CHAPTER 5

OTHER PROCESSES

I. MERCERIZING

Both Mercerizing and causticizing require cotton to be treated with concentrated solutions of sodium hydroxide (caustic soda). Mercerization requires higher concentrations of caustic soda (19 to 26 % solutions) whereas causticizing is done with concentrations ranging between 10 to 16 %. Both procedures are effective in completing the removal of motes that may have escaped the scouring and bleaching steps. One major difference between the two is that causticizing improves the dyeing uniformity and dye affinity of cotton without improving luster. Caustic soda solution swells cotton fibers breaking hydrogen bonds and weak van der Waal forces between cellulose chains. The expanded, freed chains rearrange and re-orient and when the caustic soda is removed, the chains form new bonds in the reorganized state. When done tensionless, the cotton fiber swells, the cross section becomes thicker and the length is shortened. Because of fiber thickening, the fabric becomes denser, stronger and more elastic. Held under tension, the coiled shape of the fiber is straightened and the characteristic lumen almost disappears. The fibers become permanently round and rod like in cross section and the fiber surface is smoother. Decrease in surface area reduces light scattering, adding to fiber luster. Tension increases alignment of cellulose chains which results in more uniform reflection of light. The strength of the fiber is increased about 35 %. The fiber also becomes more absorbent. The cellulose crystal unit cell changes from cellulose I to cellulose II and the amorphous area becomes more open, therefore more accessible to water, dyes and chemicals. Mercerized cotton will absorb more dye than unmercerized cotton and in addition, yields an increase in color value a given quantity of dye.

The amount of fiber shrinkage is a measure of the effectiveness of caustic soda's ability to swell cotton. Table 11 summarizes the correlation between time, temperature and caustic concentration with fiber shrinkage. The data shows that maximum shrinkage occurs with the 24% solution and that most of the shrinkage occurs in the first minute of dwell time. Higher temperatures result in less shrinkage because lower temperatures favor swelling.

Table 11

Effect of Time, Temperature, and Caustic Concentration on Yarn Shrinkage

% **Yarn Shrinkage**

	Conc. NaOH											
	10%			19%			24%			29%		
Time (min.)	1	10	30	1	10	30	1	10	30	1	10	30
64° F	12	15	17	19	20	21	23	23	23	23	23	23
86° F	5	5	6	19	20	20	20	20	20	21	21	20

A. Chain Mercerizing

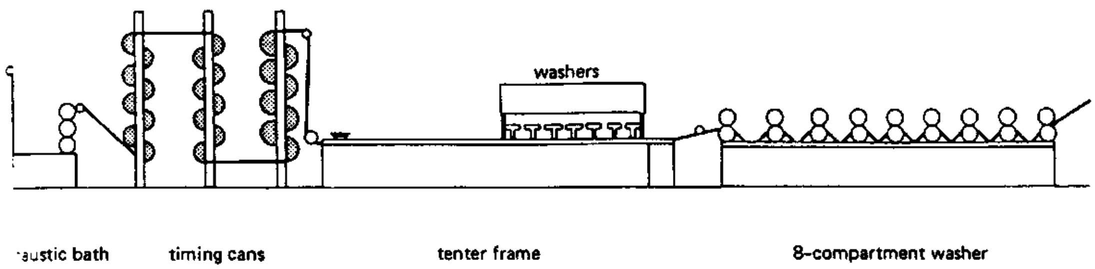
Chain mercerizing is done on a range equipped with tenter chains for tension control. The range consists of a pad mangle followed by a set of timing cans and then a clip tenter frame. Fresh water cascades onto the fabric to remove the caustic soda as it is held tensioned in the tenter frame, . The length of the frame must match the range speed and assure that the caustic level is reduced below 3% before tensions are released. The tenter frame is followed by a series of open-width wash boxes which further reduces the caustic level. Acetic acid is in one of the last boxes to complete the neutralization of caustic.

1. Procedure

1. Apply 22 to 25 % (48 - 54" Tw) caustic at the pad mangle at 100 wet pickup. 2. Pass fabric over timing cans. The number of cans must correspond to the range speed and provide at least one minute dwell time. 3. Clip fabric onto tenter chains and stretch filling-wise while maintaining warp tension. 4. Run fabric under cascade washers to remove caustic. Keep under tension until caustic level is less than 3% otherwise fabric will shrink in filling direction. This width loss is impossible to recover later. 5. Release tension and continue washing in open-width wash boxes, to further reduce the caustic. 6. Neutralize with acetic acid in the next to last wash box and rinse with fresh water in the last. It is important to control these steps because

it is important, in down-stream processing, that the alkalinity remain consistent throughout all production.

Figure 29. Chain Mercerizing Range



2. Points of Concern and Control

For best results, goods should be dry entering the liquid caustic impregnation unit. Need to get uniform and even caustic pick-up through out the fabric. Wet pick-up must be at least 100 %. A certain amount of liquid caustic must surround each fiber to provide proper lubrication so that the fibers can be deformed. For piece goods, a caustic concentration between 48 - 54^0 Tw should be maintained. Caustic stronger than 54^0 Tw does not add to Mercerized properties whereas below 48^0 Tw, the Mercerized fabric will have poor luster and appearance. Caustic solution and impregnated fabric temperatures should be controlled between 70 - 100^0 F. Above 110^0 F, there is a noticeable decrease in luster of the Mercerized goods. Below 70^0 F, there is no noticeable improvement. Proper framing during the washing step is crucial. The goods must be maintained at greige width to one inch over greige for maximum luster. The tensioned width must be maintained through out the caustic removal operations otherwise the fabric shrinks and luster is lost. If optimum washing is obtained. there will be only a slight loss in width as the goods come off the tenter clips.

B. Caustic Concentration Units

Caustic concentrations, expressed as percentages, are ratios calculated as weight caustic/weight solution. However the specific gravity or density of the solution (weight/volume) is directly related to the concentration. Calibrated hydrometers are used to determine specific gravity. The calibration scales most often used on caustic solutions are Twaddle (“Tw) and Baume’ (“Be’). The relationships between concentration and hydrometer readings are:

- °Tw equals 2.15 x [conc. %]
- °Be' approximates [conc. %]

The relationship between the Baume’ scale and concentration is not linear, the values get closer at higher concentrations. The reader is referred to various handbooks and manuals that have conversion tables.

C. Test for Mercerization

1. Barium Number

AATCC Test Method 89 is a common test used for quantifying the degree of Mercerization. It is based on the fabric‘s ability to absorb barium hydroxide. A two gram swatch of fabric is placed in a flask containing 30 ml of a standardized 0.25 N barium hydroxide solution. The fabric is stirred for two hours (to allow the barium hydroxide to be absorbed by the fabric). A 10 ml aliquot is withdrawn and titrated with 0.1 N hydrochloric acid to a phenolphthalein end point. The difference between the starting concentration and the remaining concentration of barium hydroxide is the amount absorbed by the fabric. The procedure is carried out on the fabric both before and after Mercerizing and the barium number is calculated as shown below.

$$\text{Ba No.} = \frac{\text{Amt. absorbed by Mercerized}}{\text{Amt. absorbed by unmercerized}} \times 100$$

Unmercerized fabric will give a barium number of 100 to 105. Completely mercerized fabric will give a barium number of 150. Commercially treated fabrics fall in a range between 115 to 130.

D. Mercerizing Fiber Blends

Color yield, ease of dyeing and uniformity of dyed fabric will offset cost of Mercerizing. This holds true even for yarn blends with low levels of cotton. The temptation to Mercerize must tempered with thoughts about how caustic affects the blending fiber. The following section discusses these issues.

1. Polyester/Cotton

These can be handled under the same conditions as 100 % cotton. Even though polyester fibers are sensitive to caustic, the temperature and time the fibers are in contact with Mercerizing strength caustic are insufficient to cause fiber damage. One problem with polyester/cotton blends it that they may not be as absorbent as 100 % cotton fabrics coming to the caustic saturator. This is because they have not been given the same thorough scouring and bleaching as 100 % cotton. In this case, special penetrating agents are needed to help the caustic solution wet out the fabric.

2. Cotton/Rayon

Rayon blends pose a number of special problems. Ordinary and high wet modulus viscose rayons are sensitive to caustic solutions. The degree of sensitivity is a function of fiber type and caustic concentration. For example, high wet modulus rayon can withstand caustic better than conventional rayon. Conventional rayon can be dissolved by caustic solutions. High strength caustic solution are less damaging to the high wet modulus rayon than lower strength solutions. Causticizing strength solution will cause the rayon to swell, become stiff and brittle and lose tensile strength. These conditions should be avoided. Fortunately, the higher strengths caustic solution are less damaging so conditions for Mercerizing 100 % cotton can be used. Special penetrants are also helpful in speeding up the wetting-out process to keep the time rayon is exposed to caustic to a minimum. If conditions are not correct, the damage may be so severe' that the rayon is dissolved.

E. Yarn Mercerizing

Yarns are Mercerized as continuous sheets in a fashion similar to woven fabrics. Greige yarns enter the caustic saturator and are held so they do not shrink until the caustic has been washed out. Afterwards, the yarns are dried continuously and wound onto bobbins or spools. These conditions will develop satisfactory luster, elasticity and dyeing properties; however, if higher luster and strength is desired, the yarns should be stretched beyond the greige length during the process. Increase stretch, however, reduces dye affinity and elasticity. The reasons for mercerizing yarns are: 1. To produce lustrous, strong 100 % cotton sewing thread. 2. To produce yarns for constructions that are difficult to mercerize. 3. To produce yarns for special construction effects. 4. To produce yarns for blends containing fibers too sensitive for mercerizing. 4. To provide more complete mercerization for luster and strength.

F. Chainless Mercerizing

Chainless mercerizing is practiced on a range where the cloth is maintained in contact with rotating drums virtually throughout the entire process. The tension on the fabric depends on the friction between the cloth and the surface of the drum.

This results in good control of length but limited control of width. Bowed rollers are sometimes used to stretch the width but they are much less effective when compared with the clips of the chain Mercerizer. Chainless Mercerizing is used on fabrics that cannot be handled on a clip frame such as knits. Specialized equipment has been developed for Mercerizing tubular knit goods. One arrangement is based on a spreader mechanism that resembles a floating cigar. In the USA, very little if any knit goods Mercerization is in evidence. There are some knit goods made from mercerized yarns, however.

II. SINGEING

The object of singeing is to remove projecting fibers from the surface of the fabric so as to give it a smoother, cleaner appearance. The most common singer is a row of gas burners arranged so that the material passes rapidly through the open flame. The speed of the cloth travel is adjusted to burn away the hairs without scorching the fabric. In a normal sequence of operations, the singed fabric passes directly into a quench bath that contain the desizing chemicals to douse any fuzz ball that might have been ignited. Most singers are arranged so the fabric is routed around a steel roller at the point where the flame impinges on it. This opens up the fabric to make the projecting hairs more accessible to the flame. The steel roller absorbs heat from the flame and eventually becomes hot enough to melt most thermoplastic fibers. Modern singers are designed so that chilled water passes through the rolls to keep them cool. While singeing is a simple process, care must be taken to not damage the fabric.

A. Points of Control

The fabric must move rapidly through the flame to prevent the base fabric from being heat damaged. Extremely hairy fabric may require multiple passes through the burners to remove the hairs without damaging the fabric. All the gas burners must produce a uniform flame. Clogged burners will leave a un-singed streak that will become highly visible when the fabric is dyed. The singer must be provided with a mechanism that either turns off the flame or mechanically displaces the burners away from the fabric when the line speed is decreased for any reason. If not, the fabric will scorch or burn in half. Fabrics containing thermoplastic fibers such as polyester can form hard melt balls as the fiber melts and recedes away from the heat source, These melt balls will cause the fabric to have a rough raspy hand. The fabric may require a subsequent processing step to remove the melt balls.

III. CARBONIZING OF WOOL

The purpose of carbonizing wool is to complete the removal of cellulosic impurities which is imbedded in the sheep's fleece from the animal contact with burrs, leaves and plant stems. Some of this matter will end up in the fabric having persisted through raw stock scouring and mechanical cleaning. The cellulosic matter will not dye with wool dyes so dyed fabric will have undyed specks throughout. Complete removal of this plant matter can only be effected by carbonization which is based on cellulose being degraded by strong acids at high temperatures into brittle hydrocellulose with partial conversion to dark decomposition products (carbon). Wool is not fazed by these conditions. The process involves soaking fabric in 5 -7 % sulfuric acid for 2 to 3 hours, extracting the excess acid solution, drying and baking the fabric for one hour at 100^0 C. The carbonized fabric is passed between fluted rollers which crush the embrittled vegetable matter and then through a machine which shakes the crushed matter out of the fabric. Finally the fabric is neutralized with soda ash and washed to remove all vestiges of acid.

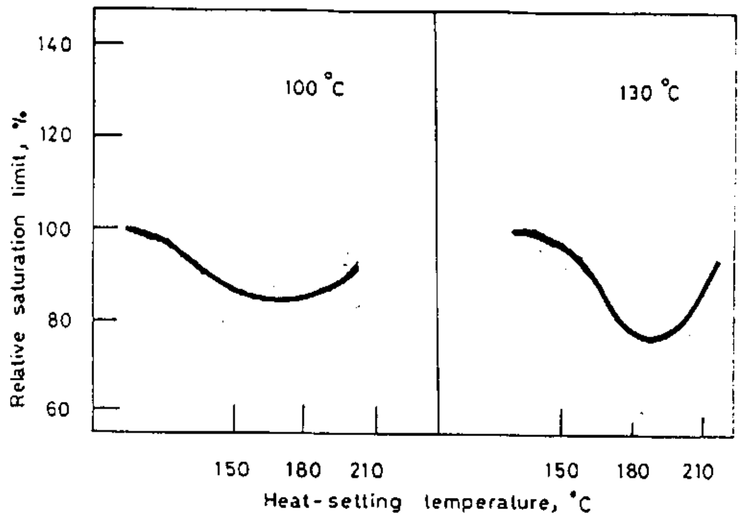
IV. HEATSETTING

The purpose of heat setting is to dimensionally stabilize fabrics containing thermoplastic fibers. Polyester and nylon are the principal fibers involved. Blended polyester/cotton fabrics are produced in large quantities. These fabrics may shrink, or otherwise become distorted either during wet processing or in the consumer's hands. Heat setting is a way of reducing or eliminating these undesirable properties. The process is relatively simple - pass the fabric through a heating zone for a time and at a temperature that resets the thermoplastic fiber's morphology memory. The new memory relieves the stresses and strains imparted to the fiber by the yarn-making and weaving processes, and makes stable the configuration it finds itself in flat smooth fabric. This newly imparted memory allows the fiber to resist fabric distorting forces and provides a way to recover from them. The time and temperature needed for the heat treatment depend on fabric density and previous heat history of the polyester. Time and temperature must exceed that imparted by previous heat treatments. Usually 15 - 90 seconds at temperatures of 385 - 415^0 F. will suffice. The heat setting equipment can be hot air in a tenter frame, or surface contact heat from hot cans. While the process is simple, careful control is required.

A. Points of Concern

Heat setting reduces polyester's dye up take. Heat-set goods dye lighter and slower than non heat-set good. For uniform shades, side to center, front to back and beginning to end exposure to heat must be controlled and uniform, otherwise these differences will show up in the dyed cloth. Heat-setting can be done either at the end of wet processing or at the beginning. At either point, the goods must be free of wrinkles and other distortions otherwise the distortions will be permanently set. Care must be taken when heat-setting greige goods sized with polyvinyl alcohol. At high temperatures, PVA will dehydrate, becoming discolored and insoluble in water. While greige heat-setting may be particularly beneficial when preparing easily distorted fabrics, one may have to settle for less than the full heat-setting benefit in order to still remove the size. For these cases, alternate mechanical handling preparation equipment may be the answer. Heat-setting harshen the hand and stiffens the fabric. The condition is more prone to happen when contact heat is used. The fabric may become flatter and develop an unwanted gloss or sheen.

Figure 30. Effect of Heat-setting on Dye Uptake



V. REFERENCES