New Values in Mercerizing Cotton

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Mercerization gives cotton a high luster, makes it easier to dye, and produces brighter and fuller shades. Although it tends also to increase strength, it is essentially a process to improve the appearance of cotton.

Mercerization under somewhat unusual and controlled conditions can bring out properties in cotton not yet developed to any extent commercially. Some of these—greater retention of high strength under conditions of dryness, improved resistance to high temperature or long heating, increased flex life, and unusual elastic properties, for example—will better adapt cotton for knitted and woven goods in which such properties are especially important.

Two types of cotton products, each developed far enough so that patents have been granted, exemplify the new possibilities of mercerization. One of them utilizes the added heat resistance of treated yarn; it is illustrated by its application in tire cord. The other utilizes the special elastic properties of treated cloth, illustrated by a semielastic surgical gauze.

The process of mercerization was discovered about a hundred years ago by John Mercer when he was filtering a caustic soda solution through cotton cloth. He observed that the cloth shrunk and puckered and acquired a closed, or fulled, appearance. His idea that he had a fulled cotton came from a similarity to the hardening, or felt-

ing, of some wool goods by fulling. Mercer obtained a patent, but he could not follow up his invention because caustic soda had not then been made commercially. There have since been numerous efforts to make a woollike cotton by such processes; and, while there has been no great success, the possibility is still intriguing. About 40 years later the method of producing luster as an effect of tension was disclosed in a patent issued to Horace Lowe. Mercer never saw any of the lustrous cotton because it was not made until 25 years after his death.

While the cotton-finishing trade has associated the term "mercerization" almost exclusively with luster, the name has come into general use as meaning any kind of treatment of cotton with caustic strong enough to swell or shrink it—a good enough usage, because that was the original meaning before luster was first observed.

The distinctive feature of ordinary mercerization is the application of tension to keep the cotton from shrinking. Caustic alkali causes cotton fibers to swell greatly if unrestrained and to shrink in length. If the alkali-swollen and shrunken fibers are constituent parts of yarn or cloth, the swelling causes the structures to shrink, too. But if the material is stretched back to its original dimensions by tension, the fibers become smooth; if the alkali is washed out while the material is still under tension, the fibers become lustrous.

The effect is also about the same if the yarn or cloth is held at its original length and prevented from shrinking during the treatment. The swelling of the restrained fibers develops high tension within the goods, and they are actually mercerized with tension, although no stretching force is applied.

Mercerization without tension—
that is, with more or less shrinkage—has been known longest. Although relatively little has been done with it in a practical way, it has possibilities that seem not to be appreciated fully. Cotton mercerized without tension differs from cotton as ordinarily mercerized (with tension) in that it has no appreciable added luster and undergoes no noticeable net change of strength, although it yields a much darker color than ordinary mercerized cotton when the two are dyed at the same time in the same bath. Yarn and cloth mercerized without tension may also assume new properties or may display old properties to a greater degree if the yarn and fabric are suitably selected for the treatment and the process is properly carried out.

The main clue leading to the study of mercerized cotton for greater heat resistance was the claim that rayon tire cord is more resistant to heat than cotton cord. Because the usual regenerated type of rayon consists of mercerized cellulose (the same type of cellulose that results from the mercerization of cotton), it was natural to test the heat resistance of the latter. Two other discoveries had claimed heat resistance for mercerized cotton, but presented rather indefinite evidence because their data had to do with breaking while dry after a moderate amount of heating, rather than with severe tests to heat.

Because the main interest at the time was tire cord, most of the work was done on yarn and cord. It was found that several changes from the ordinary yarn-mercerizing procedure would improve the strength when the yarns, or the cords made from them, were evaluated by heat tests intended to predict the behavior of the cords in tire service. Specifically, low yarn twist favors a high degree of swelling and complete mercerization; for best results the yarn must be allowed to shrink while in the caustic soda. Finally, traces of acid must not be present.

In any mercerization it is difficult to remove the caustic soda by simple washing with water, so the last of the caustic is frequently removed by treating the goods with dilute sulfuric acid. The acid, in turn, is difficult to wash out; if ordinary raw (gray) cotton is being mercerized, the "souring" with acid means that some of the noncellulose constituents (usually considered impurities) are left in the cotton as insoluble, or difficultly soluble, acids. The acids apparently derive from the consecutive actions of the caustic and the sulfuric acid. Consequently, the use of acid is avoided, either by thorough washing or by using a small amount of sodium bicarbonate, which will neutralize either acid or alkali, so that there will be no acid residues in the yarn to cause degradation during tests or while in service.

The effects of mercerization and of variations in the process are shown by the results of tests for strength after heating for 15 days at 130° C. (266° F.) in an oven with air present, in comparison with similar unmercerized samples. Mercerized yarn neutralized with sulfuric acid retained 46 percent of its strength; that neutralized with sodium bicarbonate, 59 percent; and that neutralized with various alkalis, 58 to 70 percent. Untreated gray yarn retained 45 percent and 41 to 45 percent when small amounts of alkali were present.

The specially mercerized yarn, if neutralized with sulfuric acid, had no greater heat resistance than the ordinary gray yarn. Various treatments with alkalis, which left small amounts in the yarn, made no improvement in the unmercerized, but caused appreciably better retention of strength in the mercerized.

Although the type of test made on yarn—heating with full exposure to the atmosphere—is of less interest for tire cord, which is used tightly enclosed in rubber with relatively little chance for oxidation by the air, similar tests were made on the tire cord, subject to interpretation for other uses. Two commercial-type unmercerized cotton tire cords retained 51 to 62 percent
strength, while the special mercerized cord retained 70 percent, after the 15 days of heating. The mercerized cord still had half its strength after 32 days, while the regular-type cords were down to 40 percent. The mercerized cord thus had one-fourth to one-third greater strength after exposure to heat, an increase which might be very significant for some uses of cord, as for reinforcement for conveyor or driving belts subject to unusual exposure to heat.

To make the best heat-resistant cord prepared so far from mercerized cotton, the singles yarn has been mercerized while being allowed to shrink freely by about 15 percent. At that point it is sufficiently slack to be drawn back 5 or 10 percent to recover part of its original length without any real stretch, the natural objection to the shrinkage being nearly overcome. The moderate pulling-back here, plus the usual tensions in subsequent winding and plying into cord, results in the recovery of the larger proportion of the loss of length in the original shrinking.

If the yarn starts with a low to moderate twist, preferably about the minimum with which it can be spun efficiently, and is finished without any free acidity, it will be most suitable for making a heat-resisting cord. For tire cord the yarn is given an intermediate plying and is then plied again to the full size required; the cord is submitted to some form of wet stretching to make it smaller in diameter, more compact, and stronger.

Tires, especially tires in heavy truck and bus service, frequently run very hot, sometimes up to the temperature of boiling water or higher. A cord, consequently, should be strong to withstand the air pressure in the tire and road shocks. It should retain its strength to withstand those forces while it is hot. It must also withstand an almost infinite amount of flexing as the tire flattens and recovers its shape continuously while running in contact with the road.

Because the cord embedded in a rubber tire tends to dry out and stay dry while running, cords are tested dry as a better basis of comparison than when containing their natural moisture. The usual result has been that the mercerized cord has normal strength and retains its full strength when dried, while comparative unmercerized cords drop at least 5 or 10 percent. But the improvement is still more striking when cords are heated quickly (within 5 minutes) and tested hot. At 130° C. (266° F.)—a somewhat higher temperature than that reached in most tires, but lower than those reached under extreme conditions—the mercerized cord drops 15 or 20 percent in strength, while the unmercerized cord loses 30 or 35 percent, almost twice as much.

The real test for tires is in running, but before that the cord is submitted to preliminary tests—fatigue or flex tests—to help select the best cords before making the more expensive and time-consuming tests under service conditions. On the Karrer-Grant flexing machine, developed at the Southern Laboratory, striking results were obtained with cords at 120° C. (248° F.). Ordinary cotton cord withstood 3,006 flexures; commercially mercerized cord, 3,143; cord with special mercerizing but with the usual acid treatment, 5,159; and specially mercerized cord without the acid treatment, 8,124. The specially mercerized cord withstood far more flexing than the unmercerized or the ordinary commercially mercerized. The cord made without the use of acid was better yet.

During the research, attempts have been made to obtain the same results in some simpler manner, but, despite many mercerizations and many tests on both yarn and cord, the best heat resistance has been obtained by the method I indicated. The process was granted a patent.

When the fibers in cotton cloth swell during mercerization without tension, they do not swell lengthwise, but outwardly in every other direction. Because the fibers are spiral structures, they tend to shorten as they increase in diameter. Similarly, since the yarn of
which they are constituents is twisted so that the fibers spiral within it, it also tends to shrink in length as the fibers swell in diameter. Finally, when the yarns in a piece of cloth tend to become greater in diameter as they shrink, they need to be longer in order to crimp over each other in the cloth. Because so many factors tend to make them shorter instead of longer, the whole piece of cloth shrinks.

After the caustic soda is washed out and the cloth has dried (if it has not been pulled or stretched too much during the operations while wet) it will be stretchy, because the structure will be loose and open after the swelling has gone down with the removal of the caustic. When a piece of surgical gauze is treated in that way, it is left with numerous crimps and kinks. If it is stretched moderately, it will come back elastically to approximately its original size as crimps and kinks tend to return to their original positions. If it is allowed to shrink in only one direction and restrained from shrinking the other way of the piece, the gauze is converted into a fabric with a high degree of stretchability and of considerable true elasticity in the one direction and relatively little in the other. Such fabrics should find special uses. A patent has been obtained on this type of product.

A similar product, which, however, has stretchability and elastic recovery in both directions, has aroused interest for use as a semiclastic gauze bandage. It also has been patented. A number of physicians and surgeons have tried it, and 30,000 unit strips were used in a test at the United States Naval Hospital in New Orleans during the war. It was reported consistently as meeting needs that other bandages do not.

This type of cotton bandage can be readily made on a small scale by allowing bleached $20 \times 12$ surgical gauze to shrink completely in 20 percent caustic soda, draining and washing with a few changes of water, and then neutralizing with dilute acetic acid, washing a little more, and spreading out to dry, all without stretching the gauze. It can then be readily cut up in strips— for trial as bandage, after sterilizing.

Among the properties that make the bandage successful is its moderate amount of stretch or give while it is being applied, so that it can be made to exert moderate pressure. Its stretchability and elastic properties make the bandage somewhat self-fitting and self-tightening. The high degree of crimping in the fabric gives it a nonslip surface, so that it stays in place readily, rather than tending to slip or loosen.

Those who have used the bandage professionally report its superior ability “to conform to the contours of the body and to remain in place—ideal for securing splints of all types.” For example, it is satisfactory for binding plaster splints and does not add appreciable weight to them. It is unusually suitable for pressure dressings, including those for burns, varicosities, and skin grafts. The bandage is especially useful about joints, because it will stay in place without slipping, it will exert pressure even after moderate swelling has subsided, and its elasticity and clinging power enable it to stay in place even when a patient is encouraged to use a bandaged joint. While it was available to the Naval Hospital in New Orleans it supplanted all other bandages for securing dressings about freshly operated joints. Some surgeons at the hospital found it particularly useful for head bandages.

The study of applications of semiclastic fabrics prepared by mercerization has been limited so far to their uses as bandages. Such fabrics, however, are suggested for consideration where there is need for conformability to moderately irregular surfaces, for any use where a large amount of irrecoverable stretch is desirable (to take up some sort of shock in an emergency, for instance), and for a material in which low true elasticity is needed.

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