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SUMMARY OF TEXTILE MANUFACTURING OPERATIONS

UNITED STATES

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WOVEN FABRIC FINISHING PROCESS

DESIZING

The removal of size is typically the first process in a woven-fabric dyeing and finishing plant. The sizing material, whose purpose is to protect the warp yarn from abrasive forces during weaving, is stiff, hard, and not water-absorbent and usually consists of one of the following primary sizing agents: starch, polyvinyl alcohol, carboxymethylcellulose, polyacrylics or polyester-based material. After weaving, this protective coating must be removed from the fabric if effective cleaning, bleaching, dyeing, printing, and finishing are to occur. The method used to remove the size is dependent upon the type of size being removed. For example, polyvinyl alcohol and carboxymethyl cellulose are relatively water-soluble and can usually be removed using hot water ($\approx 180^{\circ}F$) and a suitable surfactant. An oxidizing agent (usually hydrogen peroxide) is sometimes employed in the removal of polyvinyl alcohol. Polyacrylic and polyester-based sizes are soluble in mildly alkaline solutions and are readily removed with a mild alkali and a suitable surfactant. Starch, on the other hand, is not water-soluble and must be converted or broken down into water-soluble compounds with an appropriate enzyme or oxidizing agent (usually hydrogen peroxide). A suitable surfactant is also employed. Depending on the nature of the material and processing conditions, other chemical additions might include chelates, salts, acids or alkalis.

SCOURING

Once the protective surface coating is removed, other impurities must be removed from the fabric by scouring. Scouring is an operation which varies from a simple wet-out with water to a rather drastic boil-off with a strong alkali. The procedure used depends on the fiber, on the needs of the subsequent operations, and on the required properties of the end product. Fabrics constructed of synthetic yarns usually require the removal of the spin finish (applied by the fiber manufacturer) and contaminants introduced during handling. This is usually accomplished with a mild alkali, an appropriate surfactant, and in some cases, a solvent. The type and concentration of chemical used, temperatures, and times depend on the type and conditions of the fiber being scoured. Cotton yarns require the removal of natural unwanted products in addition to contaminants introduced during handling. These natural unwanted products include naturally-occurring fats, oils, and waxes as well as particles of cotton seed, stem, and leaves. The most common method for removing natural fats, oils, and waxes from cotton is to use sodium hydroxide and water to saponify these compounds. An appropriate surfactant (including an emulsifier to aid in removing non-saponifiable material) and chelate are also used. A variety of other chemicals can be utilized to aid scouring including sodium silicate, salts, and solvents.

BLEACHING

Not all fabrics require bleaching. Fabrics to be subsequently dyed black, dark brown, navy, dark grey, or other dark shades can sometimes be prepared without bleaching. In addition, most synthetic fibers are already an excellent white and require little preparation for subsequent dyeing, printing, or finishing. Therefore, the majority of bleaching theory deals with cellulosic fibers. The principal function of a chemical bleach is to decolorize the pigments naturally present into whitened fabric without damaging the cotton. The natural pigments in cotton are chlorophyll, xanthophyll, and carotene which give it a dingy grey color. In general, chemicals used for this purpose are oxidizing agents; however, certain reducing agents could also be used. The choice of oxidizing agent is somewhat restricted by the sensitivity of the fabric raw material to oxidation. Three common oxidizing agents are hydrogen peroxide, sodium hypochlorite, and sodium chlorite. The majority of bleaching operations utilize hydrogen peroxide. Chemicals employed in the hydrogen peroxide bleaching process include sodium silicate or an organic stabilizer (or a combination of the two) to help stabilize the peroxide, sodium hydroxide, various surfactants, chelates, and sometimes sodium carbonate.

As with desizing and scouring, the chemicals used, temperatures, and reaction times vary according to the type and condition of the textile material, the needs of the subsequent operations, and on the required properties of the end product.

Note (continuous vs. batch, pad/steam vs. immersion):

Desizing, scouring, and bleaching can be either continuous or batch processes. In continuous preparation (whether it is desizing, scouring, or bleaching), the fabric is immersed in some type of saturator where it is impregnated with chemical before entering a reaction chamber (usually steam-heated) where the reaction is activated. Impurities and residual chemicals are then washed off in a series of wash boxes.

Batch processes can involve any number of machines such as jet dyeing machines, becks, jigs, etc. The majority of these are immersion-type processes where the reaction actually occurs in the desizing, scouring, or bleaching solutions (which are in this case heated) and not in steamed reaction chambers. The reaction bath is usually drained, and neutralization and washing occur in the same vessel. Preparation can also be carried out by impregnating the fabric with chemical and allowing it to sit for extended lengths of time (typically 16-24 hours) at room temperature. This is commonly called "cold pad/batch" preparation.

MERCERIZING

The objectives of mercerization are improved dye affinity, luster and dimensional stability, increased tensile strength, reactivity and absorbency, and coverage of dead or immature cotton fibers. This is accomplished by treating cotton fabrics or yarns under tension with strong solutions of sodium hydroxide. During the mercerization process, the cotton fiber swells and becomes more rounded in cross-section, increasing the surface area substantially, and partially or completely changes the fine structure of the "Native Cellulose" or "Cellulose I," to that of "Mercerized Cellulose" or "Cellulose II." Mercerization may be carried out on yarns or on loom-state, desized, scoured, or bleached fabrics. Fabric mercerization is usually a continuous process. Goods are immersed in 18-25 percent sodium hydroxide solution at around 90°F, and then extracted (or padded) to 70-100 percent liquor pickup by weight. This is followed by a set of timing cans, where the fabric is allowed a 30-60 second dwell time to permit the structural changes to occur in the cellulose. The goods are then held under tension while the sodium hydroxide concentration is reduced to less than 5 percent by an on-line hot water spray system (175-195°F). Final washing and neutralization are then usually accomplished by a series of wash boxes. Mercerizing machines are primarily of two types: (1) chain-type and (2) chainless-type, with the principal difference being the lack of width control on the chainless-type mercerizer.

DYEING

Dyeing is the process in which color is added to a substrate, with the colorant being resistant to removal (i.e. having good fastness). Colorants are classified as pigments or dyes; pigments being insoluble in their application medium, while dyes are typically thought of as being soluble in their application medium.

Dyes are categorized by dye class, as well as by chemical structure within the various dye classes. There are numerous dye classes in use in the USA, being used based on the fiber type to be dyed, the desired quality of the dyed material, the type of equipment being used for dyeing, as well as several other considerations. Some commonly used dye classes include: Acid dyes, Basic dyes, Direct dyes, Disperse dyes, Fiber Reactive dyes, Vat dyes, and Sulfur dyes. Auxiliary chemicals necessary to conduct successful dyeings vary dependent upon dye class and the machinery being used for dyeing.

Woven Fabric Finishing Process (cont.)

Dyeing can be accomplished by batch, continuous, or semi-continuous (cold pad-batch) methods. Batch processes are those where a specified quantity of fabric is processed as a unit, with the necessary chemicals being delivered to the machine. Batch equipment can be further segregated based on the state of the fabric during dyeing (i.e. either rope or open-width). Open-width batch processes include beam and jig dyeing, while rope batch processes include beck and jet dyeing. Most batch dyeing equipment can be purchased as atmospheric or pressurized machines. Atmospheric equipment is typically operated below 212°F, while pressurized equipment operates to approximately 280°F. With the high temperature equipment, dyeing of thermoplastic fibers, such as polyester, can be accomplished without the use of organic carriers. Continuous dyeing is when the dyes and chemicals are held in a pad and the fabric travels through the solution(s) as it travels down the range.

PRINTING

Printing is the patterned application of color to a textile substrate. Printing can be accomplished by a variety of techniques using either pigments or dyes combined in a printing paste. Typically, a printing process involves applying the color followed by a fixation step (i.e. steaming, heating, etc.). The use of some colorants requires a final wash after fixation to remove surface color.

FINISHING

Fabric finishing processes are performed to improve the aesthetic properties of a fabric or enhance a fabrics performance properties. The fabric is usually dried before finishing using either convective (hot air) or conductive (heated cans) methods. Drying may also occur elsewhere in the process such as after bleaching, after mercerizing, etc. A variety of finishing processes are conducted based on the material being finished and the desired end-use properties. Some typical chemical finishes include permanent press or wrinkle resistance, soil release or anti-soiling, flame retardant, water repellant, and mildew resistant. Many mechanical finishing processes are also conducted, and include napping, shearing, brushing, calendaring, embossing, sanding, sueding, and sanforizing. Mechanical finishing techniques have seen an increase in use in recent years as many "effects" can be created and can be accomplished with little chemical use.