Better Ways To Handle the Bale

Charles L. Sens

By the time a bale of cotton hits the concrete floor of the opening room in a textile mill, it has run a ruthless gauntlet. Saws at the gin have separated the lint from the seed and removed some sand and plant trash. Covered with burlap or cotton bagging and girded with steel bands, the bale has undergone repeated compression, none of which is a gentle operation. At each exchange of ownership in its trade route, the bale is knifed to give up a sample. Its wrapping no longer looks the same. With the many cut places, or burlap patches, and tags, it resembles anything but a unit possessing potential beauty. Yet the down-soft contents must find their way into fine and sheer articles of wearing apparel, as well as into rugged materials for heavy industrial uses.

In this day and time, manufacturing usually is closely associated with assembly lines. But cotton processing consists of many interrelated steps, each of which is performed by human hands, often without the help of automatic machinery.

To get a better idea of this course, go with me into a typical cotton textile mill. A far different sight now meets the eye that observes a hundred or more bales of snow-white cotton, wrappings removed.

Cotton at this stage is a mass of tangled fibers of varied lengths. It contains motes, sand, particles of leaf and stalk of the cotton plant, and some seed fragments.

Its route to the spinning frame or weaving loom is long and involved. The mass of matted lumps of fibers, sometimes as compact as a board, is progressively reduced, first to small tufts and then to separate fibers. Although all the cotton in a bale may be white, it needs blending, for cotton in a single bale usually differs in character, grade, and staple length. Blending cotton is comparable to mixing paint, where a better consistency is obtained by thoroughly compounding a hundred gallons in one container than by duplicating the process in a hundred 1-gallon vessels.

To fluff the tightly matted fibers, to blend or mix the cotton for a more even consistency throughout, and to clean the cotton, a series of vigorous operations is employed. Batteries of hoppers with spiked lifting aprons and regulated air currents convey the crude cotton to revolving beaters. Under these are adjustable grid bars or perforated screens. The foreign matter is thrown through these openings into waste-collecting areas beneath each beater.

The cotton does not have to be cleaned to the same extent for all end products. But highly efficient cleaning and preparation methods are required for fine goods that are to receive special finishes, and to insure the unbroken swift passage of thread through the eye of a needle in knitting or sewing. The same cleaning is essential for cotton materials that must hold up under severe mechanical uses, such as hose or outdoor conveyor belts.

Loose and partly cleaned, the cotton is drawn by air to what is called picking, a textile term, not to be confused with harvesting. Picking is an intermediate step in cleaning. Cleaning, however, is not its only purpose. Of equal importance is that by this operation the loose mass of cotton is delivered in a predetermined form, and becomes a continuous roll of certain length and weight. The product is called a lap. For example, it may be upwards of 50 yards long and 40 inches wide, weighing generally 12½ to 14 ounces to the yard. In the picking process, blades or pins on the surface of a horizontal and fast-revolving beater remove small quantities of cotton at each blow by picking, or plucking, upon a fringe of cotton as it is delivered from between two fluted steel feed rolls.

Picking machines are much alike in principle, but vary in detail. Most of them have two or three sections. Each section generally has a control unit that regulates the transfer of cotton to feed rolls. A fast revolving beater moves forward small quantities of cotton in rapid succession. Again we find adjustable grid-bar openings beneath each beater. Through these vents is thrown more trash, in the form of motes and broken leaf particles. Aiding the beater is a stream of air, the volume of which in 1 minute is approximately equal to that filling a room 15 feet long, 12 feet wide, and 8 feet high. To avoid a turbulence like that which results when a big bag of feathers is dumped in a windstorm, the air is separated from the cotton by two revolving and converging cagelike cylinders. The cylinders not only perform this trick, but also begin to condense the fluffy, downy material. Finally, the cotton moves through a set of heavy steel rolls, which press and form the lap, or roll, of cotton, which now can be handled by hand, on a truck or by some automatic system.

The reader who asks, "What is so wonderful about this invention?" might note that one-process picking is not an invention. It is a development—the result of 15 years of experiment and research. To move cotton by an air stream through a duct or on a trough conveyor is no more difficult than carrying your hat in your hand. But to clean cotton thoroughly without damage to the fibers is a job yet to be completed. To place minute quantities of cotton at the rate of from 300 to 500 pounds every hour, with homogeneous distribution, upon moving surfaces of specified areas, and to do so economically, is a problem now engaging the talents of many engineers and scientists. This stream of cotton-laden air is moving at velocities of more than 3,000 feet a minute. Because cotton fibers are so volatile in an air current and so subtle as to lodge on the surface of glass, they defy control.

Before 1915, most processors had to use two and sometimes three picking operations. The cotton was poorly blended, insufficiently cleaned, and unevenly supplied to the first picking machine. The laps were removed by hand from the delivery end of each machine and placed on the feed end of the next one. Development of a one-process system, or a continuous picking operation, has done away in many instances with as much as one-half of the manual labor. Two of the several reasons why a virtually automatic procedure became possible are: First, compartments were supplied within the machines for a regulated storage of cotton; second, automatic devices to control the flow of cotton were developed. The result was a decided improvement in the uniformity of feed to the last, or finisher, section.

The economies and better preparation resulting from improved precleaning and the benefits of better regulation for uniformity of feed and delivery do not end at the picker. They carry forward and are reflected in all subsequent processes.

ONE EXAMPLE is at the carding machine, where the 40-inch-wide lap is reduced to a soft, ropelike strand of cotton, called a sliver. This unit is measured in, say, 50 to 60 grains a yard. The card formerly was expected to do more than its share of cleaning—to the detriment of quality. But constant improvement in the early stages of cotton preparation, with respect to the removal of heavier trash particles and to the better separation of the cotton fibers, enables the card to improve upon its cleaning task in its specialized sense. Further investigation doubtless will disclose that the card is better able to perform such other functions as fiber blending, and that a superior sliver, whose fibers are more favorably arranged, can be produced. Obviously, this would influence the adaptation for the next significant step, which is drawing, based on the principle of roll drafting, by which the fibers are drawn parallel to one another.

Still other benefits have been obtained. Bearing directly on lower costs, the improvements have shortened operations by doing away with one entire step of drawing and roving. The process of roving has changed slowly. And as we proceed from a bulky strand of cotton to a roving (smaller in diameter and many more yards to the ounce or pound) just enough twist must be inserted to give the unit sufficient strength for normal handling, such as winding.

Roving and spinning are essentially drafting processes in which the bulk or diameter of the loosely twisted strand of cotton is successively reduced, or drafted, by sliding the individual fibers along one another to produce yarn. It is accomplished by maintaining the proper ratio of progressively increasing surface speeds of each following pair of rolls or aprons (small endless bands) binding the fibers.

Since the invention of drafting, textile men have constantly been trying to reduce costs by increasing the draft in every process. The early system of drafting used three pairs of rolls, defining two drafting zones. The first zone, between the back and middle pairs of rolls, served as the break-draft zone to "unlock" the fibers; the second, between the middle and front pairs, served to thin down the bulk of fibers to the extent of the draft performed. For example, the first zone operated, say, at 1.5 and the second or extended zone at 8, the product being the total draft of 12. This system had its limitations. Having only two zones, the second draft zone for greater elongation was incapable of uniformly stretching out the bulk of mixed length of fibers. The shorter fibers reacted in waves between the nips of pairs of rolls; unevenness resulted because of thick and thin portions of the slightly twisted small strands of cotton. Even with more uniform length of fibers, the spreading tendency of the ribbons of fibers could not be kept within the bounds of the main body of the loose cotton strand. The result was yarn of inferior quality.

There are several types of high-draft systems. They perform the same function and can be considered as a whole.

While the 3-roll system of drafting gave a maximum total draft of 12, the improved, or high-draft, system is capable of 30—with as high as 50 appearing evident. The mechanical stretching of these smaller strands of cotton, consisting of long and short fibers, is now attained by an appropriate combination of aprons or narrow bands and rolls. These devices have their surface speeds in proper ratios with one another. This drafting assembly allows the fibers to be held gently and to yield under proper tensions. The fibers are then drawn forward by the pressure of the aprons and rolls. The spacing or setting between the nip of the front rolls and the delivery nip of the aprons is within the staple length of practically all fibers. In the usual commercial, so-called 1-inch cotton, the fibers vary greatly. Although the predominant number of fibers are close to 1 inch in length, there may be appreciable quantities of fibers varying in length from 1⅛ inch to ¼ inch. Besides length, such properties as fineness, strength, spirability, wall thickness, elasticity, and moisture content may complicate any drafting system in the attainment of uniformity in yarns.

Although the principle of high, or long, drafting—names synonymous with many trade names in use today—introduced obvious improvements, ap-

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plications were not widely realized until 1918, 50 years after its invention. The new draft system permitted the elimination of one roving process; but, like many advances, the improved system demanded concessions on the part of mill operators. Because of the greater number of exposed parts, more frequent cleaning was necessary and the machinery was more expensive. These objectionable features are fast being corrected.

Nearly two-thirds of the spinning spindles were equipped with the new system in 1951. In fact, in textile-machinery circles, the high-draft spinning equipment is considered standard and the old 3-roll system special.

The cotton-manufacturing industry processed 50 percent more cotton in 1946 to 1947 than in 1922 to 1923, with 42 percent fewer spindles.

Much of the change came because the industry generally switched from single-shift to 2-shift and even 3-shift operation. Some of the step-up was due to cheaper and heavier fabrics. Further analysis of data for the two postwar periods, however, shows that credit goes also to improvements that permitted higher spindle speeds or lower number of turns to the inch in the yarn, or both. These peculiarities of the textile industry, which mean more yards of output without an increase in the speed of the spindles, are manufacturing facts. Thus the quantity of yarn produced by each spindle increased greatly. In 1946 to 1947 only 22.6 spindle hours were required to spin 1 pound of cotton; in 1922 to 1923, 31.9 spindle hours were required. Granted that heavier yarns and fabrics accounted for some of the increase in efficiency of output of the spindles, better equipment and improved techniques unquestionably contributed greatly to the gain.

The yarn direct from the spinning frame cannot be processed economically at the warper. The automatic high-speed spooler has accelerated the transfer of yarn from a spinning bobbin to a package of greater continuous length for subsequent use. The spooler is a type of winding machine on which units of yarn of individual lengths are made continuous for greater yardage and wound on packages specially adapted for use in the creel of a subsequent machine. The real value of the radical improvement in this new type of spooler is that it prepares by winding units of yarn with precision and high speed. These units are especially adapted to feeding a companion process, high-speed warping.

The process of warping is the winding on a large spool, called a beam, yarn from large supply packages mounted in a creel. As many as 600 threads, uniformly arranged and with equal tension, are drawn rapidly to form the warp beam, in such number as to be an increment of the total required in the fabric to be woven, and also to accumulate the supply of yarn for the slasher, thence to the loom.

The old-style warper unwound yarn from spools at a maximum rate of less than 100 yards a minute; the modern warper, which embodies many automatic and sensitively operating features, attains 900 yards a minute. Amazingly, this high-speed, continuous operation and the mass production depend on a minute element—one end of a thread. If a single end breaks, a threaded drop wire makes electric contact and immediately the stop-motion control actuates a magnetic brake to stop the machine before the loose end has been covered by the winding. Direction of air currents prevents the accumulation of fine lint, which can cause an end to break or otherwise give rise to a defect in the product at this stage. At higher operating speeds, air friction alone provides sufficient tension to assure a compact and smooth warper beam.

In addition, a control that permits the machine to be set for a predetermined yardage helps supervision. One such improved warper can perform the work of six old-style machines. The intricacies of the unit do not increase operating costs in proportion to the increased output. The better warps can more readily be sized, or starch-treated, so that weaving becomes even more efficient. With the new machine, broken warp threads and knots are fewer because less tension and strain are put on the yarn. The elasticity in the yarn is retained to a greater extent. Fewer kinks occur. The looms can produce more cloth of better quality and at lower cost. Even yarn inventory costs are reduced.

STRENGTH OF YARN is a relative term. A yarn designated as having high tensile strength still requires a temporary coating, or sizing, such as with starch, so that it will have protection against the chafing action caused by the several surfaces with which the yarn comes in contact during weaving.

The slasher is the machine on which a sheet of parallel strands of yarn from the warper is sized and then dried, normally to a moisture content of at least 7 or 8 percent. Sizing consists of passing the yarns through an open vat, or size box, which contains a starch solution, and then between cushioned squeeze rolls for removal of excess coating. The solution has in it also a small quantity of gum and softener to give the yarn greater elasticity and pliability.

For more than a century, the steam-cylinder, or contact, method was employed in drying the size-treated warp yarns. The parallel strands of yarn in the sheet were threaded around revolving cylinders so as to obtain the maximum metal-yarn contact surface. Two general types of slashers were used. One had 2 cylinders, 5 and 7 feet in diameter; the other had 5 to 9 cylinders, generally 23 or 30 inches in diameter. The steam pressure applied was under 10 pounds, and the temperature ranged from 180° to 230° F.

Although through the years auxiliary equipment (such as controls for size level and temperature, and steam pressure and temperature) has been developed and applied to improve this method, it still has shortcomings.

In 1930 came an improved type of slasher, based on the conventional machine. It had such added features as variable-speed control governed by a constant-moisture regulator. At best, however, it did not meet the increased production needs; more general use was made of supplementary devices, and finally the design was changed.

The use of radiant heat from infrared drying lamps or gas-fired burners, employed as initial or preheating measures, speeded up slasher production, sometimes doubling it, without impairing the quality of the warps.

The direct application of heat, the most efficient method of drying sized warps, eliminated the elaborate equipment needed to provide steam for the drying cylinders and made working conditions much better.

One successful unit of the direct-fired type of warp drier is an insulated housing containing two high-temperature blowers, with a combined capacity of about 10,000 cubic feet a minute. Heat to the drier is furnished by a series of gas-type burners, which fire through the wall of the machine into the blower suction chamber. The burners operate high or low in a regulated response to the demand of a thermometer controller, which regulates at any desired point between 200° and 400° F. The drying medium—the inert products of combustion and superheated vapor, which have great attraction for water—is reheated and driven through a drying chamber 25 times a minute. Such reducing atmosphere eliminates oxidation, which occurs when heated air is used for drying. A little air enters with the burner flames and is drawn through openings.

The sheet of starch-sized yarns is drawn through the circulating hot-air chamber. Fluted rolls are arranged to serpentine the yarn in the passage and subject it to this atmosphere, according to the drying requirements. The yarn, held in suspension between the rolls of minimum contact, passes between a series of baffles, which vary the velocity of the drying gases.

In an emergency, safety and operating controls shut off the main burners and mechanical features, including those designed to prevent burning of the warp. At the same time enough heat is supplied to maintain a temperature that will preserve the quality of the product.

The improved method of drying cotton with direct firing gives 20 percent stronger yarns with preserved elasticity, and the even coating and roundness of the threads are unimpaired. Air-dried yarns feel much softer than contact-dried yarns. Other advantages are the effect of the movement of air on the uniformity of the product and the rate of drying.

Under development by the company that produced the one just described is a drier capable of treating a wider range of yarns. Much finer yarns, as well as the coarsest, are being processed under mill operating conditions. The production rate is nearly double that of the conventional can or cylinder-type slasher.

These improvements, together with the recent practice of increasing the continuous yardage supply of the warp as much as threefold in order to lessen the loom-stoppage intervals, directly reflect an increased efficiency in weaving, which is nearly always the most expensive process in textile manufacturing.

The principle of weaving on a loom is that of operating two series of yarns so that they interlace in a definite manner to form a fabric. One series, the warp, is a sheet of the required number of yarns, which are slowly drawn forward under regulated tension. The yarns in the second series—the filling yarns, or weft—pass singly and at right angle through the warp yarns. The warp threads are supplied from the beam, a large spool placed back of the loom and containing several hundred to a few thousand parallel strands of yarn. The filling yarns are supplied on bobbins in the shuttle, which passes between the alternate warp yarns as they are successively raised and lowered.

The chief motions in weaving are: The shedding motion, which separates the warp ends to form a shed or opening, according to the pattern of the fabric; the picking motion, which passes the shuttle and inserts the crosswise lay of the filling or binder; and the beating-up motion, which beats into place or strikes each pick of filling spent by the passage of the shuttle. These, with several auxiliary motions, call for a complicated mechanism, with many operating parts, principally of cast and malleable iron, some of wood and leather, and a few of rubber.

The loom, an ingenious machine, has been in use for many years, and it has been improved constantly. Improvements since 1940 have increased the speed and production of the modern loom more than 15 percent. But there has been no change in the fly-shuttle principle of weaving. To supersede it, any machine or method to weave a fabric better than the present product must indeed be revolutionary in design and operation. There have been some practical modifications, however.

One such, a loom, developed beyond the laboratory stage and placed in industry for practical testing under competitive conditions, is of precision construction, with its motions made positive. Many parts and former practices have been eliminated; metal parts have replaced practically all wooden ones. A drastic change has been in the method of inserting the filling. In place of the conventional shuttle and the bobbin of filling yarn is a small yarn-carrier shuttle, which grips and inserts a section of filling. The fabric edge, or selvage formation, is a tuck-in, or overlap, of the single filling yarn. The filling supply package is a stationary cone containing usually thousands of yards of yarn. The yarn is passed through devices that ensure proper tension and prevent mechanical yarn defects. The pick, or inserted yarn, is cut at both edges and is slightly longer than the width of the cloth. The small extensions are folded into the selvage by a tucking needle. Although the filling yarn is inserted only from one side and the carrier shuttle returns empty for a repeat course, speeds upward of 240 picks a minute are common on light fabrics as wide as 110 inches—more than twice the speed of the conventional loom.

The machine-tool design of this loom, with the absence of many conventional parts, has eliminated much vibration and reduced noise. And because eye-level superstructure is not used on it, lighting is more effective, providing for better visibility and better supervision.

THE DEVELOPMENT of fabrics from loose fibers, rather than yarns, promises products that will give cotton new outlets. These novel products conceivably could find uses where paper is not suitable and also uses in which they would be more appropriate than woven fabrics.

Early in the nineteenth century an American patent was granted for grouping cotton cards to produce "webs" preparatory to treatment with a starch solution. The demand for the product was not great at that time. Since 1940, however, research has been offering to the textile industry a low-cost way of making nonwoven materials for specific uses.

Several methods are employed. A typical one produces a thin web, or sheet, of fibers on the carding machine. These fibers are in single or multiple layers and are randomly alined to give greater strength in the longitudinal direction. Such lightweight and low-priced fabrics meet mainly the need for absorbing qualities in products like facial tissues, bibs, table mats, dusting and polishing cloths, surgical dressings, and napkins. They can absorb 10 to 15 times their own weights of water.

Attractive effects in laminated webs of fibers alined in one direction are obtained by the deposition of narrow lines of starch or other bonding agent at right angles to the warp line or direction of the fibers. The effect is that of a decorative filling. The binder line may be white, tinted, or highly colored. Decorative and colorful printing or glazed patterns can be added.

In another method, used to give a more serviceable product, the fibers are parallelized, laminated, and cross-laid to impart strength in more than one direction. They may be bonded and made repellent to stain, water-resistant, or flame-resistant.

In a third method, the fibers are alined, cross-laid, and plasticized with a bonding agent. Some of these products are stronger than woven fabrics of equal weight—possible because the inherent strength of the fibers is made use of in a way not possible in weaving.

Originally, the webs, or sheets, were made on conventional cotton textile cards, with complementary equipment for collecting, folding, and spraying with bonding agents. Specially designed production machines now are used for laminating and cross-laying multiple sheets, for applying resins or other bonding agents, and for curing them.

Most fabrics just off the loom require a special cleaning or purification treatment before they are ready for use. No matter how carefully cotton is cleaned during its manufacture, the woven fabric contains some bits of leaf, seed hull, and the like, as well as small amounts of oil or sizing left after spinning and weaving. Also present are the natural noncellulosic constituents of cotton, including wax and pectins. Such impurities are removed from the fabric by bleaching, a chemical process.

Up to the time of the Second World War, the common method of bleaching was a caustic kier boil, followed by either a hypochlorite or a peroxide bleach. It embraced usually 12 or 13 separate operations, including intermediate washings and final drying. It took 3 or 4 days. A new method of continuous (in contrast to batch) bleaching, developed commercially a few years ago, has cut processing time to less than 10 hours. But it has some limitations—it does not treat medium and heavier fabrics perfectly. It is, however, adaptable to lighter fabrics, such as print cloths, in which a slight variation in whiteness may be covered by the colored patterns.

In the continuous process, essentially the same steps are followed as in the batch process and in much the same sequence. The steps are: Singeing the fabric to remove the fuzzy surface; steaming to facilitate removal of the starch sizing by the caustic soda treatment; washing; another steam passage; hydrogen peroxide J-box bleaching; another washing; and drying.

Two methods of passing the cloth are in use in both processes. One, the chain passage, mechanically routes the cloth from one process to another in the bleaching by drawing it in unbroken lengths through porcelain rings mounted near the ceiling. The second passes the open (full) width of the cloth, as in dyeing piece goods.

In continuous processes, the significant departures from the conventional are in the use of higher-priced, but more effective, chemicals and in the equipment.

The use of hydrogen peroxide solutions to replace calcium or sodium hypochlorite is more expensive, but their quicker reactions offset the extra cost, and they do less harm to the fabrics.

The principal difference in equipment is in the use of two 3,000-pound-capacity J-boxes as containers for the chemicals, in contrast to six 4-ton-capacity kiers, or pressure-type metal vats, in which the material was formerly boiled out and subsequently bleached. Each step in the batch process took several hours. The continuous-process equipment costs more. The initial cost and the upkeep of controls to regulate all operations are factors to be considered.

Edward S. Pierce estimates these savings by use of continuous-bleaching processes: 25 percent in floor space; 40 percent in labor costs; and 75 percent in steam consumption. The capacity of the vessels for the caustic and the bleach treatments also has been cut from 24 to 3 tons, and the time to bleach has been reduced from several days to a few hours. In addition, there is less handling of the product and less mechanical damage.

Cotton used to be bought chiefly, if not solely, on the classer's judgment of staple length, grade, and an undefined item called character. Present-day buying of cotton involves the consideration of other recently recognized properties, such as fiber length, the estimated proportion of spinnable fiber and waste, and fiber fineness, maturity, and strength. It is already possible to obtain a valuation of its spinning properties by pilot-plant operation. The techniques resolve themselves, finally, into lot labeling or variety identification of lots and bales, whose known properties influence processing and adaptability for specific end uses.

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Cottonseed hulls, which often are discarded as wastes in pressing cottonseed oil or making cottonseed meal, form a good mulch in flower and vegetable gardens. A layer of hulls 2 or 3 inches thick on rose beds, applied in early spring, makes an insulating mantle that keeps the overwintered, soil-borne blackspot inoculum from reaching the newly developed foliage. As with other organic mulches, a thick layer of cottonseed hulls prevents the rapid drying and packing of the soil from heavy rains and helps to keep down weeds.—*H. R. Rosen, Department of Plant Pathology, College of Agriculture, University of Arkansas.*