Production improvement by targeted mercerization

During the last decades, success or failure in the production of textiles was clearly dictated by the price. Nowadays, however, there is an ever increasing awareness for quality. In this respect, the treatment with sodium hydroxide solutions is an efficient means of increasing the quality of conventional products.

Stephan Kehry
Fong’s Europe GmbH, Schwäbisch Hall/Germany

Already as far back as 1844, John Mercer discovered this process more or less by coincidence instead of empirical testing. When he was filtering a sodium hydroxide solution through a piece of cotton cloth, he noticed changing textile properties. After the curiosity of the hobby chemist had been stimulated (he never attended school and taught himself everything he knew) there was no turning back. He quickly discovered that “cotton fabrics shrink under the influence of sodium hydroxide solution and increase in density and strength and show a higher affinity to dye” [1]. The influence of the fabric tension on the luster of the fabrics was later documented by the British chemist Horace Arthur Lowe in the late 19th century [2].

However, it does not really matter who established this process in the Storm and Stress period of the textile industry. What matters is that all these properties make mercerized fabrics high quality products from which larger turnovers can be achieved. Particularly the luster and feel of the treated fabrics are distinctive characteristics.

Due to the variety of fabrics to be treated which range from densely-woven denim through to lightly-knitted fabric with an open structure – particularly when using the mercerization process, different characteristics must be addressed in detail. Particularly fabric tension and the transport and storage time must be observed, but also concentration and temperature of the applied sodium hydroxide solution play important roles.

Lye treatment vs. mercerization

Classic mercerization is achieved with a NaOH concentration of 28-30 Bé. In this range, the best properties in terms of luster and dimensional stability are achieved. However, already low lye concentrations (15-30 Bé) lead to compression (shrinking) of the fabric and increase its affinity to dye. The special feature: these lye treatment effects can even be achieved without an extensive amount of machinery being required. For this, a conventional Foulard (Fig. 2) is sufficient for the open, wide design required for a cold reaction process at room temperature or a conventional dyeing machine (in this case, however, the seals must be checked for lye resistance) can be used for continuous treatment with up to 65 °C. As reference value, 2–4 hours reaction time for Foulard and 20–60 minutes for continuous treatment are to be observed.

However, the full advantages of lye treatment can only be exploited when applying the full process of mercerization. It is also possible here to choose between cold and hot treatment. For example, the difference between these 2 processes can be seen in the time of the treatment as well as in luster. While the high viscosity of the sodium hydroxide solution leads to almost twice as long fabric impregnation times, particularly at low temperatures, the optical effect (lustre) is unparalleled. In contrast, hot mercerization is clearly faster and thus requires less machinery.

In general, mercerization (cold and hot) is divided into 3 steps:

Fig. 1
Comparison of cotton that was not mercerized (left) and cotton that was mercerized (right)

Fig. 2
Economica foulard for cold reaction lye treatment and continuous lye treatment of knitted fabric
• mercerization (impregnation and reaction)
• stabilization (slow dilution of the NaOH concentration under tension)
• washing and neutralization (alkali removal, particularly from the fiber core).

Mercerization: wet-on-wet or dry-on-wet?
The mercerization does not actually start with the impregnation of the fabric with the sodium hydraulic solution but instead in the step before: It is crucial whether the fabric is dry or wet. While dry fabric can directly be treated with the sodium hydraulic solution, wet fabric has to be moisturized and equally wrung out to prevent irregularities during impregnation. Nevertheless, wet-on-wet mercerization offers certain advantages: Not only can the drying step be left out and the corresponding costs avoided, the process additionally starts with a delay and runs more steadily. This way, the risk of ring mercerization is reduced. The actual impregnation with the sodium hydraulic solution takes 50-60 seconds (cold mercerization) or 30-40 seconds (hot mercerization).

Besides the exchange of water for NaOH, a uniformly low fabric tension is the decisive factor during impregnation. Here, 2 systems can be applied: classical roller impregnation and intensive impregnation with clearance in air.

Classical roller impregnation
During the classical roller impregnation (Fig. 3) the strong lye is continuously pumped into the gap of the supporting roller and applied to the fabric by deflecting it. In this process, the lye is circulated approx. 12-20 times per hour. Grooves in the impregnation rollers prevent the fabric web from shrinking. However, particularly during cold mercerization, this system reaches its limits. The high viscosity of the lye prevents a quick exchange of the fluid. As a consequence, more equipment and time is required to introduce the strong lye reliably into the fiber core.

Intensive impregnation with clearance in air
Perfect cold mercerization can be achieved by combining sections for intensive impregnation with reaction sections (Fig. 4). By means of a maximum contact time, intensive impregnation ensures that the lye even reaches the core of the fibers. In the following clearance in air section, the fabric web is guided by large rollers with a defined low tension. During this, the sodium hydraulic concentrations in the core and edge of the fibers even out. This is the only way to guarantee a uniform lye profile in the fibers. By means of a subsequent second impregnation, strong lye is repeatedly introduced into the fibers. A sophisticated drive system ensures that the fabric tension remains constant during the entire process. The result is a reproducible uniform shrinkage over the entire width of the fabric.

The strong lye is continuously filtered and, for cold mercerization, cooled because the process is exothermic, i.e. energy is released. Furthermore, the temperature is continuously monitored during this process. Older systems still use viscometers that are based on the connection between the viscosity of the lye and its concentration. This, however, has the following disadvantage: In addition to the temperature, the viscosity also changes. Under production conditions that are generally defining the dimensions of the fabric web, stabilization must be carried out evenly over the entire width of the fabric. This process is particularly important for yarn-dyed shirts with longitudinal stripes. Different numbers of threads over the width of the shirt would have an unpleasant effect on the shirt pockets as their appearance would deviate from the rest of the shirt. For this reason, stabilization usually takes place in a tensioning frame. While the fabric is held at the edges, excessive weak lye with approx. 8 Bé ensures that the lye is evenly extracted over the entire width of the fabric (Fig. 5). For densely-woven or heavy products, vacuum beams are additionally applied at the bottom of the fabric in order to ensure complete penetration with weak lye.

Depending on the quality of the fabric, modern mercerization systems offer the choice between pin or clip-tensioning chains in the tensioning frame part. Due to the low tension of the fabric, vertical pin chains are exclusively used for knitted fabric. Due to the high mechanical load, only clip chains may be applied to woven fabric. While the pins break at an excessive load and could thus damage the fabric as well as any downstream squeezing units, the edges of the fabric can be securely fastened by means of clips without leaving permanent marks. The length of the frame depends on the weight of the fabric and the treatment time.

Back staining: problem of the past
By means of the sodium hydroxide solution, a redox potential is generated on the fabric,
re-affixing dissolved dye to dyed fabric (especially denim). This process is referred to as back staining and is particularly unwanted on the inside of denim fabric. The solution to this problem is the application of an intelligent water flow at the end of the stabilization process that is specifically adjusted to the individual requirements of the customers. It can be generally said about the water and lye supply that continuous systems usually use a consistent counterflow to save on as much resources as possible (water, chemicals, energy). This also applies to the last process step, namely the washing and neutralization of the fabric.

Cleaned to the core by time and temperature
The mercerization process is not completed until the fabric is free from alkali. This is tricky, as the lye has even penetrated the fabric core that can only be accessed from the outside with great difficulty. In this respect, the neutralization process is divided into four steps:
1. Rinsing at high washing action
2. Long (diffusion stage) washing at high temperatures
3. Neutralization and
4. Washing out of the salts generated in the process.
To reach the alkali in the core, the weak lye in the outer fiber layer and on the fabric must be completely removed in an initial step. Only this way can a maximum difference in the concentration between core alkali and washing liquid be generated. This process is achieved by high mechanical washing action, e.g. by means of power sprays (Fig. 6). In this process, the washing liquid is applied to the surface of the fabric at a very high tension which directly removes any residual lye on the outside. Preferably, the fabric is proactively heated by simultaneous application of steam (thermal flush) to additionally support the following step, i.e. diffusion. Power spray or thermal flush systems are used for both woven and knitted fabric.
If the difference in concentration within the fiber is sufficient after removing the outer alkali layer, the fabric needs to be given sufficient time for diffusion. This process is positively influenced by high temperatures. Respectively, roller vats with a sufficiently large capacity or an equally high number of drum washing machines for sensitive materials such as knitted fabrics is required in this process to ensure steady diffusion of the core alkali to the outside.
The diffusion processes are not limited in terms of time which means that neutralization is the final step in balancing the concentrations. The remaining alkali is now neutralized with acid or buffer systems. The alkali value is checked on-line by a closed control circuit with a pH meter and the required chemicals are automatically dosed according to the measured data. The following logical conclusion can be drawn from this: The more efficient the previous washing and rinsing processes, the less the amount of chemicals which are required to neutralize the fabric. In the neutralization process, salts are generated which, however, can be easily rinsed out.

Conclusion
Today more than ever, mercerization offers the possibility of increasing the value of textile fabrics thus generating more turnover and even opening up new market segments. To achieve this, an appropriate process must be selected. The various mercerization options offered by Goller ensure that every individual step is optimally accounted for. The more than 70 years of experience of this traditional German brand speaks for itself and is even further reinforced by the company’s interdisciplinary cooperation with the brands Then, Fong’s and Xorella.

References