layer is raised and other lowered.

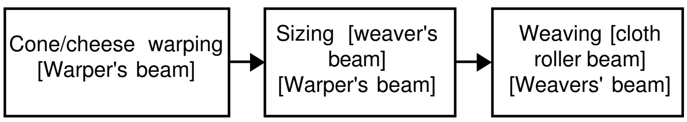

Figure 7 Flow diagram weaving process

Picking

This process refers to insert a weft thread across the warp ends through the shed.

Beat-up

This process referes to push the weft thread that has been inserted across the warp ends upto the cloth fell.

Besides the three main basic motions in weaving, there are other two subsidiary motions necessary for continuous weaving which are termed as secondary motion.

Take Up

This is the motion 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

This motion allow the warp to unwind from the warp beam during weaving and also 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. which are termed as auxiliary motions.

Warp Protector

This motion protect the warp threads by stopping the loom when the shuttle fails to reach, the selvedge side and box properly into either the shuttle box during picking.

Warp Stop

This auxiling motion to able to stop the loom when a warp thread breaks or get excessively loosened.

Weft Stop

This motion able to stop the loom when a weft breaks or the weft runs out of the pirn (weft package).

Temple

This motion holds the cloth firmly at the fell to assist the formation of a uniform width cloth.

TYPES OF LOOM

Weaving of yarn into a fabric is performed on a weaving machine which has also been called a loom. Looms can be classified in two categories. Shuttle loom and Shuttleless loom.

Shuttle Loom

These are mainly four types of shuttle looms.

- Hand loom,
- Non-automatic power looms,
- Automatic power loom,
- 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 are as follows.

Smaller weft package, that require frequent replenishment.

Limited scope for increase in speed and performance.

Noise and performance.

Space and workers required for weft pirn winding.

Complicated mechanism on Multi-colour loom.

Shuttleless Loom

Shuttleless looms can be classified in six major groups. Four classification of the some in shown in Figure 8.

Projectile Weaving

This machine contains a bullet like shuttle, which is 90 mm long and weighs 40 g, technically termed as gripper projectile, which draws the weft thread into the warp shed from a large, stationary cross-wound package always from the same side[5].

Features of Projectile Weaving Machine

- The gripper projectile are made from 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, where as weft winding is absent.
- 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 ranges from 900 m/min to 1500 m/min.

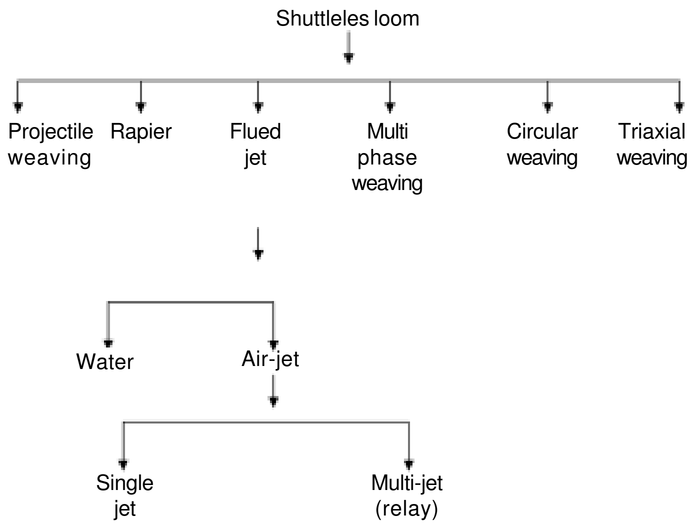

Figure 8 Classification of shuttleless loom

- Sulzer projectile weaving machine available in two-four colour versions with working width of 190 cm to 390 cm.
- The upgraded version of machine is P7200 where as the model P7100 is with central microprocessor control.
- On P7200 model, weft insertion rate is 1500 mpm (3.92 m x 400 rpm)

Rapier Weaving

Rapier weaving machine produces versatile range of fabrics from outerwear fabrics to sophisticated label weaves[6]. Rapier looms are classified as shown in Figure 9.

Single Rapier

The weft is inserted during rapier insertion, and the weft put in the shed during rapier insertion.

Advantage

Problem of weft transfer does not arise and normal range of fabric can be woven.

Disadvantage

One movement of rapier is wasted.

Loom speed is very slow. The maximum weft insertion rate is 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 from the giver end with a weft thread and other from the taker end in empty condition.

(ii) The weft is transferred from the giver to the taker.

Weft Insertion Principle

Loop Transfer Gabler System

The weft is taken by the giver rapier from supply package in loop form.

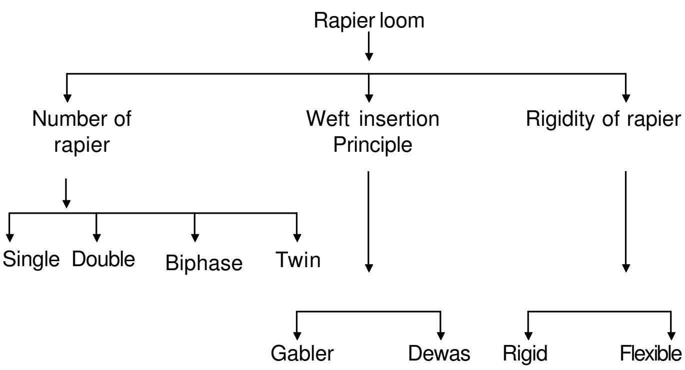

Figure 9 Classification of rapier loom

Tip Transfer Dewas System

The end of weft is directly transferred from one side of the rapier to the other side at the time of proper shed opening.

Air-jet Weaving

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 m/min. The width restriction[7] is about 150 cm for a single jet with confuser can be overcomed by a relay jet principle.

Different systems of air-jet weaving are as follows

(a) Single nozzle with confuser type guide.

(b) Multiple nozzle with guide.

(c) Multiple nozzle with profile reed.

The most commonly used air jet weaving process is the multiple nozzle with profile read.

Water Jet Weaving

Water jet weaving machine has limitation, since only hydrophobic (water-insensitive) yarns can be woven[8]. But these machines have been successful in the filament area as it is a low cost machine with low level of energy consumption, characterised with simple maintenance feature.

Multi-phase Weaving

Within the last decade, Sulzer textile has developed a new multi-phase weaving machine called M8300 multi linear shed. M8300 is a multiphase air-jet weaving machine in which four picks are inserted simultaneously. It has a filling insertion rate[9] of over 5000 m/min. Figure 10 shows the filling insertion rate for different weaving processes[10].

Single phase air-jet loom having 190 cm width typically weaves 23 m of fabric/h. However, M8300 multi-phase loom produces 69 m of fabric for the same width during the same time.

Triaxial Weaving

In this machine, 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

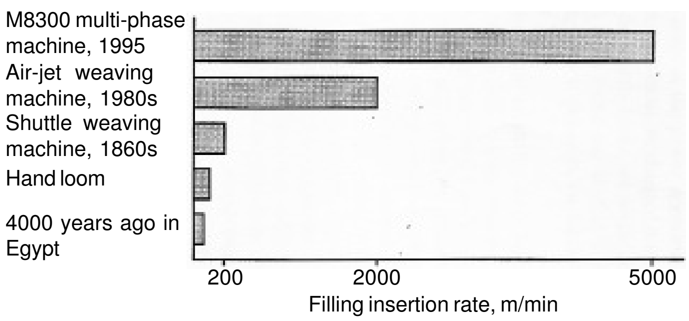

Figure 10 Major breakthroughs in filling insertion rates

above the weaving machine. The result is interlacing of warp yarn at 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 rapier with tip transfer at the centre of shed.

Development of equipment to produce biaxially woven fabric is done by Barbar Colman Company, USA.

Circular Weaving

Circular weaving machines are not frequent in the textile industry due to 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, weft revolves in a circular path.

WET PROCESSING OF FABRICS

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 three 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 shown in Figure 11.

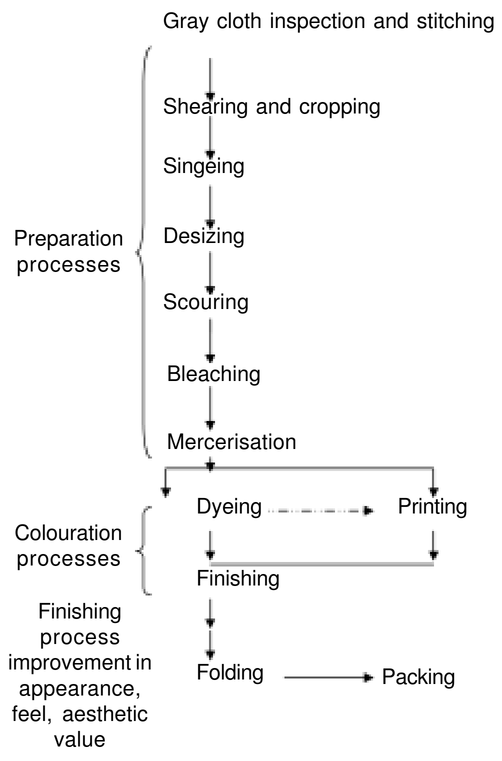

Figure 11 Sequential processes for fabric wet processing

Different sequences in fabric wet processing briefly discuss as follows.

Grey Stitching

Same surface stitched together to make it continuous.

Shearing and Cropping

This process is employed to remove the unevenness present on the surface of the fabric so as to attain even surface for further processing.

Singeing

The singeing process is carried out for the purpose of removing the loose hairy fibres protruding from the surface of the cloth as well as from the interstices fibres of yarn that 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:

1. Plate singeing machine.
2. Roller singeing machine.
3. Gas singeing machine.

The most commonly used machine is gas singeing machine.

Objects of Singeing

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.

Desizing

Sizes are applied to the warp yarns of the woven fabrics to assist the weaving process but must be removed prior to dyeing or printing. This process of removing the starch from the fabric is called desizing. Cellulosic and Synthetic fabrics contain sizes to some extent, whereas knitted fabric does not contain sizes.

Sizing is a necessary operation in which the cotton warps are sized to withstand the stress and strains during weaving. The size is applied depending upon the type of yarn, *ie*, coarse or fine or the type of twist S or Z.

To make the wet processing more efficient, desizing treatment is applied 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 hinders the further processing such as dyeing, printing. The methods available for desizing are classified in Figure 12.

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

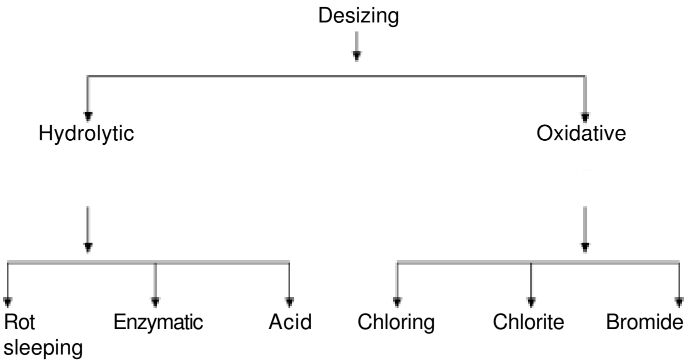

Figure 12 Classification of desizing

Scouring

Scouring is the next process after desizing in which the water insoluble impurities, the natural fats and waxes present in the fabric are removed. This provides a greater cleaning 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 facilitates further processing functions.

There are two methods come into account, which are, alkali scouring and solvent scouring.

Normally, alkali scouring is the mostly accepted process and sodium hydroxide (NaOH) is applied as alkali.

Bleaching

The scouring process of cotton removes waxes, but other majority of impurities leaving behind the natural colouring matter. In such situation, bleaching completes the purification of fibre by ensuring the complete decolourisation of colouring matter. A general classification of bleaching agents is shown in Figure 13.

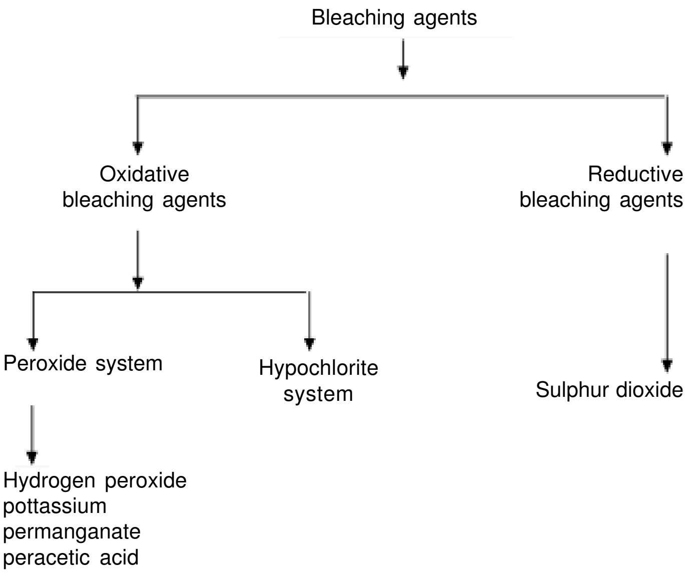

Figure 13 General classification of bleaching agents

The bleaching process must ensure.

* a pure and permanent whiteness
* level dyeing properties (there should be no variation in bleaching)
* there should not be any loss in tensile strength due to degradation of cellulose
* eco-friendly bleaching should be preferred

Mercerisation

This process is named after John Mercer in the year 1884. The main purpose of mercerization is to increases dyeability of cotton fabrics and study the effects of strong caustic dye on cotton. The process is carried out with 118% to 20% caustic soda at 20°C to 24°C.

Objectives of mercerisation are as follows.

* 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.

The mercerization process is classified as:

Caustic Mercerisation

* Cold mercerisation
* Hot mercerisation.

Liquor Ammonia Mercerisation

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, ie, printing and dyeing.

Printing is a process in which a multicolour effect is produced on the textile at discrete places where as dyeing completely covers the substrate with colour. The substances used to colour the textiles can be classified as dyes or pigments.

Methods of Dyeing

Batchwise processes: The machine used in this process is jigger, jet dyeing machine

Continuous processes: These methods are specified by continuous dyeing range. The basic units for continious process are padding, steaming, dry heat treatment and soaping.

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.

Printing

Printing results multi coloured design effects on textiles. The most economical multicoloured effects on textiles can also be produced by combining dyed fabrics or woven and knitted fabrics using coloured yarn, but the effects are restricted to simple geometrical designs. In printing, there is no restriction to the designer and all types of fabrics in any yarn, pliers or fabrics can be printed. Printing can be combined with white as well dyed fabric grounds. Broadly, printing can be classified into these group.

Flat Bed Screen Printing

The fabric is printed with the first screen and passes to the next screen. In this process all the screens for the design (one screen for each colour) are positioned accurately along the top of the long endless belt, known as a blanket.

Rotary Screen Printing

In rotary screen printing, continuous rotation of a cylindrical screen while in contact with the fabric ensures genuinely continuous printing. The print paste is fed inside of the screen. During printing it is forced out through the design area with the acid of a stationary squeeze.

Heat Transfer Printing

In this case the paper is printed, first and then it is transferred to the fabric at high temperature simply by sublimating the disperse dye.

Printing of textiles also contain various styles which can be classified as follows.

Direct Style of Printing

In this style, the print paste is directly applied either by roller or screen and desired motifs with different colours can be obtained. This style is generally applied for all type of print motifs irrespective of no. of colours, coverage of the print paste and the cost.

Discharge Style of Printing

In this style, generally the fabric is dyed all over with any class of the dye and after drying, the same is printed with certain chemicals which destroy or discharge the dyed colour in the printed portion, which is responsible in giving white portion in the dyed ground. This is called as white discharge effect or style. If a dye which is resistant to the above chemicals in the print paste is incorporated, the coloured effect instead white can be obtained and is termed as coloured discharge on dyed ground. The chemicals which destroy or discharge the colour in the printed portion is called as 'discharging agent'. The dyed colour must have good dischargeability whereas a dye in the printed portion (for getting coloured discharge) must have no dischargeability property.

Resist Style of Printing

In this style, the printing is carried out first with certain chemicals, called as resisting agents and dyeing afterwards. The resisting agents resist for the development of the colour in the printed portion and produced a white effect. If coloured effect is needed, a dye which is resistant to this resisting chemical must be incorporated in the printing paste and dyeing follows. In this case, a coloured resist effect is obtained.

Generally discharge and resist styles of printing are applied to the fabric motifs where heavy blocks are used wherein shrinkage of the fabric after printing and cost of the direct style of printing will be very high and hence discharge and resist style of printing is used.

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. The finishing can be categorised as mechanical finishing and chemical finished.

Mechanical Finishing

This can be further subdevided as calandering and napping.

Calendering

The process referes to compression of fabric between two heavy rollers to provide a smooth appearance and the fabric surface.

Napping and Shearing

This process essentially consists surface shearing and cut the raised naps to a uniform height.

Chemical Finising

As the name implies, this process refers to application of chemicals. These are eight methods for chemical finishing.

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 repellency.

6. Antistatic finishes.

7. Anti-microbial finish.

8. Both proofing and insect damage.

CONCLUSION

Textile materials are of interest to everyone, which play the most important part in human civilization. As a result, today there are wide variety of textile materials pertaining to wide application, further improvements can also be anticipated perhaps at a rate, greater than ever before.

ACKNOWLEDGEMENT

The author wishes to express his sincere thanks to Prof S K Laga, D K T E Society's Textile and Engineering Institute, Ichalkaranji, Prof. (Dr) P A Koli, Department of Economics, Shivaji University, Kolhapur, Prof (Dr) C D Kane, Prof (Dr) A I Wasif, Prof (Dr) P V Kadole for their encouragement and moral support for writing this paper.

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