EFFECT OF KNIT STRUCTURE ON DIMENSIONAL STABILITY OF KNITTED FABRICS

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Abstract

Fabric shrinkage is a serious problem facing Garment industry especially knitwear, that is caused by dimensional changes in the fabric, particularly stitches. The dimensional stability of cotton weft knitted fabrics during utilization has a significant effect on their quality. Accordingly, shrinkage affects the company place in the competitive market. The structure of knitted fabric is an interloping action of yarns into stitches. Consequently, it influences geometrical and dimensional stability of knitwear's. The main goal of this work is to study the effect of fabric design on the output shrinkage of weft knitted fabric. Experimental work studied the output shrinkage of six types of weft knitted fabrics: Single Jersey, Plating Single Jersey, Rib, Interlock, Pique Lacoste, and Fleece fabrics, at different levels of knitting parameters, yarn types and counts. Results demonstrated that Piques stitches reduce the amount of widthwise shrinkage while Miss stitches decrease the ability of fabric shrinkage in both lengthwise and widthwise directions. The addition of electrometric fibers to have plating or half plaiting knitted fabrics reduce the amount of widthwise shrinkage.

Introduction

Fabric shrinkage is a serious problem for knitwear, beginning with dimensional changes in the fabric. Accordingly, specifications of textile products always had an effect on planning of managers in all areas of textile production [Mikučionienė, 2009]. In today's competitive markets where quality is expected at low price, low shrinkage and high quality. Acceptance, rejection and discount penalties are dependent on a gathered data. Further, in depth analysis of these data can allow for a better understanding that can impact production techniques to make the shrinkage phenomena manageable [ElKateb, 2002]. Cotton fabrics are often projected to dimensional instability, especially knits which are very sensitive to applied forces or energies. Therefore, whenever cotton knit fabric is manipulated in processing, its dimensions will change. The term shrinkage can simply be defined as a change in the dimensions of a fabric or garment. This dimensional change may be in a positive (growth) or negative (shrinkage) direction for fabric length and width.

The stability of knit fabric dimensional during operation has significant effect on their quality. Dimensional stability of knitwear is influenced by fiber properties, knitwear structure, pattern of fabric and conditions of technological process [Mikučionienė, 2009]. The factors that influence the level of dimensional stability can be summarized, as first of all are yarn characteristics as its type, yarn count, and twist factor. Secondly, are knitting parameters as loop length, machine gauge, and number of wales and courses. Next, are processing tensions after knitting process. Finally, are Relaxation techniques in finishing and finishing procedure as mechanical and chemical treatment and compaction and drying conditions.

The yarn count has a direct relationship on fabric weight irrespective of any dimensional change where, the coarser the yarn, the heavier the fabric. Loop length is the most important construction variable in the knitted fabric. As loop length increases, the number of courses per cm and fabric weight decrease. [Prakash, 2010], [Mikučionienė, 1999]

The tensions in wet processing and apparel manufacturing can provide a knit unacceptable with respect to weight, width, and shrinkage. [Cotton Incorporated, 1999]. Resin finishing or cross-linking of cotton is one of the most prevalent chemical treatments given to cotton fabrics. Cross-linking occurs through reactions of poly-functional reactants with hydroxyl groups of adjacent cellulose chains [Quaynor, 1999].

Compactions as a means of shrinkage control that compress the courses loops upon themselves. It is preferable to use compaction after resin finishing. On the other hand, softener types and amounts affected the level of compaction and the output shrinkage. In addition, heat associated with compacting may reduce bursting strength and causes curing.

Finally, few researches interested in studying the effect of fabric design on the output knitted fabric properties. For an instance, [Tamoue, 2011] studied the influence of different designs on the output caver factor, but no prevalent research studied this effect on the output shrinkage. As a result, it is our target to study the relation between design and shrinkage of weft knitted fabric.

Methodology

Testing Samples

The experimental study consists of six types of weft knitted fabrics: Single Jersey, Plating Single Jersey, Rib, Interlock, Pique Lacoste, and Fleece fabrics, at different levels of knitting parameters, yarn types and counts. Theses designs are currently most used in industry. All of these fabric designs were produced at the same setting almost that the effect of stitch structure on the output fabric shrinkage will be clear. Table (1) demonstrates the chosen fabric structure and both of their knitting notation and fabric images. Table (2) introduces the used machine gauge and yarn counts for each fabric sample.

Table 1: Fabric designs, knitting notations, and fabric images

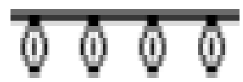
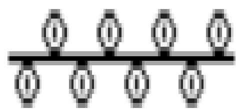
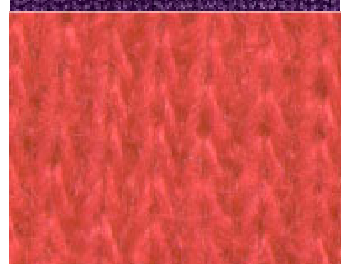
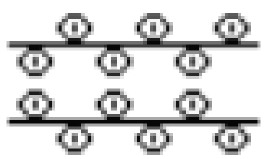
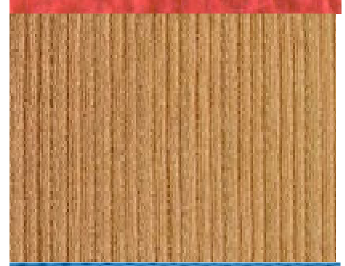
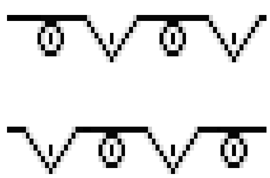
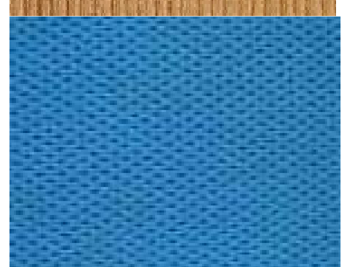
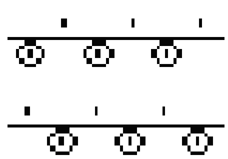
Fabric Design	**Notation**	**image**
Single Jersey		
Fine Rib		
Interlock		
Pique Lacoste		
Fleece (Melton)		

Table (2): Range of machine gauge and yarn count for each fabric sample

Fabric design	machine gauge	Yarn count (Ne)
Single Jersey	E 24	30/1
Single Jersey with Lycra (Plating)	E 24	40/1
Fine Rib	E 18	30/1
Interlock	E 20	30/1
Interlock (blended) (60% Poly - 40% Cotton)	E 20	40/1
Pique Lacoste	E 24	24/1
Fleece	E 24	30/1, 24/1

Shrinkage Evaluation Technique

The basic procedure for testing fabric dimensional stability was obtained by measuring length and width benchmarks before and after a selected refurbishing process according to the standards. Each sample was marked by 50*50 cm^2 template as bench marking process, then length and width dimensions were measured before and after washing and drying processes. After that this procedure repeated three to five times in order to reach reference state case. Finally, Shrinkage% can be measured by the following equation:

Shrinkage % = [(a-b) /a]*100 …………………………………….. Equation [1]

Where,

a = Distance between two ends before treatment
b = Distance between two ends after treatment.
Length and width changes are calculated separately.

Experimental Procedure

The used procedure of this study contains the following phases in order to attain its goals: -

- 1st phase was to express the shrinkage percentage in both widthwise and lengthwise directions for all structures involved.
- 2nd phase was to classify the shrinkage percentage in widthwise and lengthwise for single jersey, fine rib and interlock fabrics.
- 3rd phase was to study the effect of tuck stitch on shrinkage in both directions.
- 4th phase was to study the effect of miss stitch on shrinkage in both directions.
- 5th phase was to recognize the effect of lycra on shrinkage percentage.
- 6th phase was to study the effect of blending on interlock fabrics.

Statistical tools as "ANOVA analysis and Regression analysis" were applied in order to achieve these targets.

Results and Discussion

ANOVA Results

Tables (3, 5) show output results of ANOVA analysis for widthwise and lengthwise shrinkage in series. In addition, tables (4, 6) illustrate the codes of designs for used fabric samples.

Table (3): ANOVA results for Widthwise shrinkage

Object of test	Groups	*P-value*	*F*
Effect of different structure	WSL, WSJ, WP, WR, WI, WIP, WM	1.3E-16	16.78459
Effect of Lycra	WSL, WSJ	0.02374	5.23488
Effect of basic structure (different machine parts)	WSL, WSJ, WR, WI	1.7E-11	19.84028
Effect of knit, tuck and Miss stitch	WSJ, WP, WM	4E-05	10.96227
Effect tuck stitch	WSJ, WP	0.36719	0.81949
Effect Miss stitch	WSJ, WM	4.8E-05	17.94976
Effect of polyester percent	WI, WIP	7.1E-11	66.58561

Where:

Table (4): Codes for Widthwise shrinkage of each fabric type

Code	Definition
WSL	Widthwise shrinkage for Single Lycra
WSJ	Widthwise shrinkage for Single Jersey
WP	Widthwise shrinkage for Pique
WR	Widthwise shrinkage for Fine Rib
WI	Widthwise shrinkage for Interlock (100% cotton)
WIP	Widthwise shrinkage for Interlock (60% polyester, 40% cotton)
WM	Widthwise shrinkage for Melton

Table (5):ANOVA results for Lengthwise shrinkage

Object of test	**Groups**	*P-value*	*F*
Effect of different structure	LSL, LSJ, LP, LR, LI, LIP, LM	2.75E-08	8.28133957
Effect of Lycra	LSL, LSJ	0.041009	4.25933933
Effect of basic structure (different machine parts)	LSL, LSJ, LR, LI	0.01585209	3.51795435
Effect of knit, tuck and Miss stitch	LSJ, LP, LM	2.38E-05	11.565282
Effect tuck stitch	LSJ, LP	0.015628	6.01893661
Effect Miss stitch	LSJ, LM	0.00099	11.4706382
Effect of polyester percent	LI, LIP	0.000108	17.5621969

Where:

Table (6): Codes for Lengthwise shrinkage of each fabric type

Code	Definition
LSL	lengthwise shrinkage for Single Lycra
LSJ	Lengthwise shrinkage for Single Jersey
LP	Lengthwise shrinkage for Pique
LR	Lengthwise shrinkage for Fine Rib
LI	Lengthwise shrinkage for Interlock (100% cotton)
LIP	Lengthwise shrinkage for Interlock (60% polyester, 40% cotton)
IM	Lengthwise shrinkage for Melton

Effect of stitch type on lengthwise and widthwise Shrinkage

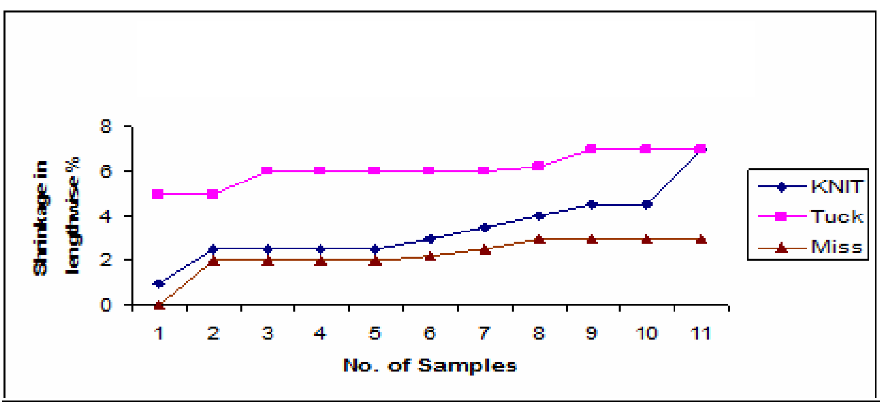


Figure (1): comparison between effects of different stitches on lengthwise shrinkage

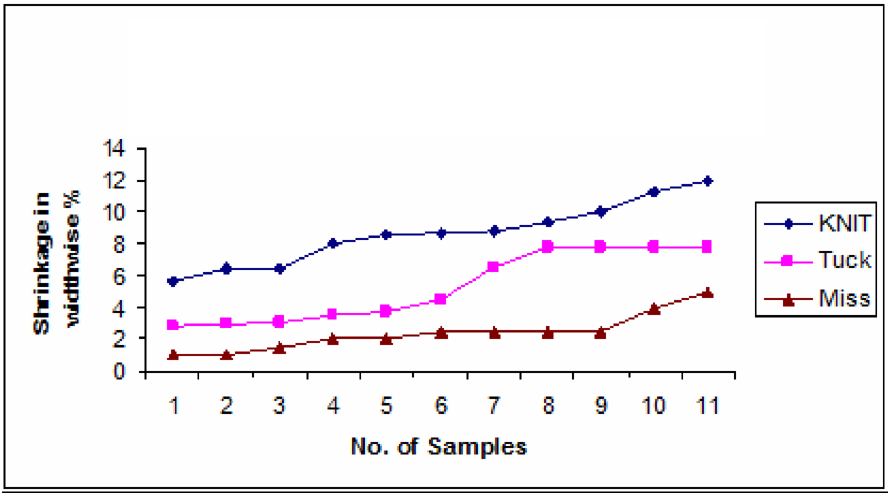


Figure (2): comparison between effects of different stitches on widthwise shrinkage

Figures (1) and (2) shows that miss stitch produces the least shrinkage possible compared with tuck and knit stitches in both widthwise and lengthwise directions. This is due to the movement of needle in the knitting process, as knit stitch is formed when a needle receives a new loop and knocks-over the old loop that it held from the previous knitting cycle [Spencer, 2001]. While tuck stitch is formed when the needle takes a new loop without clearing the previously formed loop, as for miss stitch is formed when the needle is not raised, which in fact means that the needle is missed as shown in figure (3). Results at table (3, 5) confirm that the relation between presence of tuck stitch in the design reduce the tendency of shrinkage in widthwise, but increase it in lengthwise. In contrast, miss stitch has same effect on both lengthwise and widthwise shrinkage.

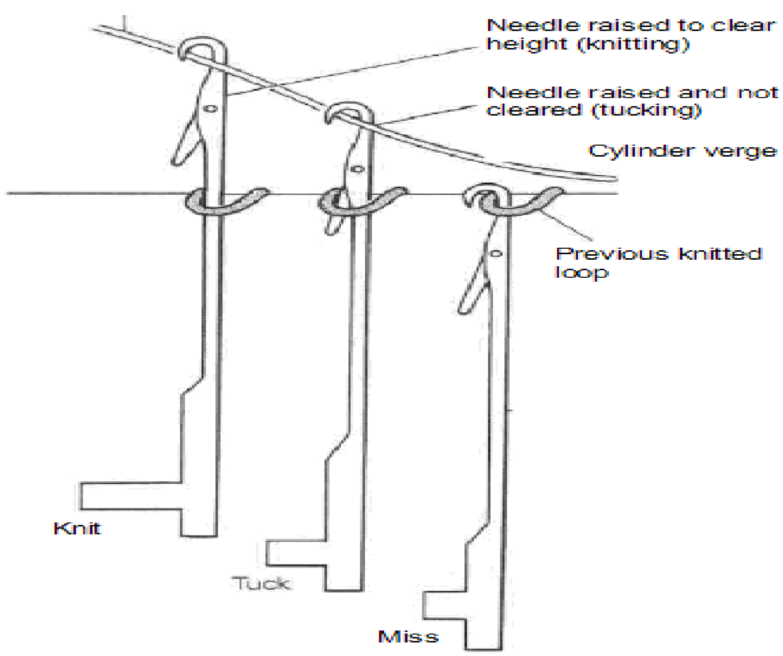


Figure (3): The movement of needle in the knitting process

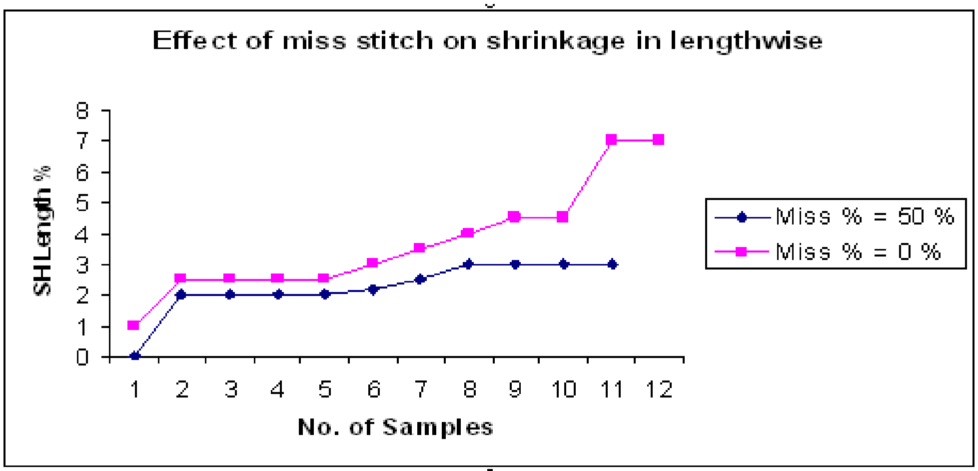


Figure (4): Effect of miss stitch on lengthwise shrinkage

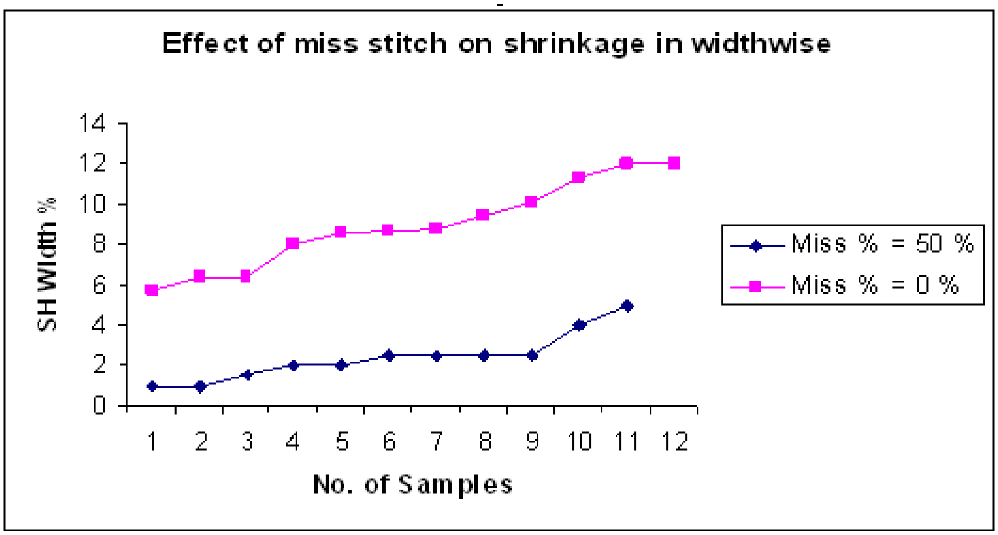


Figure (5): Effect of miss stitch on widthwise shrinkage

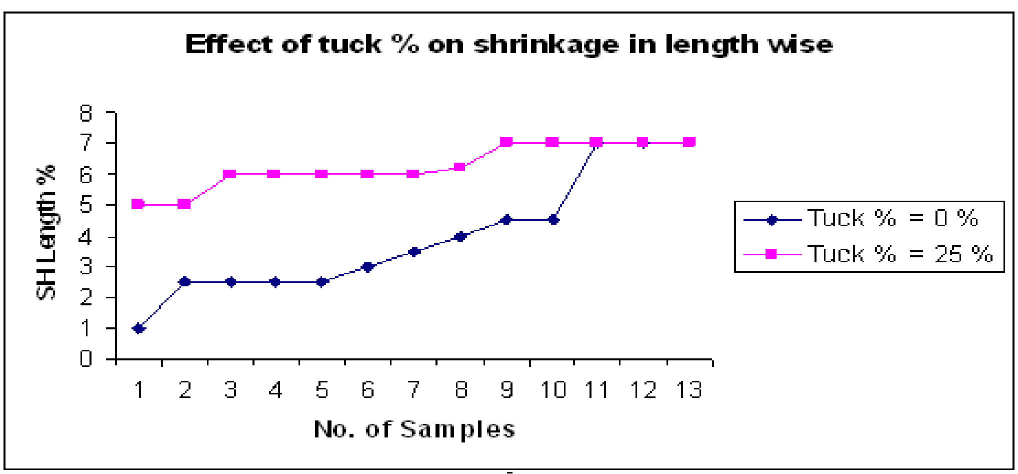


Figure (6): Effect of tuck stitch on lengthwise shrinkage

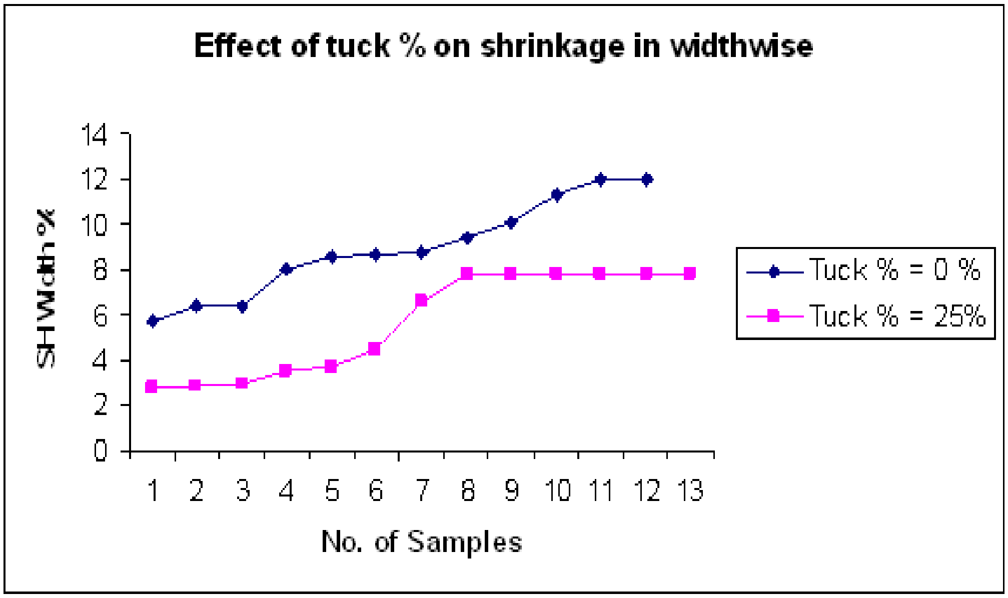


Figure (7): Effect of tuck stitch on widthwise shrinkage

As it shown in figures (4, 5, 6, 7), Tuck and Miss or float stitches are used to create patterns or change fabric appearance. It is clearly observed that presence of miss stitch reduce shrinkage of fabrics in both directions widthwise and lengthwise. On the other hand, Tuck stitches in a pique tend to make the fabric wider and less extensible. In general, pique fabrics have much higher length shrinkage than width shrinkage. As a result, the more the percentage of tuck stitches, the higher the lengthwise shrinkage and less widthwise shrinkage.

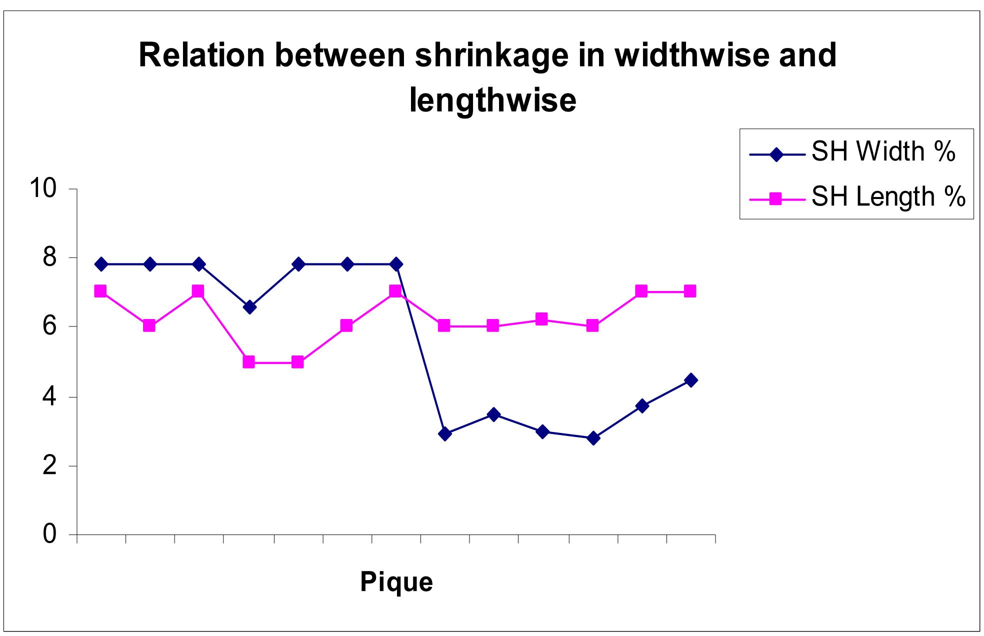


Figure (8): Relation between shrinkage in widthwise and lengthwise for pique

Effect of lycra

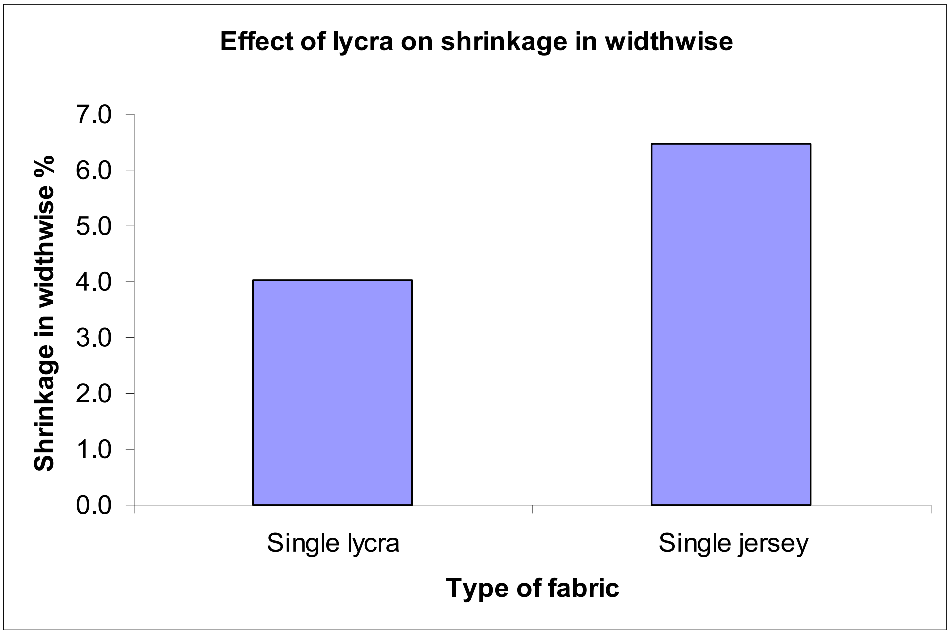


Figure (9): Effect of lycra on widthwise shrinkage

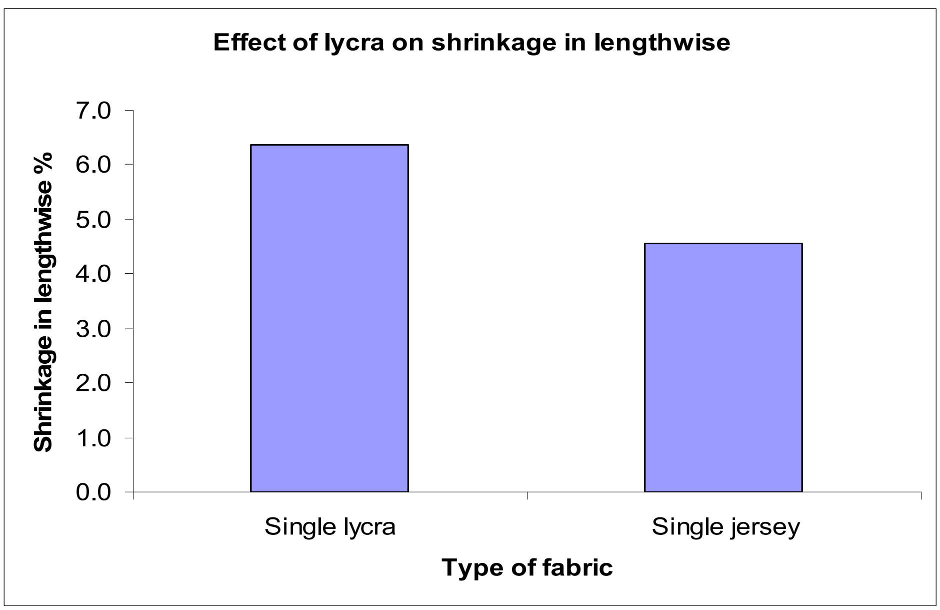


Figure (10): Effect of lycra on lengthwise shrinkage

The greatest property of Lycra is its high stretch elasticity that can be as high as 500%, while the elastic recovery reaches 95%. It can be seen that single jersey with lycra fabrics shrink less than single jersey fabrics in widthwise shrinkage. On the other hand single jersey fabrics shrink less than it with lycra fabrics in lengthwise shrinkage by about 30 %. The outcomes at table (3, 5) confirm this phenomenon.

Effect of the Primary Designs

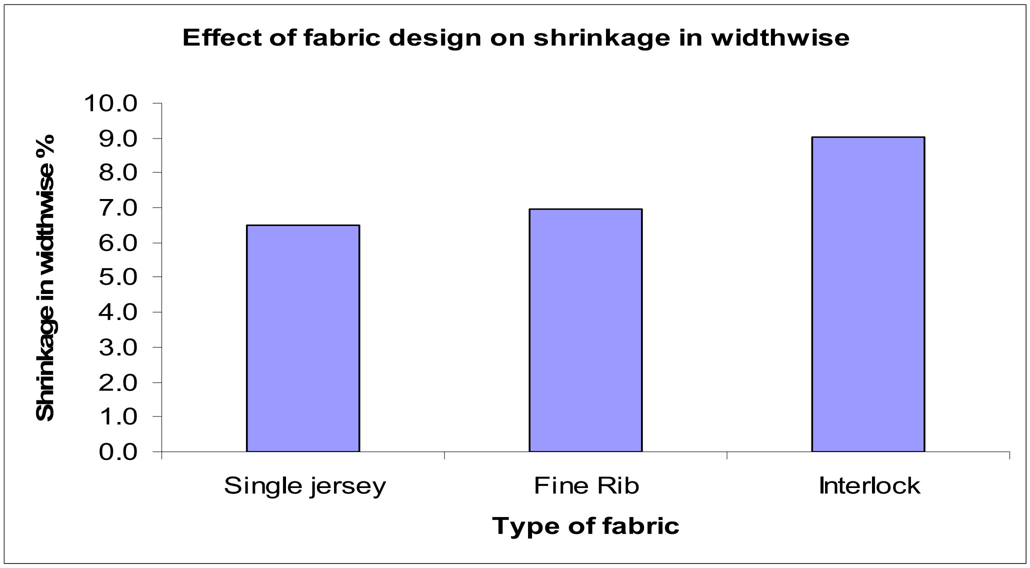


Figure (11): Effect of fabric design on shrinkage in widthwise

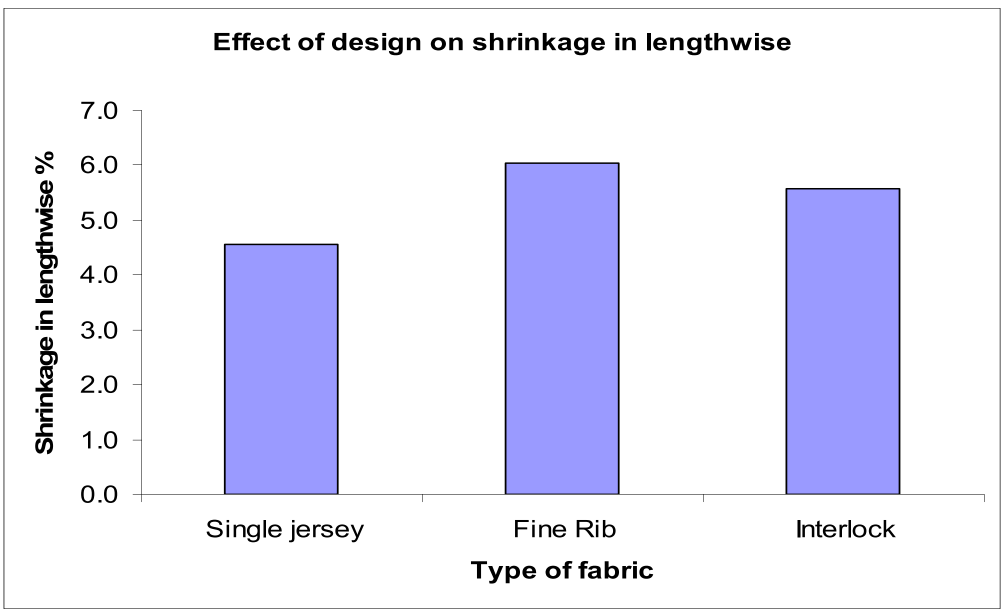


Figure (12): Effect of fabric design on shrinkage in lengthwise

It is observed that interlock fabrics tend to shrink more than fine rib and single jersey in widthwise shrinkage. On the opposite side interlock fabrics and single jersey fabrics have a significant change in lengthwise shrinkage while fine rib fabrics are less changeable. These phenomena proved by output results of ANOVA as shown by tables (3, 5).

Effect of Blending

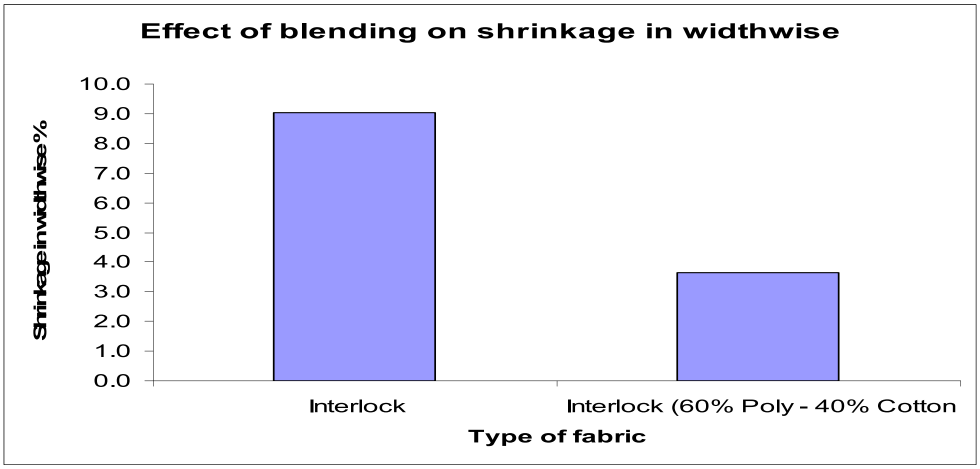


Figure (13): Effect of blending on widthwise shrinkage

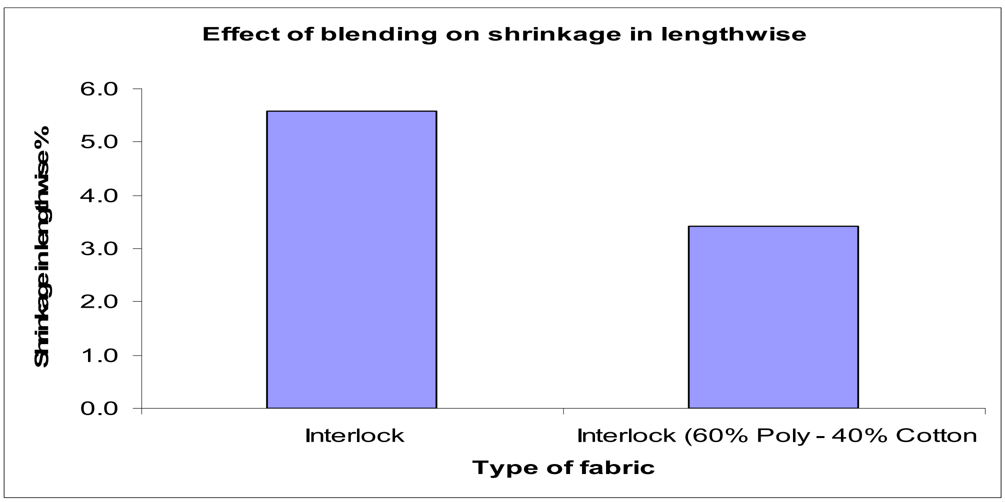


Figure (14): Effect of blending on lengthwise shrinkage

Table (7): Regression for blending and both of lengthwise and widthwise shrinkage:-

	Widthwise	Lengthwise
Regression Statistics		
Multiple R	0.84953275	0.665443
R Square	0.7217059	0.442814
	Coefficients	
Intercept	1.20448393	-5.21889
Gauge	1.2234375	-0.15586
Diameter (inch)	-0.2669708	0.198047
Ne	-0.3319699	0.267089
Polyester	0.8	-10
cotton	-1.5575221	2.053097
WT(g/m2)	0.00252818	-0.0011

Figures (13, 14) demonstrate the effect of polyester percentage on the output shrinkage of interlock fabrics. This phenomenon was studied by ANOVA as shown by tables (3, 5) and by Regression analysis as illustrated by table (7). It can be concluded that the interlock knitted fabrics, especially knitted from cotton/PES yarns blended characterized by more stable dimensions than interlock knitted fabrics. Besides, both P and F values at tables (3, 5) verify this result. As well as, the outputs of Regression analysis presented at table (7) prove it, where blended cotton yarns with Polyester maintain the stability of interlock fabric produced from this blend.

Summary

- The tuck stitch increase shrinkage in lengthwise increase. On the opposite side shrinkage in widthwise decrease.
- The presence of miss stitch reduces shrinkage of fabrics in both directions widthwise and lengthwise.
- The single jersey with lycra fabrics shrink less than single jersey fabrics in widthwise shrinkage. On the other hand single jersey fabrics shrink less than single jersey with lycra fabrics in lengthwise shrinkage.
- The interlock knitted fabrics from cotton/PES yarns blended are more stable dimensions than interlock knitted fabrics from 100 % cotton.
- For single jersey fabric the shrinkage in widthwise increases as the shrinkage in lengthwise decreases.
- For fine rib fabric, shrinkage in widthwise and lengthwise of fine rib fabric is tend to be the same.
- For interlock fabric, the shrinkage in widthwise and lengthwise of interlock fabric is difficult to be stabilized.

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