Property Risk Consulting Guidelines

A Publication of AXA XL Risk Consulting

PRC.17.21.1

COTTON PROCESSING

INTRODUCTION

In the mid 1500s immigrants brought the first cotton based fabric to England. The fiber was not made entirely of cotton because cotton yarn was not strong enough to serve as warp (the fiber strung lengthwise on the loom). Linen was probably used for this purpose. Cotton was used to the form the filling yarn (weft). In the late 1700s the English learned how to make a strong cotton warp, using the "mule-jenny." The jenny was the first spinning device that was capable of producing a consistent high-twist yarn.

Fire probably occurs more frequently in textile plants than in any other major classification of industrial occupancy, because these plants process large quantities of highly combustible fibers. The hazards of making cotton fabric include the high combustible loading of cotton and cloth storage, and the generation of large amounts of fine lint that is easily ignited.

A cotton fire produces acrid, black smoke of a distinctive odor and can rapidly make the surrounding area untenable. Cotton has an ignition temperature of 490°F (255°C). Once started, a fire in cotton is apt to spread rapidly over the entire mass. Lint concentrations need to be minimized by practicing sensible housekeeping. The amount of cotton stock stored in areas such as cotton warehouses, opener rooms and lap storage areas should be limited. Sources of ignition need to be minimized by properly designing and maintaining electrical and mechanical equipment. Synthetics have higher ignition temperatures, but generally have a higher rate of heat release.

PROCESSES AND HAZARDS

The Engineered Fiber Selection® Cotton Management System (EFS), introduced in 1982, has become the industry standard for blending cotton and is used by over 200 companies. EFS provides relevant information about the fiber and provides a system for more efficient bale production. The EFS system and its accompanying software programs have become a critical component to the textile industry enabling mills, merchants, fiber producers and ginners to benefit from its data. This information is available from the USDA's regional classing offices and from other sources.

The EFS® system makes use of the fiber frequency distributions of the cotton bale population to establish a processing scheme suitable for yarn manufacturing. Different spinning techniques require different fiber selection strategies. The wide range of yarn count and twist within the same spinning system will require different fiber selection strategies.

Blending algorithms select a proper mix of cotton bales that meet different blending strategies. A consistent fiber profile fed to the textile process will produce a consistent yarn quality.

Figure 1 shows the many processes involved in making cotton fabric. The following sections detail each process. Refer to PRC.17.21.1.A for descriptions of unique terms used in the cotton industry.

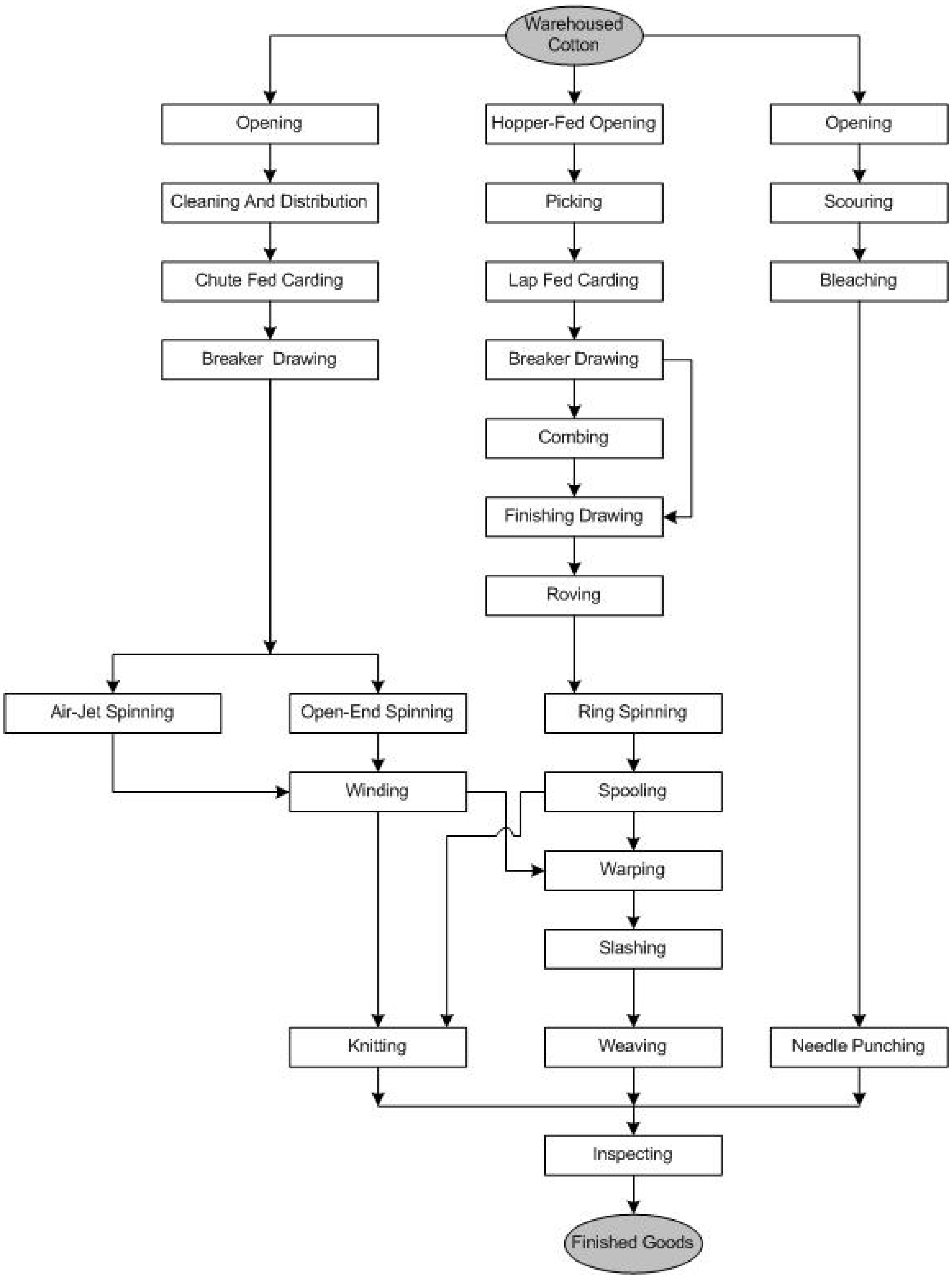

Figure 1. Flow Chart For Manufacturing Cotton Fabric.

Bale Storage

The tendency today is to limit cotton storage at the processing mill by scheduling deliveries from the cotton gin on a short cycle basis. The short cycle schedule has saved operating capital, and spacing and has reduced in the fire exposure.

Cotton is easy to ignite; it has a fast spreading flame front and an acrid, dense smoke. Cotton fire burrows into bales. Characteristics of burning cotton dictate the need to follow certain design criteria for cotton warehouses. The maximum sizes for warehouse sections generally extend 20 ft (6.1 m) high and span 10,000 ft^2 (929 m^2) of floor area.

Lift trucks unload bales from trucks or freight cars onto a receiving dock that accesses various warehouse sections. To facilitate inspection and sampling of cotton bales, workers occasionally cut a bale tie with a tie-cutter and take samples from opposite sides of each bale. High stacking of baled cotton stresses the ties of bottom bales. Should a tie slip or let go, friction or sparking may ignite the cotton.

Quality control of incoming bale shipments has reduced much of the need to test raw materials. When in-house testing is performed, small clump samples from the cotton bales are brought to the classing office in small tote boxes or in small paper wrapped bundles. Samples are checked for staple length and proper grade. Bales within 5% of grade specifications are stored in warehouse sections. Unsatisfactory bales are held in the dock area until they are returned to the cotton broker.

At one time, a standard warehouse section was about 5000 ft^2 (465 m^2), but competitive pressure for labor-saving methods and lower unit costs have forced a trend toward larger and higher one-story warehouse sections. However, larger areas create greater loss possibilities and a need for extended fire protection. At some point, the necessary fire protection becomes an economic burden.

Although cotton bales are highly compressed and are partly wrapped in burlap or woven plastic mesh, enough fiber ends are exposed to allow rapid flame propagation over the entire pile of bales. Bales wrapped in plastic sheeting usually contain synthetic fibers.

Although relatively rare today, a “fire-packed” or “hot gin” bale results when a spark or hot ember becomes trapped in the cotton while it is being baled at the cotton gin. Even though the bales are tightly packed, enough oxygen is in the hollow cotton fibers to sustain combustion. A fire can continue to burn within the bale, probably undetected, until it breaks through to an outer surface, sometimes days or weeks after initial baling. As a fire propagates over the surface of the bales, it will burrow into them and continue to burn until water is directly applied to the area. Tightly packed cotton does not absorb water readily, and as a result, “wet” water and sharp pointed nozzles are necessary to finally extinguish a burrowing fire in bales or packed cotton. See NFPA 18 for guidance. Bales of cotton must be overhauled individually before local hot spots can be finally extinguished. Complete extinguishment usually requires removing and opening each bale involved to extinguish deep seated pockets of smoldering cotton.

Opening

Modern cotton gins generally supply clean, consistent cotton; however, debris in the form of dirt, leaf matter, grass, stones, baling wire, machine dust from the ginning process and tool parts from the handling process can be present. The opening process removes stones and machine parts before they damage processing equipment or ignite the cotton. The cellulosic matter is removed before it is pulverized and becomes harder to remove. Low impact equipment removes much of the cellulosic debris.

Cotton in bales is tightly matted and highly compressed. Opening machinery loosens and separates the cotton into tufts so it can be effectively cleaned and further processed.

The opener room is one of the potentially serious bottlenecks in a cotton mill. Bales of cotton are brought from the warehouses into the opening rooms. Bale ties and coverings are removed from selected bales. The stripped bales are then laid out and allowed to sit for several hours until they reach room temperature and adjust to the humidity of the area.

To ensure uniformity in the end product, cotton must be blended from several bales to make the size, length and color of the cotton as uniform as possible. This blending process, starting with opening, continues through most processing operations.

At one time, opening and blending operations began with hand-feeding the fiber from the laid-down bales into hoppers, whose spiked conveyors and saw-toothed rollers opened (loosened) the matted fiber. These machines discharged fiber into weigh hoppers which would discharge a mixture of the appropriate blends of fiber. These openers, operating with the weigh hoppers, discharged stock onto a conveyor belt which in turn fed a pneumatic transfer system through the cleaning machinery.

Today, automated equipment takes stock from the opened bales with gantry mounted mechanical fingers. The state-of-the-art opening and blending systems start by laying a row of opened bales of fiber, arranged in the proportions of the desired blend of the end product. An automated opener containing rotating fingers (or saw-toothed shaped rollers) passes across the top of the row and removes the top few inches of fiber from each bale. (See Figure 2.) As the machine passes, the fiber is pneumatically transferred through a channel, adjoining the opening machine track, to the reserve hoppers on the cleaning machinery. High-limit switches on the reserve hopper control the speed of the opening machine as it removes fiber from the bales.

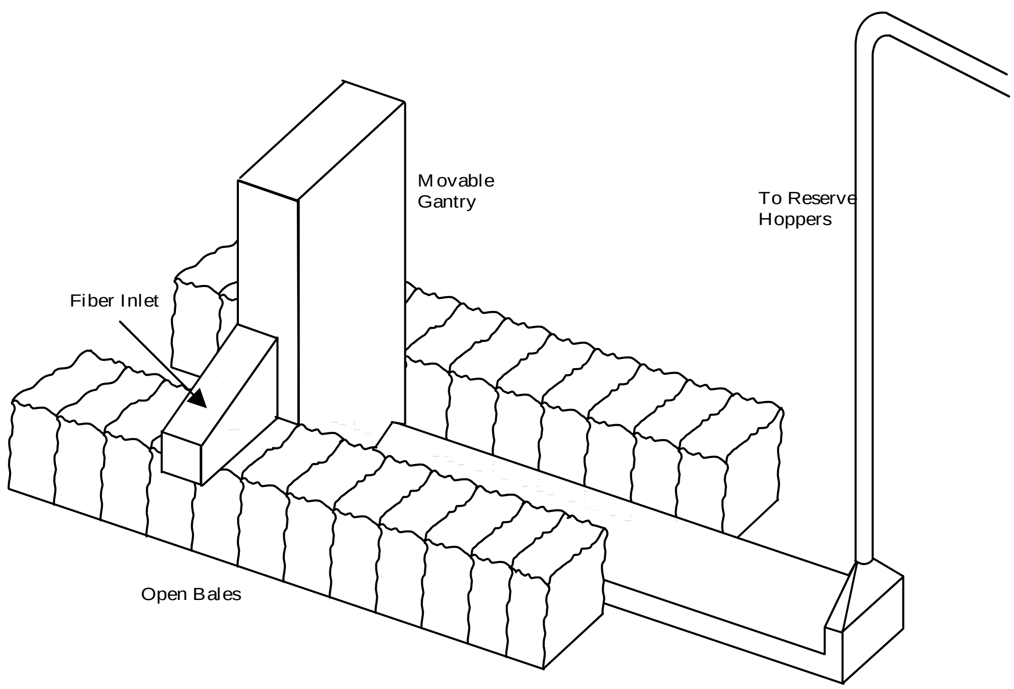

Figure 2. Typical Automated Bale Opener.

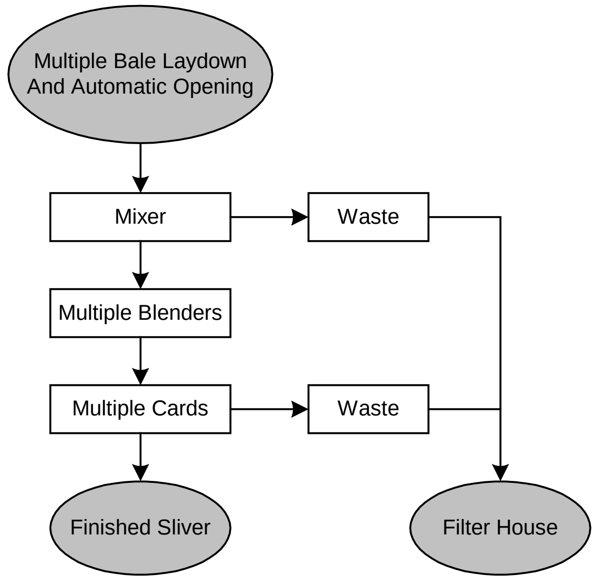

Figure 3. Details Of Modern Opening And Blending Operation.

Cleaning

Removing impurities and short fibers from the cotton fiber is essential to ensure product quality and to allow the use of high speed spinning machines.

The cleaning operations are performed pneumatically and mechanically while the fibers are further separated by spiked rollers and saw-toothed rollers. The dust and light impurities are sucked away while heavy waste is removed by inertial traps.

The efficiency and high speeds of these cleaning machines critically depend on the air flow inside the equipment and the dust removal system. (Lint control is further discussed in PRC.17.21.1.1.) Magnets and metal detectors arranged to open a diversion damper also eliminate metal. These cleaning operations can be performed in cascading single function machines or within one integrated cleaner. The fibers from the cleaning machine then discharge into reserve hoppers or into pre-feeders for the chute-fed carding operation. (See Figure 3.)

Picking

Early cotton mills used hand-fed hoppers that transferred stock on slow moving conveyors through opening machines, cleaning machines, and picker machines. Picker machines formed a rolled mat of fiber called a picker lap. Fires in these machines were common and were controlled by sprinklers installed in each hopper.

Modern opening systems automatically process stock from the time it is laid out to the time it discharges as sliver from the card machines. Chute-feed systems eliminate manual stock handling, as well as the picker process. In general, lay-down bales are automatically fed into openers connected to various mixers and blenders. The material is then air driven through steel ductwork to the carding process where card lines are fed from individual mixers/reserve hoppers. Usually, hand-fed waste opener hoppers reintroduce usable waste to the process. These chute-fed card systems could easily transport fires throughout the entire process, particularly with the high speed of the equipment.

A study of the hazards in the opening and picking area reveals the following:

- At least one of three fires in a cotton mill occurs in the opener and picker rooms.
- The most common causes of these fires, in the order of their frequency, are foreign material in the stock being processed, friction, and defective electrical equipment.

- A fire in the laid down cotton tends to spread fast and flash over an entire group of open bales before it can be extinguished.

Tramp metal in the cotton continues to be the primary cause of fires in opener and picker rooms. The development of strong and reliable permanent magnets in the 1940s brought about the use of magnetic separators, which significantly contributed to reducing the number of fires caused by foreign materials. Magnets, however, are not the complete answer to the problem. Nonferrous objects, such as stones, can still produce sparks if they strike any rapidly-moving steel part of the opening or cleaning machinery. Gravity traps, which use gravity and inertia to separate heavy foreign materials from the cotton, can be strategically installed to remove these foreign materials.

Carding

In modern mills, automated equipment opens and cleans the cotton fiber. The fiber is then chute-fed through metal ducts to the carding equipment. To prepare the cotton for the subsequent processes, carding machines separate and lay the cotton fibers parallel to each other.

During the carding process, two surfaces of wire or metallic card cloth, moving in the same direction but at different speeds on the card machine, comb the cotton into a fine web of generally parallel fibers. Wire cloth consists of thousands of closely spaced, specially bent and sharpened wires in a metal or laminated cloth backing. Metallic cloth, which consists of thousands of sawlike teeth in metal bands, is used extensively and is probably somewhat less susceptible to water damage than wire cloth.

The card machine consists of three drums: the “licker-in,” the “main cylinder” and the “doffer.” The licker-in feeds cotton from the lap to the main cylinder which is completely covered with card cloth. As the cylinder revolves, it passes the cotton over slower moving “flats,” where the basic carding action takes place. The flats are made of strips of card cloth. A rapidly vibrating vertical comb and a doffer roll removes the fibers from the main drum in a thin film known as the “web.” The delicate, wide web is then drawn through a tapered cylindrical device called a “trumpet,” which condenses the web into a soft, fleecy, rope-like strand of cotton known as a “sliver.” The sliver is coiled into roving cans for future use at the drawing frames.

Fire hazards in card rooms are not as great as in opener rooms. However, the frequency of card room losses and the magnitude of the average loss have increased over the years. The probable causes are:

- Higher operating speeds. Fires resulting from friction sources of ignition, such as overheated bearings and stock entanglement on rotating machine parts, show an upward trend.
- Insufficient maintenance or inadequate rail cleaning of electric lap conveyors. Where these conveyors are still used, a significant number of fires have started because of poor maintenance or cleaning.
- Large roving cans. Increased cotton production per card has created the demand for larger roving cans. Instead of 12 in. – 14 in. (30.5 cm – 35.6 cm) diameter cans, 20 in. – 24 in. (50.8 cm – 60.9 cm) are common, and 30 in. (76.2 cm) cans are available. Any fire is therefore likely to involve almost twice the amount of cotton at the delivery end of cards and at the drawing frames.

Higher card speeds produce more flyings and free lint than slower machines. Many cards are equipped with automatic lint collection systems with suction nozzles or flutes for lint pickup. Although this equipment is essential to good housekeeping, it creates a serious fire protection concern when ductwork for the lint collector interconnects several machines. Unless carefully engineered and properly protected, fire on a single machine may spread through the lint collection system to the other units and may damage the main filter bank. Fire damage to the filter bank can result in a loss of production. The control of lint in cotton mills is discussed in PRC.17.21.1.1.

Combing

Combing, an optional process used before drawing, produces a fine, high quality product. Multiple strands of card sliver are combined into “ribbon laps” and placed on the comber. Revolving or oscillating combs equipped with needles perform the combing operation. The purpose is to separate shorter fibers from longer ones so that the combed fiber staple length will be more uniform and longer.

The desired long staple fibers initially come off as a web. A comber delivers fiber in the form of a sliver to a roving can. The waste in the form of light, fluffy, short staple mats called “noils” is collected in pans under the comber. Waste is periodically removed and taken to the waste house for baling.

Drawing

The purpose of “drawing” or “drafting” is to further straighten the cotton fibers, reduce the size of the sliver, and accomplish some degree of blending and additional paralleling of fibers. Usually six or more strands of “card sliver” are fed into the drawing frame and passed through many sets of rolls. Each pair of rolls rotates successively faster than the preceding pair and draws the sliver out further. This “drawing out” tends to make the fibers more parallel. Multiple strands of “card sliver” are also combined into a single strand of “drawing sliver.” Untwisted sliver is coiled in roving cans. This drawing process may be repeated by feeding the cans of sliver from one drawing frame into another.

Slubbing and Roving

“Slubbing” and “roving” continue the drafting and drawing out process and impart a small amount of twist to provide enough strength so the cotton can withstand subsequent operations. This optional process is eliminated at facilities that use “air-jet” spinning.

When the feed stock first passes through the slubber frame its mass is reduced and the stock changes from a “sliver” to a thin “roving.” The slubbing and roving frames have sets of rollers similar to the drawing frame. The frame draws out the sliver and the “flyer” twists it as it is wound on a bobbin.

The number of roving operations is determined by the quality and size of the finished yarn desired. Extra fine yarn, for instance, may go through slubbing, roving and fine roving (“speeders”). However, the tendency today is to eliminate many of these steps by using improved high speed equipment.

Spinning

Many mills are installing suspended ceilings above the spinning frames to better maintain temperature and humidity control. Unfortunately, cotton fiber and lint tend to accumulate above the ceiling tiles and create a potential fire hazard.

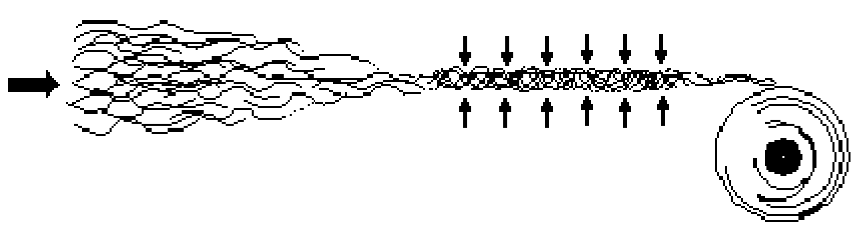

Figure 4. The Spinning Process.

The cotton textile industry uses three main spinning systems:

- Conventional ring spinning,
- Rotor spinning,
- Air-jet spinning.

Each spinning system consists of the following operations (see Figure 4):

- Drafting to reduce the bulk of the input material and deliver the proper yarn count;
- Consolidation to provide the necessary coherence between fibers and strength;

- Winding to form the yarn package.

The spinning system requires fibers that are:

- Flexible enough to accommodate the continuous arrangement and rearrangement of fibers during drafting, consolidation, and winding;
- Of high length/diameter ratio to permit flexibility, effective consolidation and inter-fiber coherence;
- Of optimum surface adhesion to allow fiber control and allow smooth drafting.

Cotton fiber has good flexibility and deforms under tension, bending, and torsion. Although cotton may seem shorter than many other natural fibers, it has an ideal length/diameter ratio that accommodates processing. Cotton fiber also has natural wax, which enhances surface friction and fiber control.

When cotton fiber is blended with other types of fibers, such as polyester, incompatibilities arise due to aspect ratio and surface friction of the two types of fiber. Polyester has more than twice the flexibility of cotton fiber under tension, yet cotton has more flexibility under bending and also under torsion than polyester. The trend is to use very fine polyester fiber, increasing incompatibility problems. The surface friction of the two types of fiber is never the same despite extensive research in the spin finish of polyester.

Ring Spinning

Ring spinning has been around since the 19th century. Ring spinning has survived due to its unsurpassed yarn quality and versatility in producing a wide variety of yarns. New designs in ring spinning have kept pace with the high productivity of other spinning systems that can produce yarn up to 6 times faster. Ring-spun yarn has somewhat greater strength than air-jet spun yarn.

Spinning frames perform four basic operations: drafting, twisting, winding and building. Drafting reduces the bulk of the roving strand to the desired size. Twisting or spinning causes the fibers to spiral around each other to bind them together and give them the desired strength. Winding delivers the finished yarn to the bobbin, building or winding yarn in a suitable shape on the bobbin. Two general bobbin configurations are used: the smaller filling bobbin and the larger warp bobbin.

The ring frame is similar to that of the roving. However, the ring frame adds a higher degree of twist to give the yarn or thread its strength. The roving is fed through two or three sets of roll running at successively higher speeds to elongate and thin the roving to the appropriate density for spinning.

A fiber strand called "roving" is fed to the drafting system of the ring spinning machine. The number of fibers in the cross-section of this strand typically ranges from 3,000 to 4,000 fibers. Lighter roving can be made from longer and finer fibers. The roving is twisted about one twist per inch to make sure it stays together during winding and unwinding. Cotton fibers usually require a higher twist than synthetic fibers, as do coarse/short fibers. A roving of high twist and light weight can lead to less yarn hairiness, but too high a twist in the roving can impair the drafting process in ring spinning, leading to yarn imperfections.

The drafting rolls reduce this the number of fibers to 70 fibers for fine yarn to 700 fibers for coarse yarn. This reduction in the number of fibers is achieved mechanically by the speed ratio between the front and the back draft rollers, which results in creating a shift between fibers as they slide against each other in the drafting zone, reducing their number.

The length of the drafting zone is a critical spinning parameter. Since draft settings are normally fixed, the real burden is on the fibers to accommodate these settings. In this regard, the important criterion is fiber length uniformity; a high variation in fiber length would result in excessive floating fibers and fiber fragments. This will impair both the uniformity and the strength of the yarn. A high percent of short fiber content will improve the strength of the yarn.

The reduced roving then passes through a guide to a movable metal loop called the traveler. The yarn receives a high degree of twist between the yarn guide and the rotating ring traveler. As the spun yarn is pulled on the rotating bobbin, the traveler turns on a metal track or ring. (See Figure 5.)

The up and down motion of the ring holder assembly builds uniform consecutive layers of yarn on the bobbin. The high speed of this equipment produces a lot of lint and waste. (See PRC.17.21.1.1 for a description of lint and waste removal.)

The fibers being delivered at the nip of the front roller form a triangle called the "spinning triangle." The bottom end of this triangle represents the point at which fibers are consolidated into a yarn. The yarn is made by twisting the fibers together. Twist is inserted to the fibers by a traveler rotating around a ring. Each revolution of the traveler inserts one turn of twist into the yarn. The driving mechanism of the traveler is the spindle that carries the yarn bobbin. The amount of twist inserted in the yarn is determined by ratio between the rotational traveler speed and the linear speed of the roving entering the spinning triangle. The fibers being twisted form a balloon shape resulting from the distribution of tension components generated by winding, and yarn/traveler contact. The spindle carrying the yarn bobbin rotates faster than the traveler and drags the traveler behind it. This causes yarn to wind around the bobbin. A building mechanism is used to move the ring vertically so that the yarn can be wound along the bobbin length.

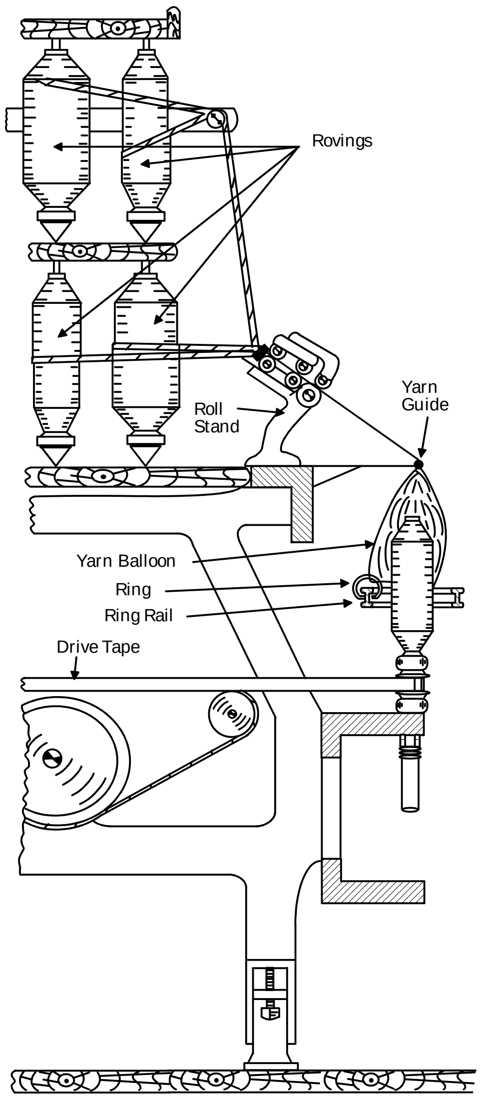

Figure 5. Ring Spinning Frame.

Important fiber properties in ring spinning are:

- Variation in fiber strength and elongation;

- Fiber length and length uniformity;
- Short fiber count;
- Fiber to fiber friction (wax content);
- Fiber fineness;
- Stickiness;
- Residual trash content.

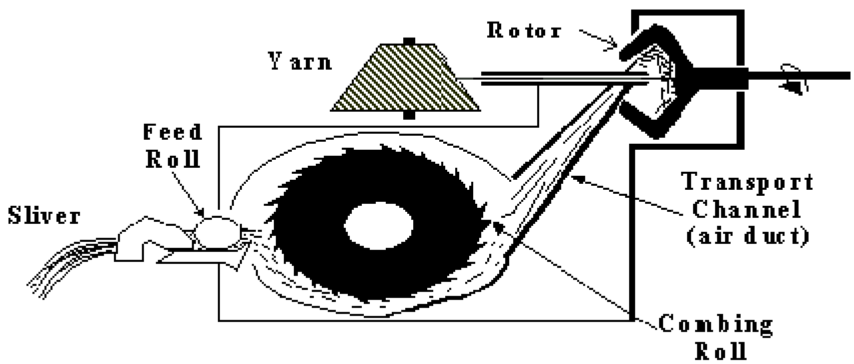

Figure 6. Rotor Spinning.

Rotor Spinning

Commercial rotor spinning was first introduced in 1969. Rotational speeds have gradually increased up to 40 times their initial speed and continue to rise. Today's rotor spinning machine has a linear production rate exceeding 650 fpm (200 m/min) compared to 130 fpm (40 m/min) in ring spinning. Rotor spinning eliminates the need for roving and after-spinning winding due to the large yarn package produced.

The amount of draft is substantially higher than that of ring spinning. Drafting in rotor spinning is accomplished using a comber roll (mechanical draft) which opens the input sliver followed by an air stream (air draft). These two operations produce an amount of draft that is high enough to reduce the 20,000 fibers entering the comber roll down to as few 5 fibers. To produce a yarn, groups of fibers emerging from the air duct are deposited on the internal wall of the rotor forming a fiber ring. The torque generating the twist in the yarn is applied by the rotation of the rotor with respect to the point of the yarn contacting the rotor navel. The amount of twist is determined by the ratio of the rotor speed to the take up speed. The winding operation in rotor spinning is completely separate from the drafting and the twisting operations. The yarn is taken up at a constant rate. This separation between winding and twisting allows the formation of larger yarn packages than those in ring spinning. (See Figure 6.)

As the opened fibers flow around with the combing roll, friction between the fibers and the comber roll metal chamber results in a fiber velocity lower than the surface speed of the combing roll. Those fibers are normally in a disoriented shape. In this regard, fiber attributes such as fiber resilience, fiber/metal friction, crimp, stickiness, and surface finish are of keen importance. The tendency to increase the combing roll speed makes these fiber properties even more critical. Increasing comber speed usually results in yarn hairiness and yarn imperfections. Normally, a wire-wound clothing is recommended for cotton and cotton blends where pinned combing rolls are suitable for fragile fibers such as acrylic and rayon.

Although the primary role of the combing roll is to open the fibers, it can also act as a cleaning unit by separating trash particles from cotton. Obviously, this additional function can easily overstress the combing roll, making it wear rapidly. It is important, therefore, that the input sliver exhibit a great level of cleanliness.

Fibers coming out of the comb roller are airborne through an air duct. This zone of draft is of a special significance because of its impact on fiber orientation. To obtain such a fast airflow, the inside of the rotor is run at a vacuum which may be achieved by designing the rotor with radial holes to allow the rotor to generate its own vacuum; some use an external air supply.

Another approach to minimize fiber disorientation in the air duct is by designing it in a tapered shape toward the rotor to allow acceleration of the fibers as they approach the rotor inside surface. This action may also straighten the leading fiber hooks coming out of the opening roll. Fibers emerging from the air duct come into contact with the rotor inside surface, which is typically faster than the fibers. This also assists in straightening the fibers disoriented in the previous zones.

The air draft reduces the fiber strand down to few fibers (2-10 fibers). These fibers are then landed into the inside surface of the rotor as it takes many layers of fiber to make up sufficient number of fibers per yarn cross-section. As successive layers of fibers are laid into the inside surface of the rotor, a doubling action occurs which tends to even out short-term irregularities in the yarn. Rotor spinning requires very fine fibers.

Microscope examination reveals that the yarn axis of rotor-spun yarn has fibers that are not completely tied into the yarn. Those fibers have a free end that wraps itself around the yarn periphery and causes constriction of the yarn. This is an inevitable defect that is peculiar to rotor-spun yarns. It is commonly called "fiber belts" or "wrapper fibers." They fail to contribute to the strength of the yarn and they provide no improvement to any quality aspect. In fact, they should be treated as waste fibers that happen to stick to the yarn body. The inevitability of wrapper fibers, however, has led many machine manufacturers to claim that they may have some merit including improvement of yarn abrasion resistance.

Long fibers tend to form wrappers that are so tight that the belt looks more like a thin place. Short fibers, on the other hand, form slack and loose belts. Other fiber attributes that may contribute to wrapper fibers include fiber stiffness and fiber fineness; stiffer and coarser fibers tend to become wrapper surface fibers.

Rotor spinning produces tighter fiber control due to the higher spinning tension. Fibers are not firmly gripped at any point of their flow. The lack of significant tension also results in some fibers that are only partially twisted, leading to inferior yarn strength. The yarn consists of three layers: a core that is truly twisted (similar to ring-spun yarn), an outer layer that is partially twisted, and fiber wrappers.

The true twist in rotor-spun yarns results in a natural curling tendency, similar to ring-spun yarns. However, this torque is partially balanced by a torque caused by the wrapping effect of the wrapper fibers, particularly those that take an anti-clockwise direction. The more such anti-clockwise banding fibers there are, the lower will be the curling tendency in the rotor yarn.

Rotor spinning has superior economical advantage over ring spinning in the coarse to medium yarn counts. In recent years, there have been many attempts to push rotor spinning further into the area of fine counts.

Fine counts are associated with high quality yarn (defect free and certainly trash free). This means that the quality of the fibers must be upgraded to produce fine counts. The sliver fed to the machine should be prepared carefully so that it exhibits the lowest irregularity possible, and the lowest trash level possible. In case of light sliver, inter-fiber cohesion is critical. Fiber properties such as trash content, short fiber content and inter-fiber friction are extremely important, not only for producing acceptable quality levels, but also for minimizing end breakage during spinning.

In recent years, low level combing has been used to upgrade cotton fibers used in producing fine rotor yarns. Combing upgrades the cotton quality by removing neps and short fibers, and by providing better fiber orientation in the fiber strand. The added-cost by combing is justified by lower endsdown during spinning, and slight reduction in twist.

Combing also provides the following benefits:

- Irrespective of raw material, yarn strength was found to increase by about 10% with combing and yarn uniformity was improved.

- Combed rotor-spun yarns yield better filling insertion rates during weaving because of lower rates of filling stops.
- Combed rotor-spun yarns result in better knitting efficiency because of the low fly deposition and the smoothness of yarns. The uniformity and handle of single jersey knitted fabrics were significantly improved as a result of using combed rotor yarns.

Important fiber properties in rotor spinning are:

- Fiber strength;
- Fiber fineness;
- Short fiber count;
- Variation in fiber length;
- Fiber to metal friction;
- Removal of unwanted residual materials.

Air-Jet Spinning

Air-jet spinning eliminates the need for the slubbing process, because the cotton fed into the machine is in the form of a sliver rather than a roving. Large tubs of stock taken from the drawing process to the spinning equipment reduce manual handling. The yarn discharging from the spinning head can be wound directly onto spools to eliminate the need of a winding operation.

Air-jet spinning requires a very clean cotton with a long staple length. Usually the cotton sliver goes through a three-step drawing operation. Air-jet spinning frames use a rotating disk to convert card sliver to yarn. The tubs of sliver are loaded down each side of the frame. As the sliver feeds through faster and faster sets of rollers, the sliver reduces in bulk. The spinning action occurs between the last roller grip and the spinning disk. Plastic starter-bobbins containing a small amount of yarn are stored at one end of the frame. As the starter bobbins are automatically fed onto the machine, a movable splicer picks up the starter yarn and splices it to the newly produced yarn tab at one of the numerous spinning stations on the frame. When the bobbin is full, it is automatically removed and replaced with a new starter bobbin. Full bobbins are discharged onto an open conveyor at the center of the machine. Heat and air are exhausted through a filter unit at each end of the center conveyor area on the machine, producing an air wash which removes fine lint.

The fundamental difference between air-jet spinning and rotor spinning is that air-jet spinning is a false-twist method. While rotor spinning requires a complete separation of fibers, and ring spinning requires a complete continuity of fiber flow, air-jet spinning requires partial separation of the fibers.

Similar to rotor spinning, the input strand in air-jet spinning is a drawn sliver that may be carded or combed. Drafting is achieved using high roller drafting to reduce the size of the input sliver to the desired yarn size. The binding mechanism is achieved by blowing compressed air through two nozzles to form an air vortex. One is the "end-opening" nozzle, and the other "the twisting nozzle." (See Figure 7.)

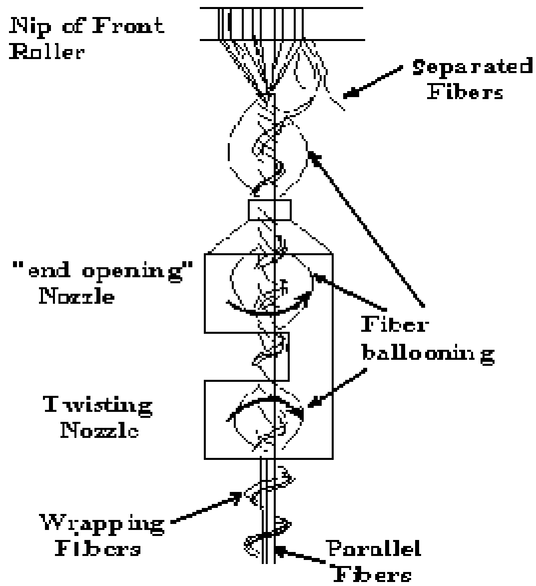

Figure 7. Air-Jet Spinning.

The yarns produced are twisted in one direction. Very fine yarns cannot be run on this equipment because the strength imparted to the yarn is not enough to withstand the rigors of further processing.

Some of these machines use a two-sliver input. The slivers are drafted through the equipment to a dual head spinning nozzle which spins the yarn in opposite directions. The two yarns are then brought together and create a two-for-one twisted yarn. The yarn passes through a yarn cleaner and a waxing device before it is packaged. The process produces a relaxed yarn with about the same tensile strength as ring-spun yarn. (See Figure 8.)

If only the twisting nozzle is working this will result in pure false twisting the fibers and forming a yarn. However, when the yarn leaves the nozzle, untwisting takes place. In the actual machine, the two nozzles apply air rotation in two opposite directions with one nozzle imparting a higher rotational speed avoiding complete false twisting. The resulting twist is the difference of the two imparted twists.

When the fiber strand, the twisted core will immediately tend to untwist and the detached fibers will wrap around the core fibers. These results in a yarn consisting of a core of parallel fibers wrapped at some points along its length with fiber wrappers. The primary source of strength of air-jet spun yarn results from effective fiber wrapping.

Important fiber attributes in air-jet spinning are:

- Fiber length and uniformity;
- Short fiber count;
- Fiber blending resistance;
- Fine trash count;
- Fiber to fiber friction.

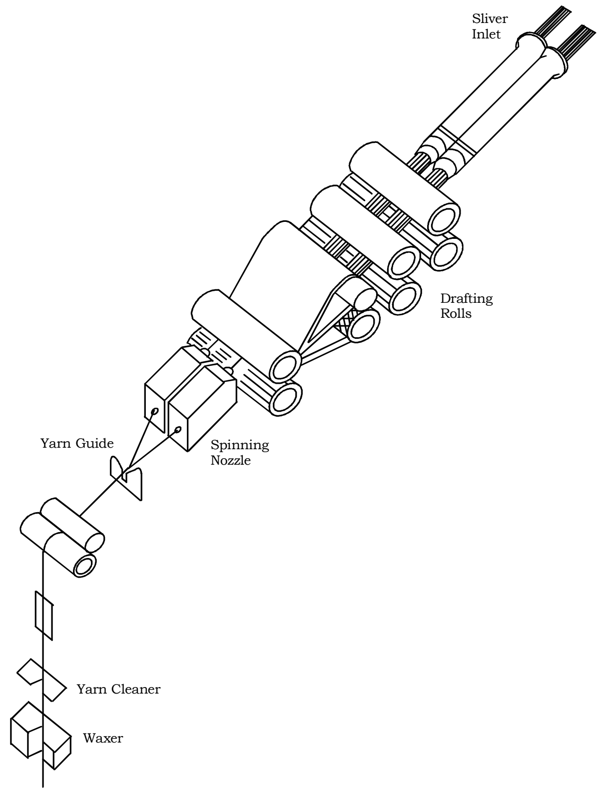

Figure 8. Duel Air-Jet Spinning.

In 1998 a new air-jet spinning process called Murata Vortex Spinning "MVS," was introduced. The system is still under change. As in the conventional jet spinning, the sliver is directly fed to a roller drafting system. The consolidation of fibers is achieved by applying a rapidly spiraling flow of compressed air at a nonrotating spindle tip in the air nozzle. It is claimed that the spun yarn possesses characteristics close to ring-spun yarn. Two fiber properties are critical to the new system: short fiber content, and dust content. The system removes a great deal of short fiber as waste fibers. This gives the yarn a combed-like quality. With an expected speed as high as 1150 fpm (350 m/min), this new technology may dominate the market in the future.

Twisting

If particularly strong thread or special effects are desired, two or more threads of yarn may be twisted together in a method similar to that of the movable ring rail and ring traveler. The product is known as a “ply yarn” (two-ply, three-ply, etc.). “Dry” twisting tends to produce more lint and requires more cleaning on and under the twister frames than the “wet” process. In “wet” twisting, the yarn passes over an emulsion roll partly immersed in a narrow trough of water or emulsion of penetrate and wetting agents. Less free lint results, but the wet twister frame may require more periodic detergent scouring. The “wet” process is being replaced by dry waxing.

Reverse twisting (plys twisted in opposite directions) results in a plied yarn that is strong, yet easier to manage, because the twist is relaxed.

Winding and Spooling

The basic purpose of both winding and spooling is to join the relatively short lengths of yarn from spinning bobbins and wind them into large packages. The winder usually produces “cones” of yarn wound onto paper or plastic cone shaped cores; the spooler produces “spools” or “cheeses” of yarn wound on wood or metal spools. Automatic spooling machines, which have a tying head that constantly moves on a track above the spooler and automatically ties broken yarns or new ends together, are available.

In mills that only manufacture yarn, the process stops here and the yarn is inspected, packaged and shipped to the customer.

Warping

One of the first steps in preparing for the weaving process is to wind, onto a large spool or "section beam," the many individual yarns or threads that will make up the "warp." "Cheeses" or "cones" of yarn are placed in a rack called a "creel." The ends are threaded through guides and eyelets of a stop-motion circuit and wound in parallel on the "section beam" at high speed. The purpose of the stop-motion device is to detect any threads that break during the winding process. Should a single yarn or thread break, the "warper" automatically stops revolving the beam. Warper beams are sometimes stored in a high piled rack configuration consisting of cantilever beams.

Slashing

Before the warp yarns can be used in a loom, they must be treated and coated to prevent the yarns from breaking from tension forces and rubbing or chafing during the weaving process. In a procedure known as "slashing," yarn is unwound from several section beams; run through a hot solution of starch, gum, and a softening agent; passed over a series of steam-heated rolls to remove moisture and finally taken up on the "loom beam." The machine on which these operations are performed is a "slasher," and the coating applied is called "sizing." Loss exposure from fire in these areas is moderate due to combustible loading. However, improperly handled starch can result in a dust explosion. The use of starch has diminished greatly. PVA (polyvinyl alcohol) is being used in its place.

Weaving

Weaving converts yarn into cloth by interlacing two sets of yarn on a "loom." One set is the "warp," the long longitudinal threads; the other is the "filling" or "weft," the shorter crosswise threads which run the width of the loom. Preparing the warp on the loom is called "drawing-in." The warp yarn comes from the loom beam. The yarn must first be drawn through three areas: the drop wire, the heddle and the reed. The drop wire stops the loom if any warp thread breaks. The heddle is the eye of the harness wire which raises or lowers the warp threads. The reed contains spaces (dents, splits) that allow the filling yarn to be beaten or pushed into place against the previous filling. Until recently, "drawing-in" was done manually, but now, automatic machines tie in new beams as preceding beams are used up.

Although weaving is basically a simple process, the loom itself is an intricate piece of machinery. Modern weaving looms can be quite costly. In the plain loom the harness supports raises and lowers various sets of warp threads which form an opening called a "shed." On the older shuttle looms, the movements of the harness and the "picker sticks" propel the shuttle from one side of the warp to the other. The shuttle contains a shuttle bobbin with a small quantity of filling thread. The semi-automatic bobbin changer has a feeler that detects when the bobbin needs changing. Bobbins are changed before they run out of thread and leave a loose end in the fabric. The shuttle action across the warp is known as a "pick." The speed of a loom is spoken of as "so many picks per minute" or the number of times the shuttle carries the filling across per minute. The picker sticks at both sides of the loom are synchronized so that the shuttle makes a single trip with its filling thread as each new shed is formed. The "batten" serves as a backrest for the shuttle and holds the reed. The reed, a flat wire comb with vertical wires, beats the thread tightly in place after each pick. These older shuttle type looms create a handling problem, due to continuous bobbin replacement, and a housekeeping problem, due to waste bobbins and broken threads. These machines require constant attention.

Modern looms do not use a shuttle to carry the filling thread. Some looms mechanically drive a "projectile" that carries a single filler thread through the shed that operates at speeds of 250 picks per minute (PPM). Other shuttleless looms have a ribbon type carrier on both sides of the loom. The right and left-hand carriers enter the open shed formed by the warp threads. The carriers touch in the center of the loom. One carrier picks up the filling yarn, and transfers it to the other carrier near the center of the fabric. As one carrier withdraws from the shed, the other carrier pulls the filling yarn the rest of the way across the warp. Shuttleless looms control the ends of the filling thread so it can be "tucked" back into the selvage for a clean-edged cloth.

Faster, more modern looms use either jets of air or water to carry the filling thread across the warp; however, water jet looms are used less frequently in cotton mills, because cotton absorbs water. These looms use sequentially opening solenoids that propel the filling thread through the shed. They can operate in the 900 PPM range but generally form a ragged edge selvage. Efforts are being made to produce a better selvage and thus reduce waste.

Losses in plain weave rooms, which are second only to cotton opening rooms, are usually small and contained in one machine. AXA XL Risk Consulting loss experience reveals the two outstanding causes are defective electrical equipment and excessive friction.

Jacquard looms differ fundamentally from the plain looms. They make more intricate patterns and tapestries requiring more flexibility in heddle operation. Heddles cannot be grouped and handled by harness frames. Each warp thread must at times be individually raised and lowered. Each thread is moved by a preprogrammed set of instructions maintained on punched cards connected in a continuous loop.

A jacquard loom has a cord running from each heddle to an overhead hooked wire. The wire hooks are arranged in rows. In front of each row is a knife or “griff” which is constantly moving up and down in proper time with each pick. A horizontal wire or needle is positioned against each hook; if the needle moves laterally, it will deflect the hook out of the path of the rising griff.

Whether or not the needles move depends on how holes in the pattern cards move over a rotating cylinder at the other end of the needles. As the shuttle moves across the warp, a card is pressed against the ends of the needles so they all move laterally, except where holes have been deliberately punched in the card. The needles that do not move are consequently lifted by the griff for that pick, creating the desired shed in warp. At each pick a different shed will be created.

The average loss on jacquard looms is approximately eight times greater than on plain looms. The reasons are:

- The maze of overhead harness cords and pattern cards provides excellent possibilities for fire spreading rapidly upward. Serious damage often results, not only to the cords and cards, but also to the cylinder, wires, needles and other components.
- Retying harness cords and replacing pattern cards are expensive and time consuming.
- The surfaces of gantry framework that supports the overhead machinery collect lint. Mezzanines over the machine shield the machine from overhead sprinkler protection. Fire tends to spread along these surfaces and often involves adjacent looms.

Nonwoven Fabrics

Cotton must be scoured and bleached for many nonwovens where absorbency, whiteness and purity are desired.

Two techniques of commercial scouring and bleaching are kier and continuous. Both processes accomplish the same results by the same chemical interactions but with different mechanical handling.

Scouring is accomplished by saturating the cotton fiber with a caustic soda (sodium hydroxide) solution. The alkali solution is allowed to remain on the fiber at elevated temperatures to speed chemical reactions. During this time the natural oils and waxes are saponified (converted into soaps), the plant matter is softened, pectins and other noncellulosic materials are suspended so they can be washed away. After a predetermined amount of time to allow for complete scouring, the alkali, saponified waxes and suspended materials are rinsed away with water.

At this point a bleaching solution is applied to the fiber. A stabilized oxidizing agent, hydrogen peroxide or sodium hypochlorite, is used in the bleaching liquor to whiten the fiber by the destruction of natural coloring matter. In the U.S., hydrogen peroxide is the most widely used agent in the bleaching of raw cotton in fiber form. This bleaching solution remains on the fiber at elevated temperatures for a fixed amount of time to allow for proper removal of the color bodies, then the bleaching solution is rinsed away. Cotton bleached with hydrogen peroxide contains no dioxins because lignin and chlorine are both absent.

After scouring and bleaching all impurities have been removed and the cotton fiber is in the form of pure cellulose. If properly done, this fiber will meet the demands for pharmacopoeia purified cotton.

Currently available bleached cotton from U.S. sources has been processed in batch kiers where both high temperatures and high pressures are used. Special opening equipment is required for processing bleached cotton going into such quality roll goods as coverstock. Other processes for cloth production including needle punching and knitting.

Needle punching involves using needles on a flat bed of loose fibers to help entangle the fibers. The fiber sheet is usually impregnated with a latex or other chemical compound to help achieve some rigidity in the fabric. Many needle punched fabrics are passed through high pressure calendar rolls, which give the fabric a better appearance.

Knitting

Knitting is the process of constructing a fabric by interlocking a series of loops on flat beds or circular machines. Fabrics produced on knitting machines range from women’s hosiery to bulky sweaters. The type of fabrics produced depend on the size of the needle, the type of machine and the type of yarn used.

Ordinary flat bed machines consist of two sets of needle beds set at a 90° angle. Flat bed machines are slower and more expensive to operate. The beds are slotted to hold the needles. The number of slots per inch is known as the “cut” and ranges from 2 to 20 slots per inch. Latch needles are free to ride up and down within the slot.

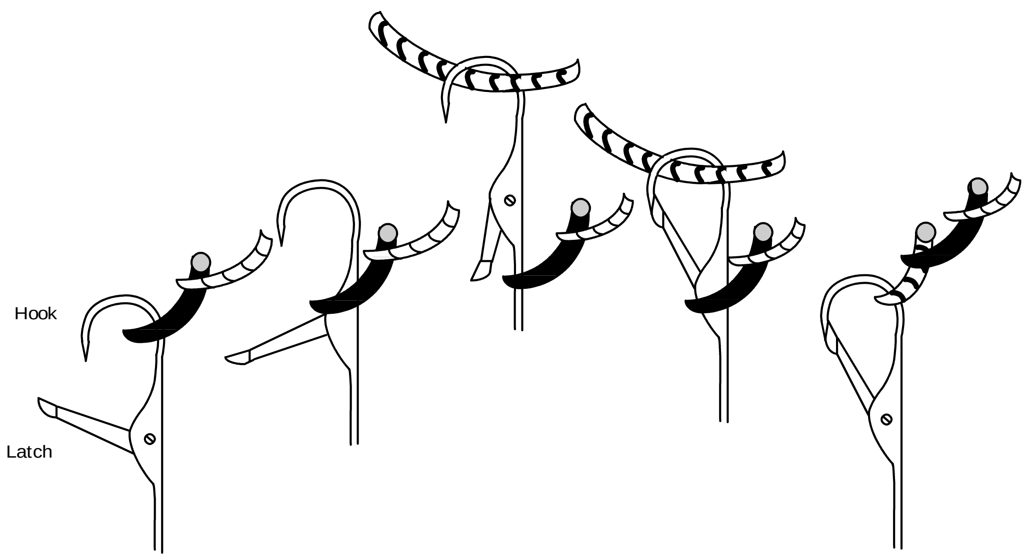

Figure 9. Operation Of An Automatic Knitting Machine.

The latch needle consists of the needle and the latch. The needle has a curved hook at one end. The latch is attached just below the curve to form a complete enclosure when the latch is in the closed position. At the opposite end of the needle is a protrusion called the “butt” which allows the needle to move up and down when the needle is run through the cam. The cam creates a path for each needle to move up and grab the yarn when the needle is open. The cam allows the needle to move down and pull the yarn through a loop which closes the latch to create a new loop. The new loop is held on the needle until the process is repeated, when the cam returns from one end of the bed to the other. (See Figure 9 for details.) Each row of complete stitches is called a course. Each vertical set of stitches is called a wale.

The fabric is created in a sheet form and is held under tension directly below the apex of the needle beds. The cams can be changed to vary the type of stitches produced and to engage needles from either bed.

Circular knitting machines are usually used for larger fabrics, fabrics which are relatively plain, and fabrics requiring smaller stitches. The process of creating stitches is similar to the flatbed machines except the cams rotate in one direction at very high speeds. The finished fabric comes off the machine in a tubular configuration.

It is extremely important to keep machine surfaces clean, and keep needles highly polished with good working latches.

LOSS PREVENTION AND CONTROL

The loss prevention and control guidelines are not all inclusive and were written for an “average” hazard level. Increased hazard levels warrant additional loss prevention and control measures.

Management Programs

Various loss prevention programs of *OVERVIEW* (PRC.1.0.1), such as smoking regulations, housekeeping, impairment supervision, and pre-emergency planning, require special attention. Tailor management programs for loss prevention and control to address the hazards at the facility.

Housekeeping

It is important that processing areas be kept as clean as possible. Loose fiber must be removed at it source. See PRC.17.21.1.1 for guidance on lint removal systems.

Operator Training Program

Educate all operators in the hazards involved and in functions of the safety control equipment. Forbid deviations from the written procedures.

Pre-Emergency Planning

AXA XL Risk Consulting pre-emergency plan from PRC.1.7.0, may be used to develop a customized plan for the facility.

Preventive Maintenance

Heavy attrition on key equipment requires redundancy so that repairs and maintenance can proceed with the plant operating at full capacity. A proper preventative maintenance program is essential to the continued performance of this equipment.

Inspect and maintain process equipment with proper consideration of design and service conditions. Include all appropriate types of modern nondestructive testing, IR scanning and vibration analysis in the inspection techniques. Establish a detailed record-keeping system that includes equipment retirement forecasts.

Other Management Programs

Incorporate these features into the comprehensive management program for loss prevention and control:

- Welding, cutting and other “hot work” permit programs.
- A program of supervision of impairments of fire protection equipment using AXA XL Risk Consulting’s “RSVP” program. All systems should be in service before operations are started.
- Smoking regulations.
- Plant security and surveillance

Facility Protection

Take all practical steps to ensure maximum protection, even during possible impairments. Normal requirements include providing:

- Sprinklers where needed because of combustible construction or occupancy. Design sprinklers in accordance with NFPA 13 and PRC.12.1.1.0.
- Adequate water supplies; redundant water supplies where necessary in accordance with PRC.14.0.1. Install additional pumped water supplies in accordance with NFPA 20 and PRC.14.2.1.
- Looped water systems with strategically located sectional control valves and hydrants installed in accordance with NFPA 24 and PRC.14.5.0.1.
- Special sprinkler valve control. The cotton mill contains a number of areas that are highly susceptible to fire. Separate control valves are recommended for these areas where frequent fires occur so that sprinkler heads can be replaced without impairing an entire sprinkler system. Some of the areas include:
- Opener lines where sprinklers are installed in machines such as feeder hoppers, openers and cleaners. Separate valved connections are recommended for each production line. Individual sprinkler control for each machine need not be provided if the machine group to which the sprinkler belongs is separately valved. Multiple valves increase the probability of unintentionally leaving one valve closed.
- Dust rooms and lint collectors.
- Waste machines.

  ○ Small inside hose connections. Connections are valuable, not only to control initial fires, but also to extinguish burrowing stock fires. Booster hose connections, often found in opener and picker rooms and waste houses, can be quickly used without having to lay out the entire lengths of hose lines.

  ○ Sodium bicarbonate dry chemical portable fire extinguishers. Such extinguishers are recommended, because they can quickly control flame spread over cotton fibers and retard further fire development without adversely affecting cotton or cotton machinery. Multipurpose ABC dry chemical tends to glaze or intumesce in fire. Acid salt components may cause corrosion in humid atmospheres. Portable hand pump tanks are useful for extinguishing smoldering and burrowing fires where hose connections are not available.

  ○ Dry chemical, Halon 1211, and carbon dioxide extinguishing systems. These agents have been very effective in protecting opening, cleaning, carding and waste collection equipment. Halon 1211 has become the most common agent due to its effectiveness and cleanliness. However, due to the environmental problems associated with the use of halon, HBFC-22B1 was introduced as an interim product. It has since been replaced by HFC-227ea (FM200). See NFPA 2001 and PRC.13.6.1 for guidance.

Cotton in its natural form is known to be one of the most readily ignitable materials of the common combustibles group. Take special steps to control possible sources of ignition, such as:

- Prohibiting smoking, except in designated areas.
- Limiting the use and type of engine-driven lift trucks. These trucks should be listed and suitable for the occupancies in which they are used. They should be permitted only in certain areas and have, among other things, spark arresting mufflers, or at least water-cooled or condensing mufflers, to prevent emission of exhaust sparks.
- Using proper electrical equipment. Incandescent light bulbs should be protected against accidental breakage. Bare globes should not be permitted in lint prone areas where their surface temperatures can ignite the lint.
- Using grounded conveyor pipes and ducts in fast-operating machinery to eliminate static sparks.

- Maintaining proper humidity to control static and flying waste in areas containing loose fibers.
- Using gravity traps and magnetic separators to remove foreign material from preparatory process lines, particularly before cotton enters high-speed cleaning equipment.
- Using advanced electrical maintenance procedures, including infrared inspection, to eliminate incipient faults in electrical equipment before the faults become hot enough to ignite the product. (See PRC.1.3.1.)
- Aggressively preventing mechanical equipment overheating by:
  - Establishing a vibration-monitoring program for equipment in hazardous areas. Vibration monitoring techniques normally reserved for heavy rotating equipment are appropriate for cotton processing equipment. Serious consequences are possible in event of mechanical failure. (See PRC.6.0.8.1.1.)
  - Using infrared inspection to locate overheated bearings, lint-clogged moving parts, rubbing, and other heat-producing conditions.

When renovating older multistory mills and contemplating new equipment, perform a load/beam analysis to ensure the structure can safely take the new loading.

When restoring an idle plant, start air conditioning before resuming operations. The proper temperature and humidity are essential to reducing the fire spread potential.

Cotton Storage

Bales received at warehouses should be carefully checked for signs of fire. Close checks should continue during the first week or two of storage.

Workers should take care to prevent sparks. They should not use axes to cut metal bale ties because this action might ignite the cotton. Cutting multiple bale ties is also discouraged. During firefighting and salvage operations, bales with intact ties can more easily be moved outside the building. Once the smoldering bales have been moved outside, the bale ties can be cut and the bales opened up for final overhaul by hose application.

Provide stackers with electrical installations satisfactory for Class III locations. Support supply cords off the floor to prevent the stackers from passing over them and causing damage. The cords should be continuous in length with no splices.

The following recommendations should be followed for cotton storage:

- Limit new warehouse structures to one story high. Use noncombustible construction materials.
- Limit the total number of bales exposed in one fire area. Considerable dollar value is involved in any warehouse. Depending on the time of year and the product being produced, loss of raw material and storage capacity may drastically affect immediate and future production.
- Limit pile height to 15 ft (4.6 m).
- Limit the number of bales per pile. A fire will most likely involve an entire pile before sprinklers can operate and begin to control the fire. The larger the pile, the greater the number of sprinklers that will operate. Available water supplies should be adequately designed so they will not be overtaxed. For further guidance, see NFPA 1.
- Provide frangible access panels or readily-pierced end-wall construction to ease removal of smouldering bales from the building. Multiple-storied warehouse buildings are undesirable.
- Provide automatic heat and smoke vents in accordance with PRC.2.1.4. Breathing apparatus and smoke vents or smoke removal by special arrangement of air conditioning systems are vital for fire-fighting and salvage recovery operations.
- Eliminate ignition sources. Enclose lights. All electric panels should be located outside the warehouse area.
- Provide parapeted, free standing, 4-h fire walls. Eliminate all but essential openings in fire walls between warehouses. Fire can still spread through any opening before open fire doors

are automatically closed. Sparks can also circumvent the closed doors. Protect necessary openings with double 3-h rated fire doors between warehouse sections.

- Avoid roof construction susceptible to early collapse or heat distortion. The fast-spreading fire in baled cotton releases large quantities of heat. A subsequent fire burrowing into bales usually results in a fire of long duration that is difficult to extinguish.
- Provide quick-opening devices on all dry pipe valves. Fast operation is essential to promptly control a cotton warehouse fire.
- Provide an early warning fire detection system.

In the past, sodium bicarbonate has been used to dust long-term, cotton bales storage to reduce flash tendencies of the cotton. Most facilities try to avoid long-term storage.

Openers

The preferred arrangement of opened bales of cotton in the opener room is as follows:

- Ten bales per row or group.
- A maximum of 50 to 75 bales total.
- Five foot (1.5 m) aisles between rows or groups and the same distance between bales and machinery.

Do not locate overhead motors and switchgear above any open cotton. Provide partitions where a larger number of bales are required for fluffing or blooming. Up to 20 bales are acceptable per sheet metal partition. Partitions should be a minimum of 6 ft (1.8 m) high and should be at least 2 ft (0.6 m) above the maximum height of the bales.

Ground floor locations are needed for opener rooms to:

- Remove burned cotton promptly.
- Prevent water damage to lower floors.
- Readily use hose lines from the outside as needed.

Provide a fire protection system capable of detecting small sparks traveling in the duct system. When the system detects a spark, the stock handling equipment and lint removal systems should shut down; the diversion dampers and an appropriate extinguishing system should operate. Infrared detection installed at the inlet and outlet ducts of cleaning machines, reserve hoppers, mixing hoppers, etc., allows the extinguishing systems to discharge as the detected spark enters the affected machine. Housekeeping and preventive maintenance are particularly important to control lint accumulations and sources of ignition.

Install magnetic separators to remove foreign ferrous material at a suitable point just ahead of the first set of fast rotating opening equipment. Also install gravity traps or separators that remove nonferrous foreign materials at suitable points where airstream conveying makes this installation possible.

Cut off opener and picker rooms from the remainder of the main mill by using parapeted masonry fire walls of at least 3-h fire resistance. Provide automatic 3-h rated fire doors on both sides of each opening. These doors should be rated for 250°F (121°C) maximum temperature rise within 30 min. Cut off opener and picker areas located adjacent to cotton warehouses by a standard fire wall of 4-h fire resistance.

Fire resistive construction for buildings is preferred, but at a minimum, use plank on timber or heavy noncombustible construction. Avoid using lightweight roof construction, such as bar joist or wood joist, not only because such construction is susceptible to fire damage, but also because large amounts of lint will collect on the many surfaces involved. Install sprinklers in the opener and picker rooms on an Extra Hazard Group 1 wet system in accordance with NFPA 13 and PRC.12.1.1.0. Install a separate OS&Y control valve for sprinklers protecting hoppers, cleaning units, reserve hoppers and condensers, where cotton tends to concentrate. Heat collectors are used with the sprinkler heads to allow the system to operate faster. Picker trunk type heads are usually used in enclosed cotton moving equipment because the smooth rounded deflector does not tend to collect cotton fiber as readily as conventional heads. Picker trunk type heads are no longer listed by sprinkler manufacturers, because of their low market share, but are available on special request.

Where an unusual amount of opened cotton is exposed, install a system of extra hazard Group 1 open pendent fixed spray nozzles above the cotton. Strategically locate a number of hand-operated, remote control stations throughout the opener room.

A sufficient number of hose stations and portable extinguishers is essential. Ten lb – 20 lb (4.5 kg – 9 kg) bicarbonate dry chemical extinguishers are particularly helpful. Provide two extinguishers for every six opener or blending hoppers; one for each end of every three pickers.

Carding

To maintain a certain degree of sharpness and uniform needle height, the card cloth is periodically ground while still in place on the card machine. The card machine should be thoroughly cleaned prior to this operation to prevent sparks from igniting lint fires.

One special concern has always been the high susceptibility of card cloth to water damage. Several precautions should be followed:

- Keep on hand a number of light, water-shedding covers of plastic or paper cloth to protect the machines if an emergency arises, particularly when card machines are on a lower floor of a multistory building.
- Start the cards as soon as possible if they become wet to sling off any free water. Apply whiting powder to assist quick drying. Rust inhibiting sprays may also be of value.
- Minimize water damage further by running cotton stock through the card, because cotton absorbs water.

In recent years, dry chemical, carbon dioxide and Halon 1211 have been used successfully in controlling frequent fires and in minimizing downtime. Halon is usually used on the clean, high-grade cotton; dry chemical is used on the waste collected during carding. Due to environmental restrictions, Halon 1211 is no longer being installed. Many Halon 1211 systems have been converted to HBFC-22B1 which has also been banned. HFC-227ea (FM-200) systems are now being used. Automatic extinguishing systems should be installed and maintained in accordance with the appropriate NFPA standard and PRC Guidelines.

Water type extinguishers can be very effective for quenching local “hot spots” on exposed cotton fires.

Drawing

To prevent the rapid spread of fires over large areas, maintain clear and clean aisle spaces between rows of drawing frames. Electrical stop-motion devices used on drawing frames should be low voltage and acceptable for textile applications.

Combing

Noils burn very rapidly. Promptly remove large quantities of noils, and provide good housekeeping.

Slubbing and Roving

Keep metal covers in place over gear trains driving the spindles at the wooden bobbins to prevent falling objects from enmeshing in the gears. The covers will also help exclude lint, although the gear trains will still require cleaning at periodic intervals.

Spinning

Provide sprinklers in spinning rooms that have suspended combustible ceilings. Periodically inspect and clean these areas.

Twisting

Do not over lubricate twisters. The combination of excess lubricant and normal lint breeds poor housekeeping and could result in a serious fire. Heavy twisting, such as that used for tire cord, requires more lubricant, because the machinery involved runs faster and gets dirtier more quickly. Supervision and housekeeping for the twisting process is especially important.

Slashing

Establish an adequate cleaning schedule for hoods and exhaust ducts. Provide sprinklers controlled by a separate control valve where housekeeping problems persist.

The requirements for starch handling used in this process can be found in NFPA 61 and NFPA 654. Inspect the dryer rolls used with slashers at least annually or more frequently if jurisdictional rules so specify. Test over-pressure protection devices in accordance with PRC.7.0.5.2.

Weaving

A comprehensive preventive maintenance program, including infrared inspection and vibration monitoring, can be a major factor in reducing loss frequency in weave rooms. The trend to use automatic or semiautomatic lubrication systems should help reduce the number of fires produced by friction. Provide proper flexible cords for loom motors or for other locations where needed. Properly maintain housekeeping at all times.

To protect jacquard loom areas:

- Keep overhead supports as free as possible of lint accumulations.
- Locate large size, portable, wheeled extinguishers within easy reach of any loom position.
- Provide sprinkler protection under machine mezzanine areas.

Nonwoven Fabrics

Reneedling knitting machines after a fire causes much downtime. Eliminate the use of dry chemical extinguishing agents in the machine room. Corrosion could damage needles and other polished surfaces. As a result, many machines not involved in direct fire damage would have to be reneedled. See PRC.13.1.3.

GLOSSARY

Bale - A large wrapped package of otherwise loose fiber. In the United States, cotton bales are of three basic types: gin, compressed and export. Gin bales are normally limited to the cotton-growing regions where bales are shipped directly from the gin to the mill. Compressed bales are most commonly found in domestic commerce. Export bales are primarily prepared for foreign shipment.

Fire-packed bale - a bale in which hot embers have become embedded at the cotton gin.

Hot gin bale - a bale in which hot embers have become embedded at the cotton gin.

Batten - Serves as a backrest for the shuttle and holds the reed in the weaving process.

Beam - Metal drum on which a large number of yarns are wound in parallel to serve as the “warp” on a loom.

Blanket - Felt covering on roll or rolls in a slasher.

Bobbin - Cylindrical or cone-shaped object of paper, wood, metal or plastic on which a single continuous yarn is wound. The bobbins hold the filling yarn.

Calendaring - Ironing or pressing cloth by passing it over hot rolls while the cloth is still under tension.

Card clothing - Leather or fabric backing to which closely spaced fine wire with mechanically ground points are attached. Also, a carding surface created by winding parallel metal bands with saw-like teeth over a drum or roll.

Carding - A process where two sets of wire pins or teeth moving in opposite directions are used to straighten fibers. May be of the chute fed or lap fed type.

Cheese - A large cylinder of yarn.

Clearer - A devise covered with an abrasive cloth and mounted so that it will tend to clean rolls in drafting (drawing) operation.

Chute feed system - Part of an automated picking operation.

Combing - A brushing or combing process used to produce high quality yarn. Short staple fibers are removed while longer fibers are arranged parallel to each other.

Cot - Cork, plastic or rubber covering used on rolls in drawing, roving, or spinning operations.

Course - A complete horizontal row of stitches in the knitting process.

Creel - A device for holding a large number of bobbins or cones while yarn is being unwound.

Doffer - One of the three major parts on a carding machine. A comb, brush or other device for removing a web of fiber.

Drafting - Same as drawing.

Drawing - The process of “pulling out” or stretching sliver by passing it through a series of rolls rotating at different speeds. This “drawing out” also helps to straighten out the fibers.

Drawing-in - The weaving preparation process of feeding the individual yarns from a beam through the heddles and the reed of a loom onto the cloth roll.

Drop wires - Slotted metal strips hung on each yarn feeding a loom, and arranged to stop the loom automatically if the yarn breaks.

EFS system - A bale mixing system that makes use of the fiber frequency distributions of the cotton bale population to establish a processing scheme suitable for yarn manufacturing.

Fell - That point at which filling is added during the weaving process.

Filling - Yarn laid down horizontally by the shuttle on a loom.

Flats - Segments of card clothing formed into an endless belt arrangement above the main drum of a carding machine.

Flyer - An inverted "u" shaped device which whirls over a bobbin, depositing roving.

Ginning - Removing the bulk of seed and other impurities from freshly picked cotton.

Gouts - Lumps or imperfections in yarn or rovings.

Greige goods - Pronounced grey." Woven, unbleached cotton cloth.

Guides - Stiff wire eyelets used to grade and position yarn.

Harness - Wooden or metal frame which supports the heddles on a loom.

Heddle - A highly polished steel strip with an eye through which an individual warp end of yarn passes on a loom.

Jacquard - A type of loom used in producing intricate patterns. An overhead mechanism moves heddles according to perforations punched in special cardboard control patterns.

Kier - A vessel used in wet processing of textile fabrics during bleaching, dyeing, etc.

Knitting - The process of producing a fabric by continuously looping yarn into long interconnecting chains.

Lap - Most commonly refers to the soft blanket roll of cotton delivered from the picker machines for use on card machines. "Ribbon laps," however, are composed of several parallel slivers for use on combing machines.

Lay-down - Laid-out bales that are automatically fed to the carding operation in the chute feed system.

Licker-in - One of the three major parts on a carding machine. Where the basic carding takes place in conjunction with the main cylinder.

Lint - That cotton (usually short staple) which comes loose during processing and is often airborne over surrounding area. Also referred to as "fly."

Main cylinder - One of the three major parts on a carding machine. Where the basic carding takes place in conjunction with the licker-in.

Motes - Small defects in roving or yarn in the form of dirt or waste particles.

Mule-jenny - An old spinning machine that traveled on tracks long enough to produce a single piece of yarn.

Needle Punching - a method of producing a fabric by entangling fibers.

Neps - Small tangled or knotted masses of fibers.

Noils - Small tangled or knotted masses of fibers.

Opening - The process of loosening fiber from a bale.

Pick - In weaving, this refers to one trip of the shuttle across the warp.

Picker - A machine that cleans raw cotton after the cotton is opened.

Pirn - A small wooden bobbin which fits the shuttle of a loom.

Quill - Another term for bobbin.

Reed - A comb-like arrangement of flattened steel wires fixed in a frame on a loom. It keeps warp threads in position, forming a guide for the shuttle, and beats the weft to the fell of the cloth.

Ring rail - That part of a ring spinning frame on which rings and travelers are mounted. The ring rail moves vertically along the length of the bobbins and is also known as a lifter.

Roving - Continuous, soft, slightly twisted strand of cotton fibers. Roving is the basic step before spinning.

Roving cans - Where the roving is stored between the carding and spinning processing steps.

Selvage - The edge of a woven fabric formed to prevent raveling.

Shed - In weaving, the passage space between the upper and lower lines of warp threads through which the shuttle passes, by the action of harness and heddle on a loom.

Shuttle - The device which carries the weft or filling, in the form of a cop or pirn bobbin, across a loom. It is boat shaped, usually made of hard wood with a metal tip at each end; near one end is an eye through which the weft passes.

Size - Starch or glue solution applied to yarn on a beam in the “slashing” or sizing operation.

Slasher - A machine which sizes, dries and beams yarn intended for the warp on a loom.

Sliver - Continuous fleecy length or “untwisted” cotton fibers formed after carding.

Slubber - Machine which uses sliver from the “draw-frame” and gives a slight twist to produce “roving.”

Spindle - Vertical driven shaft which supports and rotates bobbins.

Spinning - Process in which final twisting produces the finished yarn. The principle of the ring frame is similar to that of the roving. However, the ring frame adds a higher degree of twist to give the yarn or thread its strength.

> **Ring spinning** - Uses a ring traveler to produce and guide yarn to bobbin.
>
> **Rotor spinning** - Uses a rotor to impart twist to the fibers.
>
> **Air jet spinning** - Uses air streams to twist fibers into yarn. Capable of very high production speeds.

Spinning nozzles - Used in the air-jet spinning process.

Spinning triangle - The zone in which twisting takes place in the ring spinning process.

Spooling - Winding of yarn from small bobbins onto larger, more convenient spools or cones.

Staple - A single fiber of raw cotton, wool or synthetic material in its natural state.

Stop motion - A mechanical or electrical device for stopping machinery in case the material being processed breaks.

Stripper - A device for removing fiber or web fibers from a roll, drum, or other support.

Traveler - A small metal thread guide attached to the traveler ring of a ring spinning frame.

Trumpet - A smooth, funnel-like device which concentrates or narrows a wide web, sliver or roving.

Twisting - The combining of two or more yarns to form a ply yarn, in a manner similar to the spinning process.

> **False twisting** - Temporary twisting inserted to help during yarn processing. Partly or mostly removed in final product.
>
> **Reverse twisting** - plys are twisted in opposite directions resulting in a plied yarn that is strong, yet easier to manage, because the twist is relaxed.

Wale - A complete vertical column of stitches in the knitting process.

Warp - The yarn which runs the length of the fabric.

Warping - The winding of multiple yarns on a beam preparatory to weaving.

Weaving - a process of making fabric which uses two sets of yarns entwining at right angles. Fabric produced on a loom.

Web - A fine, filmy layer of fibers delivered by the doffer roll of a carding machine.

Weft - Sometimes applied to filling in weaving; also called “woof.”

Winding - Joining and winding the relatively short lengths of yarn from bobbins to form longer continuous lengths on cones, spools or cheese.