

**MERCERIZING**, the term applied to a process, discovered in 1844 by John Mercer, a Lancashire calico printer, which consists in treating cotton (and to a limited extent other plant fibres) with strong caustic soda or certain other reagents, whereby morphological and chemical changes are brought about in the fibre. Thus, if a piece of bleached calico be immersed in caustic soda of 50° Tw. strength (sp. gr. 1.25), it rapidly changes in appearance, becoming stiff and translucent, but when taken out and well washed in running water it loses these properties and apparently reverts to its original condition. On closer examination, however, the fabric is found to have shrunk considerably both in length and breadth, so as to render the texture quite different in appearance to that of the original calico; it is also considerably stronger, and if dyed in the same bath along with some of the untreated fabric is found to have acquired a greatly increased affinity for colouring matters. This peculiar action is not restricted to caustic soda, similar effects being obtained with sulphuric acid of 105° Tw., nitric acid of 83° Tw., zinc chloride solution of 145° Tw., and other reagents. Mercer assumed that a definite compound, corresponding to the formula  $C_{12}H_{20}O_{10}.Na_2O$  is formed when the cotton is steeped in caustic soda, and that this is decomposed by subsequent washing with water into a hydrated cellulose  $C_{12}H_{20}O_{10}.H_2O$ , which would account for the fact that in the air-dried condition mercerized cotton retains about 5% more hygroscopic moisture than ordinary cotton. This view is strengthened by the observation that when cotton is immersed in nitric acid of 83° Tw. it acquires similar properties to cotton treated with caustic soda. If, after immersion in the nitric acid, it is squeezed and then dried (without washing) in a vacuum over burnt lime, it is found to have formed a compound which corresponds approximately to the formula  $C_6H_{10}O_5.HNO_3$ , which is decomposed by water into free nitric acid and a hydrated cellulose.

When viewed under the microscope, mercerized cotton is seen to have undergone considerable morphological changes, inasmuch as the lumen or central cavity is much reduced in size, while the fibre has lost its characteristic band-shaped appearance and becomes rounded.

In Mercer's time the process, which he himself termed "sodaizing" or "fulling," never acquired any degree of com-

mercial success, partly on account of the expense of the caustic soda required, but mainly on account of the great shrinkage (20 to 25%) which took place in the cloth. An important application of the process in calico printing for the production of permanent crimp or "crépon" effects, which was originally devised by Mercer, was revived in 1890-1891 and is still largely practised by calico printers (see TEXTILE PRINTING). Another application, also dependent upon the shrinking action of caustic soda on cotton, was patented in 1884 by Depouilly, and has for its object the production of crimp effects on piece-goods consisting of wool and cotton or silk and cotton. In the manufacture of such goods cotton binding threads are introduced at definite intervals in the warp or weft, or both, and the piece is passed through cold caustic soda, washed, passed through dilute sulphuric acid, and washed again till neutral. The cotton contracts under the influence of the caustic soda, while both wool and silk remain unaffected, and the desired crimped or puckered effect is thus obtained.

By far the most important application of the mercerizing process is that by which a permanent lustre is imparted to cotton goods; this was discovered in 1889 by H. A. Lowe, who took out a patent for his process in that year, this being supplemented by a further patent in 1890. Since Lowe's invention did not receive sufficient encouragement, he allowed his patents to lapse and the process thus became public property. It was not until 1895, when Messrs Thomas & Prevoist repatented Lowe's invention, that actual interest was aroused in the new product and the process became a practical success. Their patent was subsequently annulled on the ground of having been anticipated.

The production of a permanent lustre on cotton by mercerizing is in principle a very simple process, and may be effected in two ways. According to the first method, the cotton is treated in a stretched condition with strong caustic soda, and is then washed, while still stretched, in water. After the washing has been continued for a short time the tension relaxes, and it is then found that the cotton has acquired a permanent lustre or gloss similar in appearance to that of a spun silk though not so pronounced. According to the second method, which constitutes but a slight modification of the first, the cotton is immersed in caustic soda of the strength required for mercerizing, and is then taken out, stretched slightly beyond its original length, and then washed until the tension slackens.

Not all classes of cotton are equally suited for being mercerized. Thus, in the case of yarns the most brilliant lustre is always obtained on twofold or multifold yarns spun from long-stapled cotton (Egyptian or Sea Island). Single yarns made from the same quality of cotton are only slightly improved in appearance by the process, and are consequently seldom mercerized; and the same applies to twofold yarns made from ordinary American cotton. In piece-goods, long-stapled cotton also gives the best results, but it is not necessary that the yarn used for weaving should be twofold. In the great majority of cases, the mercerizing of cotton, whether it be in the yarn or in the piece, is done before bleaching, but sometimes it is found preferable to mercerize after bleaching, or even after bleaching and dyeing. The strength of the caustic soda employed in practice is generally between 55° and 60° Tw. The temperature of the caustic soda has a material influence on its action on the cotton fibre, very much stronger solutions being required to produce the same effect at elevated temperatures than at the ordinary temperature, while, on the contrary, by lowering the temperature it is possible to obtain a good lustre with considerably weaker lyes.

Cotton yarn may be mercerized either in the hank or in the warp, and a great number of machines have been patented and constructed for the purpose. The simplest form of machine for hanks consists essentially of two superposed strong steel rollers, on which the hanks are placed and spread out evenly. The upper roller, the bearings of which run in a slotted groove, is then raised by mechanical means until the hanks are taut. Caustic soda of 60° Tw. is now applied, and the upper roller is caused to revolve slowly, the hanks acting as a belt and causing the lower roller to revolve simultaneously. After about three minutes the caustic soda is allowed to drain off and the hanks are washed by spurt pipes until they slacken, when they are taken off and rinsed, first in dilute sulphuric acid (to neutralize the alkali and facilitate washing), and then in water till neutral. The hanks are then bleached in the ordinary way and may be subsequently dyed, no diminution being brought about in the lustre by these operations. Cotton warps are usually mercerized on a machine similar in construction to a four box dyeing machine (see DYEING), but with the guiding rollers and their bearings of stronger construction and the squeezers at each end of the first box with a double nip (three rollers). The first box contains caustic soda, the second water, the third dilute sulphuric acid, and the fourth water.

For the continuous mercerizing of cotton in the piece much more complicated and expensive machinery is required than for yarn, since it is necessary to prevent contraction in both length and breadth. The mercerizing range in most common use for pieces is constructed on the same principle as the stentering machine used in stretching pieces after bleaching, dyeing or printing, and consists essentially of two endless chains carried at either end by sprocket wheels. The chains carry clips which run in slotted grooves in the horizontal frame of the machine, which is about 40 ft. in length. The clips close automatically and grip the cloth on either side as it is fed on to the machine from the mangle, in which it has been saturated with caustic soda. The stretching of the piece begins immediately on entering the machine, the two rows of clips being caused to diverge by setting the slotted grooves in such a manner that when the piece has travelled about one-third of the length of the machine it is stretched slightly beyond its original width. At this point the piece meets with a spray of water, which is thrown on by means of spurt pipes; and in consequence the tension slackens and the mercerizing is effected. When the piece arrives at the end of the machine the clips open automatically and release it. Thence it passes through a box containing dilute sulphuric acid, and then through a second box where washing with water is effected.

In most large works the caustic soda washings, which were formerly run to waste or were partly used up for bleaching, are evaporated down in multiple effect evaporators to 90° Tw., and the solution is used over again for mercerizing.

Cotton mercerized under tension has not as much affinity for colouring matters as cotton mercerized without tension, and although the amount of hygroscopic moisture which it retains in the air-dried condition is greater than in the case of ordinary untreated cotton, it is not so great as that held by cotton which has been mercerized without tension. By drying cotton which has been mercerized with or without tension at temperatures above 100° C. its affinity for colouring matters is materially decreased.

The cause of the lustre produced by mercerizing has been variously explained, and in some cases antagonistic views have been expressed on the subject. When viewed under the microscope by reflected light, the irregularly twisted band-shaped cotton fibre is seen to exhibit a strong lustre at those points from which the light is reflected from the surface. Cotton mercerized without tension shows a similar appearance. In the yarn or piece the lustre is not apparent, because the innumerable reflecting surfaces disperse the light in all directions. If, however, the cotton has been mercerized under tension, being plastic while still containing the caustic soda, it is stretched and is set in this condition by the washing. Thus in the finished product a large proportion of the rounded fibres are laid parallel to each other, as in the case of spun silk, and the lustre inherent to the fibre becomes visible to the naked eye.

See *The Life and Labours of John Mercer*, by E. A. Parnell (Longmans Green & Co); *Die Mercerisation der Baumwolle*, by Paul Gardner (Julius Springer, Berlin); *Mercerisation*, by the editors of *The Dyer and Calico Printer* (Heywood & Co.). (E. K.)