

EFFECT OF SEWING PARAMETERS AND WASH TYPE ON THE DIMENSIONAL STABILITY OF KNITTED GARMENTS

Mumtaz Hasan Malik¹, Zulfiqar Ali Malik¹, Tanveer Hussain¹, Muhammad Babar Ramzan²

¹Faculty of Engineering & Technology, National Textile University, Faisalabad-37610, Pakistan

²School of Textile and Design, University of Management and Technology, Lahore-54000, Pakistan
E-mail: mumtaz_hm@yahoo.com

Abstract:

The aim of this research is to study the effect of clothing manufacturing parameters, that is, stitch type, stitch density, sewing thread type and washing type on the dimensional stability of single jersey knitted garment. Single jersey bleached fabric, made from Ne 32 cotton combed ring spun yarn, was used to make 32 medium size crew neck T-shirts selecting two levels of stitch type, stitch density, sewing thread type and wash type according to the experimental design. After constructing the garments, four critical measurements of each garment, that is, body length, body width, across shoulder and sleeve length were measured. The constructed garments were divided into two equal groups. One group was washed with water and the other group was washed using a detergent. After washing, drying and tumbling, the same critical measurements of each garment were taken and the percent shrinkage was calculated. Analysis of data was done on responses of output variables against the input variables using MINITAB. The results showed that three input variables: stitch type, stitch density and garment wash type have significant effect on all the output variables.

Keywords:

Knitted garment, dimensional stability, stitch density, stitch type, wash type and crew neck T-shirt

Introduction:

Vests and briefs made from knitted fabric were worn next-to-skin as undergarments due to better tactile and comfort properties. As time passed, knitwear also became popular as fashion clothing and outer wear throughout the world due to its higher elasticity, good drape and soft handle. Knitwear also offers several advantages to the producer, for example, lower capital and manufacturing costs, higher productivity, shorter processing routes, etc [1]. Keeping in view the advantages of knitwear and its manufacturing processes, the quality of products must be maintained to win the confidence of the users. Perceived and visual quality, durability, reliability and cost are the factors on which the quality of the garment is based. Good quality enhances the reputation of the product, customer satisfaction and market share.

Colour, sewing, sizing and garment defects are the common quality problems being faced by the knitwear industry. Dimensional stability of the fabric is also an important parameter, which not only affects the sizing after washing but also causes seam puckering, skewness and torque in garments. Problem of shrinkage comes both in the woven and knitted fabric, but the knitted structure is prone to higher shrinkage as compared with the woven fabric due to its loose structure. Shrinkage is divided into two types: shrinkage due to the construction and shrinkage due to processing. Forces in knitting and subsequent processes that stretch the fabric result in more shrinkage than the forces that contract or compress the fabric. Therefore, the residual shrinkage is the net resultant of these two types of shrinkage.

Poor control of these forces can lead to high fabric shrinkage, which leads to poor shape retention of the garment. Many factors have been studied by the researchers [2-8] that affect the dimensional stability of knitted fabrics including the nature of fibre, blend composition, fibre fineness, yarn type, yarn linear density, yarn twist level, knit structure, fabric tightness, fabric relaxation, mercerization techniques, washing techniques and finishing methods, but a limited number of studies have been found in the literature on the dimensional stability of garments. The present work is aimed to study the effect of stitch density, sewing thread types, stitch types and garment wash methods on the dimensional stability of garments made from the single jersey cotton knitted fabric.

Experimental:

In this study, the single jersey structure, manufactured from 100% cotton combed Ne 32 yarn on a 30-inch diameter, 24-gauge circular knitting machine was used to make crew neck T-shirts. During the process of knitting, the stitch length was set at 2.7 mm, whereas the wales and courses were set at 28 and 40 per inch, respectively. The weight of greige fabric was 110 g/m², which was processed to get a bleached fabric with a weight of 135 g/m². For sewing, three thread types, that is, cotton fibre spun thread, polyester fibre spun thread and polyester multifilament yarn with two sewing combinations were used. Both cotton and polyester spun sewing threads were 2-ply from single Ne 40 yarns with a resultant twist level of 940 twist per meter in Z direction.

The polyester filament yarn of 150 denier, 48 filaments had no twist. In combination A, cotton spun thread was used on needle and multifilament polyester yarn on the looper, while in combination B, polyester spun thread was used on the needle and multifilament polyester yarn on the looper of the sewing machine. 3 threads and 4 threads over-lock stitch constructions were made at two levels of stitch density, that is, stitch per inch (SPI) 10 and 16. In 3 threads over-lock, one needle thread and two looper threads were used, whereas in 4 threads over-lock, two needle threads and two looper threads were used.

Experimental plan was developed using the full factorial design of MINITAB®. Four input variables, that is, the stitch type, stitch density, thread type and wash type, each with two levels, were used to generate an experimental plan, which is given in Table 1. Thus, thirty-two shirts were made as per design of the experiment. The constructed garments were washed using the most common types of washing, that is, water wash and detergent wash. Top loading industrial washing machine, hydro extractor and tumble dryer were used for washing and drying the garments.

Garment construction:

Crew neck T-shirts were constructed according to the given experimental plan. Each run order in Table 1 shows one garment sample. One front panel, one back panel and two sleeve panels were made for constructing a medium size garment as per the measurements given in Table 2. Pattern digitising was done using a digitising table, mouse and a computing system, which was followed by the marker making process. For pattern, digitising and marker making Accumark® software was used. Single marker consisting of all components required to manufacture a single garment was used. Thirty-two layers of single jersey finished fabric were spread manually on a cutting table and a manual hand cutter was used to obtain the required parts of the garment. Sewing process was carried out according to the run order of design of experiment using over-lock and flat lock sewing machines. Break down of the sewing process is given in Table 3. After completing the construction of garments, four critical measurements of each T-shirt, that is, body width, body length, across shoulder and sleeve length, were taken manually using measuring tape and recorded against each run order. After taking the required measurements before wash, garments were divided into two groups according to the design of the experiment, and for one group, water wash method, and for the other group, detergent wash method was used. The details of washes are given in Table 4.

After completing washing, drying and tumbling processes, measurements of each garment were taken manually using a measuring tape and recorded. The percentage shrinkage of each garment parts, that is, the body length, body width, length across the shoulder and sleeve length was calculated using the following equation:

$$\Delta L = \frac{L_0 - L_1}{L_0} \times 100$$

- Where ΔL = Change in dimension (%)
- L_0 = Measurement before wash (cm)
- L_1 = Measurement after wash (cm)

Table 1. Design of experiment.

Run order	Input variables			
	Stitch type	Stitch density	Thread type	Wash type
1	4T	10	A	DW
2	3T	10	A	DW
3	4 T	16	A	WW
4	3T	10	B	DW
5	4 T	10	B	WW
6	4 T	10	A	WW
7	4 T	10	B	DW
8	3T	10	B	DW
9	3T	16	B	DW
10	4 T	16	B	WW
11	4 T	16	B	DW
12	3T	10	A	WW
13	4 T	10	B	WW
14	3T	16	A	DW
15	4 T	10	A	DW
16	4 T	16	A	WW
17	3T	10	B	WW
18	3T	16	A	WW
19	4T	10	A	WW
20	3T	16	B	DW
21	3T	10	B	WW
22	3T	16	A	DW
23	3T	16	B	WW
24	4T	16	B	WW
25	3T	10	A	WW
26	4T	16	A	DW
27	4T	16	B	DW
28	3T	10	A	DW
29	4T	16	A	DW
30	3T	16	B	WW
31	3T	16	A	WW
32	4T	10	B	DW

(DW = Detergent Wash, WW = Water Wash, 4T = 4Threads, 3T = 3Threads)

Table 2. Medium size garment measurements.

Description	Sizes and allowances (cm)
Total length from HPS	74 + 2.5
Shoulder seam forward	2 + 0.5
Chest width - 1" below armhole	55 + 2.5
Bottom opening width	53 + 2.5
Body hem height	3 + 0.5
Across shoulder	46 + 2.5
Sleeve length from centre back	44 + 1
Armhole width straight-edge to edge	25 + 1
Muscle width (taken 1" below armhole)	22 + 1
Sleeve opening width	19 + 0.5
Sleeve hem height - self bend back	3 + 0.5
Neck depth front-image to seam	11 + 0.5
Neck depth back-image to seam	3 + 0.5
Back neck width- seam to seam	17 + 0.5

Table 3. Operational breakdown of T-shirt.

S. no.	Operation description	Machine type	Needle size	Stitch density (SPI)	Stitch type
1	Shoulder attach	O/L	10	12 & 16	4T & 3T
2	Neck rib making & attach	O/L	10	12 & 16	4T & 3T
3	Sleeve hem (closed)	F/L	11	12	D/N 3T
4	Sleeve attach	O/L	10	12 & 16	4T & 3T
5	Side seam	O/L	10	12 & 16	4T & 3T
6	Bottom hem	F/L	11	12	D/N 3T

(4T = 4 Thread, 3T = 3Thread, O/L Over-lock, F/L = Flat-lock, D/N = Double needle)

Table 4. Specifications for water and detergent washes.

Parameters	Washing machine		Hydro extractor	Tumble Dryer
	WW	DW		
Machine Capacity (kg)	120	120	60	70
Material to Liquor Ratio	1:20	1:10	-	-
Water Quantity (liter)	1200	2400	-	-
Time (min)	30	40	2	40
Temperature (°C)	50	60	-	90
Speed (rpm)	20	20	3600	12
Detergent (g)	-	200	-	-

Results and discussion:

Data of the garments made from the single jersey fabric were collected according to the experimental plan and are given in Table 5. Analysis of the design was done using MINITAB software on responses that included the body length, body width, across the shoulder and sleeve length of the garments against the input variables of stitch type, stitch density, thread type and wash type. Results of the analysis are given in Tables 6-9, which provide the significant input variables and interactions with respect to outputs of body length, body width, across shoulder and sleeve length shrinkage of the garment. Selected input variable of thread type is not significant for any of the output response, so analysis given in Tables 6-9 were carried out by excluding the thread type input variable. Table 6 provides the regression coefficients and other statistical data for the body length shrinkage.

From Table 6, it can be seen that stitch density is the most dominant factor, while wash type is the least prominent factor for body length shrinkage. Positive sign of all the factors shows that there is a direct relationship between these factors and the body length shrinkage. All the three interaction plots are given in Figure 1. These plots show that there is a sharp increase in body length shrinkage when stitch density of 16 SPI is used along with four threads. Similar is the case for other interactions: 'stitch type and wash type' and 'stitch density and wash type'. For 10 SPI, sewing machine completes its cycles 10 times. Each complete revolution creates some stresses in the garments. So as stitch density increased from 10 to 16 SPI, the stress in the fabric also increased, which increased the fabric shrinkage after washing.

Table 7 provides the regression coefficients and other statistical data for the body width shrinkage. From Table 7, it can be seen that stitch density is the most dominant factor while wash type is the least prominent factor for body width shrinkage. Positive sign of all the factors shows that there is a direct relationship between these factors and the body width shrinkage. All the three interactions and plots are given in Figure 2. These plots show that there is a sharp increase in the body width shrinkage when stitch density of 16 SPI is used along with four threads. Similar is the case for other interactions 'stitch type and wash type' and 'stitch density and wash type'. The garment manufactured by four thread over-lock machine have more residual shrinkage as compared with three thread stitch because of more mechanical forces involved in stitching. During washing, garments that are under high stress recover more to their stable shape and give a higher value of shrinkage.

Table 8 provides the regression coefficients and other statistical data for across shoulder shrinkage. From Table 8, it can be said that stitch type is the most dominant factor, while wash type is least prominent factor for across shoulder shrinkage. Positive sign of all the factors shows that there is a direct relationship between these factors and across shoulder shrinkage. All the three interaction plots are given in Figure 3. These plots show that there is a sharp increase in across shoulder shrinkage when stitch density of 16 SPI is used along with four threads; similar is the case for other interactions: 'stitch type and wash type' and 'stitch density and wash type'.

Table 9 provides the regression coefficients and other statistical data for sleeve length shrinkage. From Table 9, it can be seen that stitch type is the most dominant factor, while wash type is the least prominent factor for sleeve length shrinkage. Positive sign of all the factors show that there is a direct relationship

Table 5. Shrinkage percentage for each combination of experimental design.

Run order	Input variables				Output variables (Percentage shrinkage)			
	Stitch type	Stitch density	Thread type	Wash type	Body length	Body width	Across shoulders	Sleeve length
1	4T	10	A	DW	8.3	8.8	8.5	9.0
2	3T	10	A	DW	6.4	6.0	6.2	6.5
3	4T	16	A	WW	9.4	9.0	9.4	9.6
4	3T	10	B	DW	6.0	6.0	6.3	6.1
5	4T	10	B	WW	7.3	7.1	7.5	7.8
6	4T	10	A	WW	7.5	7.0	7.8	7.2
7	4T	10	B	DW	8.0	8.3	8.6	8.7
8	3T	10	B	DW	6.6	6.9	6.5	6.3
9	3T	16	B	DW	8.7	8.9	8.6	8.2
10	4T	16	B	WW	9.1	9.0	9.6	9.6
11	4T	16	B	DW	10.7	10.0	10.5	10.8
12	3T	10	A	WW	7.0	7.8	7.6	7.0
13	4T	10	B	WW	7.0	7.1	7.4	7.4
14	3T	16	A	DW	8.6	8.3	8.1	8.1
15	4T	10	A	DW	8.4	9.1	8.4	8.8
16	4T	16	A	WW	9.1	8.7	9.5	9.7
17	3T	10	B	WW	7.0	7.8	7.6	7.2
18	3T	16	A	WW	7.3	7.8	7.5	7.0
19	4T	10	A	WW	7.4	7.2	7.5	7.3
20	3T	16	B	DW	8.6	8.1	8.4	8.3
21	3T	10	B	WW	7.3	7.4	7.4	7.9
22	3T	16	A	DW	8.6	8.9	8.4	8.4
23	3T	16	B	WW	7.5	6.8	7.2	7.0
24	4T	16	B	WW	9.3	9.1	9.2	9.5
25	3T	10	A	WW	7.7	7.8	7.6	7.0
26	4T	16	A	DW	10.6	10.1	10.6	10.0
27	4T	16	B	DW	10.7	10.0	10.2	10.1
28	3T	10	A	DW	6.6	6.8	6.6	6.3
29	4T	16	A	DW	10.0	10.4	10.0	10.3
30	3T	16	B	WW	6.9	7.8	7.5	6.9
31	3T	16	A	WW	6.6	6.9	6.8	6.5
32	4T	10	B	DW	8.0	8.5	8.2	8.9

(DW = Detergent Wash, WW = Water Wash)

Table 6. Regression coefficients (coded) for the body length.

S. no.	Terms	Coefficient	SE coefficient	T-value	P-value
1	Constant	8.0688	0.06837	118.009	0.000
2	Stitch type	0.7312	0.06837	10.695	0.000
3	Stitch density	0.7875	0.06837	11.518	0.000
4	Wash type	0.3563	0.06837	5.210	0.000
5	Stitch type* Stitch density	0.2750	0.06837	4.022	0.000

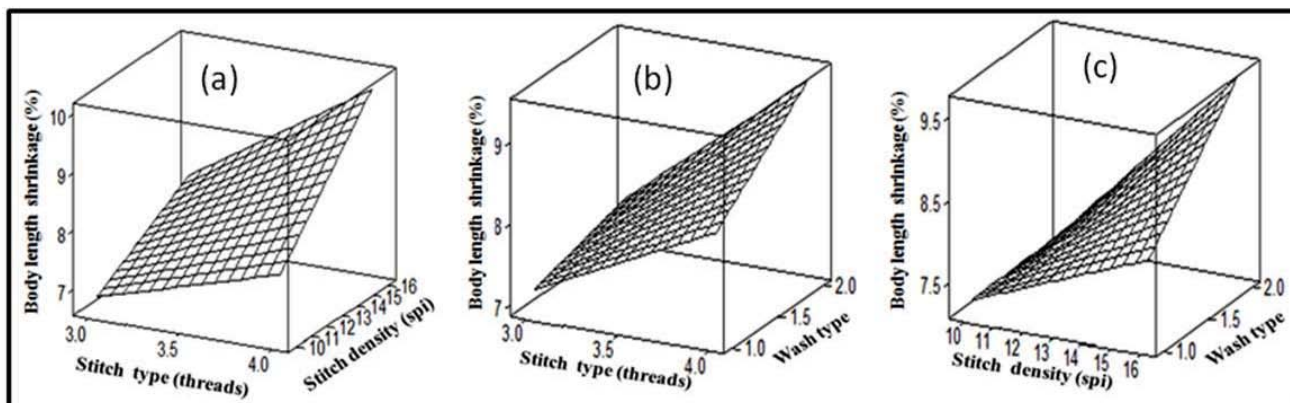


Figure 1. Interactions plots for body length.

Table 7. Regression coefficients (coded) for body width.

S. no.	Terms	Coefficient	SE coefficient	T-value	P-value
1	Constant	8.1063	0.09391	86.321	0.000
2	Stitch type	0.6062	0.09391	6.456	0.000
3	Stitch density	0.6312	0.09391	6.722	0.000
4	Wash type	0.3375	0.09391	3.594	0.001
5	Stitch type* Stitch density	0.1937	0.09391	2.063	0.050
6	Stitch type*Wash type	0.3500	0.09391	3.727	0.001
7	Stitch density*Wash type	0.2625	0.09391	2.795	0.010
R-Sq = 83.4 % R-Sq(adj) = 79.4 %					

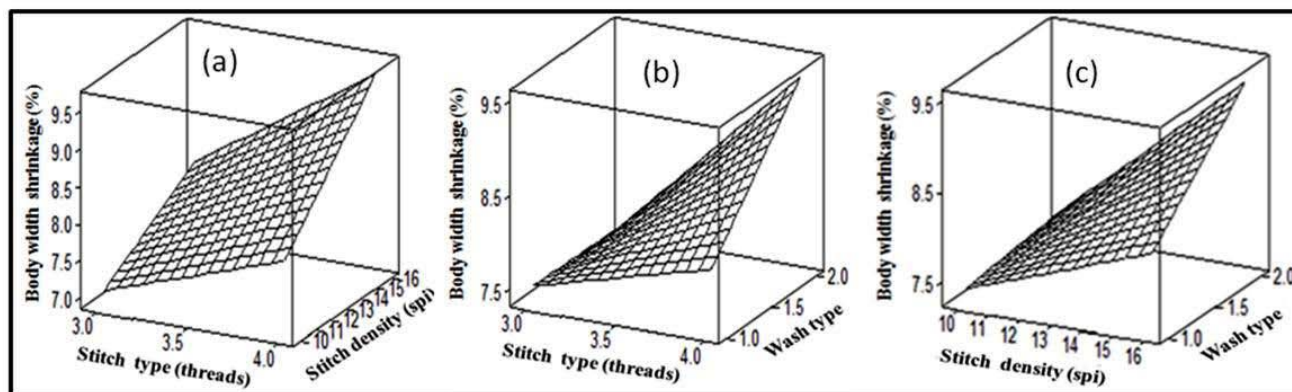


Figure 2. Interaction plots for body width.

Table 8. Regression coefficients (coded) for length across the shoulders.

S. no.	Terms	Coefficient	SE coefficient	T-value	P-value
1	Constant	8.1625	0.06719	121.490	0.000
2	Stitch type	0.7687	0.06719	11.442	0.000
3	Stitch density	0.6812	0.06719	10.140	0.000
4	Wash type	0.2188	0.06719	3.256	0.003
5	Stitch type* Stitch density	0.2625	0.06719	3.907	0.001
6	Stitch type*Wash type	0.2250	0.06719	3.349	0.003
7	Stitch density*Wash type	0.2875	0.06719	4.279	0.000
R-Sq = 92.0 % R-Sq(adj) = 90.1 %					

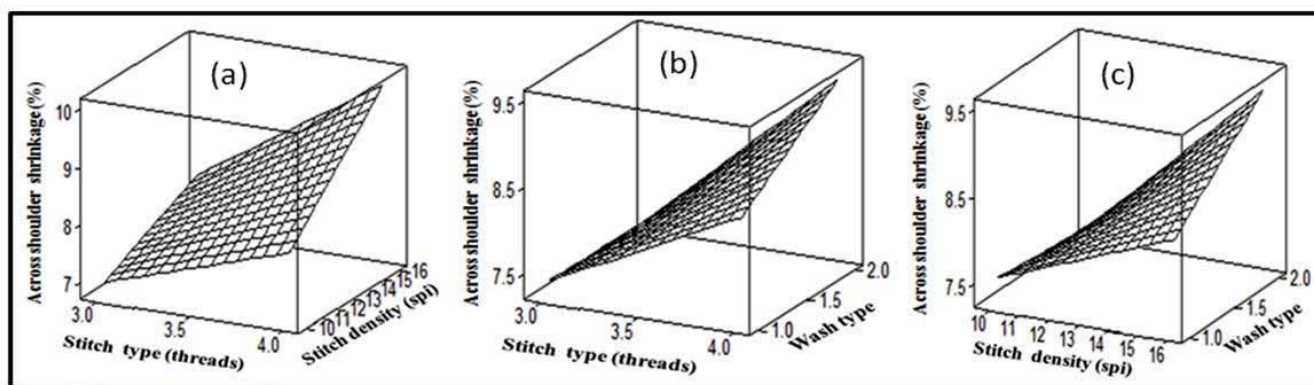


Figure 3. Interaction plots for length across shoulders.

between these factors and sleeve length shrinkage. All the three interaction plots are given in Figure 4. These plots show that there is a sharp increase in sleeve length shrinkage when

stitch density of 16 SPI is used along with four threads. Similar is the case for other interactions: 'stitch type and wash type' and 'stitch density and wash type'.

Table 9. Regression coefficients (coded) for sleeve length.

S. no.	Terms	Coefficient	SE coefficient	T-value	P-value
1	Constant	8.1063	0.08881	91.275	0.000
2	Stitch type	0.9375	0.08881	10.556	0.000
3	Stitch density	0.6437	0.08881	7.248	0.000
4	Wash type	0.3188	0.08881	3.589	0.001
5	Stitch type* Stitch density	0.2625	0.08881	2.956	0.007
6	Stitch type*Wash type	0.2125	0.08881	2.393	0.025
7	Stitch density*Wash type	0.2063	0.08881	2.322	0.029

R-Sq =88.7 % R-Sq(adj) = 86.0 %

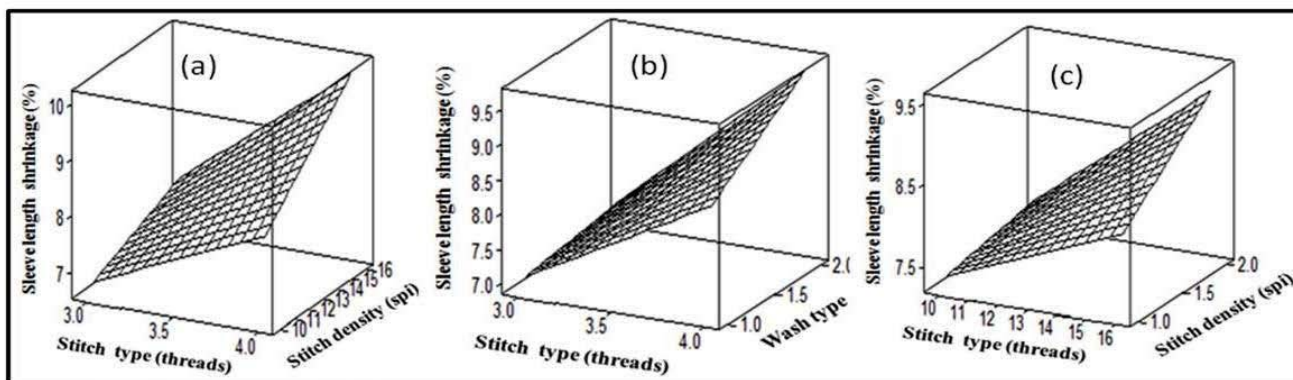


Figure 4. Interaction plots for sleeve length.

Conclusions:

Analysis of the data shows that three input variables, that is, stitch type, stitch density and wash type are highly significant, while the variable, thread type, is insignificant with respect to dimensional stability. In the case of body length and body width shrinkage, stitch density is the most dominant factor, while wash type is the least prominent. Similarly, in the case of across shoulder and sleeve length shrinkage, stitch type is the most dominant factor, while wash type is the least prominent factor. Thus, stitch density and stitch type are very important factors for the dimensional stability of knitwear.

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