EFFECT OF YARN SINGEING AND WET PROCESSING ON SPIRALITY OF WEFT KNITTED FABRICS

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BONAFIDE CERTIFICATE

Certified that this project report titled **"EFFECT OF YARN SINGEING AND WET PROCESSING ON SPIRALITY OF WEFT KNITTED FABRICS"** is the bonafide work of **Mr. K.C.KARUNAKARAN** who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

Dimensional stability is an important factor for any apparel. The raw material and type of process followed during the manufacturing stage decide this factor. The woven fabric is having good dimensional stability due to the warp and weft interlacement, in which the warp is under sufficient tension, where as the dimensional stability of knitted garment is influenced by the knitting process in which the yarn is not subjected to that much tension. Also the residual torque available in the yarn turns the fabric in the leading direction. One of the main factors that affect the dimensional stability of a single jersey fabric is 'spirality'. According to textile terms and definition 'spirality is defined as the distortion of a circular knitted fabric in which the wales in the fabric follow a spiral path around the axis of the knitted fabric. In plain weft knitted fabrics the shape and position of the loops determine the dimension stability and the degree of spirality. In this project an attempt is made to study the effect of yarn singeing on spirality of weft knitted fabric. Also, the spirality in each stage of wet processing was investigated. For this 30^s combed cotton hosiery yarn was spun from ring frame with three TM levels (3.5, 3.8 & 4.1). The yarn samples in the cone form singed using gas singeing machine. Before producing knitted fabrics, singed and unsigned yarn samples were tested for twist liveliness in the twist liveliness meter. The knitted fabric was produced in single jersey circular knitting machine. To investigate the effect of wet processing on spirality the unsigned yarn was used to produce weft knitted fabric and involved at the wet processes such as washing and scouring, dyeing and compacting. The each stage the spirality was examined. The results of the spirality reveals that the singed yarn produces lesser spirality than unsigned yarn. Similarly up to compacting the spirality is found to the gradually increased, but the percentage of increases in spirality in compacting process is only 1.6 – 3 %.

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CHAPTER 1

INTRODUCTION

The knitted garments always provide greater comfort than woven garments. The softness, fitting characteristics and dimensional stability are the important features provides these specialties. Apart from twist characteristics of the parent yarn other process factors also influences the dimensional stability of weft knit garments . The very important phenomena which affects dimensional stability is called spirality . Each process in the production of weft knit garments influence of the spirality . In this project an attempt is made to study the effect at singing in the yarn stage and dyeing & compacting in the fabric stage on spirality of weft knit fabric.

The spirality dislocates the position of wales with respect to course. Due to spirality the angle between wales and courses is always lesser than 90°.Knitted fabric was produced and processed in washing, scouring, dyeing and compacting. In all the stages spirality was studied and conclusions were made based on experiment. The results revolved that the process parameters influences the spirality.

So the fabric skews towards right or left depending upon physical characteristics. The main reason for spirality is :-

- Yarn twist liveliness

Other reasons are :-

- Number of feeders
- Type of fiber processed
- Type of rotation of knitting machine
- Stitch density

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is concerned with the literature review on spirality of weft-knitted fabrics and dimensional stability. A considerable amount of work has been carried out on spirality, physical and mechanical properties, and chemical finishing of knitted fabrics. This survey is based upon an intensive search of the journals published in textile technology. Much interest has been shown on spirality, because it is generally agreed that it plays an important part in the appearance of garments.

2.2 SPIRALITY

2.2.1 The Nature of Spirality

Fabric spirality is a complex phenomenon arising from many factors influencing the nature and degree of loop distortion in single-jersey knitted fabrics. Residual torque is believed to be the most important and fundamental factor affecting the degree of fabric spirality. Platt et al (1958) have demonstrated that total torsional stresses in a twisted yarn arise mainly from the effects of fibre bending and twisting. By using the elastic theory, they derived expressions for the yarn torque due to yarn twisting.

Postle, Burton and Chaikin (1964) went one step further and demonstrated that the total yarn torque in a twisted yarn not only arises from the stresses due to fibre bending and twisting but is also influenced by the fibre tension in the twisted configuration. These authors derived an expression for the yarn torque governed by fibre tension. Postle's work is a significant contribution to torque of yarns.

2.2.2 Fibre Factors

Fibre cross sectional shape, tensile bending and shear moduli influence fabric spirality.

Davis, Edwards and Stanbury (1934), who did work on spirality, attributed it to twist in the yarn. After experiments, in which they knitted fabrics from yarns of different twists they wrote "In every case the spirality increases directly with the yarn twist, takes a left or right direction in accordance with the yarn twist, and is increased by slackening the texture of the fabric". They found that spirality could be very much reduced by setting the twist in the yarn before knitting, or by using a balanced yarn consisting of two ends of opposite twist.

In many tension-free, tubular yarn fabrics, knitted in a plain stitch on a circular one needle system knitting machine, the lengthwise rows of loops (stitches) called needle lines or wales, should normally occupy a truly vertical line, parallel to the edges of the fabric and at right angles (90□) to the crosswise rows of loops called courses, when the fabric is undistorted. In practice, however an undesirable phenomenon becomes vividly apparent, where the wales show a pronounced bias towards the left or the right. This fault occurs particularly in single jersey knitted fabrics and garments which have a dissymmetry of the loop between the face and back of the fabric. This results in seams, which do not run parallel to the edges of garment made up from such material, although the line of courses remains perpendicular to the edges of the fabric. This defect has been approximately termed by Davis, Edwards and Stanbury (1934) as spirality since it occurs chiefly in tubular fabrics where the wales follow a spiral path around the axis of the fabric, forming an angle with the perpendicular. This angle is termed as the "spirality angle", and is a measure of the fabric spirality.

If the loops of each course on the technical face of the fabric, which has been produced on a knitting machine, are examined closely, an inclination to lean slightly to the right (or left) is observed, indicating an excess of yarn on left or right hand side respectively of the loop, i.e., the formation of each loop is just a little lop sided. The lifting of the one side of the knitted loop from plane of the fabric is the cause of the appearance of an almost rib-like structure form, as the wales are bunched together (Nutting 1960).

When the fabric is on a knitting machine, the magnitude of this distortion is unpredictable because of the imposition of strains on it due to the take-down tension (Charnock 1977). As the fabric is released from the stress due to this tension, a complete change occurs in the shape of each of its unit cell (loops). This rearrangement of the fabric structure results in an initial fabric distortion. If the fabric undergoes a process of wetting (immersing in water, dyeing, washing), there is a further distortion of the fabric which is mainly a result of reappearance of the forces in the yarn which have been "relaxed" in the earlier steam setting of yarn (Fletcher and Roberts 1953). This factor must be recognised in producing a commercially acceptable washable product (Knapton et al 1971).

Many workers (Lord et al 1974, Buhler 1986), who dealt with this phenomenon of spirality, agree that the main reason for this defect "is the unbalanced torque within the yarn, shown by its twist - liveliness, the release of torsional potential energy in the yarn" rather than just the presence of the twist alone. In combination with the unbalanced active torque in the yarn there is the contribution of fabric geometry. The degree of freedom of yarn movement in the fabric structure contributes significantly to the rise of spirality (Nutting 1960). The more slack the fabric structure, the greater the spirality. This slackness can be achieved by two ways; by changing the tightness factor or, by changing the linear density of the yarn. It has been stated that the loop twisting over to approximately the same angle as the spirality angle, is the result of the section of yarn in each loop that is trying to move to "a state of lower strain under the constraint of forces from neighbouring loops" (Haigh 1987). It has been shown by Leaf and Glaskin (1955) that much of this distortion arises from the residual torque in the yarn. Newly produced ring spun yarns exhibit a tremendous tendency to untwist, before being treated with any dry or wet relaxation method. This phenomenon could be explained by taking into consideration that elastic stresses as well as torsional forces (torque) set up in the component fibres by the twisting action during the spinning process attempt to be relieved. This tends to cause an opening up of the yarn and gives rise to yarn and fabric defects (e.g., snarls, spirality, cockling). Hence, "the greater the twist liveliness, the greater the spirality" (Nutting 1960). At this point, it is necessary to mention that, although this statement is generally acceptable, it was found in the literature that there is a confusion between the twist amount in the yarn and the yarn torque. Some statements which reflect this, are given below: "the degree of spirality is related to the twist factor (number of turns per length of the yarn)" (Brackenbury 1992) yarns with lower turns per unit length, tend to develop less spirality in the fabrics than yarns with high twist levels ..." spirality increases with the turns per inch ...". "spirality is often due to an excess amount of twist in the yarn from which the fabric is knitted ..."

2.2.3 Direction of Spirality

It is well known that the direction of the spirality in fabrics knitted from singles short staple yarns is normally determined by the direction of the yarn twist (De Araujo and Smith 1989a). If a Z-twisted yarn is used for the production of knitted fabrics, the technical face of the fabrics exhibits spirality in the Z direction and vice versa (Figures 2.1).

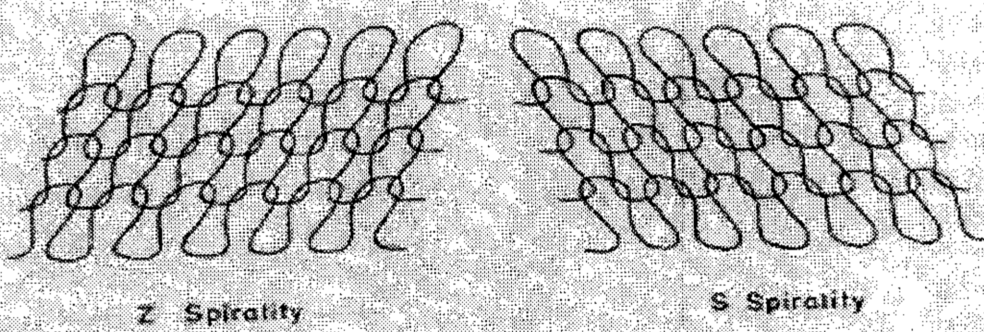


Figure 2.1. Direction of Spirality (Wale skew).

2.2.4 Measurement of Spirality

Several standards are available for determining the spirality of knitted fabrics, e.g., ASTM D3882-88-1997. British standard 2819 (1990), IWS test method No.276.

The angle of spirality can be measured with the help of a protractor of by using a specially designed transparent plastic board as is shown in Figure 2.2. The line EF, which is perpendicular to the sides AB and CD of the rectangle ABCD plays the role of the reference line of a wale in the ideal perpendicular relation that exists between wales and courses in an undistorted knitted fabric. If the line AB tallies with a course and the line EG lies along the actual line of the wales, then the angle FEG is the angle of spirality. Using the distances AD = 10 cm and FG (h cm), Oinuma and Takeda (1988) calculated the "percentage spirality" (PS %) which is expressed by the following equation: PSD (%) = (h/10) x 100, and it is considered as the sum of the "net" spirality caused by the yarn torque and the "additional" spirality caused by all other factors.

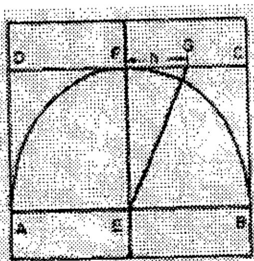


Figure 2.2. Transparent board having a protractor configuration on it.

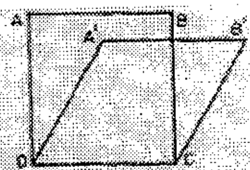


Figure 2.3. Method for the calculation of the percentage spirality by AATCC.

Another test method for measuring the spirality of knitted fabrics has been proposed by AATCC (1995). In this test, the fabrics samples are marked with a square before washing and drying Figure 2.3. The changes in the diagonals of the square are measured to calculate the percentage spirality (PS) given by the following formula:

$$PS\ (\%) = \frac{2\,(B'D - A'C)}{(A'C + B'D)} \times 100 \qquad (2.1)$$

Another test for measuring spirality involves use of "open pillowcase" construction which enables seam overlap to be measured, and hence the angle of spirality to be determined (Anand 2000; AATCC-179 2001).

2.2.5 "Acceptable" Spirality

Over many years in dealing with spirality, many workers, researchers and manufacturers have set limits of spirality acceptability. For some, the maximum spirality angle of 5 ^{o} is acceptable whereas for some others the angle of 7^{o} is taken as the upper limit. It is also found that some exporters stipulate 3 ^{o} for accepting the knitted fabrics. In U.S.A., a percentage spirality of 8 ^{o} is considered as the maximum a fabric may exhibit to be acceptable by the making-up industry.

2.2.6 Effect of Knitting Machine Factors on Fabric Distortions

A point worthy of consideration is the effect of the knitting action on fabric distortions.

First, a distinction between the "spirality" and the "drop" or "corkscrew" phenomena should be made to avoid any possible confusion.

"If the wales are skewed from the vertical, the resulting configuration is called a "wale skew". If the courses are skewed from the horizontal, the resulting configuration will be called "course skew" (Figure 2.4).

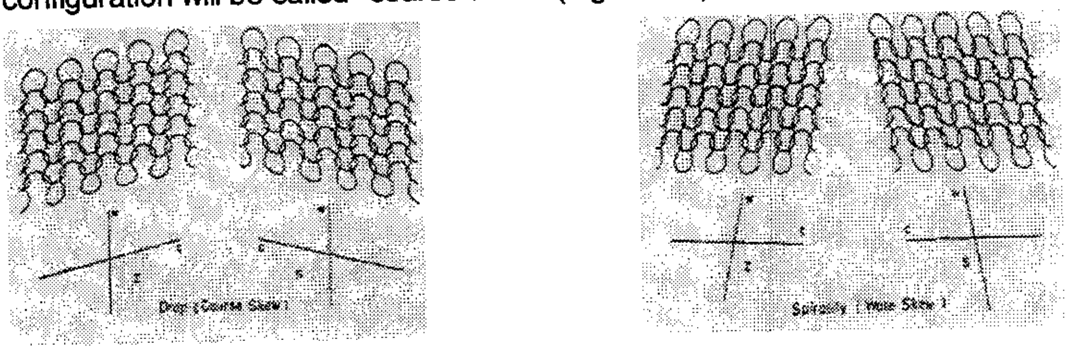


Figure 2.4. Drop (Course skew) and Spirality (Wale skew)

"Wale skew" widely accepted as the well-known term "spirality", is due to the twist liveliness (Buhler and Haussler 1985). "Course skew" has been described as the "drop" effect (Oinuma and Takeda 1988), and is inherent in the process. This occurs due to the helical disposition of the courses, and depends on the fact that articles produced with a spiral configuration have a "start" and an "end" of a coil not on the same plane.

In weft circular knitting machines, fabrics present a course skew because the yarn is knitted in the circumferential direction. The degree of the course skew or drop depends on the number of feeders used on the knitting machine (de Araujo and Smith 1989a). It is true that, in recent years, the machine manufacturers tend to increase the number of feeders. For this reason, the problem is likely to become more acute. The degree of drop is a function of the step S of the helix due to the number of courses per centimetre and the machine circumference. The direction of the inclination of the drop depends on the direction of either the revolving cam box or the rotating cylinder (Figure 2.5).

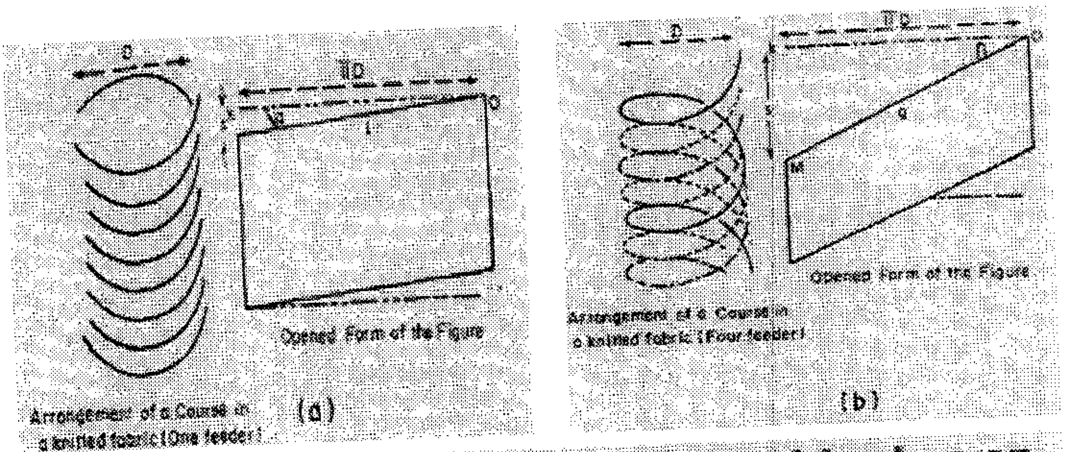


Figure 2.5. Effect of the number of feeders on the fabric drop (Course skew)

In some papers, there is a suggestion that both the spirality and drop effect contribute to the final distortion or "total" spirality. It becomes essential, therefore, to describe the effect of the number of feeders on the drop phenomenon as well as to investigate the contribution of the drop to the "total" spirality of the produced fabrics.

If the direction of the rotating cylinder reverses (i.e., clockwise) then Figure 2.6. will change to the form shown in Figure 2.7 indicating that the overall spirality angle will be reduced.

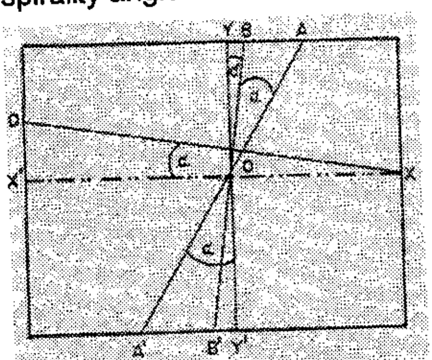


Figure 2.6. Development of spirality in a single jersey fabric knitted from a Z-twisted yarn on a multifeed circular machine with an anticlockwise rotating cylinder.

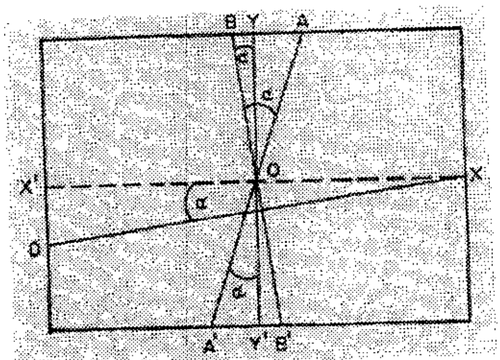


Figure 2.7. Development of spirality in a single jersey fabric knitted from a Z-twisted yarn on a multifeed circular machine with a clockwise rotating cylinder.

It could be concluded then, that in many cases it would be beneficial rather than detrimental from the "total" spirality point of view, to use a larger number of feeders on a machine, as the drop (due to the number of feeders) and the spirality (due to the yarn twist liveliness)" can combine together to create more skew, or they may partially offset each other and result in less skew". On the other hand, multiple feeders increase the chance of a strip fabric being produced because of possible yarn linear density and/or shade variation between feeders (Walker and Sleath 1950).

Further to the conclusions of the above investigation, it has been suggested that the number of feeders is responsible only for a distorted appearance of the fabric (in terms of drop effect), while the actual spirality is the same whether a single or multifeed machine is used (Figure 2.8a and 2.8b).

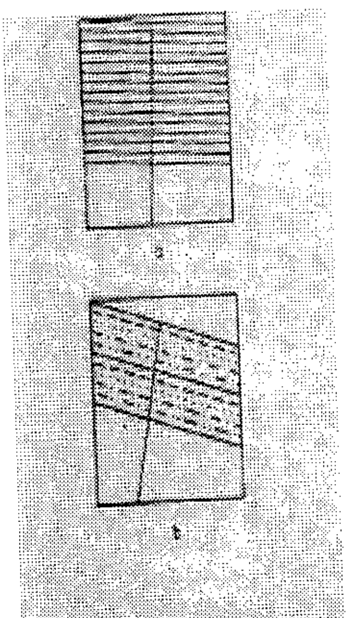


Figure 2.8a. Appearance of distorted fabric due to drop effect. (a) one feeder (b) five feeders with β spirality angle.

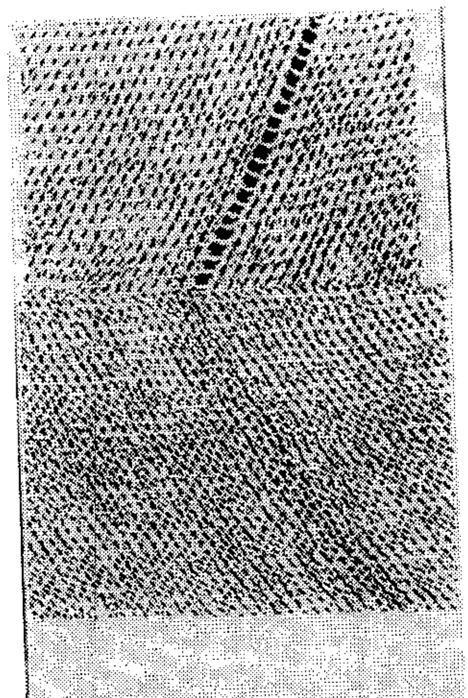


Figure 2.8b. Fabric distortion due to spirality.

2.2.7 The Effect of the Rotation and its Direction of the Cylinder and Cam Box on Spirality

In the knitting industry, two types of circular single bed machines are, in terms of their rotating parts, responsible for the knitting action: machines with revolving "cylinder cam system" (cam box) and machines with rotating "cylinder needle housing" (cylinder). These parts can be rotated clockwise or anticlockwise. Thus, when a knitting machine has a clockwise revolving cam box, the stationary cylinder is rotating relatively anticlockwise, and when a machine has a clockwise rotating cylinder, the stationary cam box is relatively revolving anticlockwise and vice versa. It has been stated that the direction of rotation of these knitting parts influences the positioning of the loops (stitches). Experiments were, therefore, carried out to determine the actual effect of the direction of rotation on the spirality of tubular single jersey knitted fabrics (Buhler 1985). In these experiments, a twist-free (neutral) polyester monofilament was knitted on a machine having an anticlockwise rotating cylinder. On a close examination on the fabric produced, a slight tendency of the loops to follow the running direction of the cylinder could be detected i.e., the individual loops were found to be inclined to the right. The loop shanks on the right were also shorter than those on the left. It has been argued that this was a result of the tension imbalance between the two "legs" of the loop during the stitch formation (de Araujo and Smith 1989ab), and this "skewness is, especially noticeable with monofilament yarn because of its high bending rigidity. "The inclination of the stitches against the direction of knitting can be traced back to the fact that the following stitch shank running in the direction of the thread-feed is subjected to higher levels of tension during interlacing process of the stitches" (Buhler and Haussler 1986).

Disagreements concerning the actual influence of the rotation of particular mechanical parts of the knitting machine exist between various workers.

It would appear advantageous in terms of spirality reduction to work with Z-twisted yarns on knitting machines with clockwise rotating cylinders. On the other hand, others are of the opinion that the total spirality is reduced when Z twisted yarns are knitted on a machine with an anticlockwise rotating cylinder. There are also some workers who make no stand, since their experiments showed opposing results. Still other researchers consider the effect of this factor as negligible (Davis, Edwards and Stanbury 1934). The results are summarised and presented in Table 2.1.

TABLE 2.1

EFFECT OF THE DIRECTION OF THE CYLINDER ROTATION ON SPIRALITY

Direction of the Additional spirality	Direction of cylinder
Z	Anticlockwise
Z	Anticlockwise
Z	Anticlockwise
Z	Clockwise
Z	Clockwise
Z	Clockwise
Z	Clockwise

This skew effect, due to the direction of the rotation of the knitting machine, is negligible when compared with the possible yarn effect on the spirality angle and can be disregarded. But, even if invisible, it contributes slightly to an increase or decrease of the spirality angle. This factor related to the spirality should be taken into account when seeking the explanation or relative defects.

2.2.8 Existing Methods for the Reduction of Spirality

"Spirality, although as old as the hills, is regarded as a mysterious disease, and as such requires mysterious cures. The facts of the problem are delightfully simple, the difficulty usually arises when a practical cure is being sought".

Theoretically the effect of spirality must exist, potentially at least, with all single yarns, except in the case of twistless yarns (King 1934).

Various methods have been adopted for overcoming this defect. These are now described.

2.2.9 Mechanical Methods

2.2.9.1 Use of folded yarns

Many workers (De Araujo and Smith 1989a; Charnock 1977) have opined that the most suitable method for producing spirality - free knitted fabrics is by using two-folded yarns. These yarns are called "dead", a term used in the industry, as they are left with a reduced or null residual torque or twist liveliness. This is because the twisting together of two ends of yarn, having the same twist direction, in the opposite direction to the spinning twist, exerts a balancing and stabilising effect. The opposing torsional forces in the singles yarns and the resulted folded yarn are counterbalanced. Because of problems in dealing with the appropriate relation between the two amounts of twist, any small amount of spirality which may develop will be in the direction of the residual twist.

Replacing singles yarn by folded yarn gives rises to an improved fabric appearance; a smoother touch even light reflection, better stretch and more vigorous recovery in the resultant fabric. Also, folded yarns are more resistant than a singles yarn to the effects of distortion and other physical effects and can be made even more stable if the yarn package is dyed in this form. On the other hand, the use of two folded yarns in knitting single jersey fabrics has the disadvantages of high yarn material and yarn production costs. Garments (e.g., T-shirts) knitted from such yarns are heavier, which is often an undesirable factor. For a given end product, the singles yarn used for the production of the two-folded yarns must be finer resulting in a dramatic increase of the production costs.

Chen, Au, Yuen and Yeung (2002) have conducted studies on the effects of yarn and knitting parameters on the spirality of plain knitted wool fabrics made with two fold yarns. That the twist factor of two ply wool yarn loop length and fibre diameter affect spirality have been pointed out by them. In general, increasing the twist factor of two ply yarn loop length and fibre diameter has led to an increase the spirality. They have used the experimental data to derive empirical equations linking the angle of spirality to the twist factor of two ply yarn, loop length and fibre diameter in both dry relaxed and simulated industrial relaxed fabrics. The most important result is that relaxation treatment of fabrics in water treatment of fabrics in water decreases the angle of spirality.

Park and Lee (1999) have found that the trend of spirality in fabrics produced from plied cotton yarns did not coincide with the general phenomenon on spirality. In this case, with an increase in tightness factor the spirality shows an increase. This phenomenon showed a reversal in the trend between spirality and tightness factor. Hence it is concluded that the plied yarns have the advantage of minimisation or elimination of spirality at a lower tightness factor and in unfinished state.

2.2.9.2 S-twisted and Z-twisted single yarns in the same feeder

When using two ends of yarns, having equal twist amounts and in particular equivalent twist liveliness but opposite twist directions (S,Z) in the same feeder, the tendency to distort the formed knitted loops - towards the one or the other direction (S,Z) are neutralised. Therefore, the produced fabric appears to be straight.

In practice, it is difficult to produce yarns with exactly similar twist liveliness, and fabrics produced by this method show a small degree of spirality. In fact, it has been suggested that the degree of spirality angle, "corresponds approximately and is smaller than anyone of them individually. In addition, the spirality of this resultant fabric assumes the twist direction of the yarn with higher twist level or twist liveliness. It may be said that this method, similar to what is termed "plaiting", is an effective technique for keeping the spirality of the produced fabrics to a maximum.

2.2.9.3 S-Z-Twisted singles yarn in alternate feeders

As stated earlier, Z-twisted yarns produce, Z spirality, and S-twisted yarns with equivalent twist levels will produce an overall "spirality free" fabric. Unfortunately this method, although reduces spirality results in a fabric which has an irregular and uneven appearance, presents a "cockling" effect on the fabric surface. The reason for this appearance can be identified by closely examining the wale loops. Loops in each course are distorted in opposite directions, following the direction of yarn twist producing a "herring-bone" effect.

Although this method is not suitable for the production of cotton or wool plain jersey knitted fabrics, it is commonly used in the manufacturing of stretch stockings made from fine nylon yarns. The "herring-bone" effect, which is not objectionable in the latter case, gives the fabric a greater potential for lengthwise stretch.

In both methods presented in the previous sections, the replacement of the yarn packages can reduce the fabric quality and lead to problems, as both these techniques are labour intensive. They include yarn package marking and inspection for the avoidance of mixing the yarn, types during the fabric production.

Recently a "Z technology" introduced by Monarch to knitting machines appears to be less prone to spirality. No information regarding this technology is yet available. It is probable that a new type of sinker movement induces less torque in knitting with latch needles.

2.3 Chemical Methods

Although fabrics produced mainly from cotton yarns are the object of this work, it may be of interest to note that, probably, the first attempt for chemical correction of the detrimental effect of spirality was made on fabrics produced from crossbred worsted yarns. King (1934) has reported that spirality in such cloths disappeared under a "cold crabbing" a process using cold sodium sulphide solutions. In explaining the mechanism of this process, he concluded that "it is the cross linkage (disulphide linking) which is mainly concerned in the spirality removal". However, the use of sodium sulphide caused decomposition of the wool fibres resulting in the weakening of the fabric.

2.3.1 Mercerisation of cotton yarns

Experiments carried out by Banerjee and Alaiban (1988) showed that there was a 10-13% reduction in spirality in dry relaxed fabrics produced from mercerised cotton yarns. In terms of twist liveliness, the mercerised yarn exhibited a drop of about 45%. Cotton yarns, which were not mercerised, were also made into fabrics. The reduction in spirality obtained by mercerising in the fabric state was 20-30%. They reported that "fabric mercerisation causes a large reduction in loop asymmetry than yarn mercerisation, though the treatment remains the same". Keeping in mind that mercerisation is a wet relaxation process accompanied by fibre and yarn swelling and resulting in appreciable mobility, it would appear that the movement of macro-elements constituting a fibre, plays a decisive role in the relaxation process. Their conclusion is an agreement with that of previous workers and states that although mercerisation is an efficient wet relaxation process giving the best results compared to others, it is not a complete solution, as the spirality of single knitted fabrics is concerned.

2.3.2 Use of small percentage of low melt polyester fibres

In this method, a small percentage of low melt polyester fibres is blended with cotton. The resulting yarn is heat treated. This process melts the polyester preventing the cotton fibres movement and reduces spirality (De Araujo and Smith, 1989a).

2.3.3 Effect of blend composition on spirality

Lord et al (1974) have demonstrated that the magnitude of spirality in single-jersey knitted fabrics increases with the increasing percentage of polyester in the blend. They attributed their results to the higher torsional rigidities of polyester fibres arising from the diameter, modulus and cross-sectional shapes. Studies by De Araujo and Smith (1989a) have also demonstrated that higher polyester content in a 30 tex cotton/polyester ring-spun yarn increased the tendency for the yarn to snarl. The increased spirality in a single-jersey knitted fabric made from the blends of polyester and cotton has been attributed to the difference in cross-sectional shape and rigidities.

This method does not completely eliminate spirality, and it is possible that the resulting texture is not pleasant to the wearer as the yarn and fabric become rather stiff.

2.3.4 Application of resins (Brackenbury 1992)

Resin treatments, known as cross linking, are used sometimes for reduction of the spirality. The resin is applied to the fabric in aqueous solution and is set by passing the fabric through a high temperature stenter. Besides spirality reduction, the process improves dimensional stability appearance and handle. The main drawback is the weakening of the cotton fabric.

2.3.5 Finishing methods

For the minimisation of the various defects such as yarn snarliness spirality and cockling that arise from the yarn "twist liveliness", the twist setting i.e., the process of relieving the stresses set up in textile fibres by twisting or relaxation process may be applied. The main requirement for this process is the action of heat in the presence of moisture on the yarn. As many workers have mentioned, twist setting results in an improvement of the mechanical stability of yarns. This process ensures that even highly twisted yarns become "dead" whilst retaining their twist level.

2.3.6 Yarn setting

A number of yarn setting methods has appeared in the textile industry that have as a common characteristic the setting of atmospheric conditions of high temperature and high humidity.

A method, used in the past showing good results in terms of twist relaxation was the "yarn storage" method (Buhler and Haussler 1986). Single yarn twists more easily when it has had a resting period of time, allowing any static to disperse and giving the yarn a chance to pick up some of the moisture content lost during drawing and spinning. Storing the yarn packages for a proper period of time at adequately high temperature and relative humidity (70-75%) contributed to a twist relaxation. However, it is necessary to exercise care to protect the yarns from condensed water, since "water condensing on walls, ceilings on pipes must be prevented from dropping on the yarn and causing subsequent stains, spots and imperfections in the goods". This technique could not be recommended for today's industrial conditions, where a speedy flow of all material throughout the mills is of paramount importance.

A more effective method of twist setting is accomplished by subjecting the yarn to a hot and humid conditions for a period of time, sufficient enough to bring out the "deadness" required depending upon the level of yarn liveliness. More severe setting will be required when the degree of the yarn twist is greater. For this method, yarn package form is placed in a perfectly enclosed chamber and regulated humid air (heated air and moisture) is forced into the chamber for a given period of time. It should be clearly understood that highly twisted yarns must be set under tension in order to avoid the permanent fixation of the snarls which can occur when the yarn is in the hank form.

2.3.7 Knitted Fabric Setting (Hurt 1966, Suh 1967)

In knitted structures such as single jersey tubular fabrics, the spirality may be temporarily corrected when it is not too severe. This can be achieved by low levels of fabric strain, achieved by using a former steam processing or steam pressing. For worsted fabrics, high temperature steaming of the fabric reduces spirality often after scouring but not after dyeing. It should be emphasized here that boarding or calendering of the fabric under ordinary finishing conditions are only transient methods because as soon as the fabric is wet again, during subsequent washing or scouring, it regains its spirality resulting in a consequent loss in appearance and discomfort in wear. In many cases, the fabric returns to the distorted shape it might have had, if it was produced from the same unset yarns: "As the fabric dries out, the configuration of the yarn in loops tends to remain unchanged from that assumed in the wet state. Thus the fabric is in a "set" condition retaining very little of the internal stresses which previously existed. The phenomenon is best observed by comparing two yarns from fabrics taken before and after washing. If this is done, it will be found that the dry, unwashed sample tends to return its original straight configuration. But the sample of yarn from a washed sample, which has been allowed to dry in the knitted state will, upon unravelling, tend to remain in the configuration of the loop. Thus, it is not surprising that the washed and shrunk fabric will not return to its original shape after drying but retains the new dimensions resulted from wetting.

One draw back of both steam and water setting processes is the drying stage which is time and energy consuming. Nowadays, the use of expensive radio frequency dryers has reduced the actual time of drying but little work has been done concerning the effect of the use of such equipment on the yarns and fabrics.

However, it should be pointed out that neither steam nor water set processes prevent the spirality of the knitted structure entirely. They merely reduce its level. Fabric relaxation (dry as well as wet treatments) can remove the residual knitting tension in the yarn introduced during the knitting process. The relaxation treatment relieves the residual yarn torques the residual yarn torque as a, result of charges in the fibres molecular structure and the increasing yarn mobility, this phenomenon promotes higher spirality. According to another hypothesis, water relaxation causes swelling and contraction of yarn dimensions. The rotation movement of a loop within the knitted structure is thus restricted, leading to reduced fabric spirality. Whether spirality will increase or decrease as a result of water relaxation treatment depends on the predominance of one factor over the other.

From an extended survey of the textile literature, it is evident that much research has been carried out investigating the dimensional stability of knitted fabrics. A significant amount of this work includes the development of theoretical models of the knitted structures. Most of the theoretical models were derived in order to explain fundamentally the experimental findings of other workers. A brief description of the various theoretical models that attempt to relate the structure of a plain knitted fabric with the properties of the constituent yarn is presented.

2.4 Singeing

2.4.1General Information

Singeing is an operation in which the protruding fibre-ends on the yarn surfaces are burnt away. This treatment improves the appearance of the cloth surface, not only before, but also after the entire wet processing and finishing treatment. The singeing process helps to eliminate the hairy and unclean appearance of the resultant textile fabric. The protruding fibre-ends are burned away either by the heat of the burner flames or by the heat of the fully combusted hot flue coming out of the special burners. In one of the new singeing techniques, these ends are burnet away by the hot radiations emanating from a special heat retention zone.

2.4.2 Singeing systems

Following are the types of the singeing systems now in vogue, which happen to be the outcome of development work on the singeing systems which were being adopted.

a. Direct singeing

The action of burning away the protruding ends of the fibres is brought about by the direct action of the flame ensuing from the gas burners. In an alternative improved system, the fully combusted hot flue acts directly on the protruding fibre-ends.

b. Indirect singeing system

The direct singeing system demands careful attention from the operative. Sometimes, overheating or scorching is a possibility. The direct singeing system utilizes the radiations from the ceramic heat retention zone for burning away the protrusions. This heat , in the form of diffused infra-red radiations, produces a more even singeing effect.

2.4.3 Flames produced by gas-burners

In the earlier singeing machines , the burner flame action used to be sidewise, which is a lower temperature region. The latest designs of singeing machines have overcome this drawback. The newly designed machines have burners positioned in such a manner that the singeing action is effected mostly by the upper higher temperature portions of the flames . Efficient and accurate gas-air mixtures now produce flames of a superior controlled character.

2.4.4 Singeing speeds :-

The yarn speed is the actual singeing speed. The usual speed ranges made available will be 100 m/min to 250 m/m. the energy output for the desired flame intensity may range from 25,000 to 100,000 K. Calories per hour. The flame outlet speeds may be controlled between 50 to 75 meters per min.

2.5 Mechanical method of reducing spirality

Primentas (1995) has conducted a very interesting study to reduce the spirality of weft-knitted fabrics. His method involves the reduction of twist to a little extent in the yarn and producing the knitted fabric. This process reduces the residual torque and leads to torque and leads to a substantial reduction in spirality (Primentas 2003a, 2003b, 2003c, 2003d).

Primentas work is a to significant contribution the study of spirality of weft-knitted fabrics.

Sikander has found that 50/50 cotton polyester blends have a low tendency to produce spirality in fabrics than the 100% cotton yarns, probably because steam setting is more effective with polyester than with cotton.

Demiroz and Dias (2000) have attributed the differences between the theoretical and experimental upper-right distances to spirality. These authors were involved in generating 3D-images of plain knitted structures by applying a cubic-spline method on a computer screen. They studied the graphical representation of plain-knitted structures and it is based on the design of a software program to generate a 3-D graphical representation. They used the basic fabric parameters, i.e., the yarn diameter, the course-spacing, the wale-spacing, and the stitch length.

2.6 MEASURING YARN TWIST LIVELINESS

2.6.1 Introduction

In ring spinning process, a strand of fiber in a more or less parallel form is drafted and twisted on its own axis to form a yarn. A twisted yarn has a tendency to untwist, and attain the minimum state of energy. Higher the value of twist multiplier (T.M), this effect is more pronounced. This factor influences dimensional stability of a fabric, particularly a knitted fabric, as the yarn is not subjected any tension during knitting. The main problem in the knit fabric due to yarn twist liveliness is spirality. This tendency is called twist liveliness and is defined as the Tendency of a yarn to twist or untwist spontaneously.

2.6.2 Twist Liveliness Testing Methods

The measurement of yarn twist liveliness is made by using testing techniques which have been classified as follows:

a. Methods in which the free end of yarn held from other end is left to rotate.
b. Methods based on the snarl formation procedure.

The steps in testing includes the following:

a. When the 2 ends of a known length of yarn tensioned with a weight suspended from the middle of the yarn and brought together
b. Allowing the formed loop to rotate until reaching □immobility state□ and
c. Counting the number of turns of the loop.

2.6.3 Novel Technique for measuring yarn twist liveliness

In all the instruments available for testing the yarn twist liveliness, one end is fixed and the other end of the yarn is moving towards the fixed end. This system causes in balance in moving end and the reading varies often. In a novel technique, an instrument is fabricated in which both ends are moving in a similar fashion results in a balanced way of measuring the twist liveliness.

2.6.4 Description about the instrument

The instrument has a screw rod driven by a motor. 50% screw rod is having LH thread and the rest is having RH thread. Fixed on bearings, the screw rod is kept above 500 mm from the table. Two yarn clamps are kept 1000 mm apart. The motor rotation is reversible and controlled by a special electronic circuit. Yarn is pretensioned with suitable arrangements. Since the screw rod pitch is 1 mm, the counter attached to the screw rod shows direct reading of the number of rotations. The details of the parts as mentioned below in the Table 2.2 are also shown in Figures 2.9

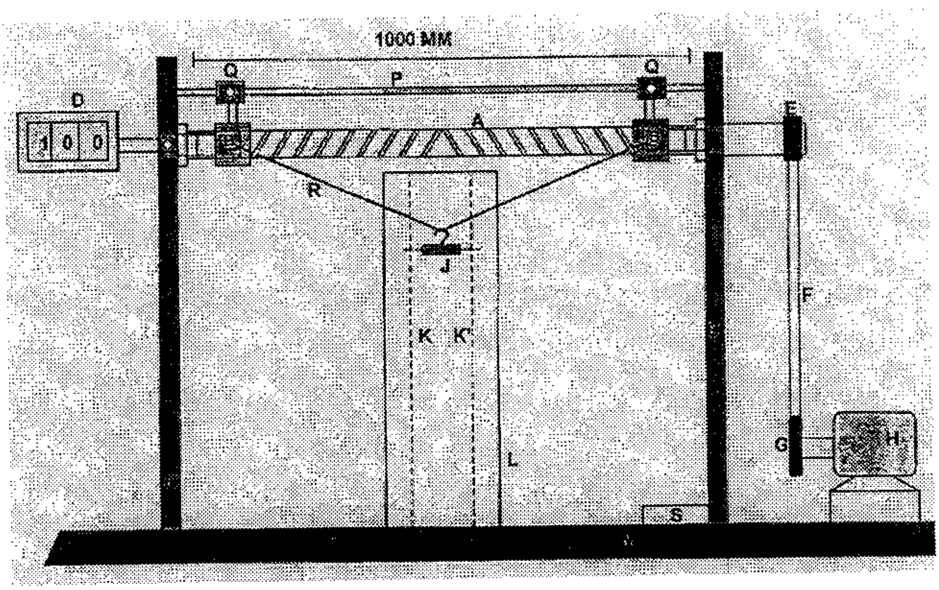


Figure 2.9 Twist Liveliness Meter

TABLE 2.2

PARTS OF THE INSTRUMENTS

A. Double threaded (Two directional) shaft	J. Flat Metal Weight (0.2 Grams)
B. Spring loaded clamps	K. Continuous metal wire connected to relay
C. M/C Frame	L. U shaped transparent plastic tube with 2 sides open
D. Mechanical Meter	M. Base board
E. Driven Wheel 13 teeth	P. Guide rod
F. Chain Drive	Q. Guiding Bracket
G. Driving Wheel 26 teeth	R. Yarn sample
H. Motor	S. Control box

2.6.5 Principle

This instrument works on the principle that when two ends of a certain length of yarn, which is twist lively, is brought towards each other, after a certain distance, the first loop starts forming due to the residual torque present in it. The distance between the yarn clamps at the moment of formation of first loop by the yarn is taken as a measure to express twist liveliness in the yarn.

2.6.6 Working

Initially, the distance between the two clamps is 1000 mm i.e. yarn sample length of 1 metre is used. When the motor rotates in forward direction, the threaded shaft rotates at a speed of 120 RPM as driven to driving gear wheel ratio is 2:1. Hence each of the clamps will move at 120 mm/minute towards the center. A dead weight of 0.2 gram is hung at the middle of the yarn before testing starts. When the clamps move towards each other, the yarn sample assumes a shape of >V= in the vertical direction. Once the yarn starts forming the first loop, the motor is stopped immediately. The twist liveliness value can be found out from the following formula:

Twist liveliness = 1000 B (2 X Counter Reading) mm

where, counter reading = distance moved by either clamps

2.6.7 Machinery details - Twist liveliness tester

2.6.7.1 Specimen for testing

! Length of Yarn Tested = 100 cm

! Maximum Test duration = 240 seconds

! Speed of moveable part = 0.4 cm/sec

! Atmospheric Conditions = 65 ± 2 % r.h and 25 ± 2EC

2.6.7.2 Electrical components

! Motor: 220 V, AC, Synchronous Motor, Reversible, 60 RPM

! Gear (Driver) = 26 Teeth

! General Switch, on-off button, indication lamp, DPST Switch

After the test is over the motor is driven in the reverse direction to bring the clamps to the original position. Once the clamps reach their initial position the limit switch provided will automatically switch off the motor.

2.6.7.3 Operational instructions

During testing it should be ensured that standard testing atmosphere. i.e. RH% = 65 ± 2% and 25 ± 2EC should be maintained. Care should be also taken so that no external air disturbance is there to prevent turbulence to the yarn sample.

Initially the yarn sample should be carefully withdrawn from the supply package without causing any stretch to the yarn. The end of the yarn is fixed to the right hand clamp of the instrument and then carefully drawn over the left hand clamp without releasing the spring. Now pretension weight is attached to the left hand end of the yarn and the left side clamp is closed. Now the dead weight of 0.2 gram is hung at the middle of the yarn and the yarn is cut from the left side clamp and power supply is switched on. Now forward rotation of the motor is selected by the selector switch. After the test is over, the yarn sample is removed from the clamps and reverse rotation of the motor is selected by the selector switch.

2.6.7.4 Electronic components

! Forward Relay: 12V DC
! Reverse Relay: 12V DC
! Adapter: 240V AC (I/P), 12V DC (O/P)
! Limit switches (Forward and Reverse)
! Counter: Mechanical Type

2.6.7.5 Weights

! Center Weight = 3 grains (0.2 grams)*
! Pretension Weights are Calculated according to the formula.

* Weight (Grams) = Tex / 2 $\pm$ 10%

2.6.7.6 Mechanical parts

* Threaded rod: 1 mm pitch
* Ball bearings
* Gear wheel (driven) = 13 teeth.

CHAPTER 3

RESEARCH OBJECTIVE

- To investigate the effect of yarn singeing on spirality of weft knitted fabric

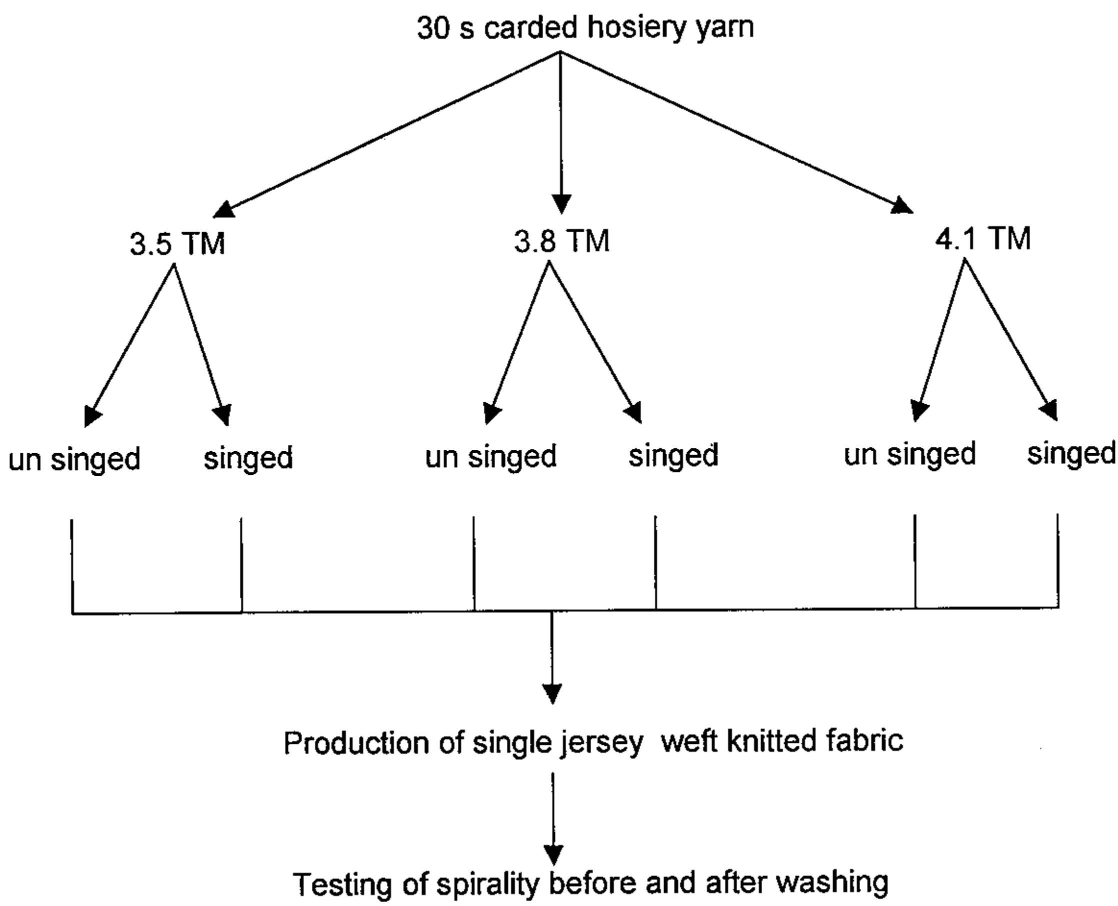
- To investigate the effect of wet processing on spirality of weft knitted fabric

CHAPTER 4

METHODLOGY

4.1 SAMPLE PLAN – I

EFFECT OF SINGEING



4.2 SAMPLE PLAN II

Effect of Wet Processing :

Single jersey weft knitted grey fabric(from unsigned yarn)

↓

Spirality Testing at grey stage

↓

Washing and scouring

↓

Spirality Testing

↓

Dyeing

↓

Spirality Testing

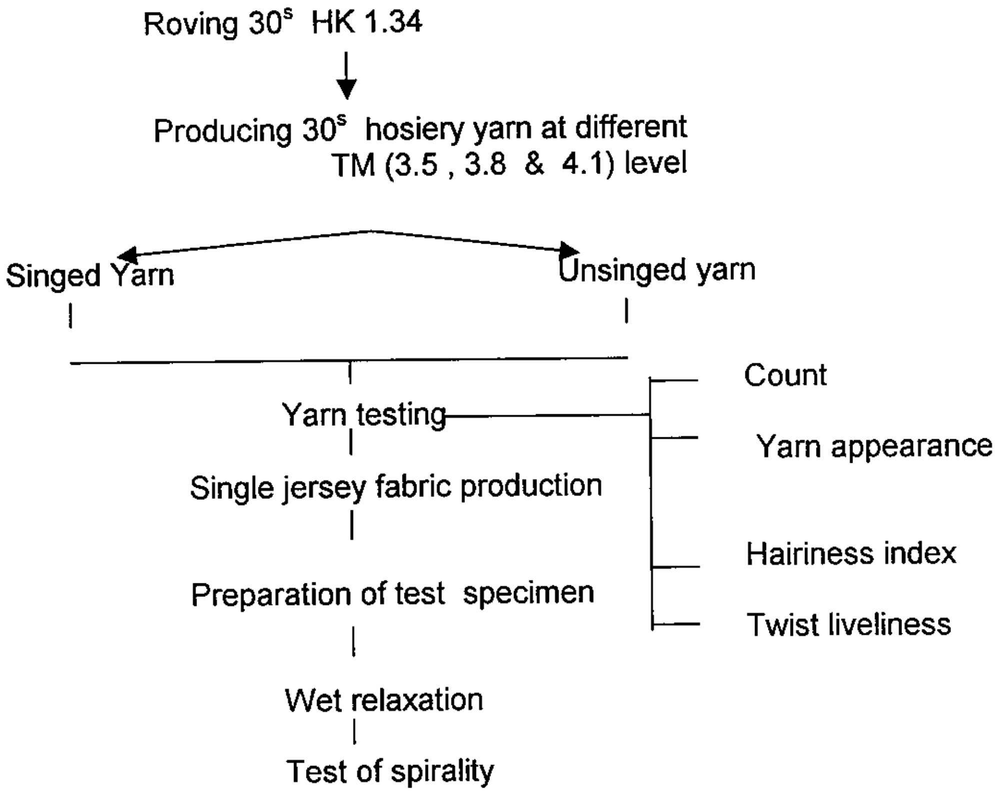
↓

Compacting

↓

Spirality Testing

4.3 YARN & FABRIC PRODUCTION



4.4 WET PROCESSING FLOW CHART

GREY FABRIC

↓

WETTING PROCESS(80°C WITH 30 MIN)

↓

COLD WASHING(10 MIN)

↓

DYEING

↓

50°C HOT WATER WASH (10 MIN)

↓

50°C ACETIC WASH(30MIN)

↓

COLD WASH

↓

80°C SOAPING (20 MIN)

↓

80°C HOT WASHING(10 MIN)

↓

FIXING PROCESS

↓

SOFTENING PROCESS

↓

COMPACTING

4.5 MATERIAL DETAILS

4.5.1 YARN PRODUCTION DETAILS

Raw material	-	cotton
Cotton variety	-	shankar-4
Station	-	Gujarat
2.5 % span length(mm)	-	28
50% span length	-	13.5
Uniform ratio	-	48.1
Finess value (micro gms/inch)	-	3.6
Bundle strength	-	22.5 gm/tex
Trash	-	3.2 %

4.5.2 FABRIC DETAILS

Course per inch	:	42
Wales per inch	:	29
Loop length	:	0.12 inches

4.6 PROCESS PARAMETERS

4.6.1 RING SPINNING:

Roving hank	-	1.4
Break draft	-	1.157
Main draft	-	18.42
Total draft	-	21.43
Spindle speed	-	12,000
Travella number	-	3/0
Ring dia	-	50mm
Traveler Speed	-	28.80 m/sec

4.6.2 M/C SPECIFICATION :

Make	-	MEI
Model	-	MK-II
Spindle gauge	-	70 mm
Ring dia	-	50mm
Traveler number	-	3/0
Lift	-	8"
Drafting system	-	wst ut – 620 (3/3 draft)

4.7 FABRIC PRODUCTION

4.7.1 CIRCULAR KNITTING M/C:

Machine	:	single jersey weft knitting m/c
Make	:	knit mac – tirpur
Type	:	sn
Diameter	:	16 inches
Gauage	:	20
No. of feeders	:	22
Rpm	:	24
Total dealers	:	996 of type 10252
Total sinkers	:	996 of type 3823
Direction of knitting	:	counter clockwise

4.8 YARN SINGEING

4.8.1 SINGEING M/C

M/C	:	GAS singeing machine
Make	:	PS.METTLER
Model	:	PSM
Flame type	:	gas burner
Speed	:	120 m/min
Flame length	:	40mm

4.9 DYEING M/C DETAILS

TYPE	:	SOFT FLOW
DYES	:	REACTIVE HOTBRAND
METHOD	:	HOT BRAND
TEMPERATURE	:	80°C

4.10 FABRIC WASHING

4.10.1 WASHING M/C (TUMBLING PROCESS):

Make	-	IFB
Capacity	-	4kg of dry cloth
Spin speed	-	700 rpm
Temperature selection	-	60°c
Water consumption	-	19 to 76 litres
Cycle time	-	45 minutes
Water pressure	-	1.03 to 10.3 kg/cm^2

4.11 TESTING

4.11.1 Yarn testing

PARAMETER	INSTRUMENT USED
Count	Yarn count balance
Yarn appearance	Yarn appearance tester
Hariness	UT 3
Twist liveliness	Twist liveliness meter

4.11.2 Fabric testing

- Test specimens are made from all the samples.
- The fabric is washed in domestic washing machine
- Drying of samples
- Testing fabric samples for spirality

4.11.3 Spirality testing :

4.11.3.1 Specimen preparation :

The test specimens are prepared by cutting them to required dimensions i.e.,38 X 38 cm by using a template.

4.11.3.2 Spirality :

In a hosiery fabric knitting in plain stitch , the length wise rows of stiches called needle lines or wales , should always be at right angles to the cross wise courses of stitches. In most of the cases the wales are not perpendicular to the courses but skew towards right or left depending on its characteristics , this is called spirality. The angle of skewness is called angle spirality.

4.11.3.3 Test methods for measuring spirality:

The three well known standard test methods available for determining the spirality of knitted fabrics are :

- IWS Test Method No. 276
- British Standard 2819
- ASTM 3882.88
- AATCC Test Method 179 – 2001

For the project the adopted test procedure is based on AATCC Test Method 179-2001

4.11.3.4 AATCC TEST METHOS 179 – 2001 :

Washing :

The cut test specimens are prepared for washing by stitching for samples using an over lock stitch for three sides leaving one side open which is known as pillow case method. A 25 X 25 cm square is marked on the stitched samples. Now the test specimens are washed in a domestic washing machine for 45 minutes using water at 60°c and finally dried

MEASUREMENT :

After washing and drying or in other words after relaxation the wales are not perpendicular to the courses which are evident by the lines of the square drawn earlier now appearing skewed. This angle of skewness to the direction of courses is measured which gives.

5 RESULT AND DISCUSSION:

5.1 Count And CV% Results

TM	UN SINGED		SINGED	
	COUNT	CV%	COUNT	CV%
3.5	29.56	0.93	32.41	0.86
3.8	29.28	1.00	31.84	0.92
4.1	28.35	1.20	31.36	1.05

The Test result reveals the count cv% of unsigned yarn is higher than singed yarn this may be due to removeval of protruding fibres and make the surface of yarn more even.

5.2 Twistliveliness Values (CM)

TM	UN SINGED	SINGED
3.5	15.31	16.63
3.8	16.50	17.56
4.1	17.77	18.73

The results reveal that there is almost a linear relationship between the level of twist and twist liveliness value. With increasing T.M. value the Twist liveliness values increase. The linear variation is due to the quantum of energy stored because of twisting. Twistliveliness value is more with high twist and low for yarn with low twist, higher the twist liveliness, greater will be the energy stored. The graph is enclosed in the annexure

5.3 Imperfections Results

YARN TYPE		THIN PLACES (-50%)	THICK PLACES (+50%)	NEPS (+200%)	TOTAL IMPER FECTION	UN EVENNES S %	HARI NESS INDEX
UNSING ED	TM3.5	48	232	188	468	11.2	7.3
	TM3.8	54	320	221	495	11.5	7.0
	TM4.1	61	278	172	511	12.2	6.5
SINGED	TM3.5	38	113	208	359	10.0	4.8
	TM3.8	34	122	233	389	10.7	4.6
	TM4.1	28	108	297	433	10.9	4.2

The imperfections and hariness are found more in unsinged yarn when compared to singed yarn. This is due to remveval of protruding fibres in singeing process . It is also observed that TM level increases the hariness value decreases.

5.4 Spirality Results (Degree)

YARN TYPE	TM 3.5	TM 3.8	TM 4.1
UNSINGED(DEGREE)	4.1	4.9	5.43
SINGED (DEGREE)	2.99	3.8	4.9

The angle of spirality of weft knitted fabric produce from unsigned yarn is higher than the spirality of weft knitted fabric produce from singed yarn at all TM levels. It is also influenced that the TM levels increased the spirality value also increased. This is due to more twist liveliness value in the yarn. Refer annexure

5.5 Wetprocessing Results

PARAMETER		SPIRALITY (DEGREES)			
		GREY STAGE	AFTER WASHIN& SCOURING	AFTER DYEING	AFTER COMPACTING
UNSINGED SAMPLE	TM3.5	2.1	4.1	5.2	5.4
	TM3.8	2.29	4.8	6.1	6.2
	TM4.1	2.4	5.4	7.3	7.5

The result reveal that the spirality value is found increased in all stage compared to grey stage. After washing and scouring, After dyeing the spirality value slightly increased. But After compacting, only a marginal increase in spirality is observed.

6. CONCLUSION

The following conclusions were obtained from the studies conducted

- The Spirality of weft knitted fabric was found decreased by 27% because of yarn singeing.

- Compare to grey stage , washing and scouring process shows considerable increase in the spirality which is in the order of TM 3.5 < TM 3.8 < TM 4.1

- Dyeing process also results in the increase of spirality to the range of 26% to 35% at three TM levels.

- Compacting process increase the spirality value only by 1.6% to 3% in three TM levels

7. SCOPE OF THE PROJECT

There is a further scope to study various physical properties of weft knitted fabrics such as bending ,shearing and compression properties in each stage of wet processing.

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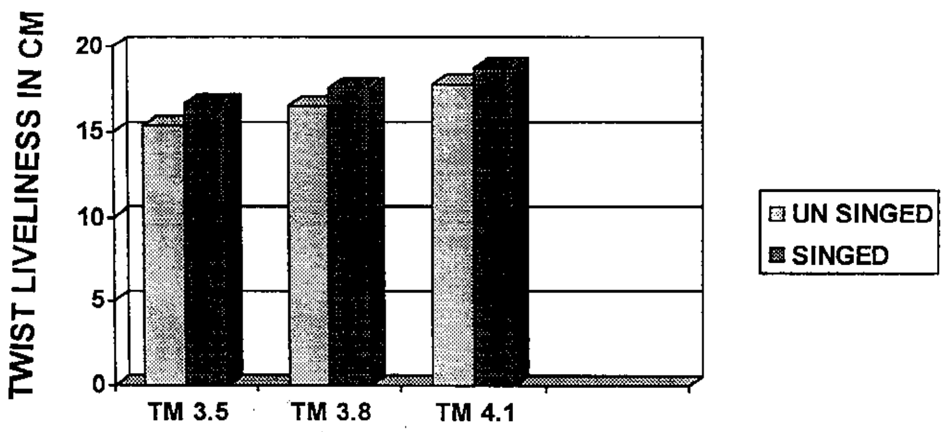
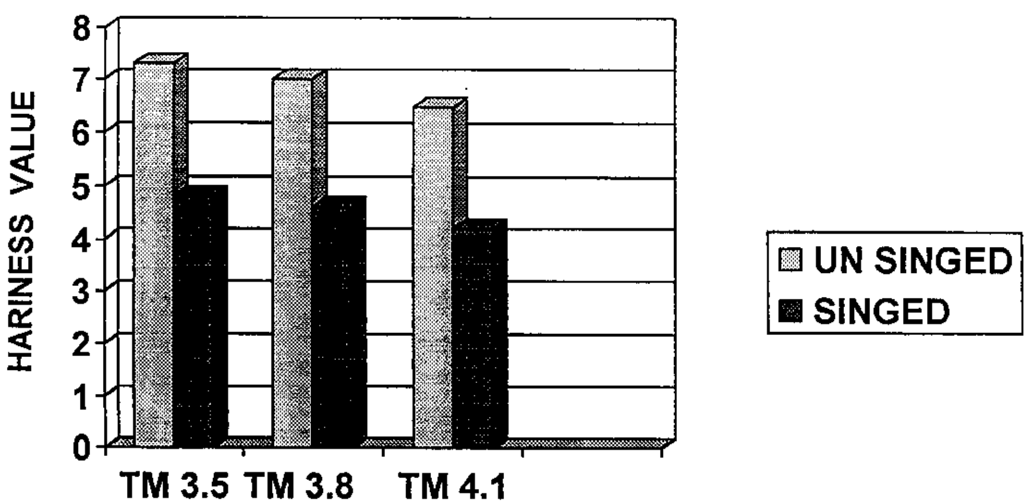
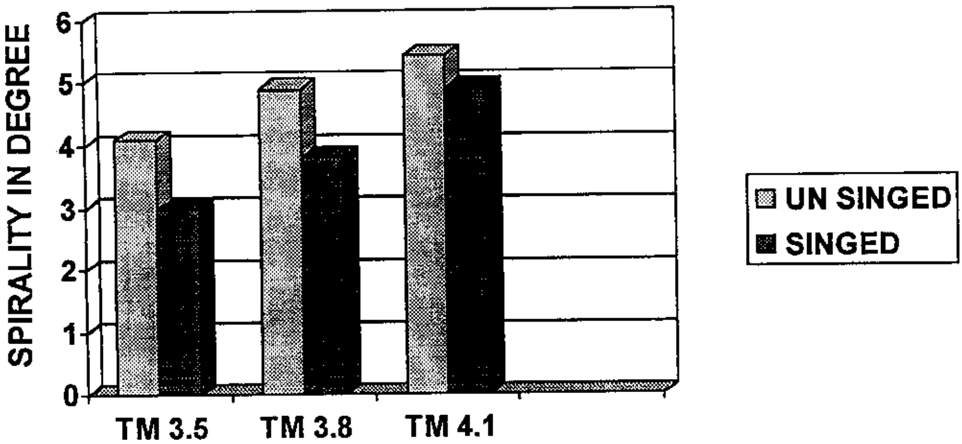
TM VS TWISTLIVELINESS



TM VS HARINESS



TM VS SPIRALITY



Spirality Vs Wet Processing Stages