InternationalJournalofInnovativeResearchandReviewISSN:2347–4424(Online)
AnOnlineInternationalJournalAvailableathttp://www.cibtech.org/jirr.htm
2015Vol.3(3)July-September,pp.84-103/Gokarneshan et al.
Review Article

DIMENSIONAL CHARACTERISTICS OF COTTON AND VISCOSE WEFT KNITS

***Gokarneshan N.,Viswanath S.R., Nagarajan V.B. and Veeraprabhakar J.**
Department of Textile Technology, Park College of Engineering and Technology, Coimbatore, Tamil Nadu, India
**Author for Correspondence*

ABSTRACT
Knitted fabrics are subjected to large changes in dimensions and are often prone to distortion upon repeated laundering. The changes occurring after laundering were largely caused due to the agitation during tumble drying. The agitation was found to have caused 34% of the changes during laundering followed by the spin cycle during washing, which caused 24% of the dimensional changes and distortion. Mercerization appears to be an effective chemical treatment to stabilize the structure of plain knitted fabric produced from cotton yarn. Knitted fabrics have been mercerized considering variation in concentration of alkali solution and bath temperature. Increase in alkali concentration had a positive effect on dimensional stability at room temperature. The dimensional properties of viscose, modal and lyocell single jersey knitted fabrics have been investigated considering three levels of loop lengths under dry, wet and fully relaxed conditions. The influence of the fiber types on the dimensional stability has been studied. The course and wale spacing values of lyocell fabrics is found to be lower than that of viscose and modal knitted fabrics. Lyocell fabrics exhibit greater areal density with decreasing loop length. Also, the ks values of lyocell fabrics increases proportionately with increase in the value of tightness factor, compared with viscose and modal fabrics. The lyocell fabrics exhibit maximum bursting strength and lower spirality as compared with viscose and modal fabrics due to the structural characteristics of lyocell fibres. Single jersey lyocell knits exhibit better dimensional properties in comparison with viscose and modal fabrics.

Keywords: *Cotton, Dimensional Stability, Knits, Regenerated Cellulose, Loop Length, Mercerization, Laundering, Regenerated Fibres*

INTRODUCTION
The knitting sector of the textile industry has grown fast during the recent years. A demand for weft knitted garments has increased many folds over the years in the domestic and export markets. Dimensional stability of knitted fabrics has been one of the most discussed areas in the textile industry as well as in research fields (Moon, 1967).

Due to the dimensional instability loop construction, single jersey knitted fabrics suffers from various forms of dimensional distortion (Jiang, 1997). Efforts have been taken to render a knitted fabric more comfortable by changing the fibers, yarn parameters(twist, bulk, count and finish), knitting parameters(courses per inch, wales per inch, loop length and fabric weight) and post knitting finishes(enzyme and chemical).

The single jersey knitted fabric properties especially the dimensional and physical properties are mainly influenced by the constituent fibers, yarn properties, knitting machine variables, processing and finishing treatments (Parmar and Srivastava, 1999). The dimensional characteristics of cotton and wool knit fabrics have been extensively studied and it has been predicted that the length of the yarn in the knitted loop plays a major role in determining the dimensions of knitted fabrics (Munden, 1959; Doyle, 1953). Investigations have been carried out on fabric relaxation and fabric geometry with wool yarns. Two relaxed states have been defined.

When a fabric after knitting has been allowed to lie freely for a sufficient length of time, it eventually reaches a stable state which is called the dry relaxed states. In the dry relaxed state, the natural configuration of yarn is almost straight so that when it is unrowed, the yarn takes up an approximately

straight form. The state of equilibrium reached by a fabric after static relaxation in water and subsequent drying is called the wet relaxed state. In the wet relaxed state, yarn is set so that the natural configuration of yarn is not straight but is set into a form approximating the loop shape in the fabric. This implies that the forces which are necessary to keep the yarn in loop shape in the dry relaxed state, are reduced in the wet relaxed state. The dimensional properties of wool knitted fabric properties have been studied and concluded that the K values are important (Knapton, 1968). The dimensional properties of acrylic knitted fabrics have been investigated and concluded that the fabrics made from different yarns and counts, the courses per inch and Wales per inch vary inversely with the length of yarn knitted into the stitch (Sharma, 1984). The dimensional and physical properties of weft knitted fabrics, particularly made with cotton, wool and acrylic has been investigated by a number of researchers (Hurley, 1966; Hearth and Bok, 2008; Hearth, 2007).

Influence of Laundering on the Dimensional Stability of Cotton Knits

It is well known that weft knitted fabrics tend to undergo large changes in dimensions and are often prone to distortion upon repeated laundering. A large number of factors are responsible for causing these undesirable effects in knitted structures; these are all associated with the yarn, knitting, finishing and making-up of the fabrics. It is also a fact that consumers are becoming increasingly concerned and aware of fabric quality and expect higher standards of performance than ever before, even after a number of wash and dry cycles. Knitted cotton fabrics possess certain qualities to allow garments to fit closely and snugly, making them ideal for next-to-skin wear (Munden, 1959). However, knitted fabrics are prone to stretching and mechanical deformations (Zanaroli, 1990); this is due to the fact that the yarns are put under a high stress factor whilst the fabric is being produced and finished. These torsion forces within the yarns are present when the fabric is taken off the machine and the fabric is left in a highly distorted state (Hepworth, 1989). Knitted fabrics often never fully recover from these strains and have to withstand the considerable wear and tear due to every day use and laundering processes (Munshi *et al.*,1993).To meet the demands of an increasingly discerning market, knitters have called for increased research into the dimensional stability of knitted cotton goods. With the rising popularity of cotton, greater demands in terms of quality were required as the customer became more aware of the negative properties, e.g. shrinkage from laundering. The properties of cotton are limited due to its natural origins (Thomas, 1994), therefore, if the consumer continues to expect higher quality and dimensionally stable garments, the actual construction of the fabric needs to be investigated.

Another problem manufacturers have to contend with is the factors affecting variability in customer washing processes. Munshi *et al.*,(1993) compiled the following list:

1) No two persons wash identically.
2) Different detergents are invariably used.
3) No two localities have identical water.
4) Water temperature often varies.
5) No two washing machines are identical.
6) No two loads are the same.

The prediction of washing performance is therefore an enormous task. It requires an in-depth knowledge of the geometry, stability and forces held within the fabric. Knitted fabrics are inherently difficult to stabilize, as the construction allows for contraction of up to 40%. The commercial knitter will therefore benefit from any research into the dimensional behavior and techniques of predicting stable dimensions (Munshi *et al.*,1993).The major aims of the research were, therefore, firstly to systematically study the effect of principal variables on the dimensional stability and distortion of knitted fabrics; and secondly, to study the mechanism of shrinkage and distortion both empirically and theoretically of knitted fabrics upon repeated laundering. From this, a preliminary investigation into the effect of home laundering was devised by initially looking at the main variables contributing to fabric shrinkage and distortion. The variables included firstly testing with detergent against water alone, and secondly tumble drying against line drying.

Plain single-jersey, 1x1 rib and interlock cotton fabrics were subjected to systematically controlled laundry regimes in order to quantify the relative contribution, if any, of each of the variables.
Birkett (1986) has stated that "up to about five cycles, there are relatively large differences between different fabrics; beyond five cycles the changes in dimensions are small and for most practical purposes can be ignored". Therefore, each fabric type was subjected to five cycles of each regime (labelled as 0-5). For accuracy, specimens were duplicated and analyzed after being fully conditioned for 48 hours. The second stage of the research project was concerned with the isolation of the wash, rinse, spin, agitation during drying and the heat applied during drying into five separate stages of the full laundering process. The different regimes have been studied in order to enable each stage of laundering to be isolated. Again, each fabric type was subjected to each given regime five times.
The ultimate aim of the ongoing research project is to formulate a generalized model to predict, determine and control fabric stability upon washing and drying. This will enable commendations to be made to the sponsoring company as regards possible modifications to the design and programming of their washing and drying equipment.

Stitch Length
Stitch length remained more or less constant after the fabrics were subjected to the four different washing and drying regimes as shown in Figure 1. This was the case in all three structures. This confirmed that the fabrics were washed according to the conditions appropriate to the fiber type used in these fabrics. Therefore, the changes in fabrics' dimensions and properties were largely caused due to changes in loop shape rather than loop length. The distortion was a result of distortion in the loops themselves and not in yarn structure. This also confirmed that the classical geometrical relationships applied, even after washing and drying treatments. The mean stitch lengths together with 95% confidence limits have been measured for all three structures.

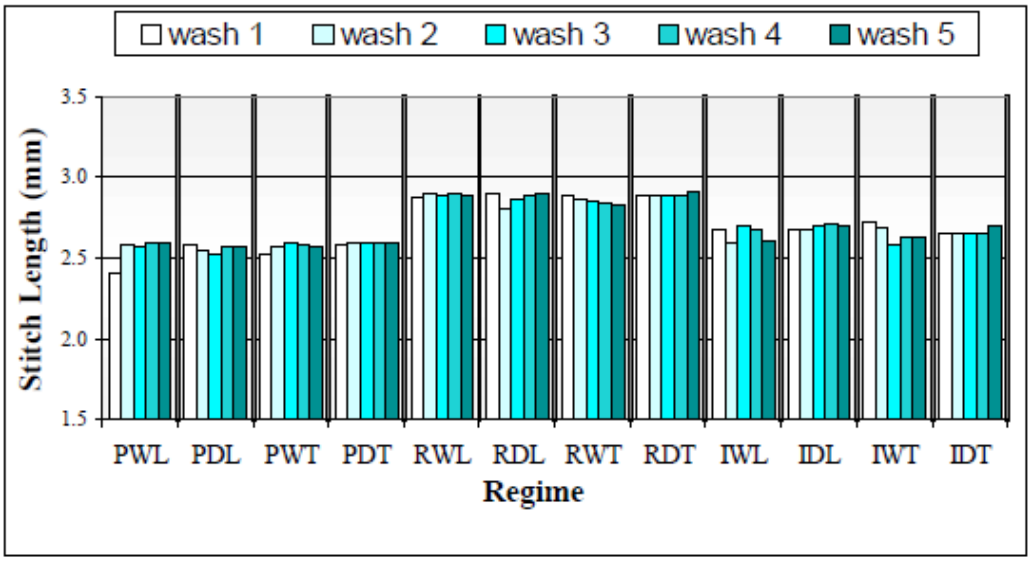

Figure 1: Influence of laundering on stitch length

Linear Density
Changes in yarn linear density after five washing and drying cycles were also insignificant in all three structures. This also confirmed once more that the majority of dimensional changes in the fabric samples must have been caused due to changes occurring in the loop shape rather than loop length as shown in Figure 2 (Anand *et al.*,2002). It is well known that the loop shape alters significantly upon repeated washing and drying treatments, due to the loop distorting and bending out in the third dimension. This

occurs as the loops attempt to take up their minimum internal energy state or stable state (1). The mean yarn linear densities have been obtained together with 95% confidence limits.

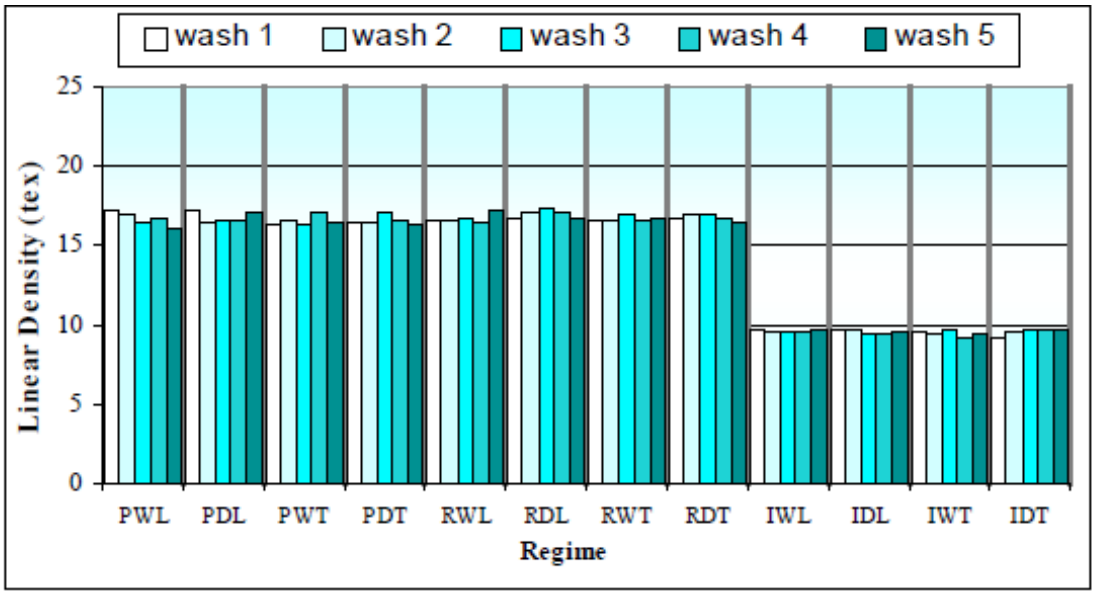

Figure 2: Influence of laundering on linear density

Loop Shape Factor

The changes brought about by the different wash regimes on the loop shape factoror Poisson's ratio in the three different structures have been found (Anand *et al.*,2002). In plain single-jersey, the effect of tumble drying was evident because the loop shape factor changed from 1.24 to 1.36 for the water wash-tumble and 1.26to 1.35 for the detergent wash-tumble. This also indicated that that the detergent had virtually no effect upon the loop shape.

In both 1x1 rib and 1x1 interlock structures, the loop shape was almost constant for all four washing and drying regimes. This indicated that the loops had taken their least energy state or stable state in each wash and dry regime. The studies enable to draw significant conclusion that plain single-jersey, 1x1 rib and 1x1 interlock structures have attained their fully relaxed state after five wash and dry cycles. This is because the values achieved are extremely close to those reported by a number of other researchers.

Dimensional Stability (Length)

It was expected that the results obtained for the dimensional stability tests carried out would be significantly different for the three fabric structures, due to the distinct nature of each structure. A positive dimensional stability test result indicates an increase in length, which represents length extension (Anand *et al.*,2002).

A negative value represents a decrease and hence shrinkage. The results obtained for the plain fabric specimens indicated that there was a significant difference between lines drying and tumble drying for plain single-jersey. The tumble-dried specimens produced shrinkage in the length direction, whereas the line dried samples displayed extension in length. The water/line-drying regime caused more extension than the detergent/line regime, whereas detergent/tumble drying tended to produce higher shrinkage results than the water/tumble dried regime. It would therefore appear that washing with detergent caused higher shrinkage in the fabric length than with water alone.

Higher length shrinkage values obtained for tumble-dried specimens in all three structures illustrated the severity of the tumble drying process. The loops were slowly agitated during drying, which resulted in their taking up a minimum energy state configuration, otherwise known as a fully relaxed, stable or reference state.

Dimensional Stability (Width)

The dimensional stability tests carried out in the width direction for the plain fabric samples showed similar trends for all four regimes. The maximum shrinkage took place after the first wash cycle, and thereafter virtually no change in width dimensions occurred upon further washing treatments (Anand *et al.*, 2002). The overall dimensional stability results shown for the width direction indicated that there was a significant difference between regimes and structures, and are therefore very important to this investigation. The elastic nature of 1x1 rib was evident here, as the line drying show extension rather than shrinkage; therefore the coefficients of variation show significant differences between the three structures.

Skewness

Results obtained for the skewness tests after five cycles are given in Figure 3. The results indicated that there were significant differences between the three structures investigated (Anand *et al.*,2002).Plain single-jersey specimens produced large percentages of distortion; the average final value of percentage skewness was 8.1%.

The main reason for this is because the structure is highly unbalanced. The forces created by interlacing loops are substantially different on the technical face and technical back due to the fact that loops are continuously formed in one direction only. This creates different forms and levels of forces on the two fabric faces.

The main reason for achieving lower values of distortion in both 1x1 rib and interlock fabrics were that both structures are perfectly balanced. The rib fabrics exhibited lower skewness values than the plain single-jersey fabrics, with an average value of 2.8%, whereas the interlock specimens appeared to be most stable as they achieved the smallest percentage skewness of 2.2% on average. These results demonstrated that both the double jersey structures used were perfectly balanced, and hence produced low values of skewness after laundering.

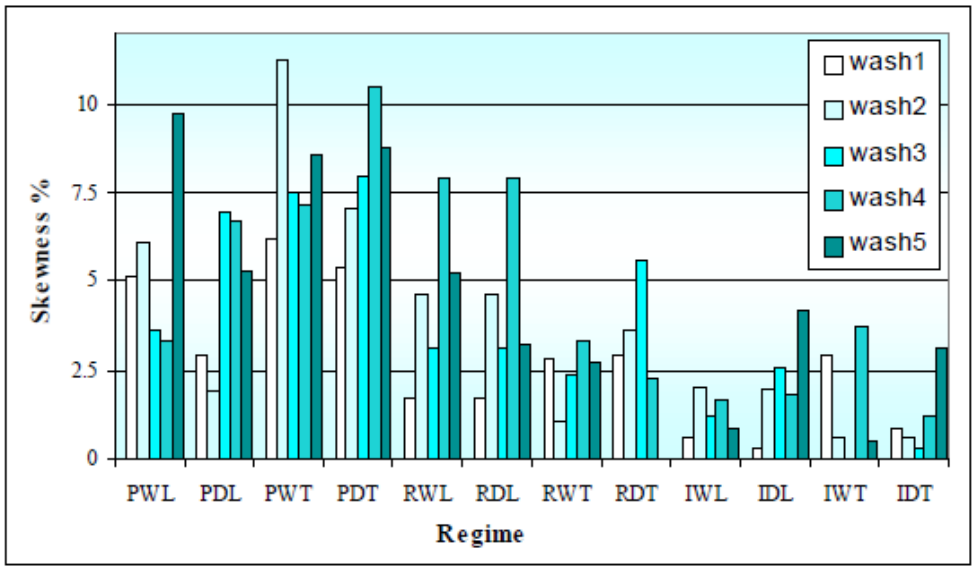

Figure 3: Influence of laundering on skewness

Spirality

The spirality angle results shown in Figure 4 demonstrated similar trends to the skewness distortion results already discussed in Section 3.6. The plain single-jersey specimens showed higher angles of spirality, the average angle being 5.75°, with no clear trend among the regimes (Anand *et al.*,2002). The rib structure proved to be more stable in this aspect as it displayed extremely low degrees of spirality. The

interlock structure showed slightly higher spirality angles due mainly to the water/tumble-dried regime. Again for detergent/tumble-dried specimens, no spirality angles were recorded, showing no wale distortion at all for interlock samples.

Again, this phenomenon is largely due to the balanced configuration of the interlock structure. These results confirm that distortions (skewness as well as spirality) are mainly prevalent in single-jersey structures.

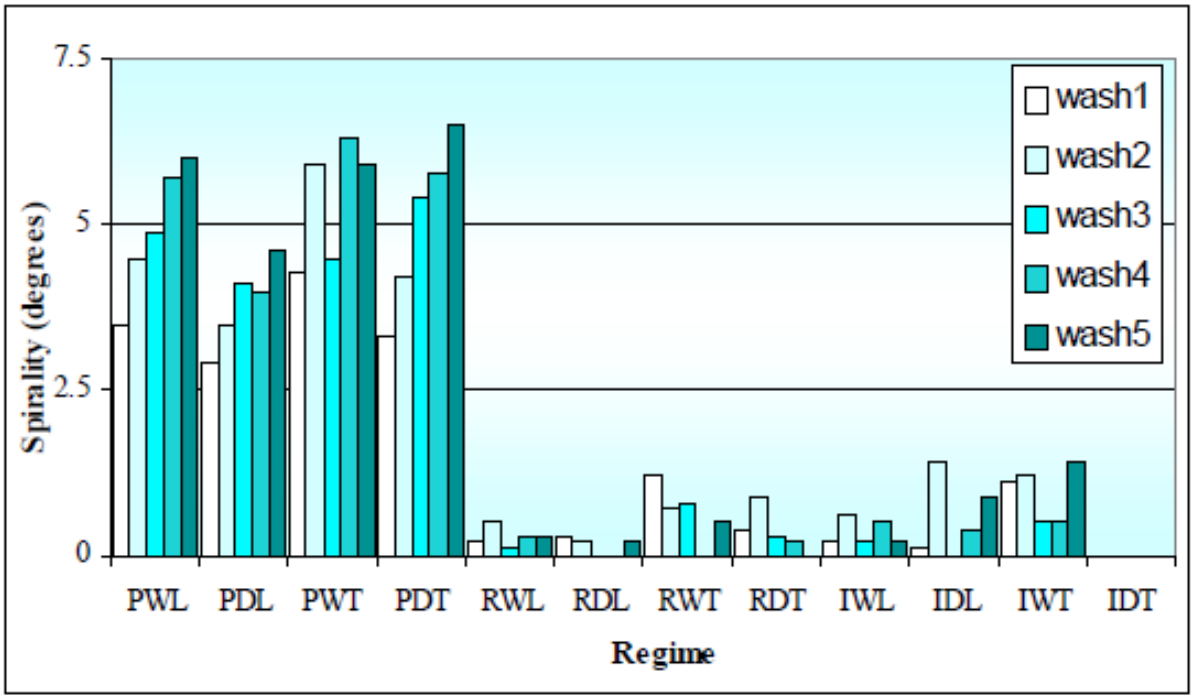

Figure 4: Influence of laundering on spirality

This part of the investigation enabled the following five stages of laundering to be examined individually:

1. Initial wash,
2. Rinse,
3. Spin,
4. Heat in the tumble dryer, an,
5. Agitation in the tumble dryer.

The overall objective was to quantitatively ascertain the influence of each major part of thelaunderingcycle on fabric dimensional properties and distortion.

Loop Shape Factor

The results shown in Figure 5 indicated that the wash cycle only caused a significant change in theloop shape factor in the case of interlock structure (Anand *et al.*,2002). The highest percentage change during the whole laundering process occurred here in the interlock structure, indicating that the wash cycle played the most significant part in relaxing the interlock structure. The rinse cycle caused an average change of+2.6% in the three fabrics tested; however, the spin cycle caused the opposite effect to this with an average change of -4.6%.

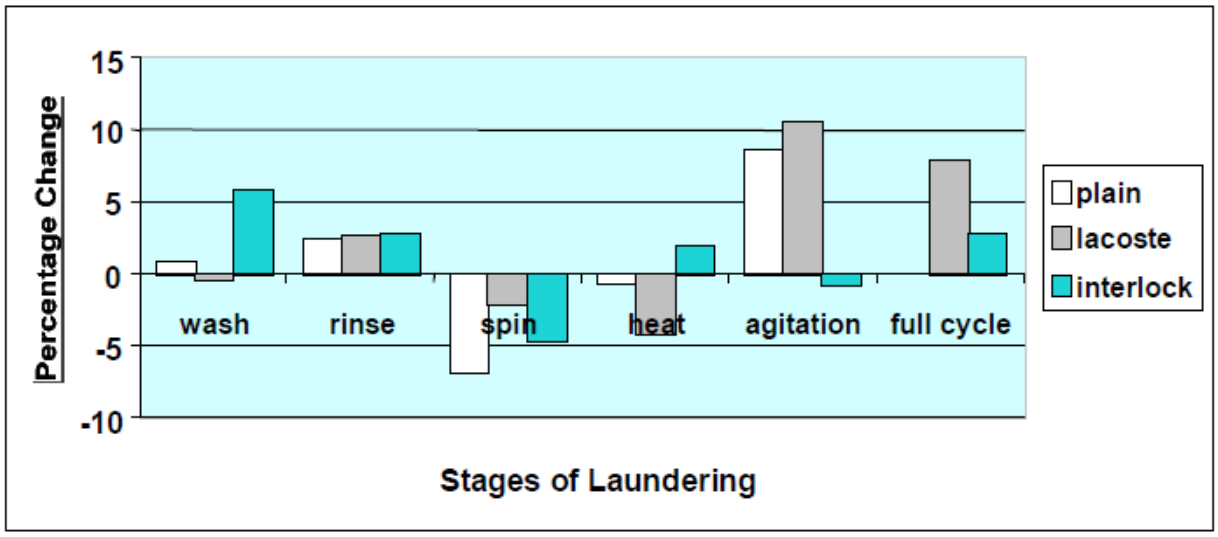

Figure 5: Changes in loop shape factor

This suggested that the spin cycle left the fabrics in the most unbalanced state. The heat applied during drying tended to cause a negative percentage change in the single jersey fabrics, more so in lacoste than in plain single-jersey.

The interlock structure displayed a slight increase in loop shape factor due to the heat of the dryer, perhaps suggesting that the heat tends to relax the more balanced structures whilst disturbing the relaxation of the more unbalanced structures. Both the single-jersey fabrics appeared to relax the most, due to the agitation during tumble-drying.

The three-dimensional movement of the fabrics during drying appeared to allow the single-jersey structures to relax to their minimum internal energy state. This was not true for the interlock structure where the agitation of the dryer actually caused a slight negative percentage change in loop shape factor. The percentage changes occurring in the full cycle suggested that overall loop shape factor changes occurred significantly in the lacoste fabric, whilst minimal changes occurred in the interlock structure. The changes that were observed for the plain single-jersey fabrics must have cancelled each other out. No changes were observed in the loop shape factor after five full wash and dry cycles.

Dimensional Stability (Length)

Firstly it must be stated that the positive percentage changes recorded were due to length extension, whilst the negative values were caused by length shrinkage (Anand *et al.*,2002). Negligible percentage changes were recorded for the wash, rinse, spin and heat applied during tumble drying for all three fabrics tested. This was except for the figure of -5.3% in the interlock structure caused by the spin cycle, showing that the single-jersey fabrics appeared to be more stable during this cycle. The largest percentage changes were observed lengthways, due to the agitation during tumble-drying, where all three fabrics shrank by an average of 8.5%.

Again, the three-dimensional movement of the fabric during drying caused a considerable amount of change within the structure. The results shown in Figure 6 for the dimensional changes in the length direction indicated that there were significant variations in the lengthways-dimensional stability in the three different structures after five full laundering cycles.

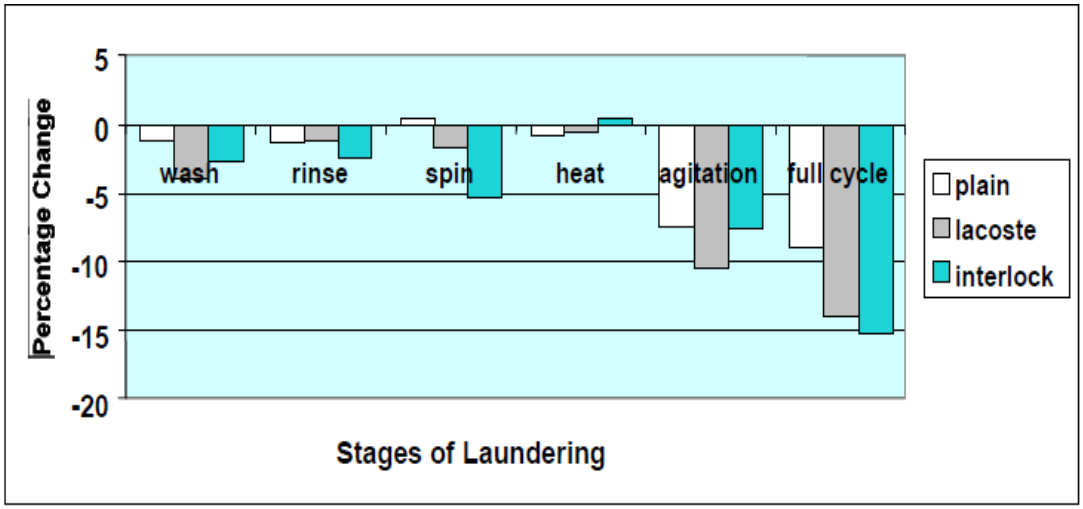

Figure 6: Change in shrinkage of length

Dimensional Stability (Width)

The results of the wash and spin cycles illustrated in Figure 7 show that the interlock structure displayed excessive percentage changes in the width direction during these particular cycles (Anand *et al.*,2002). Overall, the interlock structure underwent the most significant amount of dimensional change in the width direction, as shown by the full cycle results in Figure 7. The plain single-jersey and lacoste fabrics displayed lower changes in the width direction.

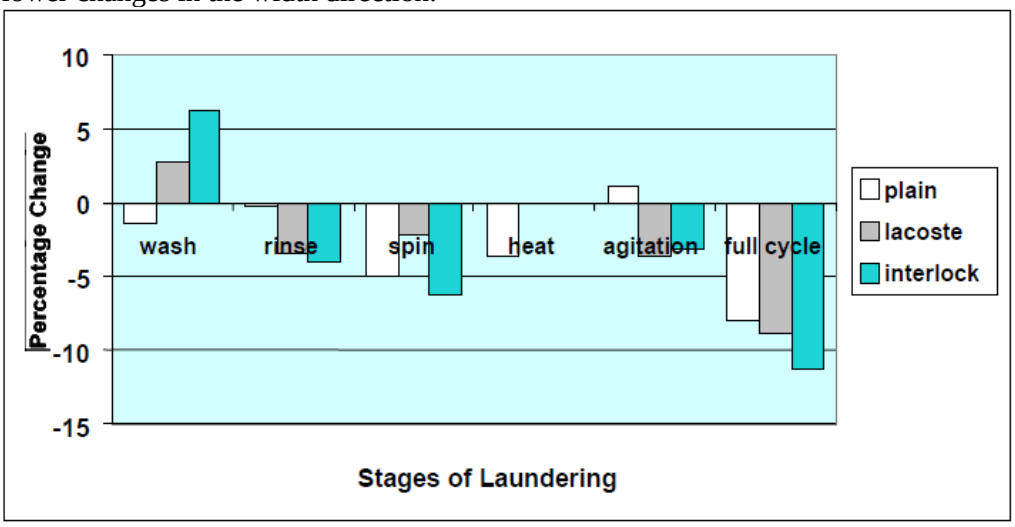

Figure 7: Change in width shrinkage

Skewness

The percentage changes in skewness after five cycles of different regimes indicated that the wash, spin, heat and agitation had minimal effect on the fabrics investigated, with percentage changes in all cases being under 3% (Anand *et al.*,2002). Only the rinse cycle exhibited high skewness in the plain single-jersey fabric, with a figure of 3.6%.The lacoste and interlock fabrics displayed no skewness during the rinse cycle, confirming the greater instability of the plain single-jersey structure. However, after five full cycles had been carried out on the fabrics, the interlock as well as the plain single-jersey structure underwent significant changes in fabric skewness (see Figure 8).

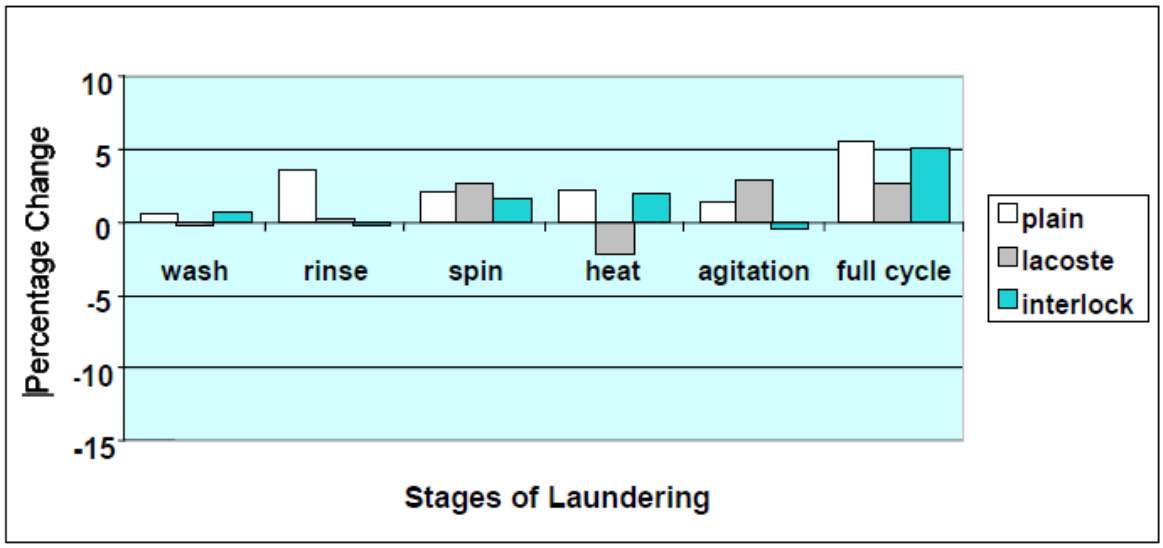

Figure 8: Change in skewness

Spirality

The spirality results in Figure 9 indicated that all the significant changes in spirality, regardless of the wash regime, occurred in the plain single-jersey fabric (Anand *et al.*,2002). It has already been established in previous work that plain single-jersey is highly susceptible to spirality. The full cycle programmed again confirmed this and demonstrated that the largest spirality change occurred in plain single-jersey structure. Interestingly, a negative value was obtained for the plain single-jersey fabric due to agitation during tumble-drying.

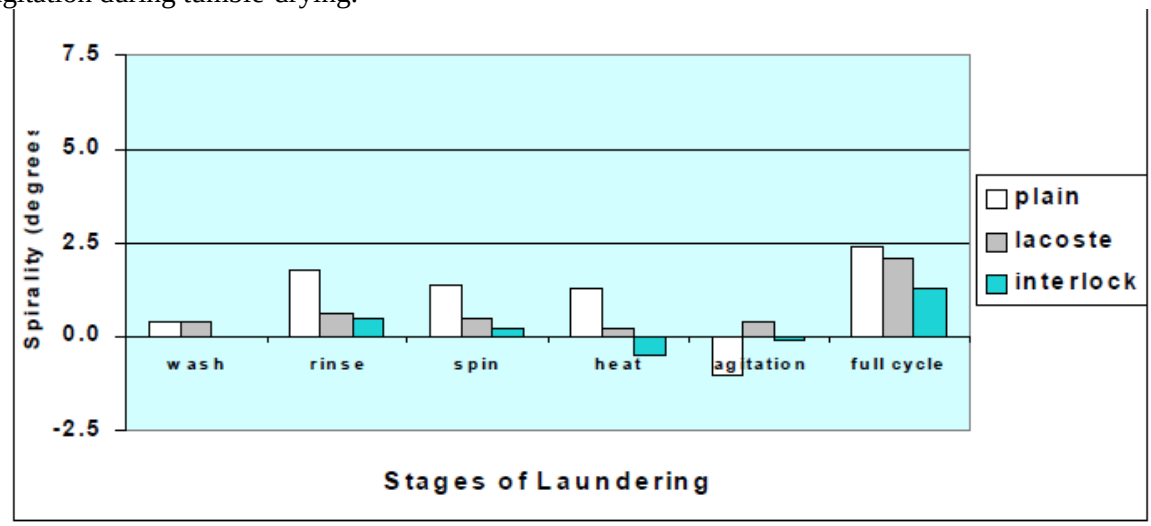

Figure 9: Changes in spirality

Overall Mean Changes Observed from the Laundering Cycle

The average results obtained for different properties, as well as different parts of the wash and dry cycle, were analyzed by using an analysis of variance statistical technique (Anand *et al.*,2002). This enabled the determination of an overall mean change to be calculated for each individual part of the laundering cycle as shown in Figure 10. The results confirmed that the agitation during tumble-drying was the major contributor to changes within the fabrics, causing 34% of the changes observed. This was followed by the spin cycle, which again involved the use of agitation causing 24% of the changes. Agitation was also involved in the rinse cycle, which caused 15% of the changes, equal to the wash cycle.

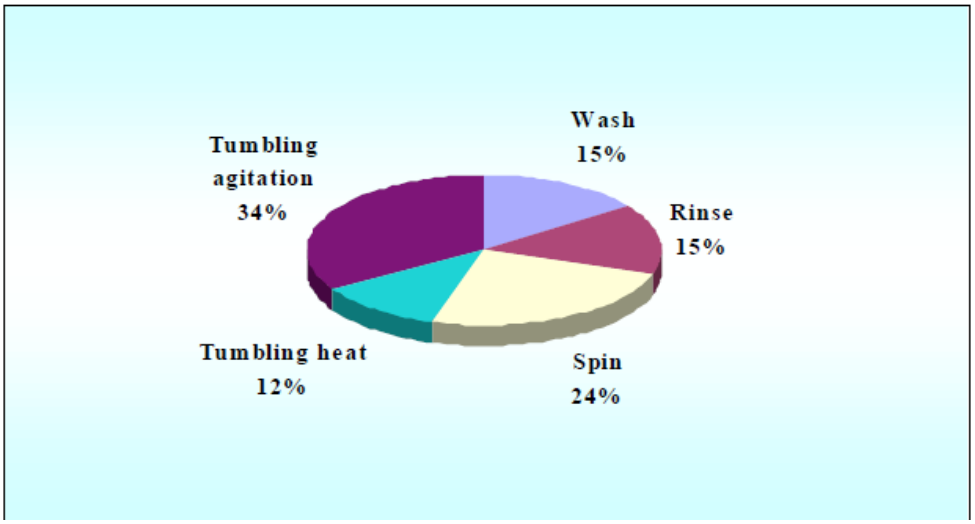

Figure 10: Mean percentage change

Influence of Mercerization on the Dimensional Characteristic of Weft Knit

The behavior of fabrics in end products is decisively influenced by their performance characteristics. These characteristics can be optimally adapted to the quality requirements by varying physical and technological parametersof the finishing process.

Various chemical treatments are in existence to improve the performance characteristics of the fabric. Among these, mercerization is of major interest to the researchers as it improves the process quality of the yarns and the quality of the products produced from them (Dhamija and Manshahia, 2007).

Extensive knowledge and experience on the subject already exists as there are numerous publications reported by various researchers. For example, Hebsiba and Thambidumi have reviewed tensile properties of cotton yarn after slack swelling (Anita and Thambidurai, 2007). Performance characteristics of mercerized ring and compact spun yarns have been investigated as well (Dhamija and Manshahia, 2007). The effect of mercerization on the tensile properties of rotor spun yarn has been reported by Hari *et al.*, (1985).

The influence of mercerization treatment on the properties of woven fabrics e.g dye absorption, weight, reduction and dimensional stability is another field that has been evaluated by the researchers (Needles *et al.*,1985; Shet *et al.*,1982; Shet *et al.*,1981; Latta, 1984; Brinkman, 1992). The findings of all the researchers confirmed improvement in tensile characteristics, sorption properties and dimensional stability of the yarns and fabric samples after treatment. However, processing parameters that are involved in mercerization bath, yarn kind, fibre kind and fabric structure affects results of these studies (Yousefi, 1989; Seddiqui, 2002).

Besides woven fabrics, the plain knitted fabric is another structure that is ideal for next-to-the-skin wear, since it possesses high extensibility under low loading conditions which allows it to fit snugly and without discomfort on any form on which it is pulled. These properties, together with the fact that the knitted fabric is often very slow to recover to its undistorted state, make it impossible to measure accurately its dimensions.

Therefore stabilization of knitted fabrics and introduce suitable methods to stabilize knitted structure is a major subject that has received significant attention. In this regard researchers have defined the dry, wet and the fully relaxed states in which fabric takes up a a fixed geometrical shape and stable state (Dhamija and Manshahia, 2007).

However, different fibres react in different ways to these treatments, so that the equilibrium values of these geometrical constant (K5) vary (Wolfaaedt and Kanpton, 1971). Also, previous considered models for dimensional properties of the plain knitted fabric showed that, the theoretical K5 value (25.986) was

higher than the experimental value for fully relaxed plain weft knitted fabric (Jeddi *et al.*,1999; Semnai *et al.*,2003). Therefore, more suitable relaxation methods should be used in finishing treatments. Steam setting and using ultrasonic waves are in existence to improve dimensional stability of plain knitted fabric (Jeddi *et al.*, 2007).

Though a few researchers have investigated the properties of the hot mercerized knitted fabric (Rusznak, 1984), the work in the field of chemical treatment in relation to processing parameters and their effect on dimensional properties of cotton plain weft knitted fabric is scanty. In this connection an understanding of the behavior of mercerized cotton plain knitted fabric is of fundamental importance and would be worthwhile to be studied. The present study was therefore aimed at investigating the influence of mercerization process and its two important parameters on dimensional characteristics of the plain knitted fabric.

Calculating Values of the Constants Termed the Fabric Dimensional Parameters

After each relaxation state and mercerization treatment the change in length (wale direction) and width (course direction) of the fabrics called shrinkage was measured (equation 1) at the area with dimensions of 25cm*25cm marked on the fabrics. The average of six measurements for each sample was calculated and is shown in table 2.

Shrinkage (%) =((25-L2)/25) * 100 (1)

Where; L2 is the dimension of the fabric after mechanical relaxation and mercerization treatments measured by the ruler.

Then the no. of courses per cm (CPC), the no. of wales per cm (WPC) and stitch density or the no. of loops per unit area (SD) of the samples were calculated. Stitch density was calculated by multiplying (CPC) by (WPC). At the end, the constants termed the fabric dimensional parameters were calculated according to Munderrs equations (Equations 2, 3, 4) (Mundan, 1959) and the results are shown in table 2.

CPC=Kc/L (2)

WPC=Kw/L (3)

SD=Ks/L2

Where L is the length of the loop; Kc, Kw, Ks are the constant dimensional parameters of the fabric.

Independent Effects of the Processing Parameters on Dimensional Properties of the Fabrics

In the first phase of the research, the effects of each processing parameter itself on dimensional properties of plain weft knitted fabric (Ks value) were investigated. In this case, one parameter was selected as the variable and the rest of the parameters were chosen as constants. Specification of the samples in each group is shown under figures 2,3.

A statistical analysis (one way ANOVA) was carried out to analyze the difference between the test results for different group s of samples at 95% level. Also, a Tukey's procedure multiple range test was performed for a better analysis within groups.

The mercerization treatment causes shrinkage in fabric and by making progress in mercerization process the fabric tended to shrink more. It means that the fabric loops tended to shrink more. It means that the fabric loops tended to become displaced towards each other, like the threads contact more and more with each other.

This is clear from the obtained values of shrinkage for dry relaxed, wet relaxed and mercerized samples. Shrinkage of the mercerized samples is more than the dry and the wet relaxed samples. Similar results have been reported by other researchers (Jeddi *et al.*,2007; Mohammadi and Jeddi, 2006).

Knitted structure has different elasticity in wale course and different directions that is inherent properties of the fabric. However, fabric shrinkage is considered when CPC and WPC are calculated. Also, the trend of the change is shrinkage is divergent in wale and course directions (due to fabric structure) and also under different mercerization conditions.

According to the literature, Ks value is indicator of dimensional stability of the weft knitted fabric. This factor is calculated by using stitch density and loop length. Stitch density is calculated by multiplying

CPC by WPC. These two parameters are increased by increase in fabric shrinkage after relaxation and mercerization treatments. Reflection of the change in fabric shrinkage after treatments is shown in CPC and WPC values consequently affects Ks values of the samples.

The Effects of Concentration of Alkali Solution

The effect of concentration of alkali solution has been shown in figure 11. Based on the results it was cleared that, change in dimensional stability of sample No.1 in which considered values for both CAS and BT were the lowest at the level that is used in this study in very low in comparison with other samples probably due to incomplete mercerization. In this condition considering higher values for BT is mandatory to achieve complete processing purposes. Dimensional stability improvement is observed for samples no.2, 3 and 4 in which mercerization is carried out 200g/l of caustic soda (NaOH) and temperature higher than 20^0C. However, BT has an optimum value in these samples that was 40^0C. On the other hand, dimensional stability (Ks value) of the sample no.2 that mercerized in 40^0C was the highest and decreases towards sample no.4 that mercerized in 80^0C.

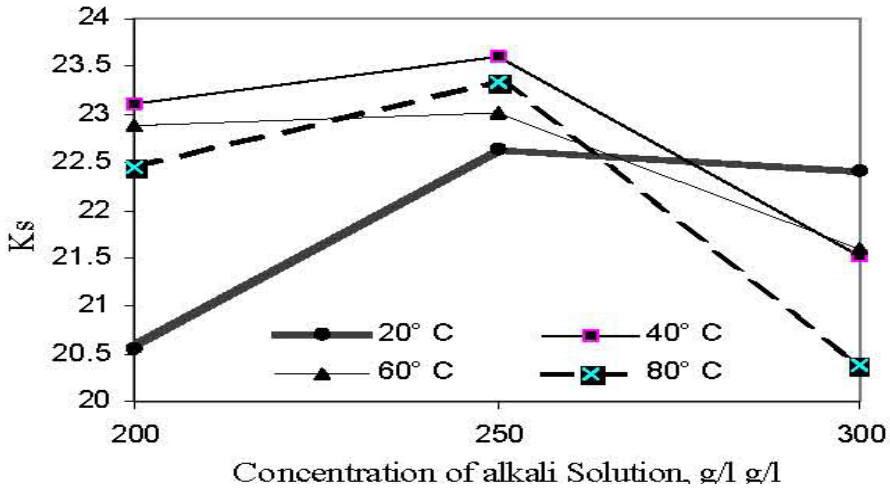

Figure 11: Influence of concentration of alkali solution on K

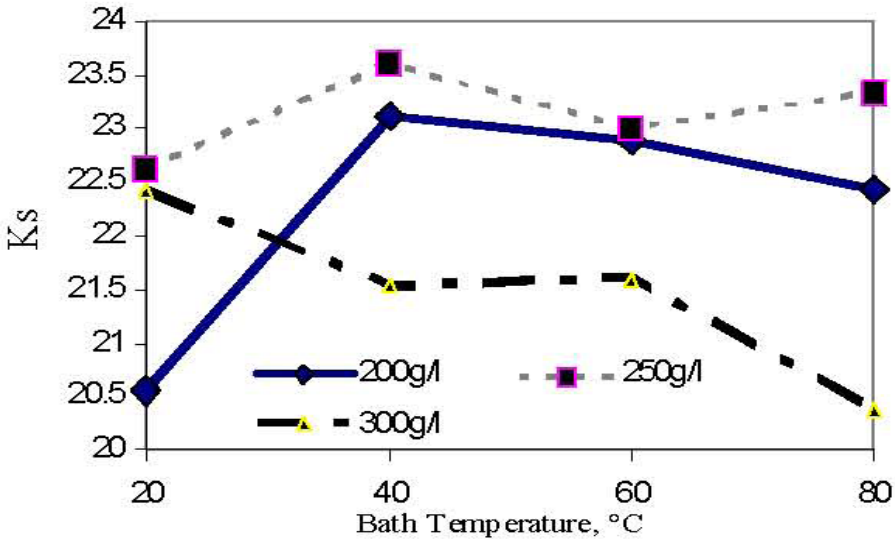

Figure 12: Influence of bath temperature on K

Increase in CAS had a positive effect on dimensional stability for the samples that mercerized at the temperature of 20^0C. But for the samples mercerized at temperature higher than 20^0C, increase in CAS

(240g/l) improved dimensional stability of the fabrics. Further increase in CAS had a destroying influence on Ks value.

In addition, at the temperature higher than 20^0C alkali concentration of 200g/l was profitable in comparison with the alkali concentration of 300g/l. Alkali concentration of 300g/l shows destroying effect when bath temperature were 60, 80^0C (samples no.10, 11, 12). Consequently, for the samples mercerized at the temperature higher than 20^0C regardless of the alkali concentration value, the proper temperature to achieve the highest Ks value was 40^0C.

The Effect of Bath Temperature on Dimensional Stability

The effect of bath temperature on dimensional stability of the samples has been shown in figure 3. According to the results and statistical analysis it was concluded that, the effect of the temperature must be discussed in each alkali concentration separately. Figure 12 shows that, in concentration of 200g/l, bath temperature of 20^0c had the least impact on the dimensional stability in comparison with three other temperatures.

Difference between Ks value of the sample no.1 mercerized at temperature of 20^0c and alkali concentration of 200g/l is very sensible in comparison with the Ks value of the samples No.2, 3, a mercerized at temperature of 40, 60, and 80^0c respectively and alkali concentration of 200g/l. Dimensional stability of these samples increases by increase on bath temperature from20^0c towards80^0c but optimum value for the temperature was 40^0c.

For the samples mercerized in alkali concentration of 250g/l, and bath temperature of 20, 40, 60, 80^0c dimensional stability is high and close to each other. Dimensional stability increases even at a temperature of 20^0c when alkali concentration increases from 200g/l to 250g/l. the highest Ks value is obtained in temperature of 40^0c when alkali concentration is 250g/l. in this condition difference between Ks, value for the samples mercerized at temperature of 20, 60, 80^0c is not meaningful statistically.

In mercerized conditions in which concentration of alkali solution was selected as 300g/l the optimum temperature to complete mercerizing purposes was 20^0c. Increase in bath temperature from 20^0c towards 80^0c when considered value for alkali concentration is 300g/l cause a reduction in dimensional stability. Reduction in Ks value was less for the sample mercerized at temperature of 40^0c and increases by increase in bath temperature.

Consequently it was concluded that, among three considered temperature, 40^0c is the proper value to carrying out the process and to achieve suitable dimensional stability.

Simultaneous Effect of All the Variables on Dimensional Stability of the Fabrics

Value of the area geometric constant (Ks value) which is related to the stitch density or the number of loops per square centimeter is obtained from multiplying Ks value by Ks value. One way analysis of variance shows that, there is a meaningful difference in Ks values of the samples in 0.05 levels of significance.

Research showed that, sample No.7 has the highest value of Ks (23.7). More dimensional stability of the sample is the result carrying out mercerization process at the temperature of 60^0c, tension of 10% alkali concentration of 250g/l and time of 300sec. but statistical analysis showed that, the mean value of Ks has no significant difference between samples no. 6, 7, 8 and 2. It means that, the same qualified properties can be obtained in easy condition. Sample no.6 (Ks = 23.59) was mercerized in the alkali concentration of 250(g/l) and temperature of 40^0c with 10% tension and time of 300sec. this sample has easier better process condition compared with samples no. 7, 8, 2.

Finally the results confirm that, the mercerization process improved dimensional stability of plain weft knitted fabric, close to the theoretical value. Compared with other dimensional dimensional stability improvement methods, in which the Ks value was raised to 24.35 (Jeddi *et al.*,2007), mercerization method is considerable as a method for dimensional stabilization of cotton plain weft knitted fabric. Also, Ks values for all mercerized samples are more than that of for dry relaxed (Ks = 17.60) and wet relaxed

(Ks =18.39) fabric samples. More investigation is in progress concerning a wider domain of variables in order to increasing the Ks factor and achieving more accurate results.

Dimensional Properties of Single Jersey Knits from Viscose and Regenerated Cellulosic Fibers

Though a good deal of work has been reported on the dimensional and physical properties of weft knitted fabrics made from cotton, wool and acrylic, very little work has been reported on weft knits made from viscose, modal and lyocell fibers.

There has been a growing demand for absorbent fibers with the need hinging on comfort and fashion. All regenerated cellulosic fibers have the same chemical composition, yet they differ in density, molecular mass, degree of polymerization, super molecular arrangement, and above all, their degree of crystallinity and orientation. The main differences in structure, and consequently fiber properties, originate from variations in production processes. Regenerated synthetic fibers, especially modal and lyocell fibers production has helped in the development of new apparels and created tremendous possibilities to achieve improved dimensional, physical, mechanical and aesthetic properties of apparel fabrics (Srinivasan, 2007; Chavan, 2004; Tatjana and Sonja, 2003; Young, 2003). In order to study the influence of fiber type, loop length and relaxation treatments on dimensional properties of knitted fabric, three different fibers such as viscose, modal and lyocell with similar fineness and fibre lengths were used. The influence of viscose, modal and lyocell fibers, loop length and relaxation treatments on the dimensional properties of single jersey knitted fabrics have been discussed herein.

The dimensional properties of single jersey weft knitted fabric made from 14.8 tax viscose, modal and lyocell spun yarns with three different loop lengths has been investigated under three different conditions such as dry, wet and fully relaxation for a knitted fabric involves change in the internal force an equilibrium state of minimal internal energy.

Effect of Course and Wale Spacing

Course and wale spacing are directly related to stitch densities which represent the change in loop shape during relaxation treatment. Figure 13 shows the relationship between course spacing and loop length of viscose. Modal and lyocell single jersey fabric (figure 14) shows the relationship between wale spacing and loop length of viscose, model and loycell single jersey fabric. The value of course and wale spacing are plotted against the loop length for viscose, modal and lyocell structures gradually decreased under dry and wet relaxation treatment and comparatively increase in fully relaxed states. The lower course and wales spacing variations have been observed in viscose, model and lyocell fabric than viscose and model fabric.

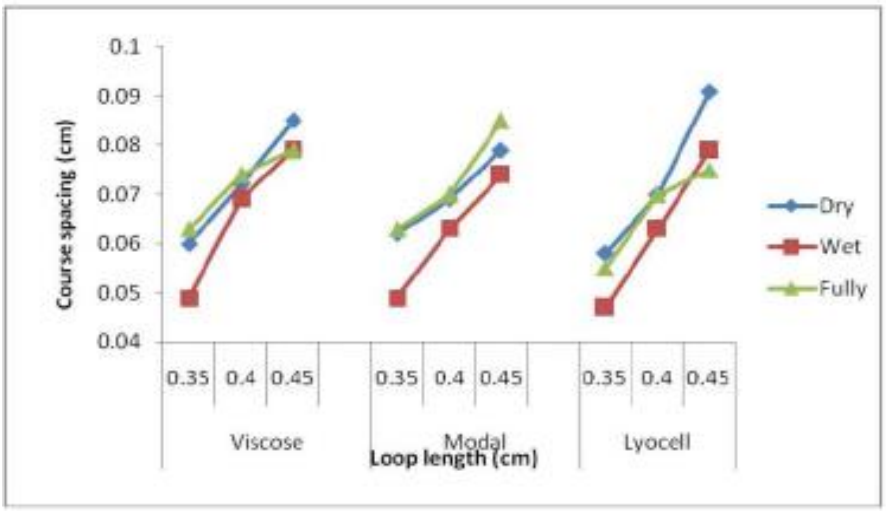

Figure 13: Relationship between course spacing and loop length of viscose, modal and lyocell single jersey knitted fabric

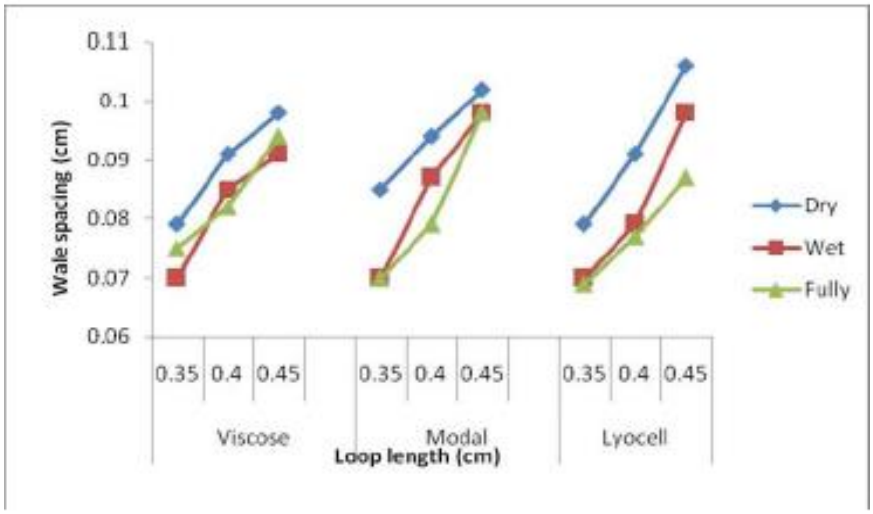

Figure 14: Relationship between wale spacing and loop length of viscose, modal and lyocell single jersey knitted fabric

A possible reason is that, due to lower wet elongation of lyocell fibers in the loycell yarns, loop shape is in comparatively stable state in the lyocell knit structure compared to modal.

Effect of loop length on course and wale spacing

The viscose, modal and lyocell single jersey knitted fabrics have significant at 95% confidence level.

Effect of Stitch Density

The use of stitch density or number of loops per area of fabric is preferred, since it is less affected by distortion. It is observed that for the viscose, modal and lyocell structure, the stitch density varies linearly with the reciprocal of loop length.

Figure 15 shows the relationship between stitch density and reciprocal of loop length for viscose, modal and lyocell single jersey fabric. Course and wale spacing are directly related to the stitch densities of the kintted fabrics. The lower values of course and wale spacing in lyocell fabrics is responsible for higher stitch densities in the fabrics compare than viscose and modal fabrics. Stitch density is directly responsible for determining the dimensional stability of the knitted fabric. The influence of loop length on stitch density of the viscose, modal and lyocell single jersey knitted fabric have significant at 95% confidence level.

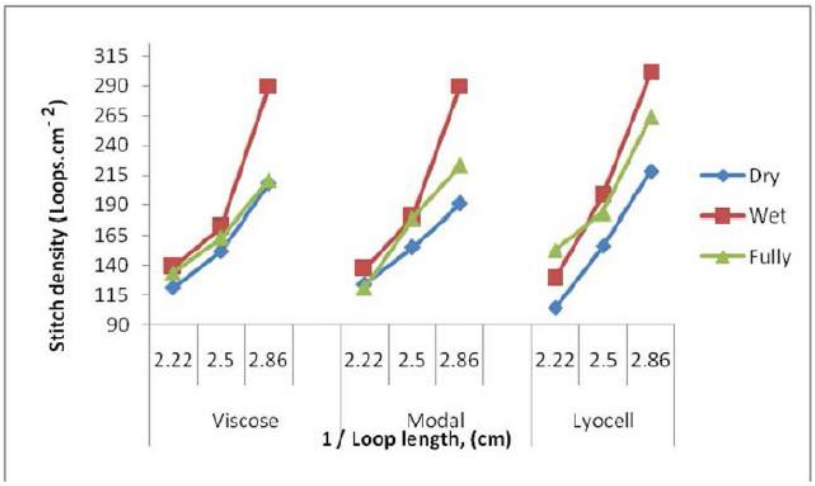

Figure 15: Relationship between stitch density and reciprocal of loop length of viscose, modal and lyocell single jersey knitted fabrics

Effect of Fabric Weight per Unit Area

Figure 16 shows the relationship between fabric weight and reciprocal of loop length for viscose, modal and lyocell single jersey fabrics. Fabric weight is plotted against the reciprocal of loop length for the viscose, modal and lyocell fabric dry, wet and fully relaxed states. It is observed that areal density of the viscose, modal and lyocell fabrics is linearly related to the loop length. However, lyocell fabrics shows, higher compare then viscose and modal fabrics. A possible reason is that due to more stitch per unit area compare than viscose and modal fabrics. The influence of the weight of the viscose, modal and lyocell single jersey knitted fabrics have found to be significant.

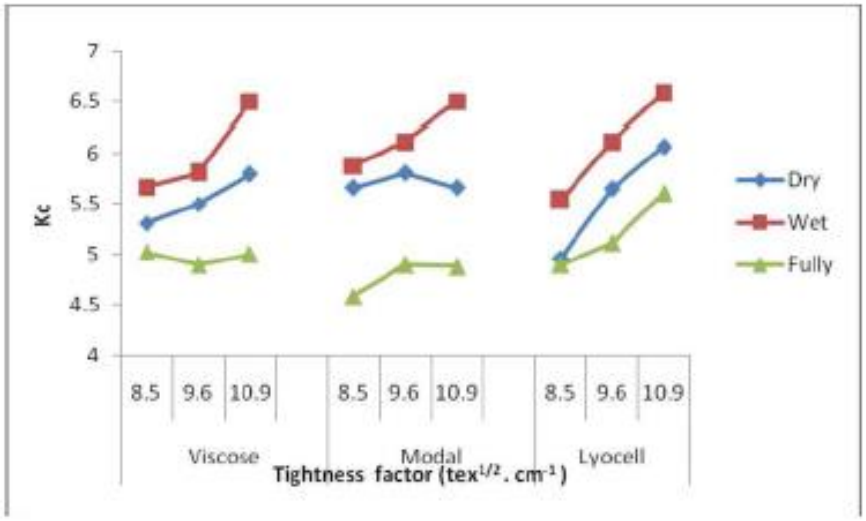

Figure 16: Relationship between fabric weight and reciprocal of loop length of viscose, modal and lyocell single jersey knitted fabrics

Effect of Relaxation Treatment on Kc, Kw and Ks

Kc, Kw and Ks are the geometrical constant of the single jersey knitted fabrics and depend on the actual configuration of the knitted loop. The length and width dimensions of the viscose, modal and lyocell knitted fabrics are dependent on the tightness factor. Figure 17 shows the relationship between Kc and tightness factor for viscose, modal and lyocell single jersey fabrics.

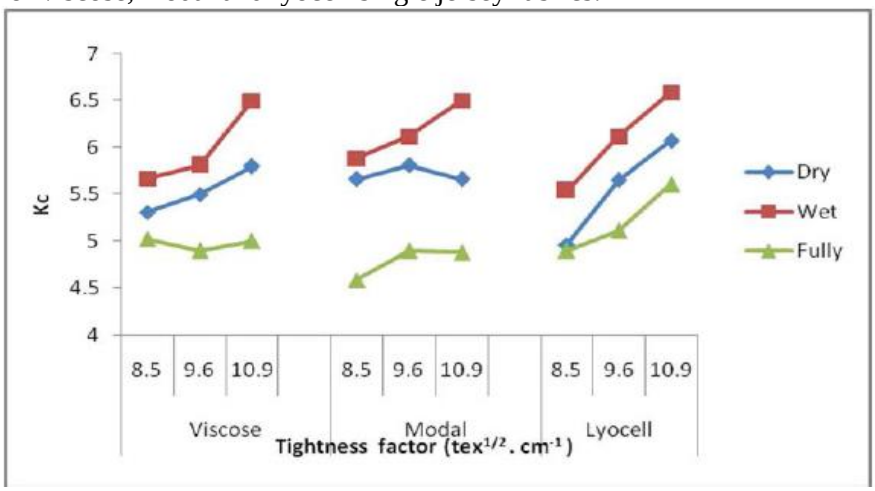

Figure 17: Relationship between Kc and tightness factor of viscose, modal and lyocell single jersey knitted fabrics

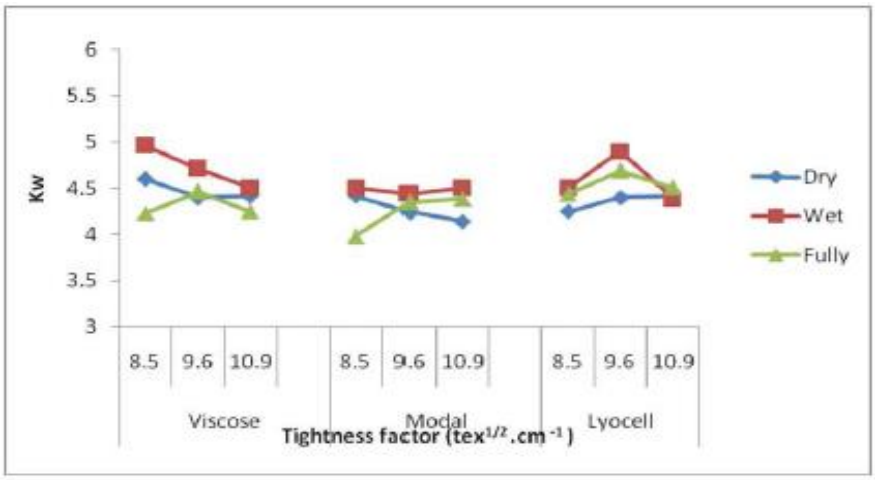

Figure 18: Relationship between Kw and tightness factor of viscose, modal and lyocell single jersey knitted fabrics

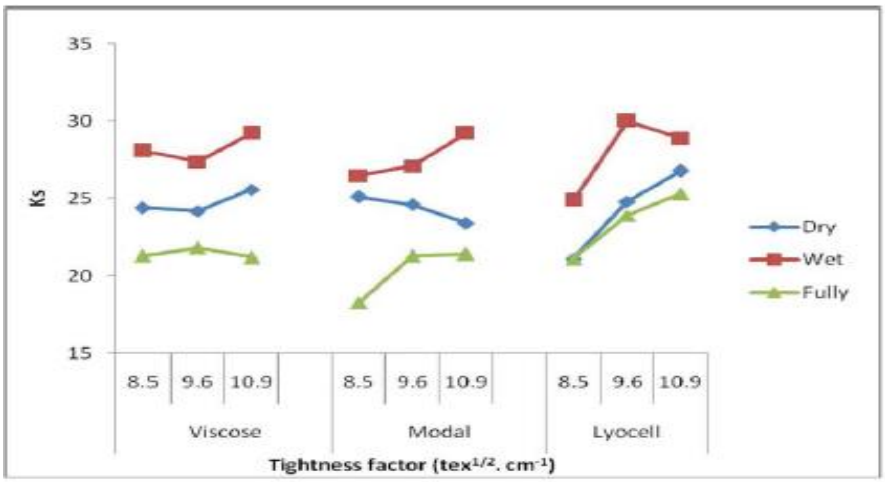

Figure 19: Relationship between Ks and tightness factor of viscose, modal and lyocell single jersey knitted fabrics

The values of Kc, Kw and Ks are plotted against tightness factor of viscose, modal and lyocell knitted fabrics. Figure 18 shows the relationship between Kw and tightness factor for viscose, modal and lyocell single jersey fabrics. It is observed that the difference in the values of Kc, Kw and all the fabric is noticeable but small. It is also found Ks value of the lyocell fabric increases proportionally with increase in the value of the tightness factor, compare than viscose than modal fabrics as shown in figure 19. The effect of tightness factor and relaxation state on dimensional constants such as Ke, Kw and Ks were also studied for three different fabrics. It was observed that, the tightness factor has no influence on dimensional constants of the fabrics. But, Ke and Ks were influenced by relaxation treatments.

Effect of Viscose, Modal and Lyocell Fibers on the Fabric Properites

The properties of viscose, modal, and lyocell fully relaxed knitted fabrics have been studied(Table 1). The changes in loop shape factor of the fully relaxed fabrics made from viscose, modal and lyocell is noticeable but small. Loop shape factor is measure of the ratio of the loop width to the loop length. The fully relaxed fabric is made from lyocell showers lower spirality compare than other fabrics. It shows that, lyocell single jersey knitted fabrics has minimum distortion. Loop length significantly affects the spirality in the fabrics at 95% confidence level. It is also found that the skewness of the viscose modal and lyocell fabrics decreases with the increase in loop length.

The thickness of the viscose, modal and lyocell fabric is influenced by loop length and fibre type. The loop length and fibre type has signifant effect on bursting strength of the knitted fabrics. The fabrics made from lyocell shows maximum bursting strength compare than modal and viscose fabrics, it is due to the structural characteristics of lyocell fibres, reveal their good mechanical properties. The special properties of lyocell fibres is higher strength, high degree od crystalline and molecular orientation in comparison with viscose fibers

CONCLUSION

The dimensional characteristics of cotton, viscose and regenerated knits have been investigated. The influence of laundering on cotton knits has been studied. It has been found that the changes occurring after laundering have been largely due to the alterations in the loop shape rather than yarn or loop length shrinkage. The fabrics had taken up their fully relaxed dimensions after five wash and dry cycles and appropriate conditions for laundering had been applied, since no significant yarn stitch length or linear density changes occurred. Further studies have been carried out to study and thus isolate the area of the laundering cycle causing the most dimensional changes and distortion in knitted fabrics. The knits have been subjected to five cycles of different washing and drying regimes which isolated the wash, rinse, spin, agitation during drying and the effect of heat during drying. The study showed that changes occurring after laundering were largely caused due to the agitation during tumble drying. The agitation was found to have caused 34% of the changes during laundering, followed by the spin cycle during washing, which caused 24% of the dimensional changes and distortion. Mercerization is considered to be an effective treatment for stabilizing the structure of plain knit cotton fabric. Cotton knits have been mercerized with variation in alkali solution and bath temperature. Then numerical values of constant geometry of the fabrics have been calculated. Individual and simultaneous effects of the variables on dimensional properties have been assessed. The area geometry constant values, Ks in the case of mercerized knits are higher than the dry and wet relaxed knits. The dimensional properties of regenerated fibres, viscose, modal and lyocell fibre knits have been investigated at three level of loop lengths under dry, wet and fully relaxed conditions. The effect of different fibre types on the dimensional properties has also been studied. The course and wale spacing values of lyocell fabrics were found to be lower than that of viscose and modal knitted fabrics. Lyocell fabrics shows higher areal density with decreasing loop length. The Ks values of lyocell fabrics increases proportionately with the increase in the tightness factor, compared to that of viscose and modal fabrics. The fabrics made from lyocell exhibit maximum bursting strength and lower spirality as compared with viscose and modal fabrics, due to the structural characteristics of lyocell fibres. Single jersey knitted fabrics of lyocell fibres exhibit better dimensional properties than viscose and modal fabrics.

REFERENCES

Anand SC (1997). Private Communication, *Bolton Institute*, U. K, October.

Anand SC, Brown KSM, Higgins LG, Holmes DA, Hall ME and Condrad D (2002). Effect of laundering on the dimensional stability and distortion of knitted fabrics. *Autex Research Journal***2**(2) 85-100.

Anita Hebsiba G and Thambidurai S (2007). Tensile properties of cotton yarns after slack swelling and stretching in presence and absence of sodium hydroxide.*Indian Journal of Fibre & Textile Research* **32** 284-289.

Birkett FH (1986). The Starfish Project - An Integrated Approach to Shrinkage Control in CottonKnits. Part 1: Introduction and Definition of the Reference State. *Knitting International*(4) 40-42.

Brinkman K (1992). A New Economical and Ecological Mercerizing Process. *ITR, Dyeing,Printing, Finishing***38** 1-7.

Chavan RB (2004). Development and processing of lyocell. *Indian Journal of Fibre & Textile Research***29** 483-492.

Dhamija S and Manshahia M (2007). Performance characteristics of mercerized, Ring compact spun yarns produced at varying levels of twist and traveler weight. *Indian Journal of Fibre & Textile Research* **32** 295-300.

Doyle PJ (1953). Fundamental aspects of the design of knitted fabrics. *Journal of the Textile Institute* **44** 561-573.

Hari PK, Balasubramanian P, Sengupta AK and Chavan RB (1985). Effect of mercerization on the tensile properties of rotor spun yarns.*Textile Research Journal***55**(2) 122-124.

Hearth CN (2007). Dimensional stability of cotton spandex interlock structure under relaxation, fibers and structure under relaxation. *Fibers and Polymers***8**(1)105-110.

Hearth CN and Bok Choon K (2008). Dimensional stability of core spun cotton/spandex single jersey fabric under relaxation. *Textile Research Journal***78**(3) 209-216.

Hepworth B (1989). Investigating the dimensional Properties of 1x1 Rib Fabrics. *KnittingInternational*48-51.

Hurley RB (1966). The dimensional stability of acrylic knit fabric. *Textile Research Journal*989-993.

Jeddi A, Hamzh A and Latifi F (1999). A comparative Theoretical Analysis for Knitted loop Model. *International Journal of Engineering* **12**(1) 39-44.

Jeddi AA, Mohammadi AV, Rahimzadeh and Honarvar F (2007). Knitted Fabric Relaxation by Ultrasound and its Characterization with Yarn Pullout Force. *Fibers and Polymers***8**(4) 408-413.

Jiang T (1997). Effects of yarn and fabric construction on spirality of cotton single jersey Fabrics. *Textile Research Journal***67**(1) 57-68.

Knapton JJF (1968). The dimension properties of plain knitted wool fabric Part I: the Plain knitted structure. *Textile Research Journal*999-1012.

Latta BM (1984). Improved Tactile and Sorption Properties of Polyester Fabric through Caustic Treatment. *Textile Research Journal***54**(11) 261-268.

Mohammadi V and Jeddi A (2006). Dimensional Stabilization of Cotton Plain Knitted Fabric by Using Ultrasonic Waves. *Indian Journal of Fibre & Textile Research***31** 339-341.

Moon WS (1967). A study of the shrinkage of plain knitted cotton fabric based on the structural changes of the loop geometry due to yarn swelling and deswelling. *Textile Research Journal*417-431.

Mundan DL (1959). The Geometry and Dimensional Properties of Plain –Knit Fabric. *Journal of the Textile Institute* **50** 448-471.

Munden DL (1959). The geometry and dimensional properties of plain knit fabrics. *Journal of the Textile Institute* **50** 448-471.

Munden DL (1959). The Geometry and Dimensional Properties of Plain Knit Fabrics. *Journal of the Textile Institute* **50** 448-471.

Munshi VG, Ukidve AV, Raje CR, Basker P and Pai SD (1993). The Effect of Laundering on the Mechanical Properties of Apparel Fabrics. *Colourage***2**(2) 34-38.

Needles L, Brook B and Keighley H (1985). Hot alkali treatment affect polyester, cotton and polyester/cotton. *Textile Chemist and Colourist***17**(7) 177-180.

Parmar MS and Srivastava SK (1999). An unconventional way to incorporate comfort in knitted fabrics. *Indian Journal of Fibre & Textile Research* **24** 41-44.

Postle R and Munden DL (1967). Analysis of the Dry Relaxed Knitted Loop Configuration-Part 1:Two Dimensional Analysis. *Journal of the Textile Institute* **58** 329-351.

Rusznak I (1984). Hot Mercerizing of Cotton and Polyester/Cotton Knitted Fabrics. *Journal of Industrial Textiles***1149** 1029-1030.

Seddiqui S (2002). Study on the Effect of Hot Mercerization on the Properties of 100% Cotton Fabric. M.SC thesis, Textile Development, Isfahan University of Technology (IUT).

Semnai DM, Latifi S, Hamzeh A and Jeddi A (2003). A New Aspect of Geometrical and Physical Principle Applicable to the Estimation of Textile Structure and Idea Model for the Plain-Knitted Loop. *Textile Research Journal***94** 204-213.

Sharma IC (1984). The dimensional stability of plain weft knitted fabric. *Indian Journal of Fibre & Textile Research* **9** 13-18.

Sharma IC, Ghosh S and Gupta NK (1985). Dimensional and Physical Characteristics of Single-Jersey Fabrics. *Textile Research Journal***55** 149-156.

Shet RT, Zeronian SH and Needles NH (1981). Modification of polyester-cotton Blendfabrics by Hot Alkali Treatment. *38th All Indian Conference* 261- 268.

Shet RT, Zeronian SH, Siddiqui SA and Needles HL (1982). Modification of Polyester and Polyester/cotton by Alkali treatment. *Textile Chemist and Colorist***14** 233-237.

Srinivasan J (2007). A study of knitted fabrics from polyester micro denier fibres. *Journal of the Textile Institute***98**(1) 31-35.

Tatjana K and Sonja M (2003). Structural characteristics of new and conventional regenerated cellulosic fibres. *Textile Research Journal***73**(8) 675-684.

Thomas K (1994). From Liable to Stable: Dimensionally Stable Knitted Fabrics Today. *KnittingTechnique***16** 360-361.

Wolfaaedt C and Kanpton JF (1971). Dimensional properties of the all-wool 1x1 Rib Structure. *Journal of the Textile Institute* **62** 561-568.

Young Soo W (2003). Preparation and properties of new regenerated cellulosic fibres. *Textile Research Journal***73**(11) 998-1003.

Yousefi M (1989). Study on the Effect Alkali Solutions in Finishing Process on the Properties of Polyester (AUT). M.SC Thesis, Textile Department.

Zanaroli P (1990). Novel Compressive Shrinkage of Knits. *American Dyestuff Reporter* 33-47.