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Investigating the Abrasion Resistance and Pilling Properties of Knitted Fabrics: Effect of Yarn Type and Machine Gauge

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Abstract. Abrasion resistance property of the fabric determines its capability to sustain its appearance under various kinds of forces acting on its surface. Both abrasion and pilling properties of the fabric have high correlation with the properties of the yarn from which that fabric is made along with other operational and machine parameters like number of needles of the knitting machine. Siro and two fold yarns are basically plied yarns that are made by adopting different spinning techniques. These yarns have different quality behaviors that highly depend upon their twist level. Hence, the present research study is a plausible approach for determining the abrasion resistance and pilling properties of knitted fabric made from different types of siro and two fold yarns at various numbers of needles of knitting machine. The results disclosed that all the above selected parameters put significant effect on the appearance value of the knitted fabric.

Keywords: abrasion resistance, pilling, siro spun yarn, two fold yarn

Introduction

Siro and two fold yarns are basically plied yarns. Siro yarns are made by feeding two roving in drafting zone of conventional ring frame. The two strands are twisted together to form a two ply structure. Siro spinning is an improvement in conventional ring spinning technology (Huo, 2008) while two fold yarns are made by folding together two already manufactured yarns. Folding is a process which is used to produce a strong, balanced yarn. In two fold yarn manufacturing process, the two strands are combined by twisting them together in opposite direction than that in which they were spun. Textile industry extensively uses the folded yarns. Folded yarns are used in many woven and knitted fabrics (Bashir, 2010).

In yarn spinning process there are many factors that influence the quality parameters of the product. Yarn twist is one of the major factors that have significant effect on its quality. The twist of yarns and threads influences their form and structure. Twisting positively influences the thread's making throughput and the barrier ability of the fabrics made from such a yarns (Rosiak and Przybyl, 2004). In addition to yarn quality some other machine parameters like number of needles of knitting machine also put plausible influence on the quality of the end product. Number of needles affects the yarn tension property that ultimately disturbs many characteristics of knitted fabric and their subsequent performance and applications (Koo, 2004) like fabric deformation, permanent change in internal structure of the fabric, luster of fabric etc.(Lanarolle *et al.*, 2017).

Machine gauge of the circular knitting machine is an important parameter that puts significant effect on the structural properties of the resulted fabric. Pilling is one of those characteristics that have high correlation to the number of the needles of the knitting machine. Development of pills on the fabric surface is a serious problem for the apparel industries. Fabric pilling, in addition to consequent in an ugly appearance begin the friction of the garment and can cause premature wear. Change in the number of the needles of knitting machine affects the looseness factor of the fabric that ultimately influence the distance between the wales. As a result the fabric surface is disturbed in form of affecting its abrasion resistance properties and results in pilling. So there is high correlation between pilling properties of knitted fabric and number of needles of the knitting machine (Abedin *et al.,* 2014). Hence keeping in view the significant role of different types of yarn and number of needles of knitting machine, the present research

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study was planned to investigate their effects on the abrasion resistance and pilling characteristics of knitted fabric. So as the selection of these parameters may be optimized for better quality of end product in order to pave the guide path for the manufacturers.

Materials and Methods

Spinning process. The yarn samples for siro spun (Y1) and two fold (Y2) were prepared at three twist levels T1= 3.5, T2=3.7 and T3=3.9. Six yarn samples S1, S2, S3, S4, S5 and S6 were made under the combinations S1= Y1xT1, S2= Y1xT2, S3= Y1xT3, S4= Y2xT1, S5= Y2xT2, S6= Y2xT3 with same count 20s. The yarn samples so made were tested for their physical properties and results so obtained are presented in Table 1.

Knitting process. Circular knitting machine with the specifications given below was engaged to fabricate knitted sample from the yarn samples especially run for this research project under various machine gauges, N1=144, N2=156 and N3=168.

Brand = Lonati; Stitch length = 0.30 cm; No. of feeders = 4; Machine speed = 220 rpm; Cylinder diameter = 4 inch

Testing of knitted fabric characteristics. The knitted fabric samples made from siro and two fold yarns were placed on flat surface for 24 h at 65±2 relative humidity and 27±2°C temperature for conditioning purpose. Then abrasion resistance and pilling properties of the samples were observed and evaluated adopting standard test methods recommended (ASTM, 2008) having designations D:4966, D:123, D:3512. The details of these methods are given below.

Abrasion resistance. Abrasion resistance is the resistance of the fabric to wearing and flexing when a specimen of fabric is subjected to unidirectional reciprocal folding and rubbing over a bar having a specified characteristics. It is measured in weight loss percentage. The instrument used was accelerator fitted with abrasive liner over foam rubber cushion and with 114 mm S-shape rotor. Cut specimens of fabrics were bound to hit the chamber wall or abradent liner and a strip of adhesive was applied to each cut and after letting it to dry weight loss was calculated in percentage.

Pilling. Pilling and other change in surface appearance, such as fuzzing, that occur in normal wear are simulated on a laboratory testing machine. Fabrics are mounted on the Martindale Tester, and the face of the test specimen is rubbed against the face of the same mounted fabric in the form of a geometric figure, that is a straight line, which becomes a gradually widening ellipse, until it forms another straight line in the opposite direction and traces the same figure again under light pressure for a specific number of movements. The degree of fabric pilling or surface appearance change produced by this action is evaluated by comparison of the tested specimen with visual standards that were the actual fabrics showing a range of pilling resistance. The observed resistance to pilling is reported using an arbitrary rating scale. Following pilling grading scale was used to know the pilling behaviour of the fabric.

Table. 1. Physical properties of yarn samples used for knitting fabric

Yarn characteristics	Yarn types					
	S1	S2	S3	S4	S5	S6
Yarn lea strength (lbs)	125.17	126.30	127.15	124.19	125.07	125.92
Count lea strength products(CLSP) [hanks]	2485.3	2545.1	2602.5	2369.7	2417.2	2501.4
Single yarn strength (g)	473.91	474.38	475.73	470.13	472.25	473.87
Yarn breaking length(RKM values)[g/tex]	15.48	16.79	17.90	14.88	15.93	16.57
Elongation (%)	5.91	6.48	6.93	5.37	5.99	6.43
Evenness (U%)	6.93	7.11	7.55	7.23	7.83	8.15
Yarn thick places/km	1.3	2.0	2.6	2.3	2.90	3.3
Yarn thin places/km	0.594	0.632	0.689	1.221	1.897	2.000
Yarn neps/km	6.534	5.213	4.879	9.647	9.313	8.883
Yarn hairiness	4.332	4.987	5.432	4.731	5.670	5.912

5- no pilling; 4-slight pilling; 3-moderate pilling; 2-severe pilling; 1-very severe pilling

Analysis of data. The collected data was analyzed by using Duncan's multiple range test for highlighting the difference among various quality characteristics applying statistical package for social sciences (SPSS) using Micro- computer Statistical Programme.

Results and Discussion

Abrasion resistance (weight loss %). The comparison of individual treatment means regarding abrasion resistance for different yarn types by applying Duncan's multiple range test is given in Table 2 and Fig. 1, which indicates that abrasion resistance values range from 6.34333 to 6.8600 (%) i.e. for S3(Y1×T3) to S1(Y1×T1) and followed by 6.933 to 7.4867 (%) i.e. for S6(Y2×T3) to S4(Y2×T1), respectively. These values differ significantly from each other (Table 3).

Table 2. Comparison of individual treatment means for abrasion resistance (weight loss %).

Yarn types(S)	Means	No. of needles (N)	Means
S1	6.8600d	N1	7.8317a
S2	6.6567e	N2	6.9267b
S3	6.3433f	N3	5.9717c
S4	7.4867a		
S5	7.1800b		
S6	6.9333c		

Any two values not sharing a letter in common differ significantly at 0.05 level of probability.

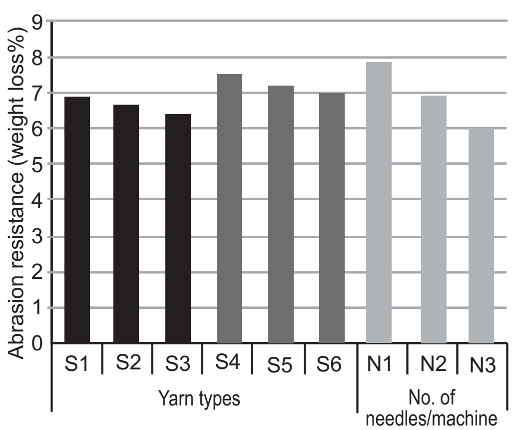

Fig. 1. Graphical representation of individual mean values for abrasion resistance (weight loss %)

It is clear from the results that the best value of fabric abrasion resistance in case of siro yarn and two fold yarns was noted at high twist. These results are in line with the research work of Barella and Manich (1984) who observed that with increase in twist abrasion, resistance increased first slowly and then rapidly, but the abrasion resistance slowed down at a certain twist multiplier. Similarly Cheng and Sun (1998) described that the abrasion resistance of siro spun yarn increased with increased twist multiplier. Moreover, Beceren *et al*. (2010) suggested that twist had a significant effect on the abrasion behaviour of the fabrics from siro spun yarns.

Duncan's multiple range test and individual comparison of treatment means in respect of abrasion resistance for different machine gauge is given in Table 2. The abrasion resistance values for N1, N2 and N3 are 7.8317, 6.9267 and 5.9717 (%) respectively. These values differ significantly from each other. From these results it can be depicted that the higher gauge gives the better results regarding the abrasion resistance. These findings are in line with the research of Sharma *et al*. (1985) who observed that there was a significant effect of twist level and machine gauge on the abrasion resistance with increase in machine gauge abrasion resistance increased.

Pilling. The effect of different yarn types and number of needles of knitting machine has been analyzed statistically and the results regarding the rating of pilling under these variables is shown in the Table 4. The rating of pilling of yarn type S1(Y1×T1) for different number of needles was severe (2) for N1, severe to moderate (2) and moderate to slight (3-4) for N2 and N3, respectively. For yarn type S2(Y1×T2) the pilling of the fabric appeared severe (2) for N1, moderate (3) & moderate to slight (3-4) for N2 and N3, respectively. Fabric made from yarn type S3(Y1×T3) disclosed the pilling rate severe to moderate (2-3) for N1, moderate

Table 3. Analysis of variance for abrasion resistance

S.O.V	D.F	S.S	M.S	F.Values	P
N	2	10.3813	5.19065	6515.46	0.0000**
S	5	2.3813	0.47627	597.82	0.0000**
N×S	10	0.0087	0.00087	1.09	N.S
Error	10	0.0080	0.00080		
Total	27	12.7793			

** = Highly significant N.S = Non-significant

Table 4. Fabric pilling

Yarn types(S)	No. of needles		
	N1	N2	N3
S1	2	2	3-4
S2	2	3	3-4
S3	2-3	3	4
S4	1-2	2-3	3
S5	2	2-3	3-4
S6	2	3	3-4

5= No pilling, 4= Slight pilling, 3= Moderate pilling, 2=Severe pilling, 1=Very severe pilling

(3) & slight (4) for N2 and N3, respectively. Similarly pilling rate on the knitted fabric when it was made from the yarn type S4(Y2×T1) was noted very severe to severe (1-2) for N1, severe to moderate (2-3) and moderate (3) for N2 and N3, respectively. While the knitted fabric manufactured from yarn type S5(Y2×T2) showed severe (2) pilling for N1 and severe to moderate (2-3) for N2 while for N3 the pilling rate was recorded moderate to slight (3-4). In the same way pilling rate for the fabric made from yarn type S6 (Y2xT3) was noted severe (2) for N1, moderate (3) and moderate to slight (3-4) for N2 and N3, respectively. It can be depicted from these results that fabric made from siro spun yarn showed better performance in sense of pilling resistance as compared to that of made from two fold yarn. It can also be observed that as the number of needles of circular knitting machine was increased the pilling resistance property of knitted fabric improved. These results are in line with research of Beceren *et al*. (2010) who observed that plain jersey fabrics from siro-spun yarn had a slightly higher resistance to pilling than fabrics from ring yarns. Furthermore, fabric knitted from high twist siro-spun yarn performs relatively better than those from normal twist siro-spun yarn.

Conclusion

The aim of the current study was to investigate the physical properties like abrasion and pilling of knitted fabric made from siro and two fold yarns at varying machine gauge of Lonati knitting machine. The findings disclosed that the fabric abrasion properties were noted well when it was knitted with high twisted siro and two fold yarns. Comparative analysis depicted that siro yarn knitted fabric showed better abrasion resistance than two fold yarn knitted fabric. Similarly the increase in the machine gauge of Lonati knitting machine put positive impact on the abrasion resistance property of the knitted fabric.

In respect of pilling behaviour of the knitted fabric made from siro and two fold yarns, better results were observed for the fabric made from siro yarn. In the same line the increased number of needles of Lonati knitting machine put positive impact on the pilling resistance properties of the resulted fabric.

Hence siro yarn knitted fabric proved better in respect of its abrasion resistance and pilling properties as compared to two fold yarn knitted fabric. This is because of good fibre holding ability of siro yarn that increases its compactness and gives enhancement to resulted fabric to withhold its appearance in better form under external load.

Conflict of Interest. The authors declare no conflict of interest

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