

short fiber and trash is accomplished. The sliver is laid in an ascending spiral in a can of about 12 in. diameter.

The card sliver will follow one of several paths, according to end product. For heavy, low count (length per unit of weight) yarns of average or lower quality, it will go directly to drawing. For lighter, high count yarns requiring fineness, smoothness and strength, it must first be combed.

Lapping

Combing is preceded by the preparatory operations of sliver lapping and ribbon lapping. In sliver lapping, several slivers are placed side by side and drafted. In ribbon lapping, the resulting ribbons are laid one upon another and again drafted. The doubling and redoubling averages out sliver irregularities while drafting improves fiber parallelism.

Combing

After lapping, the fibers are combed with fine metal teeth. This removes substantially all fibers below a predetermined length, removes any remaining foreign matter, and greatly improves fiber arrangement. The combed lap is then attenuated by drawing rolls and again condensed into a single sliver.

Drawing

Drawing follows either carding or combing, further improves uniformity and fiber parallelism by doubling and drafting several individual slivers into a single composite strand. As in other processes, doubling averages the thick and thin portions of each while the drafting action further attenuates the mass and improves parallelism.

Roving

Roving continues the drafting and paralleling processes until the strand is down to a size suitable for spinning. A slight twist is inserted and the strand wound on large bobbins suitable for either the next roving step or spinning.

Spinning

Spinning is the final step in all systems of yarn making and is marked by the simultaneous application of draft and twist. The packages (any form into or on which one or more ends can be wound) of roving are creel at the top of the frame. The unwinding strand passes progressively (Fig. 2) through gear-driven drafting rolls, a yarn guide, the C-shaped traveler, and, thence, to the bobbin. The rotation of the spindle and the somewhat slower orbiting of the traveler, twists the yarn and winds it upon the bobbin. The vertical traverse of the ring causes the yarn to be placed in predetermined layers.

The difference in peripheral speed between the back and the front rolls determines the draft. The rate of front roll feed, together with spindle speed and the drag which is related to the weight of the traveler, determine the twist.

In Fig. 2, the space between the nip or bite of the rolls is adjustable and must be slightly greater than the longest fiber. The speeds of front and back rolls are independently adjustable. Cotton spindles normally run at 8000 to 9000 rpm but may exceed 14,000 rpm. In ring twisting, the drawing rolls are omitted and some few spindles are run as high as 18,000 rpm.

Spinning is the final step in the cotton system and the one feature that distinguishes it from twisting, is the application of draft. The amount and point of application of draft also accounts for many of the subtle differences which require different humidities for apparently identical processes.

Atmospheric Conditions

Through carding to roving, the loosely bound fibers are especially vulnerable to the detrimental effects of static electricity. In most instances static can be adequately suppressed with a humidity not too high to cause other troubles. In others, it is necessary to suppress electrostatic properties with anti-static agents. Wherever draft is applied, the important consideration is a constant humidity to maintain the optimum of frictional uniformity between adjacent fibers and, hence, uniformity of cross section.

The required horsepower per square foot is higher in spinning than in other processes, but for almost all, machinery loads are sufficiently high to require cooling during all seasons. Air changes up to 30 per hour are not uncommon. In addition, the motors are often lined up in aisle ways to simplify electrical connections. This irregularity is a major heat source, usually causes streaks of high temperature and low-humidity at right angles to the frames. To improve these conditions, air is often supplied directly to the motor aisles. For general heat absorption it is desirable that the blow of outlets should be parallel to the spinning frames.

In all of the processes preceding spinning and in spinning itself, tremendous amounts of lint and fly become airborne. This is at its worst with cotton but only somewhat less troublesome with man-made fibers. Special provisions in the design and maintenance of air conditioning systems are required for minimizing the troubles arising from these short fibers.

WOOLEN AND WORSTED SYSTEMS

The woollen system is generally used for the coarser yarns, while the worsted system is used for the finer ones of somewhat harder twist. Both may be used for the lighter blends of wool as well as for those man-made fibers which are given the same general characteristics of wool. The machinery used in both applies the same general principles of draft and twist but dif-

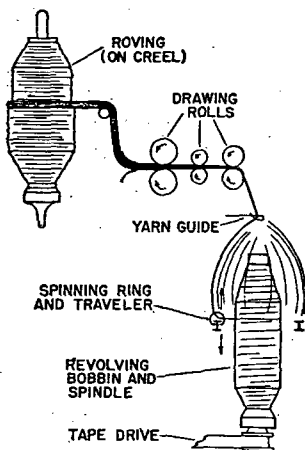


Fig. 2 The Principle of Ring Spinning

Textile Process Air Conditioning

fers greatly in detail and is somewhat more complex than that used for cotton.

Wool fibers are dirtier, more greasy, and more irregular. They must be scoured to remove grease and are usually re-impregnated with controlled amounts of oil to make them less hydrophilic and to provide better inter-fiber behavior. Being scaly and curly, they are more cohesive and require somewhat different treatment.

The wool differs from cotton and the man-made fibers in that it requires somewhat higher humidities up to and including spinning than it does in the processes which follow. Both processes and approximate humidities are given in Table 1.

TWISTING FILAMENTS AND YARNS

The process of twisting was originally applied to filaments of silk and first became known as throwing. Several filaments were doubled and then twisted to improve such characteristics as strength, uniformity, and elasticity. Essentially, the same process is used today but is now extended to spun yarns as well as to single or multiple filaments of man-made fibers. Twisting is widely used in the manufacture of sewing thread, twine, tire cord, tufting yarn, rug yarn, ply yarn, some knitting yarns, and others.

Twisting and doubling is done on a *Down- or Ring Twister* which draws in two or more ends from packages on an elevated creel, twists them together, and winds them into a package. Except for the omission of drafting, down twisters are similar to conventional ring spinning frames in design and appearance.

Where yarns are to be twisted without doubling, another type of machine called an *Up-Twister* is used. These are built in double and triple deck arrangements, and are so named because the yarn passes from the bottom to the top of each deck. *Up-Twisters* are used primarily for throwing man-made monofilaments and multi-filaments to add or vary such characteristics as elasticity, light reflection and abrasion resistance.

As with spinning, the characteristics of the yarn are controlled by making the twist hard or soft, right or left. Quality is appraised largely by the uniformity of twist which depends primarily upon tension and is promoted by the stability of atmospheric conditions. Approximate relative humidities are shown in Fig. 1.

Since as the frame may be double or triple decked, high concentrations of power will be found in twisting. The frames are otherwise very similar to those used in spinning and present the same problems in air distribution. In twisting, lint is not a serious problem.

PREPARATORY PROCESSES

When the spinning or twisting has been completed, both types of yarn must be prepared for either weaving or knitting. The principle processes are one or more of winding, spooling, creeling, beaming, slashing, sizing, dyeing, etc. The broad purpose is two-fold. The first is to transfer the yarn from the type of package dictated by the preceding process, to a type suitable for the next. The second is to impregnate some of it with sizes, gums, or other chemicals which may not be left in the final product.

Filling Yarn

Filling yarn is wound on quills suitable for use in the loom shuttle. In some instances it may be pre-dyed and must be put into a form suitable for package or skein dyeing before it is quilled. If the filling is of relatively hard twist, it may be put through a twist-setting or conditioning operation in which

Table 1 Recommended Humidities for Wool Processing at 75-80 F*

Departments	Humidity, Percent
Raw Wool Storage	50-55
Mixing and Blending	65-70
Carding—Worsted	60-70
—Woolen	60-75
Combing, Worsted	65-75
Drawing, Worsted—Bradford System	50-60
—French System	65-70
Spinning—Bradford Worsted	50-55
—French (Mule)	75-85
—Woolen (Mule)	65-75
Winding and Spooling	65-60
Warping, Worsted	50-55
Weaving, Woolen and Worsted	60-60
Perching or Clothroom	55-60

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internal stresses are relieved by the application of heat, moisture, or both.

Warp Yarn

Warp yarn is impregnated with a size or starch as a transient coating which adds strength and resistance to the chafing to which it will be subjected in the loom. The first step is re-winding onto a cone or other large package from which it will unwind speedily and smoothly. The next is warping which rewinds a multiplicity of ends in parallel arrangement on large spools, called warp beams. In the third step, slashing, the threads pass progressively through the sizing solution, through squeeze rolls, and round cans or steam heated drying cylinders—or, as an alternative, through an air-drying chamber. As much as several thousand pounds may be wound on a single beam.

Knitting Yarn

Knitting yarn, if hard spun, must be twist-set to minimize kinking. Filament yarns must be sized to reduce strip-backs and improve other running qualities. Both must be put in the form of cones or other suitable packages.

Uniform tension is of great importance in maintaining uniformity of package density. Yarns tend to hang up when unwound from a hard package or to slough off from a soft one, and both tendencies are aggravated by spottiness. The processes which require air conditioning, and the recommended relative humidities, are shown in Fig. 1 and Table 1. The dilution and removal of excesses of vapor is required to prevent destructive condensation in most dye houses and is more of an art than a science. Spot-cooling is indicated where both dry and moist heat is excessive.

WEAVING

In the simplest form of weaving, harnesses raise or depress alternate warp threads to form an opening called a shed. A shuttle containing a quill is kicked through the opening, trailing a thread of filling behind it. The lay and the reed then beat the thread firmly into one apex of the shed and up to the fell of the previously woven cloth. Each shuttle passage forms a pick, and these actions are repeated up to frequencies of 300 per min.

Each warp thread usually passes through a drop-wire