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EFFECT OF YARN STRUCTURE ON MECHANICAL PROPERTIES OF SINGLE JERSEY FABRICS

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Abstract: *Knitted fabrics are known to more complex and dimensionally sensitive structures than the woven fabrics. Variations in material, structural, mechanical processing and finishing parameters are bound to significantly influence the mechanical and comfort properties of knitted fabrics, as well as their qualities. It is obvious that the knitted fabric properties depend mainly on the constituent yarn properties and the knitting parameters. Yarns produced using various spinning technologies not only differ from one another in respect of their structures, but also in their bulk, mechanical and surface properties. The properties of the knitted fabrics produced from such yarns are bound to be influenced by their constituent yarn properties. This study was about the effect of yarn structure (ring/rotor) on some of the major mechanical properties of single jersey knitted fabrics.100% cotton carded ring and rotor yarns were spun using the same yarn parameters (count and twist) on ring spinning and rotor spinning machines using the same card sliver as the feed material. Two different single jersey fabrics were knitted using these two yarns separately using the same knitting machine and knitting parameters such as machine speed, loop length, gauge and machine diameter. These knitted fabrics were tested for their bursting strength, abrasion resistance and pilling resistance as per ASTM standards. From the results, it was found that fabric knitted using ring spun yarn was having better bursting strength and abrasion resistance than the knitted fabric knitted using rotor spun yarn.*

Key words: *ring yarn, rotor yarn, single jersey fabric, mechanical properties*.

1. INTRODUCTION

Knitted fabrics are popular for their shape fitting properties, softer handle, bulkiness and extensibility. Knitted fabrics have been extensively used in readymade apparel owing to their excellent mechanical and comfort properties [1]. Compared to woven structures, knit fabrics can more easily deform or stretch by compressing or elongating the individual stitches that from the fabric [2].Knitted fabrics are complex and dimensionally sensitive structures. Variations in material, structural, mechanical processing and finishing parameters significantly influence the mechanical and comfort properties of knitted fabrics, as well as their qualities. The knitted fabric properties depend mainly on the constituent yarn properties and the knitting parameters. Yarns produced using various spinning technologies not only differ from one another in respect of their structures, but also in their bulk, mechanical and surface properties. The properties of the knitted fabrics produced from such yarns found to be affected by yarn properties, as well as by their fabric construction parameters [3].

For knitted fabrics, the major mechanical properties are bursting strength, abrasion resistance and pilling resistance. The bursting strength of a knitted is very important because in a weft knitted structure, there is only one set of yarn. Multi- directional bursting strength testing is an alternative criterion to judge the fabric strength because the force is applied perpendicular direction to the plane of the fabric to rupture the yarn at a weak place [4]. A comparative study was carried out of open end spun yarn and ring spun yarn on single jersey weft knitted hosiery fabric using 20s nominal yarn count which was prepared from J34 cotton. All the fabric samples were produced in a circular knitting machine and concluded that the bursting strength of fabric samples in grey state is lower by 50% for fabric made from rotor spun yarn than for from ring spun yarn. [4].

The resistance of a fabric against the force of friction is known as the abrasion resistance. Abrasion is the physical destruction of fibers, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface. Obviously from the consumer point of view, abrasion resistance is the most important mechanical characteristics of fabrics. Abrasion occurs during wearing, using, cleaning or washing process and this may distort the fabric, may cause fibers or yarns to be pulled out or remove fiber ends from the surface. Abrasion ultimately results in the loss of performance characteristics, such as strength, but it also affects the appearance of the fabric [5]. There are many factors, such as the yarn spinning system, fabric construction and finishing operation, which affect the abrasion resistance. Researchers did a comparative study on ring, rotor and vortex yarn knitted fabrics produced with 30/1 Ne yarns spun using three different spinning systems and the properties of yarns and knitted fabrics were studied and concluded that abrasion resistance of rotor spun yarn is better than ring spun yarn [6].

Pills are small knots or balls of mixture of large number of small fibers accumulated at the surface of the fabric and entangled by the mild frictional action during processing or wearing Pilling is a fabric defect observed as small fiber balls or a group consisting of intervened fibers that are attached to the fabric surface by one or more fibers**.** [6].There are many factors which affect the pilling resistances of knitted fabrics such as the yarn spinning system, fabric construction and finishing operation. A study of the dimensional, pilling and abrasion property of weft knitted fabric was conducted and the reported results showed that both structural differences of yarns and fiber types play a large role in determining the pilling property of knitted [7]. The yarns produced by the three spinning systems have major structural differences that are expected to impact pilling resistance. It was concluded that fabrics knitted from rotor spun yarns have a lower propensity to piling. The results showed that the ring spun fabric was slightly more pill- resistant than the rotor spun fabric [8].

Currently, there are many different methods of yarn manufacturing such as ring spinning, rotor spinning, air jet spinning ,break spinning, friction spinning etc. employed by the textile industry. Obviously, the type of yarn (ring spun, rotor spun, Dref spun, air jet spun) used for knitting (and hence, its properties) will be exerting considerable influence on the knitted fabric properties. For the purpose of our study, we have taken up two popular types of yarns namely the ring spun yarn and the rotor spun yarn as these two types of yarns are the most widely used among the different types of yarns spun in the textile industry. We have taken up weft knitting as it is the most popular method for producing knitted fabrics and the plain or single jersey as the weft knitted structure for our study as this is the simplest of all weft knitted constructions produced on machines employing only one set of needles.

2. MATERIALS AND METHODS

2.1 Material

100% cotton was used for this study as it is the dominant raw material in Ethiopia and the fiber properties of the same are tested using random sampling method and are listed below in Table 1. Both the ring-spun and rotor-spun yarns used for this study are produced from the same mixing only.

Table 1: *Fiber properties*

Staple length in	Short fiber content	Trash %	Micronaire
30.6	10.4	3.58	3.78

The yarn used for knitting the required fabric samples were 28's Ne single spun using 100% cotton using the ring spinning and rotor spinning machines of M/s. MAA Garments and Textiles, Mekele, Ethiopia at 16000 rpm and 120000 rpm respectively. Both the yarns were spun using the same sliver produced from the same mixing and were spun with same twist levels 1050 tpm. Both the fabric samples (knitted using ring spun yarn and rotor spun yarn separately) knitted for this study are produced in the said textile mill on a circular knitting machine as per the knitting machine parameters shown in Table 2 below**.**

Table 2: *Knitting Machine Parameters for knitted fabric sampling*

Speed (rpm)	Adjusted loop length(mm)	Number of needles	Gauge	Needle type	Number of feeders	Number of cam track	Machine diameter (inch)
20	3.21	2976	28	Latch	108	4	34

2.2. Method

This research is designed to study the effect of yarn structure on the mechanical properties of single jersey knitted fabric properties by producing and testing the knitted fabric samples obtained using two different types of yarns spun using the same mixing and yarn parameters on different spinning systems namely the ring spinning and rotor spinning. The fabric samples thus produced were tested for their mechanical properties as per ASTM standards [9-12] under the standard atmospheric conditions, at 21±1°C and 65±2% at EiTEX laboratory.

3. RESULTS AND DISCUSSIONS

3.1 Results

3.1.1 Bursting Strength

The bursting strength of the single jersey weft knitted fabrics tested with the Bursting Strength Tester as per ASTM in Test Methods D 3786 (option B) [10]. Full width fabric sample is used with laboratory sampling for acceptance method. The test results are shown in Table 3.

Table 3: *Bursting Strength Test Results (kg/cm^2)*

Yarn	Sample no										
	1	2	3	4	5	6	7	8	9	10	Mean
Ring	6.27	6.81	6.75	6.65	7.33	6.75	6.81	7.13	6.92	6.80	6.89
Rotor	4.63	4.74	5.18	5.13	4.70	4.92	5.02	4.74	4.59	4.69	4.69

3.1.2. Abrasion Resistance

The testing of abrasion resistance is done as per ASTM D 3886 by using the Martindale Abrasion Tester. The test option used was option 1 and the thickness test results are given below in Table 4.

Table 4: *Abrasion Resistance Test Results*

Sample Weight loss in %						
Yarn type	1	2	3	4	5	Mean
Ring spun	1.23	0.93	1.21	0.97	0.96	1.06
Rotor spun	3.11	3.28	3.98	3.86	3.65	3.576

3.1.2. Pilling Resistance

Martindale pilling tester was used to assess the pill formation on the fabrics. The determination of pilling resistance is done as per ASTM D 4970 standard for Abrasion resistance of Textile Materials [12]. These test results of pilling resistance tests are: Ring spun yarn fabric pilling grade is 2-3 and the rotor spun yarn fabric grade is 3-4.

3.2. Discussion

For the analysis of the test results, one way ANOVA in SPSS and Microsoft Excel are used.

3.2.1. Bursting Strength

The bursting strengths of single jersey weft knitted fabrics made out of ring and rotor spun yarns were studied and the results in Table 3 show that the bursting strength for single jersey fabric produced from ring spun yarn has an average of 6.82 kg/cm$^{2.}$ The single jersey fabric knitted with rotor spun yarn has an average of 4.83 kg/cm^2. As observed from the test results, bursting strength of single jersey knitted fabric knitted with ring spun is higher than that of single jersey knitted fabric knitted with rotor spun yarn. This is due to the fact the tensile strength of ring spun yarn is higher than that of the rotor spun yarn. The mean difference of 1.99 kg/cm2 is significantly different with (F = 319.064, Sig. = 0.000). It is confirmed with ANOVA analysis that p value is less than 0.05 at 95% confidence level, indicating significant differences in bursting strength of ring and rotor spun yarn fabrics. Knitted fabric from ring spun yarns has higher bursting strength than rotor spun yarn due to the fact that the work of rupture of rotor yarn (which is a product of strength and elongation) is lower than that of ring spun yarn.

3.2.2. Abrasion Resistance

The abrasion resistances of single jersey weft knitted fabrics made out of ring and rotor spun yarns were studied and Table 4shows that the single jersey fabric produced from ring spun yarn has the mean fabric Weight loss of 1.06% and the single jersey fabric produced from rotor spun yarn has an average of 3.576%. The ANOVA for the abrasion resistance shows that the mean difference between the two fabrics is highly significant (F=25.229, .001). It is confirmed with ANOVA analysis that p value is less than 0.05 at 95% confidence level, indicating significant differences in abrasion resistance of ring and rotor spun yarn. The fabrics knitted from rotor spun yarn have higher weight loss value than ring spun yarn. This may be because the wrapping fibers of the rotor spun yarns gradually break due to the abrasive forces, facilitating the removal of loose fibers from the yarn structure.

3.2.3. Piling property

The extent of pilling is assessed visually by comparison with the visual standards. Pilling characteristics of single jersey weft knitted fabrics made out of ring and rotor spun yarns were studied. Rotor spun yarn knitted fabric showed 3-4 scale pilling grade as compared to 2-3 of ring spun yarn knitted fabric. The piling grades of the samples show that the fabrics knitted from rotor spun yarns better than the single jersey fabric knitted from ring spun yarn. This maybe because of the fact that the ring spun yarns are more hairy than rotor spun yarns, which may allow easy exposure of the raised fiber ends to the abrading force.

4. CONCLUSIONS

The major mechanical properties such as bursting strength, abrasion resistance and pilling of single jersey knitted fabrics knitted with ring spun yarn and rotor spun yarn have been tested, studied analyzed and reported. From the results of this work, it was found that the type of yarn structure (ring/rotor) has a significant influence on the above said major mechanical properties. Single jersey fabric knitted using ring spun yarn was having better bursting strength and better abrasion resistance than single jersey knitted fabric knitted with rotor spun yarn. This can be attributed to the fact that the ring spun yarn is stronger than the rotor spun yarn. Therefore, this is in concurrence with the similar results obtained in the case of denim fabrics [13]. On the contrary, it can also be seen that the pilling resistance of single jersey knitted fabric knitted with rotor spun yarn is better than that of single jersey knitted fabric knitted with ring spun yarn. The improved pilling resistance of rotor spun yarn fabric could be due to the wrapper fibers, which have mobility on the yarn core and thus reduce the pilling tendency during normal use. It may be because of the fact that the wrapper fibers in the fabric are trapped and rotor yarns, by flattening, give a greater area of contact between the abradent and fabric, thus reducing pilling tendency.

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REFERENCES

[1]. Rahman, S., & Smirithi, S. A. (2015). "*Investigation on the Changes of Areal Density of Knit Fabric with Stitch Length Variation on the Increment of Tuck Loop Percentages*". Journal of Polymer and Textile Engineering, *2*(3), 1-4. Retrieved from http://www.iosrjournals.org/iosr-jpte/papers/Vol2-issue3/A0230104.pdf

[2]. Akaydin, M., & Can, Y. (2010). "*Pilling Performance and Abrasion Characteristics of Selected Basic Weft Knitted Fabrics*". FIBRES & TEXTILES in Eastern Europe, 18(2), 51-54. Retrieved from http://www.fibtex.lodz.pl/2010/2/51.pdf

[3]. Kane, C., Patil, U., & Sudhakar, P. (2007). "*Studies on the Influence of Knit Structure and Stitch Length on Ring and Compact Yarn Single Jersey Fabric Properties*". Textile Research Journal, *77*(8), 572-582. doi:10.1177/0040517507078023

[4]. Mukherjee, S., & Chindalia, S. C. (1983). "*Comparative Performance of Open-end Spun Yarn and Ring-spun Yarn In Single Jersey Weft-knitted Hosiery Fabric"*. Indian Journal of Fibre &

Textile Research, 8(83), 121-124. Retrieved from http://nopr.niscair.res.in/bitstream/123456789/33086/1/IJFTR%208(4)%20121-124.pdf

[5]. Zdil, N., Zelik, G., & Spren, G. (2012). "*Analysis of Abrasion Characteristics in Textiles*". Abrasion Resistance of Materials. doi:10.5772/29784

[6]. Rameshkumar, C., Anandakumar, P., Senthilnathan, P., Jeevitha, R., & Anbumani, N. (2008). "*Comparative studies on ring rotor and vortex yarn knitted fabrics*". AUTEX Research Journal, *8*(4), 100-105. Retrieved from http://www.autexrj.com/cms/zalaczone_pliki/2-08-4.pdf

[7].Candan, C., & Önal, L. (2002). "*Dimensional, Pilling, and Abrasion Properties of Weft Knits Made from Open-End and Ring Spun Yarns*". Textile Research Journal, *72*(2), 164-169. doi:10.1177/004051750207200213

[8].Alston, P. V. (1992). "*Effect of Yarn Spinning System on Pill Resistance of Polyester/Cotton Knit Fabrics*". Textile Research Journal, *62*(2), 105-108. doi:10.1177/004051759206200208

[9]. Textile Standards. (n.d.). Retrieved from https://www.astm.org/Standards/textile-standards.html

[10]. ASTM D 3786, Standard Test Method for bursting strength testing

[11]. ASTM D 3886 Standard Test Method for Abrasion resistance testing

[12]. ASTM D 4970 Standard Test Method for Pilling resistance testing

[13]. Iqbal, S., & Kolhatkar, A. W. (2014). Denim fabrics: Ring vs rotor spun yarns. *The Indian Textile Journal*. Retrieved from http://www.indiantextilejournal.com/articles/FAdetails.asp?id=2467