Mechanical Processes of Shrinkage Control of Cotton Textiles

P. J. Kangle*

IT is a common man's complaint that the cotton goods shrink out of fit on laundering. All of us, at one time or another, have experienced inconvenience caused by the shrinkage of our personal clothing during laundering, collars and shirts in case of men and undergarments and frocks with women..

In the beginning, all cotton fabrics were 'preshrunk' by soaking in water and drying them in slack condition. Later on, garments were cut with an extra allowance to provide for the anticipated shrinkage. However, both these methods were ineffectual.

Later on, an attempt was made to obtain more uniform preshrinkage by means of hydraulic press, used to press the water through and out of the piece goods, followed by the usual slack drying.

Then, an attempt was made to manufacture "ideal" fabric, by incorporation of some extra amount of twist within the yarns themselves, with the hope that this twist would open up enough during the bleaching and finishing operations, to compensate for the shrinkage. However, the warp tensions exerted during the wet processing were far too much, even for this special ideal fabric.

Other methods of preshrinking the cotton fabric are mechanical, chemical or physicochemical which prevent either or both the swelling and contraction. In this article, mechanical means of controlling shrinkage will only be dealt with, including the recent advances.

The idea of modern mechanical methods seems to have occurred more or less simultaneously to Sanford Cluett of Cluett, Peabody and Co. Inc., U.S.A., and Messrs. Wrigley and Melville of Bradford Dyers' Association, England. The basic patent seems to be that of Sanford Cluett and possesses a very broad claim. The basic principle, of both these processes is the same, but the methods of operation are different. The method of Wrigley and Melville led to the 'Rigmel' process and the method of Sanford led to the well-known "Sanforised" process.

The original idea of controlling was to shrink the fabric in the warp direction by means of an overfeeding device attached to a pin stenter-frame. The idea was first put into practice by Payet. Later on, a simple modification of the above was presented by Krantz, using an improved overfeed system of producing unshrinkable cloth on a stenter.

However, there were several disadvantages with all the above mentioned processes of the pin stenters. Firstly, the fabric occasionally came off the pins thus lowering down the production. Secondly, there was no positive method of insuring the shrinkage within 1% tolerance, which was desired. Thirdly, pin holes were objectionable. Fourthly, the finish and the feel obtained were not able to attract the market, compared to the high pressure calendered fabric.

Recognizing these faults, entirely new and novel machines for compressively shrinking fabrics, that would overcome all these difficulties, were designed. Before going deep into these processes, the causes of the shrinkage of the cotton fabrics will be dealt with.

*Technical Assistant in Dyeing and Printing; Textile Chemistry Section.

Factors Responsible for Shrinkage :

At the out-set, it can be traced that the shrinkage problem on cotton fabric began with the mechanization of spinning, weaving, bleaching and finishing. The way of handling the fabric in long continuous pieces during wet processing, as well as heavy calendering for glaze in finishing, resulted in excessive warpwise tensions, which left the finished goods with high residual shrinkage.

This, then, was the type of material supplied to the cotton garment industry for many years. Thus the shinkage of cotton goods was a funny and puzzling problem, both to the garment and laundry industries. It is but for the constant demand of shrink-resistant cloth from the consumer, that led to the constant attempts in the direction of supplying present " Preshrunk " fabrics.

The shrinkage of cotton goods can be explained on the basis that shrinkage is not only due to the release of strains, imposed during manufacturing processes, but to the swelling produced during wetting process, which brings about an internal rearrangement of the material resulting in external shortening. It is usually assumed that shrinkage of cotton goods is merely a relaxation of tension and extension inherent in the manufacture of the fabric. In other words, the water acts as a molecular lubricant causing the micells, fibres and yarns to contract to the position of minimum strain, from which they were originally displaced.

In the case of yarn (cotton), the hair passes around and along the yarn, so that when the yarn diameter is increased by the swelling action of water, the fibre or hair must either pass around or along the yarn to a less degree. If the first condition was released, the yarn has a tendency to untwist, but it is not free to do so in most cases, hence the fibre, in order to pass around the yarn as before, must shorten its path along the yarn, resulting in the shrinkage of the yarn.

The explanation of the garment shrinkage and ultimately the cloth shrinkage lies mostly in the fabric-structure or construction. The type of weave of the fabric also plays an important part in the shrinkage. The different types of weaves, such as plain weave, twill weave, drill weave, satin weave etc., etc., have different mechanisms of shrinking and the problem is under investigation at present. Even the single yarn fabric and doubled yarn fabric have different potential wash shrinkages.

In the case of plain weave fabric, the yarns of the warps and wefts bend round one another and in general, the warp yarns bend round the weft yarns to a greater extent, the difference between the cloth length and the yarn length being accounted for by the crimp of the yarn. When the cloth is wetted, the yarns increase in diameter and if the crossing weft threads were to remain the same distance apart, as in dry state, then the warp would have to extend. Such extension would require a force for its accomplishment, just as with the fibres in a swollen yarn, but as there is no such force and the fabric is under no constraint, the weft threads move closer together in order that the warp yarn can retain the same length. The cloth, therefore, shrinks in the warp direction. Alternatively, where the warp threads are straight, then the weft threads are crimped and the fabric shrinks weft way. In most fabrics, the warp yarns are finer than the weft and therefore, bend more easily and secondly, they are closer together for good cover and are less able to bend weft threads. Hence, the stable structure is that in which the warp crimp is high and weft crimp is low. There is a considerable tension on the warp during wet processing, resulting in lengthwise extension. This stretched or under tension structure has a low warp crimp and is more unstable. On wetting or laundering the cloth takes up more stable position, being free from restraint, resulting in shrinkage.

At the same time, it must be borne in mind the fact that a fully shrunk material is not difficult to extend. This is due to the collapse of the swollen material on drying to leave some free space in the structure. For these reasons, 'zero shrinkage' is not desirable.

Sometimes, it has been found that cotton materials are not completely shrunk on first laundry washing, but continue to shrink in subsequent washings. This is known as "Progressive Shrinkage". This can be partly attributed to the extent of severity of washing treatment. But it has been found that the construction of the fabric plays an important rôle in the shrinkage of this type. This problem has yet to be attacked fully and solved. Even this may be due to local strains due to yarn adhesion, which are not capable of easy removal at one stretch.

Controlled Compressive—Shrinking Processes:

The worth quoting advantages of controlled compressive machine are (1) shrinkage control positively ensured to 1% residual shrinkage in both warp and filling, (2) high speed consistent operation giving high production, (3) finish and feel of the fabric made attractive and (4) elimination of pin holes in the selvages.

Main Principle:—

It is a well-known fact that when elastic material describes a convex path, the convex surface of the elastic material is extended and when it describes a concave path, the concave surface of the elastic material is contracted. Now, when cotton material is placed or fed onto the extended surface formed by the elastic material during its convex path, and moved with it into the concave path, then the cotton material will be contracted by compression. The cotton material is held firmly in contact with the elastic material during its convex and concave paths.

In "Sanforised" process, the elastic material used is an endless elastic woollen felt blanket, and in the case of Rigmel process, a thick rubber sheet is used.

In both these processes the principle is same as described above.

"Sanforised" Process:

The word "Sanforised" (trade mark) is now familiar and famous in the cotton market. "Sanforised" fabric means preshrunk fabric which will not shrink anymore, during subsequent laundry washings. The garments stitched out of these "Sanforised" fabrics will never shrink out of fit. This credit goes to the scientific and careful way of processing the fabric, during this last stage of finishing.

This process has been standardised and can be controlled efficiently with the modern plants.

"Sanforised" department is usually accompanied with its own laboratory to check the efficiency and accuracy of the process.

Compressive shrinking is a well-controlled operation and therefore it is absolutely essential to know the potential wash shrinkage, both lengthwise and widthwise, before processing the fabric on the plant. And this job is done in the laboratory by the chemist. A standard wash test, as described in U.S. Bureau of Standards CCC-T 19-Ia, is carried out on a sample of 22″ in length and having 18″ wide marks, both lengthwise and widthwise. This test is carried out in a reverse wash wheel having a definite diameter. After the test is over for a definite period, the samples are removed and extracted in a centrifugal extractor and pressed directly on flat bed press. The samples are cooled and the change in dimensions are noted down and passed on to the operator of the plant.

After the fabric has been run through the controlled compressive shrinking plant, a wash test is again made to determine the potential wash shrinkage or gain of the shrunk fabric. The trade mark "Sanforised" is never applied to any fabric which fails to meet the U.S. established standard of not more than .75 to 1.0% shrinkage or gain in either warp or filling, after the fabric is yarded off, rolled, doubled and rolled or baled. The wash tests on the samples are carried out for every 2,000 yards, in any lot. From this, it can easily be concluded that every care is taken to supply cotton goods to the consumer in its natural feel and structure.

For general information, it can be quoted that ordinary poplin can have 1 to 2″ potential wash shrinkage per yard lengthwise, and poplin coating can have 2 to 3″, potential wash shrinkage per yard, lengthwise.

The potential wash shrinkage not only depends on the construction of the cloth, but also on the colour. The fabrics of different colour and patterns, but of the same construction and finished apparently under the same conditions, very often show quite different wash shrinkages. The potential wash shrinkage also depends on the number and type of operations the fabric has undergone. Also the mercerised and unmercerised fabrics of the same construction show different potential wash shrinkages. The efficient and successful operation of the plant mainly depends upon the condition of the fabric as it is fed to the plant.

The fabric to be processed in the plant should be water absorbent. Fabrics usually come to the machine in either of the two conditions (1) in grey or (2) finished. The fabrics to be compressively shrunk are prepared or finished in such a way that they are water absorbent, irrespective of their grey or finished condition. Usually the finished fabrics, i.e. boiled, bleached, mercerised etc., etc., as the case may be, are water absorbent. In finishing, only those ingredients are applied, which will keep or retain the fabric absorbent. In general, thin boiling corn starch and some wetting and rewetting agents with varying amounts are used to give the desired hand and weight to the fabric.

Controlled Compressive Shrinking Ranges:

There are four general combinations available, viz.,

(1) Single range—without clip expander—consisting of rubber control rolls, skyer and main machine.

(2) Single range—with clip expander—consisting of rubber control rolls, skyer, clip expander and main machine.

(3) Duplex range—Fabric guiders, rubber control rolls, skyer, clip expander, main and auxiliary machines.

(4) Tandem range—which is used when majority of the fabrics to be compressively shrunk do not require the same finish on both the sides. It is same as No. 3 with the two main machines facing in the same direction.

The Duplex range is in general

use and will be dealt with in this article.

Shrinking Action :

An endless felt blanket is led over a roll, known as feed-in-roll, so that its outer surface is stretched and its inner, compressed. This is more clear in Fig. 1. The feed-in-roll and the blanket are held firmly against a steam-heated drum of large diameter, around which the blanket passes after leaving the feed-in-roll. At the point of transfer from the feed-in-roll to the drum, the blanket reverses its curvature, so that the outer and previously stretched surface changes to the inner or compressed surface. The electrically heated steel shoes are adjusted over the blanket, above the feed-in-roll. Shoes hold the fabric firmly against the stretched surface of the blanket, above the feed-in-roll. The fabric is allowed to go on the blanket at the point where the blanket is in a maximum stretched condition over the feed-in-roll. The fabric is first held in firm contact with the blanket surface by the shoes and then by the main drum. When the blanket reverses the curvature as it goes onto the drum from the feed-in-roll, the stretched condition of the surface of the blanket comes back to normal and then to a contracted or compressed condition. And along with it the fabric is also shortened. Depending upon the thickness of the blanket, the shortening of the fabric takes place.

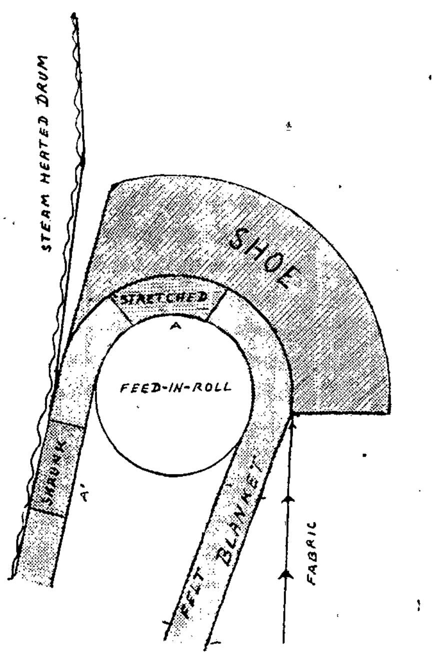


FIGURE SHOWING HOW AND WHERE SHRINKAGE IS OBTAINED

Fig. 1.

Path of the Fabric Through the Plant :

The fabric, as it is fed to the machine, is guided with the help of pneumatic guiders in its fully opened form, over the tension bar and the high skying bar. Then it passes over the Rubber Control Rolls, the function of which is to allow only the required or adjusted amount of the cloth to the machine, or in other words, to control the feeding of the fabric onto the machine, or onto the blanket. The adjustment of the roll should be accurate, to grip the fabric lightly. Both the rolls (top and the lower) have the same circumference. The proper and accurate setting up of the rubber control rolls, then, results in a certain lengthwise tension on the fabric, between these rolls and the feed-in-roll.

After passing through the nip of the control rolls, the fabric enters the enclosed skyer, where the fabric is sprayed with water, which makes it pliable and softer, due to which the fabric can easily be compressed by the felt blanket. The skyer essentially consists of a number of guide rollers, enclosed in a chamber. Water is sprayed with the help of spray blocks, having spray jets. The spray blocks are adjusted at a certain distance from the fabric. The air jets of the spray block are in the horizontal position and spray the water at right-angles to the fabric. The water nozzles of the spray blocks require the correct and accurate adjustment of the distance from the air nozzles for efficient working. The finish and the feel of the fabric purely depends on the efficient and uniform spraying of water. The finish also depends upon the uniform and just sufficient spraying of water. In the case of thick or somewhat water-repellent fabrics, steam spraying is done with the aid of steam sprayers, fitted in the skyer to make the fabric flexible. The correct spraying of water for a particular type of goods is a matter of experience and no fast rules and regulations can be laid down. There is a limit for the amount of water to be sprayed, beyond which, numerous troubles start encountering loss in production and finish. The sprayers automatically stop when the machine stops, avoiding excess of wetting of the fabric. Then, it passes over the heated cylinder, where the water is driven into the innermost fibres of the fabric, thus attaining more uniformity in the distribution of water over the surface of the fabric. The other part played by the cylinder, is to preheat the fabric, thus helping to keep the shoes from cooling down and ultimately playing the part of increasing the rate of production.

Then, the fabric passes through the clip expander, 3½ feet in length. Here uniform and desired width can be had, as per wash test. The entering end of the clip expander is fitted with automatic electric guiders. In case the fabric of uneven width comes to the stenter, the clip rails adjust themselves accordingly.

Next, the fabric passes onto the felt blanket over the feed-in-roll, where it is held in firm contact with the stretched blanket surface by means of electrically heated steel shoes. Then, it is held in firm contact with the blanket by the main Palmer (heated drum of large diameter). The reversal of the path of the blanket, as it starts around the main Palmer, shortens the fabric in contact with it.

The amount of shortening of the fabric depends upon the thickness of the blanket. For example, a blanket having a thickness of 0.275″ has a capacity of shortening the fabric to the extent of 2.80″ per yard. A blanket having a thickness of 0.500″ can shorten the fabric 5.20 inches per yard lengthwise. In short the thickness of the blanket determines the maximum amount which a fabric can be compressively shrunk. In the market, the blankets of different qualities are available, from coarse to superfine. The quality of the blanket also determines the final finish of the fabric. Usually, thicker the blanket, rougher is the finish obtained. Special fine blankets of diversified texture and fine wools are available, which are necessary to produce proper finish on voiles and other fine fabrics.

When the machine is running, the blanket is under tension throughout the operation. A semi-automatic sensitive blanket tension device is used. It is a mechanical device, having the basic principle of lever and weights, to give proper tension to the blanket. The same uniform tension is maintained as the blanket elongates or shortens due to the blanket getting wet or moist while it is running, or as it dries when machine is stopped. Even slight wrong adjustment of the rolls may cause the blanket to come on one side and hence to avoid accident, the electric "stop motion" (limit switches) switches are installed to stop the machine automatically. Also electric or air guides are installed, usually to keep the blanket in proper place automatically. The steam pressure is regulated to keep the blanket dry during the process.

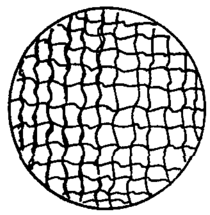
Also, it is worth noticing that the fabric is completely dry before leaving the main palmer, lest the fabric may elongate, producing faulty processed fabric.

The feed-in-roll is a chromium plated steel roll, located at the front of the palmer, over which the blanket passes, under heated shoes (see Fig. 1). The correct size of the feed-in-roll must be used for the correct setting up of the range to run a particular fabric. Usually, a set of feed-in-rolls, advancing by 1/32″ in diameter, is supplied to compensate for wear or thinning of the blanket and also for the different types of fabric. The electrically heated shoes must be adjusted in such a way that they ride on the blanket smoothly, neither too loose nor too tight to avoid faulty finish and appearance of the fabric. The feed-in-roll has also to be adjusted against the drum. This adjustment is as important as subsequent adjustments such as shoe adjustment etc. These are all fine adjustments and can only be acquired by experience. The shoes are electrically heated and attain a temperature of 350°F. The temperature of the shoes is controlled by means of a thermostatic arrangement, fitted individually. The shoes are heated by four electric heating elements. The adjustment of shoes on the machine is a matter of accuracy and experience. There is an automatic shoe lifter, whose function is to lift all the heated shoes when the machine stops, thereby avoiding blanket and fabric scorching. The shoes are heated because if cold shoes were used the friction of steel would overcome blanket friction resulting in less shrinkage.

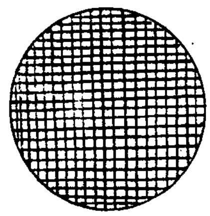
After leaving the main Palmer or drum, it passes over a very fine spray of water and then to the auxiliary unit set at the back of the main unit. Just sufficient water must be sprayed, otherwise with excess of water the finish will be reversed. The main function of the auxiliary unit is to give the same finish on both sides of the fabric. The auxiliary unit is of the same construction and details as the main unit.

Means of Controlling the Shrinkage:

Firstly, as mentioned, the blanket thickness is one of the criterian. Secondly, the amount of shrinkage can closely be regulated by means of change



APPEARANCE OF THE FABRIC BEFORE SHRINKING



(FABRIC) SHRUNK APPEARANCE

Fig. 2.

gear boxes on the main machine and on the rubber control rolls. These controls can be adjusted and set to obtain any desired shrinkage upto the shrinkage capacity of the felt blanket with which the machine is equipped. The surface speeds of the main palmer and the rubber control rolls are adjusted by the change gear boxes. They have the same surface speed when the change gears of both are set at zero.

When a particular lot is running, yard marks are placed at several places along the selvage of the unshrunk fabric. These marks are checked as fabric comes out at the other end, thus checking the actual shrinkage taking place. In addition, wash tests are also carried out in the laboratory. The maximum speed with which the machine can be run is 120 yards per minute.

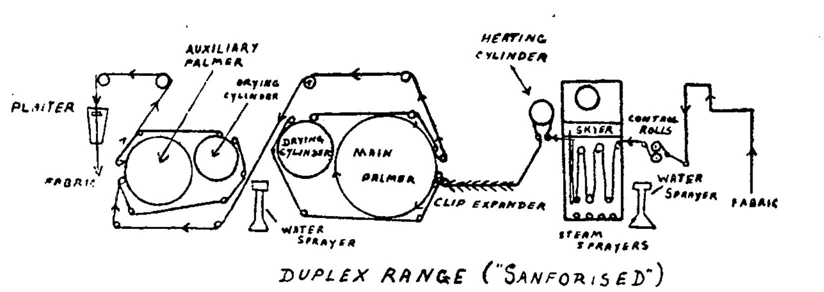
Rubber belt machine:

The latest development in the compressive-shrinking process is a rubber belt machine. This is a really unique achievement of interest. Rubber belt machine can shrink a fabric to a definite predetermined amount, up to a maximum, depending on the thickness of the belt at speeds as high as 100 yards per minute. In this type, no electrically heated shoes are necessary. Secondly, a micrometer adjustment provides for changes in the nip as fine as 0.025 inch per yard, thus holding the finished fabric within the tolerance limits of 1% gain or loss. The belt carrying the dampened fabric is squeezed as it passes between a pressure roll and the large metal drum. This pressure results in perfect contact between the belt and the back of the fabric and between the fabric and the smooth surface of the drum. Thus very fine and smooth finish can be produced on both sides of the fabric simultaneously. A rubber belt can be used to process nearly 10,000,000 yards of the fabric. However, a grinding operation (unit attached on the machine itself) must be done after about every half-a-million yard to keep the entire surface of the belt absolutely smooth. The finish obtained is more preferred in the present Indian market. On the other hand woollen felt can process 10 lakh yards of the fabric.

These things lead to say that this process of controlled compressive shrinkage has been successful, because it elimiated shrinkage troubles with the finished cotton fabrics. Indian processers have recognised the importance of the process, and nearly six or seven mills are running the plants to meet the consumers' demands in India.

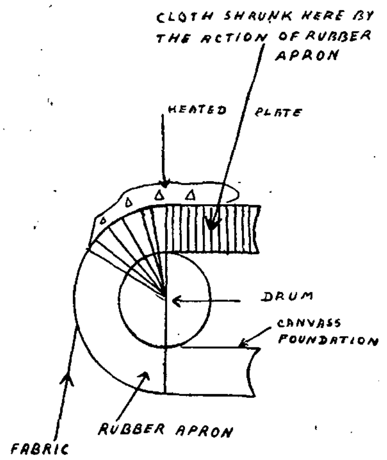
Rigmel process:

The Rigmel machine is a compact machine, having the same main principle of "Sanforised" process. In this machine, a rubber apron (endless) is used. On account of larger thickness and elasticity, it is easy to contract when it passes from the curved drum to the straight path. The rubber apron moves round a pair of rotary drums. The outer surface of the rubber apron will be extended as it passes over the peripheral surface of half the circumference of the drums, until it reaches its straight path i.e. on leaving the surface of the drums. A heated pressure plate is so mounted (as shown in Fig. 3) above the drum to which the fabric is first fed, that it makes a contact with the surface of the rubber apron. This plate is made with its leading edge reaching over a portion of the curved periphery of the rubber apron on one side and a similar portion of the straight path of the apron on the other, thus conforming to the path in wihch the apron travels.



DUPLEX RANGE ("SANFORISED")

Fig. 3.



PRINCIPLE OF RIGMEL MACHINE

Fig. 4.

The cloth, which is to receive the shrinkage treatment, is fed into the machine so that it enters between the pressure plate and the stretched apron. The gripping surface of the contracting rubber engages the fabric as it passes under the heated plate and carries it forward. The contraction of the rubber forces the weft threads into closer proximity to each other and therefore causes the warp threads to follow a more sinuous path, and hence the shortening of the length of the fabric.

The rotary drums are about 18-24″ in diameter. The thickness of the rubber varies from 2-3″. Actually, there is a small Palmer machine attached to the Rigmel machine, but it plays no part in the shrinkage, being only employed to dry the fabric completely and set the cloth in a stable state.

The word "Rigmel" is also a trade name.

From this, it can easily be concluded that "Sanforised" process is a pure mechanical process of fine adjustments. Now-a-days, "Sanforised" garments are also getting popular in our country. At present, we can find "Sanforised" goods capturing the market.