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Cotton and Fibre Processing - Past Insights on Basic Processes

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Fibre Processing refers to a series of steps employed on a raw fibre to convert it into a textile fibre. This concept of conversion is in vogue since ancient times. It has been revealed in a classic book 'The Structure of Cotton Fibre' by Bowman, F.H in 1908 and more critically dwelt in 'Textile Fibre' by Mathews J.M. in 1923, in the Chapter - 'The Chemical Properties of Cotton Fibre'. The historical development about the concept of Mercerization has been analytically depicted by Mathews in his book 'Textile Fibre'. The articles in the earlier issues by the same author have highlighted the processes of spinning and weaving. In this article, the aspect of fibre processing resulting in the making of a textile fibre has been dealt with in detail with a historical perspective.

Principles and Application

The discovery of treatment of raw fibre with chemicals had potential implications in textile fibre processing. As depicted by Bowman in 1908, John Mercer, a Lancashire chemist discovered the phenomena that when cotton fibres were soaked in a solution of caustic soda, Sodium Hydroxide (NaOH), of a specific gravity of 1.2 they got converted into a useful textile fibre. This process was later patented and came to be known as Mercerisation. This process made the fibres stronger and finer and the fibres also attracted more colouring matter. It was generally perceived that chemical reagents weaken the fibres, but in this case it was the reverse.

In 1863, Walter Crum came out with a paper on this aspect. He recorded that when unripe and perfectly collapsed cotton fibre was subjected to the chemical treatment, the fibres achieved strength and got converted into a usable textile fibre.

It is different from the naturally matured and ripened cotton fibres as the former was smaller, more cylindrical and having a larger aperture or lumen in the centre. Thus, it was inferred that it was now possible to arrive at this structure by converting the unripe fibres rendering them good strength.

The cell membrane become elastic within the cell wall itself. This results in the separation of cell or concentric lamina from each other. The tube walls of a fully matured or ripe cotton fibre really consists of tissues of pure cellulose which are separated from each other by a series of intervals of more or less uniform cellular tissue forming a series of capillary surfaces. They act with utmost energy upon any liquid in which the fibres may be immersed. Thus is the fully absorbent cotton created. Crum attributed this to the fact that the thin pellucid outer sheath of cellulose acted as a dialyser. This dialysing process results in the formation of a perfect fibre.

Mercerisation

In fibre processing process lot depends on the 'Mecerising Process', the key process, its impact on the raw fibre is of immense value as a converted textile fibre. The properties attributed to the textile fibre are, better lustre, increase in strength of yarn and increase in elasticity. This is governed by time of mecerising, temperature of the process, basic chemical reactions viz., steep immersion in caustic soda solution.

Mechanism of Textile Fibre Formation

Cotton when exposed to high temperature, i.e. 169 degrees Celsius, whether moist or dry heat, results in the dehydration of cellulose accompanied by a strain stressed disintegration in the fibre. The presence of colouring matter viz., structures like endochromes irregularly distributed in the fibre, occuring mostly in the walls of the fibre immediately surrounding the inner cavity or lumen. This is observed in Egyptian cotton. The removal of these structures makes the fibre more amenable to the dyeing process resulting in a value-added textile fibre.

Notable Changes Occurring in the Mercerising Process

Cotton fibre when immersed in a concentrated solution undergoes a distinguished physical modification . The fibre absorbs the alkali swelling to a cylindrical form. This gives a hair like appearance, the fibre also untwists itself becoming more straightened, shrinking considerably in length. The internal portion of the fibre acquires a gelatinous appearance.

Though it is firm in its structure, the surface of the fibre shows a wrinkled appearance, translucent due to a somewhat unequal distension of the inner part. There is a small degree of lustre in the portions of the surface. Due to the uneven stretching and wrinkling of the external surfaces, the smooth lustrous portions are irregular in occurrence. The fibre also shows a slight increase in weight. These changes in the physical appearance of the fibre are associated with a remarkable increase in its tensile strength. This amounts in most cases increases upto 30 to 50 percent. The fibre acquires a greater power of absorption of many solutions especially dyestuff. The increase in tensile strength is probably due to the fact that mercerising causes the inner structure of the fibre to bind solidly together by filling up the interstitial spaces between the molecular components of the cell wall.

Thus, the fibre acquires a greater degree of solidity. The internal strain between the cell elements is quite high after the drying and shrinking of the ripe fibre. The shrinkage of the fibre is accompanied by the contraction of cell elements transversely on the collapse of the fibre canal. These are further distended by the action of the caustic alkali.

These cell elements become shortened longitudinally and are more tightly packed together. The increased affinity for dyestuffs exhibited by mercerised cotton does not imply the inherent property of the modified cellulose due to a change in the chemical composition. It is no doubt the result of a modified cellulose structure of the fibre itself.

The cell elements become distended like a sponge, gaining greater power of absorption and retention of liquids than when in a flattened condition.

Lustre

The high lustre of the fibre imparted to cotton does not occur by the mere action of the mecerising process, but by the conditions prevailing during that time. The swelling of the cell walls and consequent contraction of the fibre remains wrinkled and uneven due to unequal strain of expansion. The ends of the fibres when fixed, restrain them from contraction during chemical action of the alkali. The swelling of the cell wall results in a smooth structure resembling a polished surface of the reflecting light but with little scattering of the rays.

It is observed that the ribbon-like fibre resulting in a change in the twist is of great importance in the production of lustre. This is caused above 40 degrees Tw, a unit of concentration of the alkali. The untwisting follows the swelling. This 40 degrees Tw is considered the lowest concentration at which mercerisation takes place resulting in lustrous cotton.

Another reason for the lustrous appearance is the physical modification of the cell elements. The swelling due to absorption of the alkali gives a gelatinous and translucent appearance. This renders an alteration of optical properties of the fibre.

Thus, the lustre is enhanced with the reduction in the proportion of light absorption.

Tension and Elasticity

There is a considerable difference in the strength and elasticity of cotton mercerised without tension and with tension. It is the strength of the yarn which is more desired in practice. In mecerising yarn or cloth, it is to be kept in mind that the fibres shrink considerably resulting in closely knit fibres.

Thus, an increase in tensile strength adds to greater coherence of the fibres with one another, rather than an increase in the strength of the individual fibres. There is no breaking of a yarn spun from the long fibres but only pulling apart.

The chemical was reasonably defended by Mercer himself besides Gladstone, Cross and Bevan, Beltzer and many other prominent chemists. However Ristinpart was of the view that the mercerisation process is principally an osmotic action and the contraction which the cotton undergoes in mercerisation without tension is due to purely physical cause.

The cotton fibre is surrounded by a cuticle which acts as a dialysing membrane inducing osmotic action when the fibre is immersed in strong caustic soda solution, the water tends to diffuse faster from the fibre into the surrounding liquid, while the soda tends to diffuse faster into the fibre.

This osmotic condition demands an increased pressure within the fibre, causing it to swell. Thus it assumes a form which will give it the greatest internal capacity for a minimum surface. Thus the fibre reduces in length and assumes a straight cylindrical form.

Thus, mercerisation has a major impact on subsequent key processes like singeing calendering and other finishing processes.

The basic general fibre processes as depicted in 'Textile Fibres' by Katherine Hess is listed below:

1. Bleaching -whitens the cloth
2. Crabbing- sets warp filling
3. Decating- sets naps and adds lustre
4. Mercirising- increases lustre, strength, only for cotton
5. Scouring and Kier boiling - removes waxes, oils and sizing for cotton and linen
6. Shearing- clips ends of fibres for cotton and wool
7. Shrinking and filling - releases strains and shrinks somewhat
8. Singeing - removes loose yards and fibre ends
9. Sizing and weighting - Increases weight and give body for cottons, some rayons and silks
10. Tentering- Straightens and sets warps and filling at right angles

The above processes differ somewhat

depending on fibre and the effect desired. The hidden qualities of textiles rely on the processes they are subjected to and the care with which the cloth is handled. The appearance of the cloth may have been influenced by the general processes subjected to.

Other processes essential for altering the surface structure of the cloth are as follows:

1. Beetling- Softens and adds lustre to linen and cotton
2. Calendering - Smooths and adds lustre to cotton linen and other some synthetic fibres
3. Embossing and Schreinering - Adds lustre and design to all fabrics
4. Moiereing - Produces a patterned effect to all fibres except wool
5. Raising (gigging and napping) - lifts fibres ends to form nap for cotton, wool and spun yarn

Thus, fibre processing undergoes many processes leading to a finished yarn of textile fibre and a refined cloth with greater tenacity, lustre and elasticity. These processes result in value-added, user-friendly textile products, reasonably amenable to dyeing and designing of fabrics. The functionality, durability and sustainability of textile fibres have been duly enhanced in recent years by the application of nanotechnology in the textile industry. Automation has enhanced these processes and shaped the emerging textile industry.

These processes have been meticulously dealt with in classic books like 'Textiles' by J. F. Parker and 'Textile Fibres' by Mathews.

In a nutshell, fibre processing plays a pivotal role in the making of a usable textile fibre.

(The views expressed in this column are of the author and not that of Cotton Association of India)
