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Seam grinning behavior of single jersey fabric

Payal Bansal[a], AK Choudhary & Monica Sikka
Department of Textile Technology, Dr B.R. Ambedkar National Institute of Technology, Jalandhar 144 011, India

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Influence of fibre, yarn count, loop length and fabric direction on seam grinning behavior of a single jersey fabric has been investigated. A 3^3 Box–Behnken design is employed to investigate the influence of various parameters on seam grinning behavior of single jersey fabric. The test results show that the seam grinning d5ecreases for the specimen having lycra filament but it is maximum for 100% cotton specimen. At higher value of loop length, seam grinning decreases in cotton and polyester/cotton fabrics but increases for polyester-lycra and cotton-lycra fabric samples. It had also been seen that seam grinning is higher in wale-wise and bias direction as compared to that in course-wise direction. Hence, seam grinning can be reduced by choosing appropriate values of yarn count, loop length for a particular kind of fibre. This study will be helpful for garment industrialist to minimise the seam grinning effect among knitted garments and to improve quality of producing seam.

Keywords: Fibre, Fabric direction, Lycra, Loop length, Seam grinning, Single jersey fabric, Yarn count

1 Introduction

In any apparel industry, fabric construction parameters are the major factors influencing seam quality of the garment. For achieving good quality of seam, industrialists are primarily focusing on fabric constructional properties, such as yarn count, loop length, etc[1,2]. One of the dominant processes while producing a garment is sewing which is the process of joining fabrics by means of seams and stitches[3,4]. The seams are subjected to various stresses and the amount of stress to which the seams undergoes is dependent upon the garment application and the position of seam in the garment. The forces acting on the seam varies with different intensities according to the body movement of the wearer as certain parts of fabric are stretched in different direction[5,6]. The seam in the garments is also subjected to cyclic loading during their application which causes defects, such as seam grinning, seam slippage and seam failure[7,8]. Seam grinning is one of the defects which majorly deteriorates the appearance and aesthetics quality of garment. It may be described as a situation when the seam line widens, exposing the gap of sewing thread when joined layers of fabric undergoes continuous stresses[9]. The behavior of stitches in seam line depends upon various factors such as sewing thread properties, sewing machine parameters and mechanical properties of fabric[10]. Among these parameters, mechanical properties of fabric are highly vulnerable of creating seam defects. These properties of fabric further depend upon the fabric composition, construction and structure, such as fibre type, yarn count and loop length[11].

Shimazaki and Liloyd[7] studied the opening behaviour of lock-stitch in woven fabrics under cyclic loading conditions and developed a theoretical model. This model predicted the influence of thread properties, stitch density, applied load and number of loading cycles on the amount of seam grinning, and further experimental results were compared with the calculated values which was effective in predicting seam opening behavior under cyclic loading conditions. During another study, seam slippage and grinning behaviour of lock stitch in elastic woven fabrics under cyclic loading condition was investigated by Gurarda and Meric[8]. A rise in seam slippage and grinning values with increased extensibility and reduction in weft density was noted. A study on the effects of repeated extension and recovery on selected physical properties of ISO-301 stitched seam in knitted, woven and wool fabrics was conducted by Webster *et al*.[9] The results revealed that fabric type and thread type are the most important variables while affecting the breaking load and breaking extension of cycled seams. In their further study, Webster *et al.*[10] studied theoretical model for the effects of repeated extension and recovery on selected physical properties of ISO-301 stitched seams.

[a] Corresponding author.
E-mail: payal888y@gmail.com

Theoretical predictions of load versus time gave the best agreement with experimentally derived tensile cycling curves for seams cycled between the lowest extension limits. The grinning behaviour of ISO 514 stitched seams on knitted fabrics under the effects of repeated extension and recovery were evaluated by Ucar[12]. The study reported that seam grinning increases with decreased stitch density and rises with thread extensibility. A study about dynamic seam fatigue of denim fabrics with different constructions has been done by Kadem and Gulsen[13]. The results revealed that seam openings were lowering at weft direction containing lycra as compared to seam openings in warp direction i.e. with lycra. But for 100% cotton sample seam openings in weft direction were higher than in warp direction.

From all the reported studies, it can be summarized that the fabric material, sewing thread and machine parameters influence the repeated extension and recovery of seamed fabric. The previous researches were carried out on different fabric structures; machine parameters and sewing thread for analysing the seam grinning behaviour taking into account the woven fabrics in most of the cases. While studies related to knitted fabrics in this regard has been very limited and requires further investigation. Therefore the present study is aimed at analysing the effect of different types of fibres, yarn count, loop length and fabric direction on seam grinning in knitted fabric.

2 Materials and Methods

2.1 Preparation of Single Jersey Fabric Samples

The fabric samples prepared for the experiment are 100% cotton, polyester/cotton, polyester-lycra and cotton-lycra. All the fabric samples were single jersey and prepared with three different levels of yarn count and loop length according to 3^3 Box–Behnken design as shown in Table 1. The fabric samples were produced on a circular knitting machine (MV4-Mayer and Cie) of gauge 28. Amongst all the single jersey fabrics, polyester-lycra and cotton-lycra fabrics were produced using 40 denier spandex yarns in half plating. The finished fabric samples were conditioned for 24 h at standard temperature (27±2ºC) and relative humidity (65±2%) before sewing operation. The essential properties of all fabric samples are shown in Table 1.

2.2 Measurement of Seam Grinning Behaviour

All the fabric samples were tested in three directions, i.e. course, wale and bias. According to ASTM D 1682-1683, test specimens were prepared from each fabric samples in course, wale and bias directions. Then the samples were sewn with 24 tex spun polyester sewing thread (3 ply , 28.59 cN/tex breaking strength, 15.04% breaking elongation and 136.5 cN/tex initial modulus) and 90/14 needle size on an over-lock sewing machine (3000 rpm). ISO-514 stitch type was applied using 12 stitches/inch. Cyclic loading for seam grinning was done on Instron tensile testing machine at 75 gauge length and 150 mm/min speed. For each specimen, 30 % extension was applied in all three directions during cyclic loading. The length of seam grinning was measured after 20 cycles and seam opening values were measured immediately with a linear compass. Also seam grinning behaviour of specimen during cyclic loading is observed under image analyser (Leica). The scheme of experimental runs in accordance with Box–Behnken experimental design and three different levels of each parameters, viz. yarn count, loop length and fabric direction, were chosen as shown in Table 2. The levels of variables were chosen based on the literature survey and parameters used in the knitting industries. Applying ANOVA, F values were obtained and their significance was evaluated at 95% confidence level ($p > 0.05$).

3 Results and Discussion

3.1 Seam Grinning

Seam grinning is one of the seam defects which occurs when load is applied to the specimen. When load is applied on seam, initially fabric deformation occurs followed by seam deformation which is mainly responsible for seam grinning. For all single jersey samples, seam grinning behavior with respect to the fabric direction follow the same trend. Figures 1(a-f) show seam grinning of sample C1 and sample C9 during cyclic loading as observed under image analyser (Leica).

3.2 Effect of Fibre type on Seam Grinning

The effect of different fibres on seam grinning in wales, course and bias directions are shown in Fig. 2. The results of the fabrics prepared with 24Ne yarns count at 2.6 mm loop length have been considered for results and discussion. It has been observed that 100% cotton fabric has higher seam grinning value out of the four single jersey fabrics taken for investigation. This may be due to inherent non-elastic nature of cotton that shows less elongation and more delayed recovery/ permanent set. The polyester/cotton knitted fabric shows lesser seam grinning than 100% cotton because polyester/cotton knitted fabric has less permanent set. In polyester-lycra and cotton-lycra

Table 1 — Physical properties of single jersey 100% cotton, polyester/cotton, polyester-lycra, and cotton-lycra fabrics

Fibre	Fabric code	Count Ne/dtex	Stitch length mm	Courses/cm	Wales/cm	Fabric mass g/m^2	Thickness mm
100 % Cotton (C)	C1	24	2.6	21	13	182	0.99
	C2	24	3.0	19	15	176	0.65
	C3	24	3.4	19	14	171	0.59
	C4	30	2.6	21	16	178	0.92
	C5	30	3.0	20	15	151	0.64
	C6	30	3.4	19	15	139	0.57
	C7	34	2.6	24	16	177	0.91
	C8	34	3.0	23	15	150	0.64
	C9	34	3.4	22	13	137	0.55
Polyester/Cotton (70/30) (PC)	PC1	24	2.6	28	16	186	0.67
	PC2	24	3.0	26	15	167	0.63
	PC3	24	3.4	24	14	165	0.61
	PC4	30	2.6	27	18	163	0.65
	PC5	30	3.0	24	14	157	0.64
	PC6	30	3.4	23	14	155	0.63
	PC7	34	2.6	25	17	127	0.62
	PC8	34	3.0	19	15	126	0.61
	PC9	34	3.4	17	14	124	0.61
Polyester-Lycra (PL)	PL1	24/40	2.6	37	22	237	0.70
	PL2	24/40	3.0	29	16	239	0.72
	PL3	24/40	3.4	28	15	245	0.73
	PL4	30/40	2.6	38	23	231	0.68
	PL5	30/40	3.0	37	22	235	0.69
	PL6	30/40	3.4	36	21	240	0.72
	PL7	34/40	2.6	38	24	229	0.67
	PL8	34/40	3.0	37	23	233	0.68
	PL9	34/40	3.4	37	22	238	0.70
Cotton-Lycra (CL)	CL1	24/40	2.6	28	18	237	0.90
	CL2	24/40	3.0	28	16	241	0.92
	CL3	24/40	3.4	27	15	252	1.07
	CL4	30/40	2.6	28	19	236	0.88
	CL5	30/40	3.0	27	18	238	0.91
	CL6	30/40	3.4	26	18	248	1.03
	CL7	34/40	2.6	28	20	230	0.87
	CL8	34/40	3.0	27	20	233	0.89
	CL9	34/40	3.4	27	19	245	1.01

fabric, the elastic potential energy helps the structure to come back to its original position which shows lowest value of seam grinning. It is also seen that the seam grinning values are higher in cotton-lycra single jersey fabrics than in polyester-lycra fabric samples. Although lycra enhances the fabric elongation and recovery behavior but cotton restricts the recovery due to non-elastic behaviour which reduce the seam grinning in cotton fabric.

3.3 Effect of Loop Length, Yarn Count and Fabric Direction on Seam Grinning in 100% Cotton Single Jersey

As shown in Fig. 3(a) for lower loop length, seam grinning value in finer yarn is less than that in coarser yarn. This may be due to the fabric rigidity which decreases with finer yarn count, thus helping the fabric structure to regain its initial position. In coarser yarn count seam grinning declines with rise in loop length. As loop length increases, loop density reduces, further making the fabric structure more open and extensible. Thus, with longer loop length, seam grinning value reduces because of the more elongation and recovery during cyclic loading. But with finer yarn count, seam grinning value rises with higher loop length [Fig. 3 (a)], which has been plotted by considering course direction constant. This can be

Table 2 — Experimental design (3^3 Box–Behnken)

Factors	Coded levels		
	-1	0	+1
Yarn count (A), Ne	24	30	34
Loop length (B), mm	2.6	3.0	3.4
Fabric direction (C)	0°	45°	90°

attributed to the fact that knitted fabric has already high extension in course direction and its elongation enhances with increase in loop length. The sewing thread used to make a four thread over lock stitch, are less extensible than fabric. The extensibility of fabric and sewing thread do not meet the required compatibility with each other and hence sewing thread does not come back to its initial position after a certain time while subjected to cyclic loading, thus causing permanent set of thread which is responsible for higher seam grinning. In case of wale and bias directions [Fig 3(b)], seam grinning decreases with increase in loop length due to the cumulative effect of extensibility of sewing thread and fabric. Also, it has been observed that seam grinning is higher in wale-wise and bias directions than in course-wise direction. Higher seam grinning in wale and bias directions may be due to the lower elongation of knitted fabric in wale and bias directions as compared to that in course direction since the fabric is single jersey weft knitted.

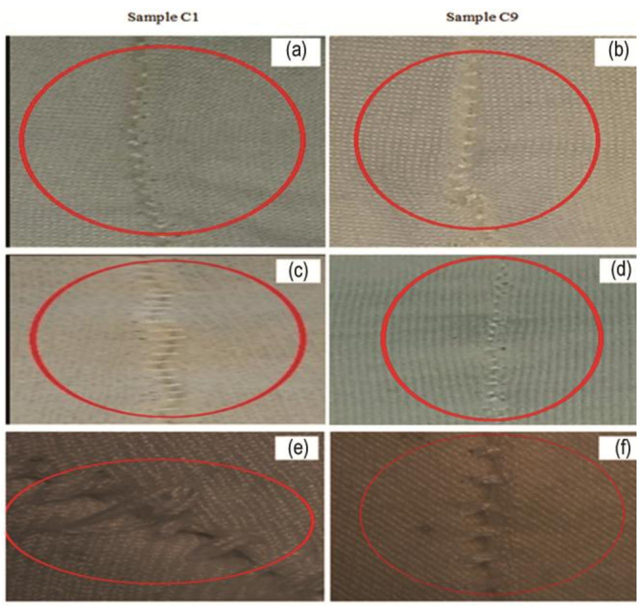
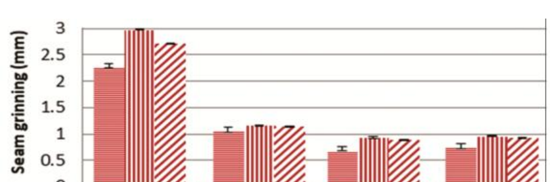


Fig. 1 — Seam separation during cyclic loading in samples C1 and C9 [(a) & (b) course, (c) & (d) wale and (e) & (f) bias directions]



	C1	PC1	PL1	CL1
Course	2.26	1.05	0.69	0.74
Wale	2.98	1.16	0.93	0.96
Bias	2.71	1.14	0.88	0.93

Fig. 2 — Effect of different fibres on seam grinning

In course direction, higher fabric extension occurs due to straightening of loops. But in bias and wale directions the loop structure does not support complete extension, as the loops are locked by threads of stitch structure. When the fabric elongation is higher, the load applied is shared by the fabric to a larger extent and does not influence the seam, thus reducing the seam grinning. Hence, high elongation of knitted fabric in course-wise direction is the reason for its lower seam grinning. Also it has been observed that when the loop length rises, seam grinning value decreases in bias direction rapidly. This happens because with increase in loop length, fabric becomes more extensible but due to bias direction loop structure does not support the fabric recovery. So,

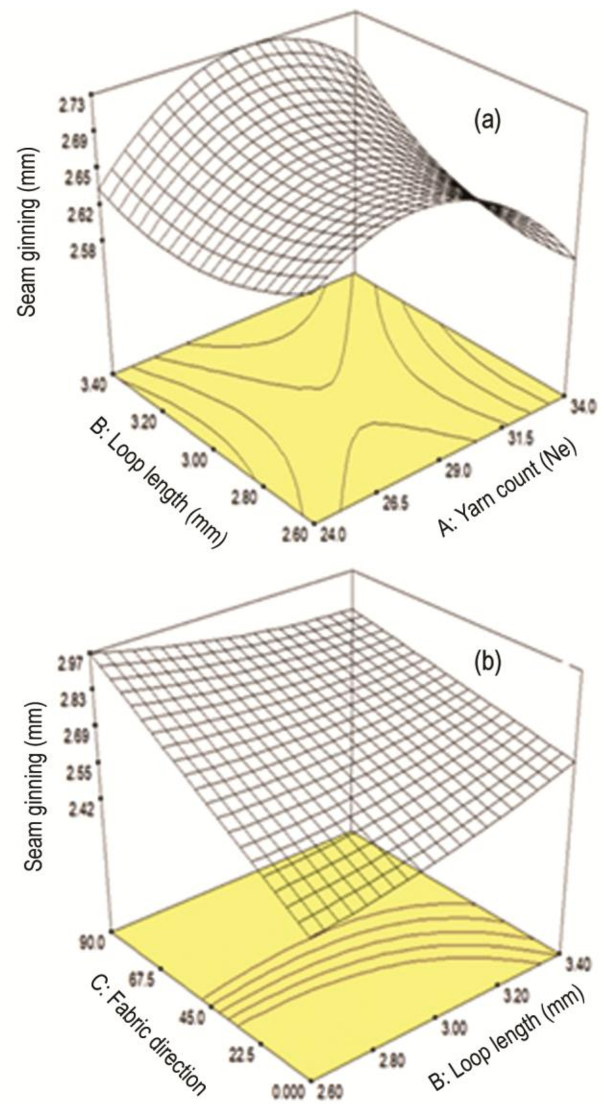


Fig. 3 — Effect of (a) yarn count & loop length and (b) fabric direction & loop length on seam grinning in 100% cotton fabric

seam grinning can be optimized by considering fabric direction during sewing process in order to improve the appearance of seam line in knitted garments.

In 100% cotton fabric, analysis of variance shows that factor C has the highest contribution of 78.69 % and another individual/interactive effects like factor A (Contribution 0.181 %) and B (Contribution 0.624 %) have very small contribution percentage for seam grinning. The regression equations can well predict the relationship between responses and three independent factors with the help of the coefficient of determination (R^2). The proposedmodel for the seam grinning responses adjust very well to the experimental data and there is a logical agreement between R^2 and adjusted R^2. The empirical relationship of the seam grinning to the process variables was obtained with R^2 value 0.993. The Model F-value of 151.67 implies the model is significant. In this case B, C, A^2, B^2, *AB*, *AC*, *BC* are significant model terms. The model equation is given below:

$$\begin{aligned}\text{Seam grinning for cotton} = &+2.68 - 0.00875 \times \mathrm{A} + 0.0163 \times \mathrm{B} + 0.183 \times \mathrm{C} \\ &- 0.0691 \times A^2 + 0.0309 \times B^2 \\ &+ 0.0300 \times \mathrm{A} \times \mathrm{B} - 0.0375 \times \mathrm{A} \times \mathrm{C} \\ &- 0.0925 \times \mathrm{B} \times \mathrm{C}\end{aligned} \quad \ldots (1)$$

3.4 Effect of Yarn Count, Loop Length and Fabric Direction on Seam Grinning in Polyester/Cotton Single Jersey

The effects of yarn count, loop length and fabric direction on seam grinning in polyester/cotton single jersey fabric have been analyzed by response surface methodology and results are shown in Fig. 4(a). It has been noted that when yarn count increases, seam grinning values reduce due to the same reason as discussed earlier for 100% cotton. The seam grinning value decreases with higher value of loop length for both finer and coarser count. The higher value of loop length reduces the loop density due to which fabric extensibility and recovery increase. Figure 4(b) shows that seam grinning values are higher in wale & bias directions as compared to that in course direction for 100% cotton. From the analysis of variance, it is observed that the factor C has 55.55 % contribution which is highest than factor A (Contribution 7.56 %) and B (Contribution 12.5 %) for polyester/cotton fabric. The empirical relationship of the seam grinning to the process variables is obtained w ith R^2 value 0.914. The Model F-value of 23.36 implies the model is significant. In this case A,B,C,A^2, C^2 are significant model terms. The model equation is given below:

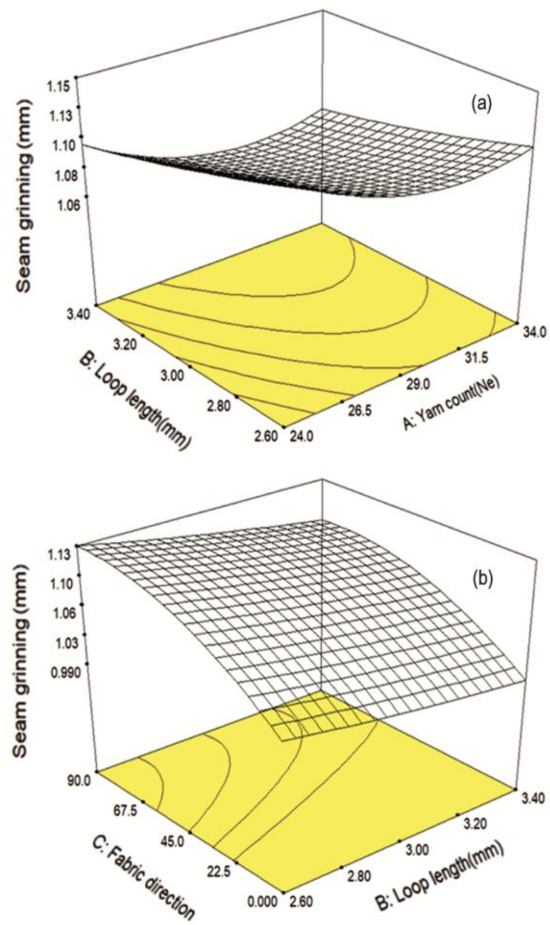


Fig. 4 — Effect of (a) yarn count & loop length and (b) fabric direction & loop length on seam grinning in polyester/cotton

$$\text{Seam grinning for polyster/cotton} = +1.08 - 0.0175 \times \mathrm{A} - 0.0225 \times \mathrm{B} + 0.0475 \times \mathrm{C} + 0.0229 \times A^2 - 0.0271 \times C^2 \quad \ldots (2)$$

3.5 Effect of Yarn Count, Loop Length and Fabric Direction on Seam Grinning in Polyester-Lycra and Cotton- Lycra Single Jersey

It is observed that from Figs 5(a) and 6(a) that the yarn count affects the seam grinning in similar manners as in case of cotton fabric for polyester-lycra and cotton-lycra. Seam grinning value rises as the loop length increases in fabric samples, because knit loops contract due to lycra in structure, which restricts the movement of polyester or cotton loop, thus compacting the fabric structure. For longer loop length, the lycra amount in the loop increases which restricts the movement of the loop without lycra in half plaited structure. Thus, when load is applied the elongation and recovery of the cotton-lycra loop is

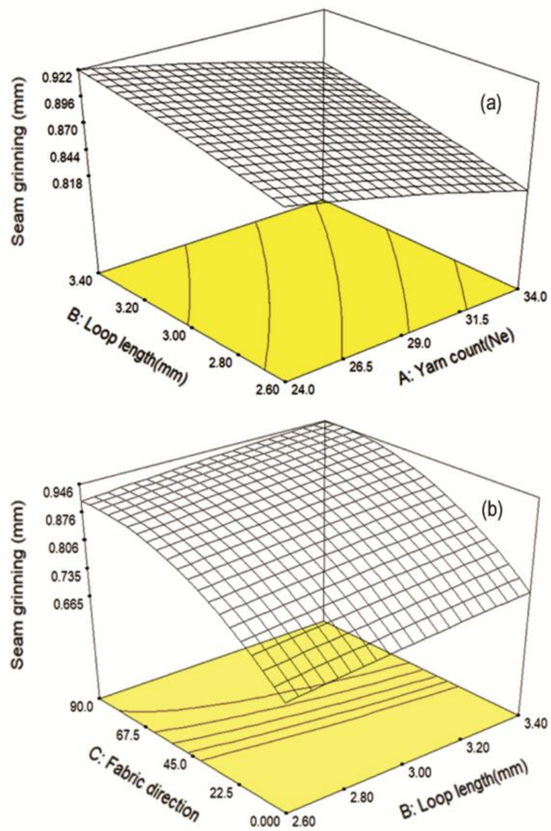


Fig. 5 — Effect of (a) yarn count & loop length and (b) fabric direction & loop length on seam grinning in polyester-lycra

restricted, which contribute to permanent set. Also in Figs 5(b) and 6(b), the seam grinning in the three directions shows the same trend as for 100% cotton.

It is observed that for the polyester-lycra fabric, the factors A (Contribution 5.07 %), B (Contribution 2.85 %) and C (Contribution 77.46 %) show an individual effect and are found to be significant. In the cotton-lycra fabric, it is observed that factor C has the highest contribution of 78.50 % for seam grinning. The other factors, A (Contribution 5.65 %) and B (Contribution 3.78 %), also show a very small interaction effect. The empirical relationship of the seam grinning to the variables is obtained for polyester-lycra with R^2 value 0.997. The Model F-value of 914.10 implies that the model is significant. In this case A,B,C,C^2 are significant model terms. It shows that cotton-lycra have R^2 value 0.989. The Model F-value of 197.94 implies that the model is significant. The model equations are given below:

$$\text{Seam grinning for polyester} - \text{lycra} = +0.876 - 0.030 \times \text{A} + 0.0225 \times \text{B} + 0.118 \times \text{C} - 0.0682 \times C^2 \quad \ldots (3)$$

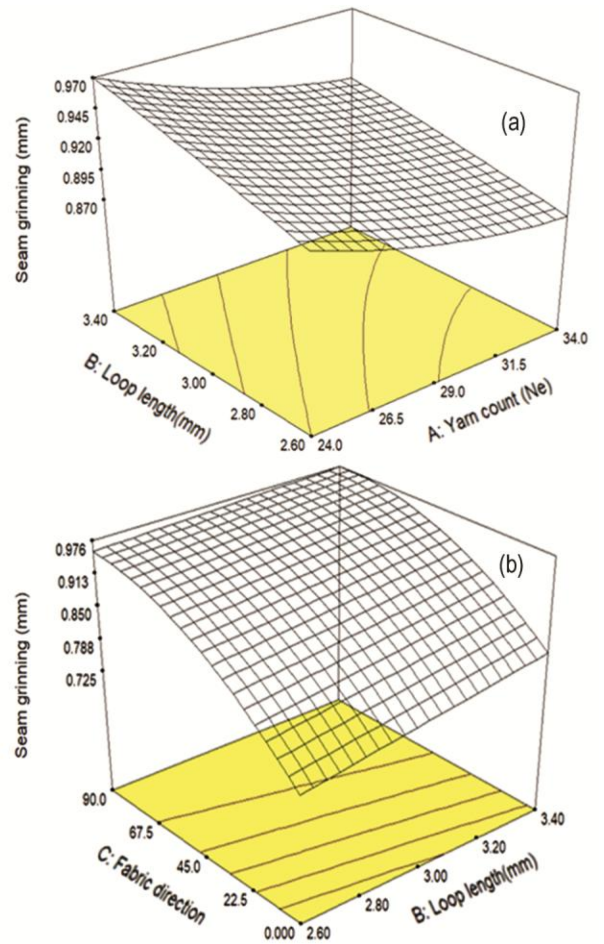


Fig. 6 —Effect of (a) yarn count & loop length and (b) fabric direction & loop length on seam grinning in cotton-lycra

$$\text{Seam grinning for cotton} - \text{lycra} = +0.913 - 0.0275 \times \text{A} + 0.0225 \times \text{B} + 0.102 \times \text{C} - 0.0508 \times C^2 - 0.0125 \times \text{B} \times \text{C} \quad \ldots (4)$$

4 Conclusion

Seams are subjected to large numbers of loading cycles during various body movements in knitted garment. The repeated loading gives rise to seam defects, such as seam grinning. The present study shows that seam grinning in 100% cotton fabric is higher than in polyester/cotton, polyester-lycra and cotton-lycra single jersey fabrics. This is because 100% cotton has inherent non-elastic nature which increases the seam grinning. But in polyester-lycra and cotton-lycra fabric, the elastic potential energy helps the structure to come back to its original position. Seam grinning is higher in wale-wise and bias directions than in course-wise direction in all the specimens. The seam grinning reduces with increase in loop length in cotton and polyester/cotton fabric, but in lycra fabrics, seam grinning increases as loop length increase. Seam grinning can be reduced by choosing appropriate values of yarn count and loop length for a particular kind of fibre. Also the sewing direction needs to be considered to get the best sewing performance.

References

1 Mandal S & Abraham N, *Pakistan Text J-Apparel Knitwear*, 59(1) (2010) 40.

2 Jankoska M & Demboski G, *Adv Technol*, 6(2) (2017) 78. doi: 10.5937/savteh1702078J.

3 Pavlinic D Z, Gersak J, Demsar J & Bratko I, *Text Res J*, 76 (2006) 235.

4 Choudhary A K, Sikka M P & Bansal P, *Res J Text Apparel*, 22(2) (2018) 109.

5 Uzair H, *J Eng Fibers Fabrics*, 10 (2015) 1.

6 Ozgen B, *Tekstil ve Konfeksiyon*, 24(3) (2014) 272.

7 Shimazaki K & Lloyd D, *Text Res J*, 60(11) (1990) 654.

8 Gurarda A & Meric B, *Tekstil ve Konfeksiyon*, 20(1) (2010) 65.

9 Webster J, Laing R M & Niven BE, *Text Res J*, 68 (1998) 854. doi.org/10.1177/004051759806801111.

10 Webster J, Laing RM & Enlow RL, *Text Res J*, 68(12) (1998) 881. doi.org/10.1177/004051759806801202.

11 Bansal P, Sikka M P & Choudhary A K, *Indian J Fibre Text Res*, 45 (2020), 388.

12 Ucar N, *Text Res J*, 72(11) (2002) 944.

13 Kadem F D & Gulsen G, *Proceedings, 15th Autex World Textile Conference*, edited by Mirela Blaga (Curran Associates Inc.), 2015.