Effect of heat on mercerizing

by M. Aslam Khan

Mercerization is defined as a physio chemical process, in which caustic soda reacts with the Cellulose and form Cellulose I at first stage and Cellulose II at 2nd stage. This is suggested that these two compounds are formed at concentrations i.e. 12.5g / 100g of Cellulose alkali Cellulose I ($C_6H_{10}O_5$) NaOH is formed. John Mercer discovered the process of mercerization in 1844.

Since the beginning of the sixties, mercerization with hot caustic soda at a temperature between 60ºC to 70ºC has become known as hot mercerization. Kusters developed the process especially for hot mercerization, and offers a number of process-technical advantages compared to the classical cold mercerization. In classical cold mercerizing, processing takes place at temperatures of 12ºC to15ºC. At that range cotton swells best but also fastest. This fast swelling increases the outer edge density of the fibre also rather swiftly. This hinders the penetration of the lye into the core. The high viscosity of the cold caustic soda additionally hinders penetration into the core. This results in poor mercerization of the core. To increase penetration into the fibre, wetting agents are necessary. These have to be extremely resistant to alkali and are expensive. In addition, the effluent load is considerable and ecologically critical.

In hot mercerizing, with caustic soda at 60ºC, the cotton swells more slowly. The outer edge density of the cotton fibre does not increased as fast as in cold mercerizing and therefore penetration into the core is easier and improves core mercerization. Due to the higher temperature and its higher diffusion into the core the dwell time of the material in the mercerizing section can be reduced from 50 s (cold) to 20 s (hot). In other words, the mercerizing installation for the same production speed is shorter than the one based on cold mercerizing.

Properties

The mercerization imparts the following properties:

a. Enhanced luster.
b. Greater power of absorption for dyes (the affinity as such is not increased, but the cotton undergoes a physio-chemical modification which facilitates dye diffusion on to the fibre).
c. Improved dimensional stability.
d. Increased density giving the fabric a more compact appearance.
e. Coverage of immature and dead Cotton.
f. Shrinkage in the length of yarn or the area of cloth.
g. Increase in tensile strength.
h. Preferential absorption of NaOH during the process.
i. Increased water absorption.

Conditions: Hot mercerization

Caustic concentration Beº	28 – 30º
Temperature	60ºC
Time duration	20-40 seconds.
Tension	adequate

Effect of heat

The reaction between the cellulose fibre and the alkaline solution is an exothermic reaction, and any increase in the treatment temperature reduces the absorption of the alkali, thus reducing the effectiveness of the mercerization. Furthermore, if an increase in the concentration of the alkaline solution is done to counteract the reduced absorption, then the same effects from the mercerization will not necessarily be successful.

A cotton yarn treated with a wide range of alkaline concentrations and processing temperatures was analyzed with X-ray diffraction, the results obtained were divided into the three divisions of complete mercerization, partial mercerization and un-mercerized and presented as graph (See figure 1) showing the relationship between the alkaline concentration and temperature.

According to these results, regardless of the increase in the concentration of the alkali over 60ºC, the complete mercerization does not take place. The concentration should be around 30ºBe in mercerization at room temperature of around 20ºC is in the middle of the chart for complete mercerization, and this, interestingly, is fairly consistent with stable conditions determined by experience in practical mercerization and with the results of all researchers.

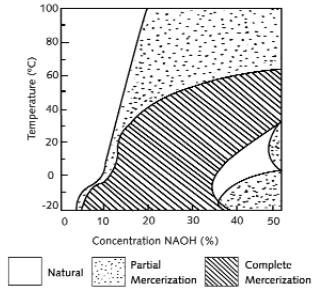

Fig. 1: The temperature and concentration of for the mercerizing of cotton.

For example, these results are consistent with the results of Beltzer, who investigated the relationship between shrinkage and the effects of temperature and alkaline concentration in the mercerization of cotton yarn, and the results show that the concentration of 20ºBe represents a line beyond which behavior during mercerization changes.

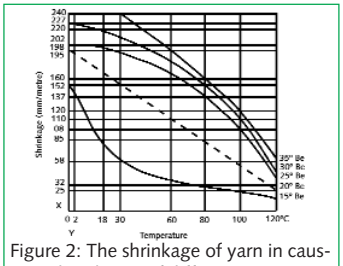

Figure 2: The shrinkage of yarn in caustic soda solution of different temperatures & concentrations.

Similarly, the results of Birtwell, Chblenens et al show that temperature has its greatest influence on the shrinkage of cotton yarn at concentrations of 3NaOH, (approx, 16ºBe), and anything more or less than that, the influence diminishes correspondingly (figure 3).

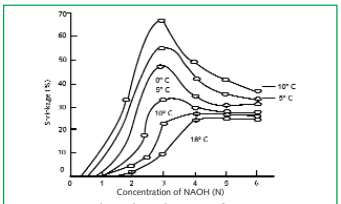

Figure 3: The shrinkage of cotton yarn in NaOH.

H. Flecken, measured the shrinkage of cotton yarn at concentrations of 30ºBe and 38ºBe for temperatures from 0ºC to 40ºC, and reported very small variations for temperatures in the range of 10-30ºC at a concentration of 30ºBe, and this result can also be found in the centre of Sisson's mercerization chart. From the above, it can be seen that in order to conduct stable mercerization, appropriate conditions are those at which the influence of the alkali concentration and the temperature are minimal, that is, those conditions as displayed in the centre of Sisson's mercerization graph. This is obvious from the graph that at low temperature the effect of mercerization is more consistent, however practically it is very difficult to maintain this temperature through out the production.

The mercerization at 60ºC is more consistent and easy to control. The cost of heating at 60ºC is comparatively cheaper than the chiller cost. At this temperature the viscosity of the strong lye is reduced which promotes the penetration into the core of yarn. Arguments have been given on the luster of the yarn, but practically the degree of mercerization and the luster has a negligible difference between hot mercerization and cold mercerization, therefore, the author suggests practicing hot mercerization in production. ◆