Juniper Online
Journal Material Science
ISSN: 2575-856X

Juniper Publishers
key to the Researchers

Research article
Volume 8 Issue 1 - July 2023
DOI: 10.19080/JOJMS.2023.08.555726

JOJ Material Sci

Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns

MD Rakib Hassan Gazi[1]*, Hasan Mazharul Haq[1] and Mushfiqur Rahman[2]

[1]*Department Name of Yarn Engineering, Bangladesh University of Textiles, Bangladesh*

[2]*AGM, Mahmood Spinning Ltd, Mahmood Group, Shafipur, Gazipur*

Submitted: June 17, 2023; **Published:** July 20, 2023

***Corresponding author:** MD Rakib Hassan Gazi, Department Name of Yarn Engineering, Bangladesh University of Textiles, Bangladesh
Email: rakibhassangazi2@gmail.com

Abstract

Ring and rotor spinning systems have their own yarn manufacturing principle. It was our interest to study the impact of yarn manufacturing principle of ring- and rotor spinning on their corresponding yarn properties. In this context, 7 Ne and 12 Ne ring- and rotor yarns were produced from the same fiber and the structure and properties such as uneven-ness (Um%, CVm%), imperfections, hairiness, CSP and elongation%, were analyzed by Evenness tester and Lea Strength Tester. Unevenness and imperfections in both ring- and rotor yarns were found comparable. Hairiness value of rotor yarns was observed somewhat lower that may be attributed to the influences of wrapper fibers. Strength of ring yarns was higher compared to rotor yarns. The reason can be ascribed to the higher fiber migration caused in ring spinning in the spinning triangle.

Keywords: Ring Yarn; Rotor Yarn; Yarn; Spinning; Textile; Characteristics; Structure

Abbreviations: QC: Quality Control, CSP: Count Strength Product

Introduction

It is very difficult to ascertain the historical period precisely by which man first started spinning fibers into yarns. However, based on the archaeological evidence, we can understand that this particular skill was well practiced at least 8000 years ago. Certainly, the weaving of spun yarns was developed around 6000 BC. Among the various spinning systems available in the spinning technology, ring spinning is still dominant for more than 150 years [1]. It is due to the versatility of this spinning system to produce wide range of counts ranging from coarser to superfine counts in natural, manmade and blends. Today, yarn spinning or production is a highly advanced technology that enables the engineering of different yarn structures having specifically desired properties suited for particular end use applications. The basic difference between ring-spun yarns and rotor yarns is in the way they are formed. The former produces yarn by inserting twist into a continuous ribbon-like strand of cohesive fibers delivered by the front rollers, while the latter forms yarn from individual fibers directly by collecting them from the inside surface of a rotor by twist forces [2]. This project work was undertaken in order to compare the principle of yarn formation of ring and rotor spinning on their respective yarn characteristics. 7 Ne & 12 Ne ring and rotor yarns were produced from the same raw material and different yarn properties such as unevenness (U%), co-efficient of mass variation (CVm%), imperfections, hairiness and count strength product (CSP) were analyzed.

Materials & Methods

Materials

Raw material represents about 50 - 75% of the manufacturing cost of a short-staple yarn. This fact alone is sufficient to indicate the significance of the raw material for the yarn producer. Hardly any spinner can afford to use problem free raw material because it would normally be too expensive [3].

Fiber

For this project we are used 100 percent cotton fiber. Cotton is a cellulosic fiber. 80-90% cellulose is in cotton but oil, wax, protein, pectin and some coloring content are also present. The polymer chain of cotton cellulose is linear. It is a polymeric sugar of polysaccharide made of up to 4000 - 9000 repeating cellobiose unit, which consist of two glucose units connected to each other by 8- ether linkages [4].

In this experiment Brazilian 100% cotton fiber was used. The particulars of this cotton are given below (Table 1):

Table 1: HVI test result of Brazilian cotton.

Cotton Fiber Property	Value
Upper half mean length (UHML)	27.85 mm
Uniformity Index (UI)	81.4
Fineness	4.59 mic
Maturity ratio (Mat)	0.89
Strength	29.9 gm/tex
Elongation (Elg)	6.90%
Reflectance (Rd)	80%
Yellowness (+b)	8.2
Color Grade	21-2

Yarn

Yarn may be defined as a linear assembly of fiber or filament that are twisted (Z and S twist) in order to make strong or laid together to form a continuous strand, which is suitable to manufacture fabric [5].

Properties of Yarn

Yarn Evenness: Yarn evenness deals with the variation in yarn fineness. This is the property, commonly measured as the variation in mass per unit length along the yarn, is a basic and important one, since it can influence so many other properties of the yarn and of fabric made from it. Such variations are inevitable, because they arise from the fundamental nature of textile fibres and from their resulting arrangement. The spinner tries to produce a yarn with the highest possible degree of homogeneity. In this connection, the evenness of the yarn mass is of the greatest importance. In order to produce an absolutely regular yarn, all fibre characteristics would have to be uniformly distributed over the whole thread. However, that is ruled out by the inhomogeneity of the fibre material and by the mechanical constraints.

In consequence, the thicker yarn region will tend to be deeper in shade than the thinner ones and if a visual fault appears in a pattern on the fabric, the pattern will tend to be emphasized by the presence of color or by some variation in a visible property, such as crease resistance controlled by a finish. Other fabric properties, such as abrasion or pill-resistance, soil retention, drape, absorbency, reflectance, or luster, may also be directly influenced by yarn evenness. Thus, the effects of irregularity are widespread throughout all areas of the production and use of textiles and the topic is an important one in any areas of the industry. [6].

Experimental Materials

Blowroom

TRUTZCHLER blow room line was used in this project. The description of the blow room line is given below (Tables 2-7):

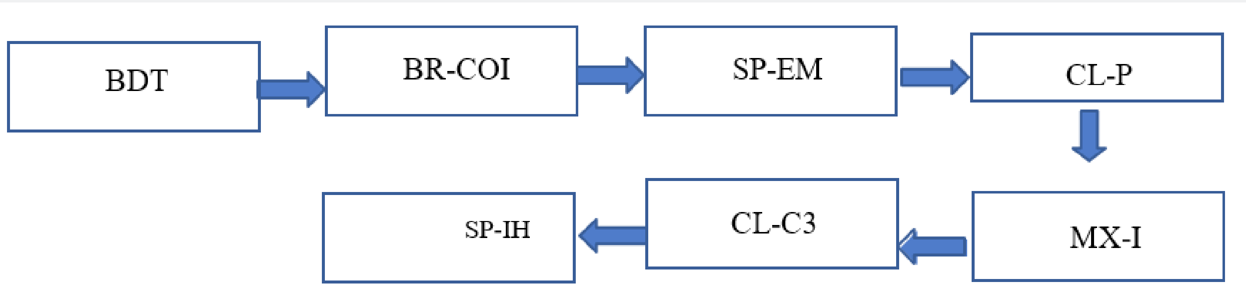

Figure 1: Blowroom section.

Table 2: Carding.

Company Name	Toyota
Model No.	FL-100
Year	2006
Country Name	Japan
Flyer Speed	1350 rpm
Delivery Speed	32 m/min
T.P. I	1.07
Roving Count	0.6 Ne

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

Table 3: Simplex.

Company name	Trutzschler
Model no.	9132207(TC-03)
Year	2006
Country name	Germany
Taker in Speed	1249 rpm
Cylinder speed	562 rpm
Flat speed	300 mm/min
Delivery speed	192 m/min
Efficiency	68%
Sliver count	92 grain/yard

Table 4: Breaker Drawframe.

Company Name	Toyota
Model No.	DX8
Year	2006
Country Name	Japan
Delivery Speed	558 m/min
Total Draft	8.601
Back Draft	1.417
Sliver Count	480 grain /6 yrd

Table 5: Finisher Drawframe.

Company Name	Toyota
Model No.	DX8-LT (With Autoleveller)
Year	2006
Country Name	Japan
Delivery Speed	554 m/min
Total Draft	8.6
Back Draft	1.1
Sliver Count	480 grain /6 yrd

Table 6: Ring frame.

Company Name	Zinser	
Model No.	RM-315	
Year	2006	
Country Name	Germany	
	For 7 Ne	For 12 Ne
Spindle Speed	6495 rpm	11000 rpm
TM	4.2	4.3
Traveler No.	12	5

Table 7: Rotor.

Company Name	Schlafhorst	
Model No.	SE-12/360	
Year	2006	
Country Name	Germany	
	For 7 Ne	For 12 Ne
Rotor Speed	75000 rpm	105000 rpm
Opening Roller Speed	7500 rpm	9000 rpm
TM	4.2	4.3
Rotor Diameter	33 mm	40 mm
Efficiency	83%	85%

Methods

Research methodology is the path through which researchers need to conduct their research. It shows the path through which these researchers formulate their problem and objective and present their result from the data ob-tained during the study period. This research design and methodology chapter also shows how the research outcome at the end will be obtained in line with meeting the objective of the study [7].

Sample Preparation

Steps of Sample Preparation in Ring & Rotor Frame

a) At first in blow room section opening, cleaning, mixing operation were done.

b) Then cotton was passed to the carding section through chute feed and eight large cans of card sliver from carding machine no. 3 were produced.

c) Then card sliver cans were fed into the breaker drawframe (machine no. 1) and sixteen breaker drawn sliver cans were produced.

d) Then produced breaker drawn sliver cans were fed into finisher drawframe (machine no. 6) and twelve cans of finisher drawn sliver were manufactured.

e) After that six-finisher drawn sliver were fed into simplex machine to produce ring yarns and another six finisher drawn sliver cans were taken to autocoro machine to produce rotor yarn.

f) From simplex machine (machine no. 2) twelve roving packages were produced and fed six roving in ring frame (machine no.2) for producing count 7 Ne and an-other six were fed in ring frame (machine no. 3) for producing 12 Ne carded yarn.

g) Other six finisher sliver cans were fed into autocoro (machine no. 3) to produce 7 Ne rotor yarn. After this operation, we took this sliver can and again fed into autocoro (machine no. 4) to produce 12 Ne rotor yarn.

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

h) Finally, all produced yarn were taken to the QC department for testing and analyzing.

Results

In this part, the various physical properties of ring carded and rotor yarns are evaluated comparatively. The mean differences of different properties are evaluated and explained through Uster Evenness Tester and Mesden Lea Strength Tester. Uster testing result of yarns for unevenness (U%), co-efficient of mass variation (CVm%), hairiness, tenacity, thick place, thin place, neps and Mesden strength tester result for CSP and Elongation values are shown below in different tables.In this case of experiment, the velocity is kept of material is 200m/min and duration of passing material is 1 min. The parameters and test results are shown in table below (Table 8):

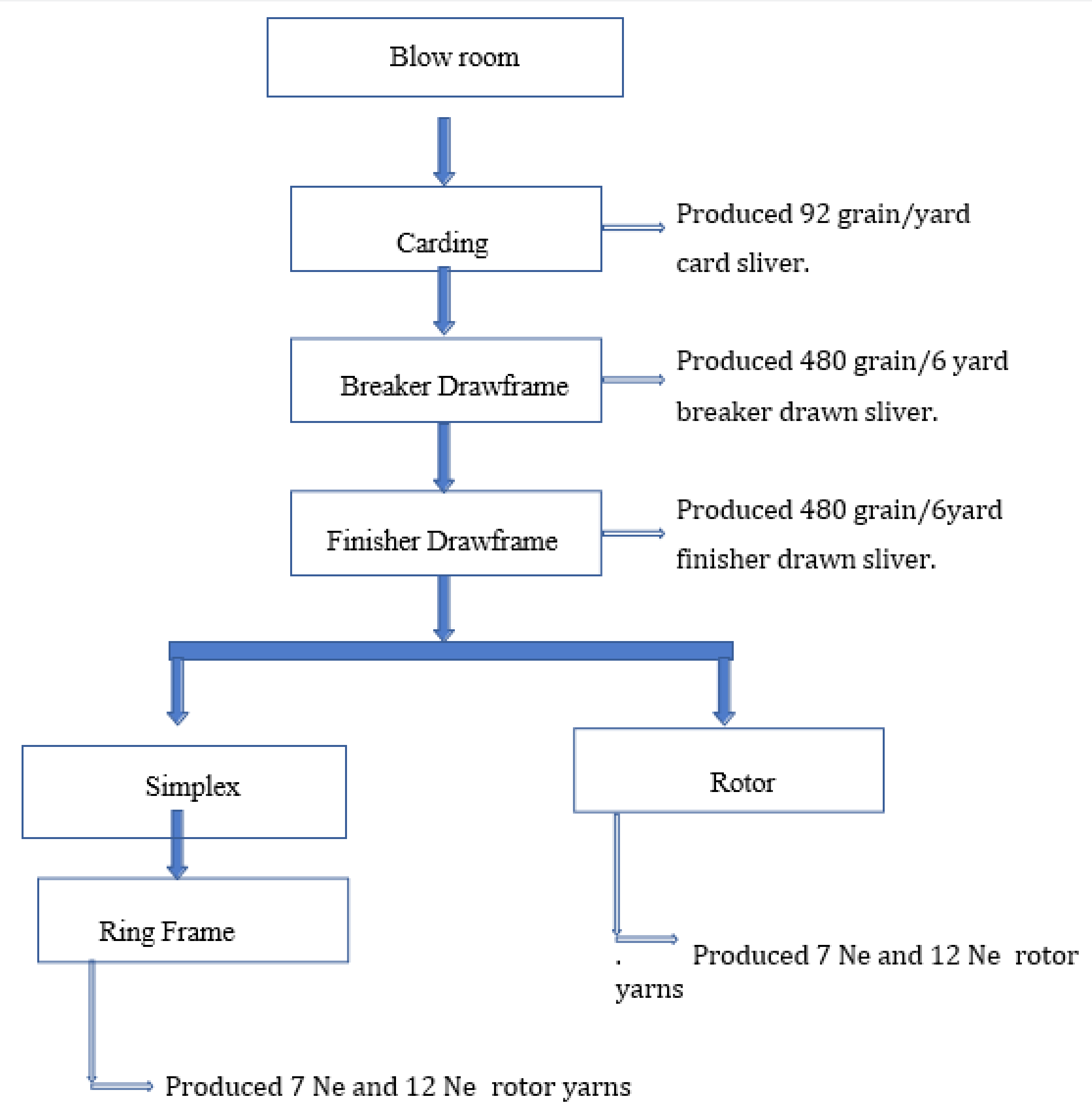

Figure 2: Flowchart of yarn preparation in ring and rotor yarn.

Table 8: Test Report for Evenness Testing.

	Ring	Rotor	Ring	Rotor
Count	7 Ne	7 Ne	12 Ne	12 Ne
U %	9.33	9.17	9.99	9.76

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

CVm%	11.61	11.78	12.69	12.29
H	11.41	7.81	9.95	5.33
Thin (-40%) /km	15.8	4.2	30	44.2
Thick (+50%) /km	14.2	11.7	44.2	17.5
Neps (+280%) /km	1.7	2.5	10	0.8
Neps (+200%) /km	10	18.3	69.2	18.3

Strength means the quality or state of being strong. In this experiment, Mesdan Lea Strength Tester is used to de-termine the breaking strength of the yarn in bundle form. A sample of yarn with 640 mm length is taken to test and attached to the clamp of the machine. The clamp speed is kept 500mm/min. The test result are show below (Table 9).

Table 9: Test Report for strength testing.

	CSP [Ne×lb]		Elongation [%]	
Count	7 Ne (Ring)	7 Ne (Rotor)	7 Ne (Ring)	7 Ne (Rotor)
Avg.	2599.725	2129.555	9.95	10.23
Max.	2651.405	2191.502	10.1	10.52
Min.	2448.933	2071.655	9.6	10.01
CV	2.30%	2.70%	2%	2%
	CSP [Ne×lb]		Elongation [%]	
Count	12 Ne	12 Ne	12 Ne	12 Ne
	(Ring)	(Rotor)	(Ring)	(Rotor)
Avg.	2543.819	2128.174	7.883	7.88
Max.	2672.931	2193.855	8.492	8.123
Min.	2371.492	2018.885	6.6	7.431
CV	4.90%	3.40%	9.70%	3.60%

Discussion

The changes of value of given parameters are presented in graphical method. Then the result is discussed below the graphical representation:

The mass per unit length variation due to variation in fiber assembly is general as yarn irregularity or unevenness. It is also necessary to have a numerical value that represents the mass variation [8]. The coefficient of variation is the ratio of standard deviation of mass variation divided by average mass variation. The higher CVm value is the more irregular the yarn [9].

a) In the present study as it is seen in figure1: here mass variation (U% and CVm%) of ring and rotor yarns are similar to each other.

b) In the previous similar work done by Sharif et al. [10], it was observed that ring yarn has more unevenness than rotor yarn for 20 Ne yarn.

c) Usually for finer yarn, unevenness of ring yarn is higher than the rotor yarns. `Because in ring spinning, fibers are passed through various drafting system (Simplex and Ring frame), for where the more unevenness is produced. When, the roving passing through the drafting arrangement, then there starts to produce static charge for the friction between materials to roller. Moreover, due to this static charge sometimes fibers are wrapping on the cot roller.

d) which is called lapping. For this unwanted reason in ring spinning the mass variation is more [11, 12].

e) On the other hand rotor yarn is produced by transforming sliver into individual fibers. Here fiber to fiber doubling (back doubling) is occurred and there are no drafting arrangement present here, so the mass variation is much lower in rotor yarn [13].

f) In the above figure: it is seen that mass variation is similar for both ring and rotor yarns, it may be due to the number of fibers are presented more in the cross section for coarser count. Therefore, the fibers are equalized and reduced the mass variation.

Yarn hairiness is defined as fibers protruding from the main body of a yarn. The amount of hairiness is important to both the textile operations and the appearance of fabrics and garments [14].

In the above figure 2 for both count (7 Ne & 12 Ne) it is seen that hairiness of ring yarn more than rotor yarn. In ring spinning for roller lapping and frayed fibers in the spinning triangle are caused more hairiness. Besides that, the ballooning tension also here creates a great impact on hairiness of ring yarns [15]. But in rotor spinning there are back doubling occurred in the rotor groove. Where the fibers are laid down on each other and more wrapping fibers are presented in the structures of rotor yarns. So the hairiness of rotor yarns are less than ring yarns [16]. The product of the lea strength (pound force), and the actual count of cotton yarn (Ne) is known as Count Strength Product (CSP) [17].

In the above figure 3 for both count yarns, CSP is higher for ring yarns than rotor yarns. Ring yarn has more strength than rotor yarn because of (i) different twisting system and (ii) fiber migration which are elaborated below:

a) In ring yarn twist is enveloped outside to inside of the yarn. And all the fibers are contributed in twisting. So, the friction between fiber to fiber is higher. So, the strength is also increased. But in rotors yarn the twist is generated from inside to outwards.

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

So, the degree of parallelism of rotor yarn is low as well as CSP is lower than ring yarns [18].

b) The ring spun yarn exhibits the highest fiber migration, followed by rotor spun yarn. A higher migration factor corresponds with a higher yarn breaking tenacity. The degree of fiber migration in rotor yarn is much lower than that of ring-spun yarns, because the fibers do not form a flat ribbon immediately before twist is inserted [19].

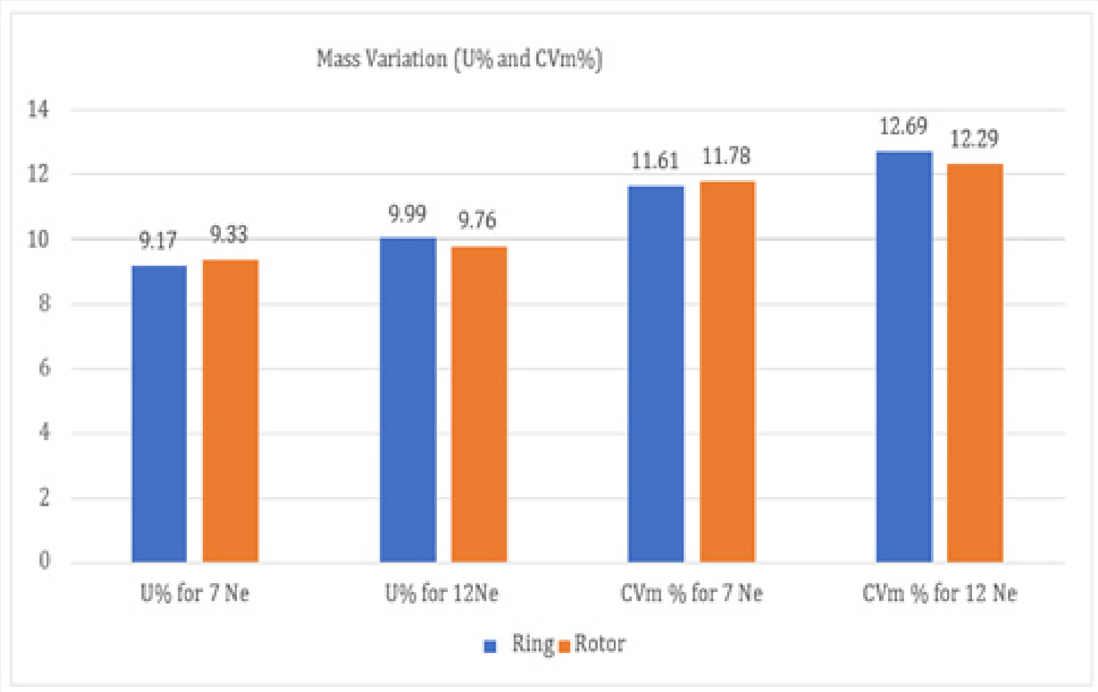

Figure 3: Mass Variation (U% and CVm%).

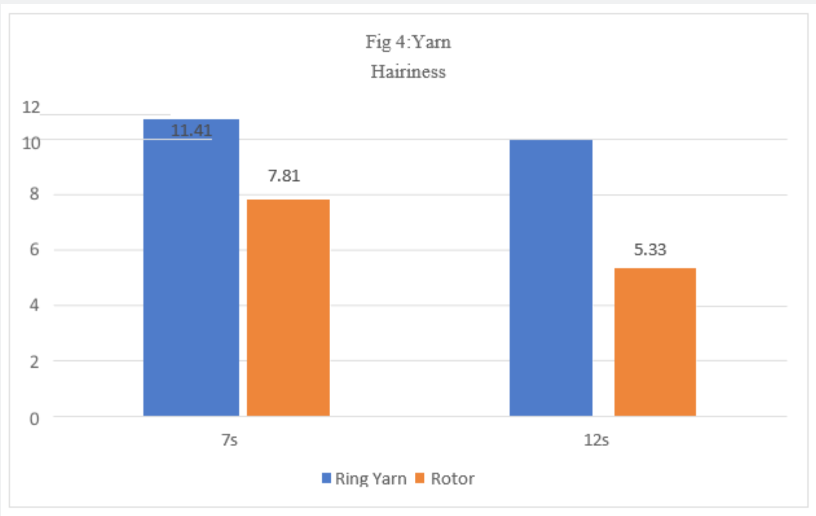

Figure 4: Yarn Hairiness.

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

The increase in length of a specimen during a tensile test, expressed in units of length or percentage value [17].

In the above figure 4 we show that the elongation property of both rotor and ring yarn is similar to each other. In the previous similar work done by Sonkusare Chetan R et al. [20], it was observed that rotor yarn has more elongation than ring yarns. Although rotor spun yarns are known to be somewhat more extensible, fuller, and softer than ring yarns. Elongation property of ring and rotor yarns is not a constant result, it depends on various parameters. If any parameter change then result can be reversible [21].

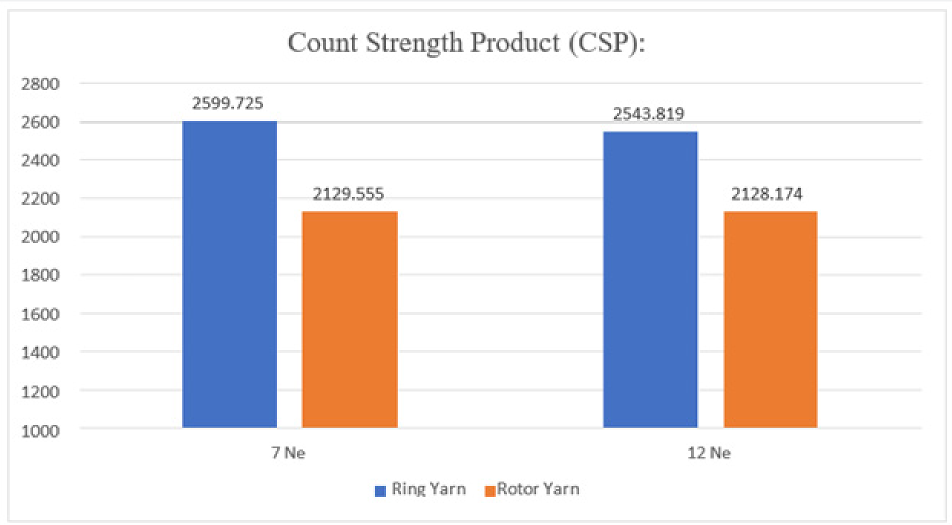

Figure 5: Count Strength Product (CSP).

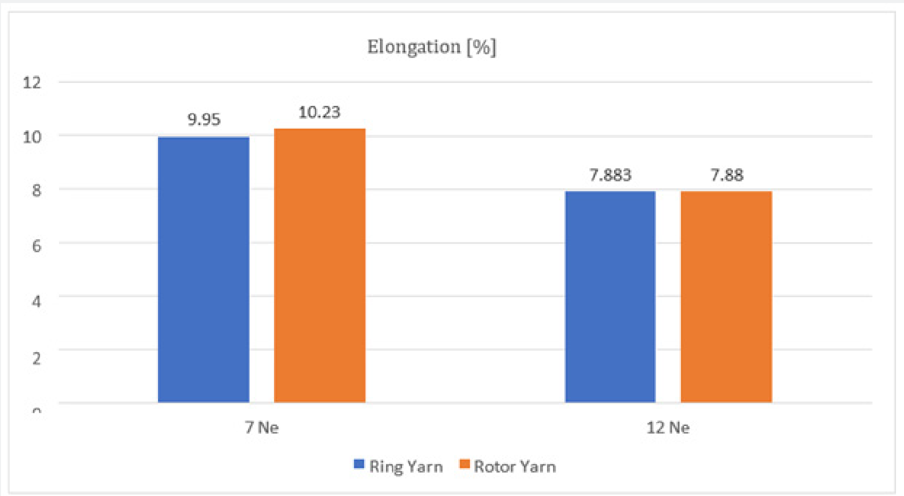

Figure 6: Elongation.

Neps may be considered as small tight balls of entangled fibers, which lead to the downgrading or yarn and fabric. The cross-sectional size of neps is + 140% to +400% of normal yarn and its fault length is 1mm. In the above figure 5: 4.2.7 it is seen that neps in of ring yarn is higher than the rotor yarns for both counts. Usually due to back doubling low fiber entanglements occur in rotor yarn [13]. Neps in rotor yarns tend to be spun into the solid yarn body rather than remaining on the yarn surface, which is typical for ring-spun yarns. It is embedded in the yarn core. So these neps shows a short mass defect, which is not exceeding the preset threshold value. Therefore, the neps of rotor yarn is less than ring yarn [22].

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

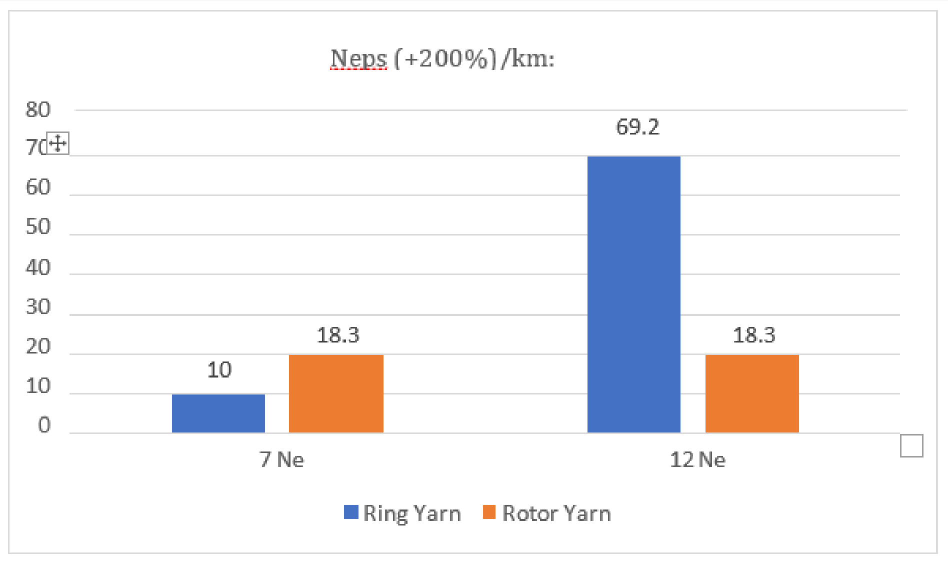

Figure 7: Neps (+200%).

A place in the yarn having yarn diameter in excess of +50% of the average yarn diameter and the length 8-12 millimeters is considered as a thick place. A place in a yarn having yarn diameter -50% or more than average diameter and any length is considered as a thin place [23].

In the above figure 6, it is seen that the thick place (+50%) of ring yarn for 7 Ne is less than the rotor yarn. Nevertheless, for 12 Ne it is significantly higher than the rotor yarns. In the previous similar work done by Sharif et al. [12], it was observed that ring yarn has thicker place (+50%) than rotor yarn for 20 Ne yarns. In our observation it is also found that ring yarn has thicker place than rotor yarns for 12 Ne. But for 7 Ne the result is reversed. It may be due to more fibers present in the cross section of coarser yarns that enables the yarns to withstand higher spinning tensions. Thin places lie in the range of -50% with respect to the mean value of yarn cross-sectional size and their length ranges from 4-25mm. Thin place -40% means the x-section at the thin place is only 60% of the yarn x-section or less (Figure 7) [24-31].

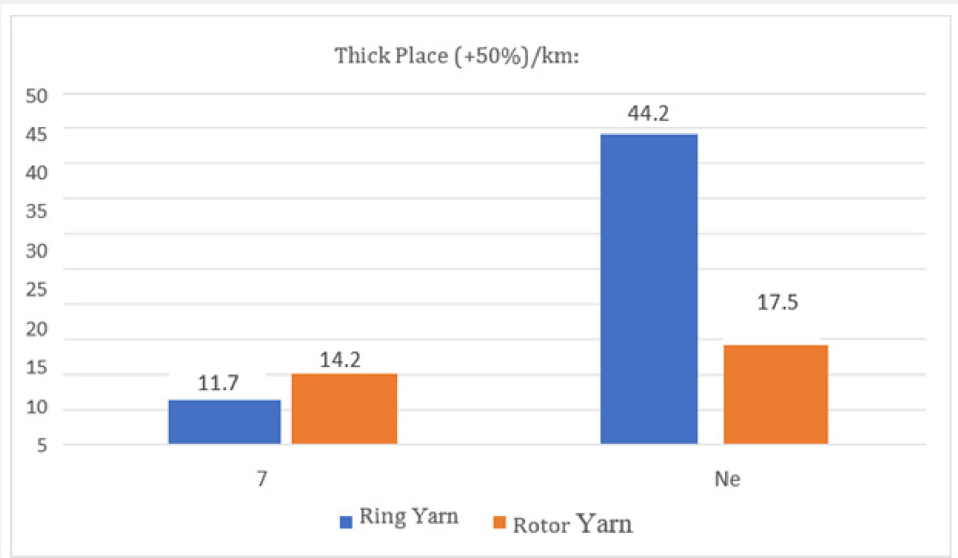

Figure 8: Thick Place (+50%).

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

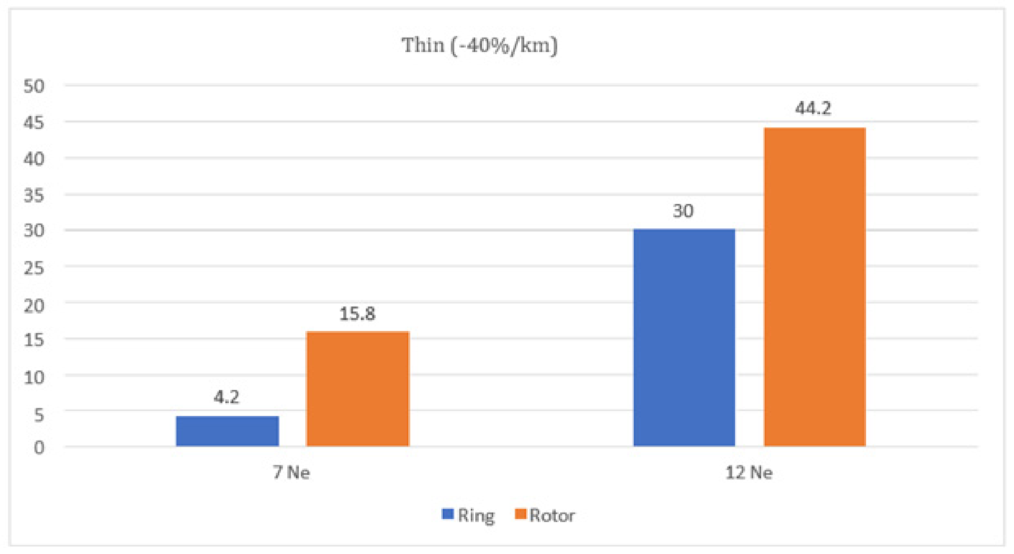

Figure 9: Thin Place (-40%).

Conclusion

In the current study, the reflection of yarn manufacturing principle of ring- and rotor spinning on the characteristics of yarns was studied. 7 Ne and 12 Ne ring- and rotor yarns were produced from the Brazilian cotton and the structure and properties were analyzed by Uster Evenness Tester and Mesdan Lea Strength Tester. After a thorough study, much differences were not found in the unevenness and imperfections of both ring- and rotor yarns. Hairiness value of rotor yarns was slightly lower due to the presence of wrapper fibres. Strength of ring yarns was higher in compare to rotor yarns. The reason of higher strength of ring yarns can be ascribed to the occurrence of higher fibre migration in the spinning triangle (Figures 8 & 9).

Acknowledgement

The authors are extremely thankful to the production and quality control department of Mahmood spinning Ltd. For their good co-operation & selfless support in conducting the work.

References

1. Articles on various textile topics (2020).
2. America's Cotton Producers and Importers (2003) Introduction to open end spinning. Cotton Incorporated p. 3.
3. Klein W (2016-2017) Manual of Textile Technology. The Textile Institute, UK 1: 6.
4. Siddique AB, Begum HA (2014) Introduction to Textile Engineering. Books Fair Publications. Dhaka, p. 42.
5. Siddique AB, Begum HA (2014) Introduction to Textile Engineering, Books Fair Publications. Dhaka, p 72.
6. Yarn Evenness (2020).
7. Yarn Unevenness (2020).
8. Unevenness and Coefficient of Variation of Yarn (2020).
9. Ahmed S, Syduzzaman M, Sultan M (2015) Comparative study on ring, rotor and air-jet spun yarn.
10. Klein W (2016-2017) Manual of Textile Technology, The Textile Institute, UK, 3: 153.
11. Purushothama B (2016) Handbook on Cotton Spinning Industry, Woodhead publishing India pvt ltd, India; page-105
12. Klein W (2016-2017) Manual of Textile Technology. The Textile Institute, UK, 3: 274-275.
13. Tyagi GK (2010) Advances in Yarn Spinning Technology.
14. Klein W (2016-2017) Manual of Textile Technology, The Textile Institute UK, 4: 195-196.
15. Klein W (2016-2017) Manual of Textile Technology, The Textile Institute UK 5: 274-275.
16. Denton MJ, Daniels PN (2010-2011) Textile Terms and Definitions, The Textile Institute, UK.
17. Sonkusare CR (2015) Comparing the Properties of Ring and Rotor Spun after Doubling. International J of Science Technology & Engineering 1.
18. CSP of yarn (2020).
19. Uddin AJ (2014) Fiber migration in Yarn. Preview, Dhaka, Bangladesh.
20. Lawrence AC (2010) Advances in yarn spinning technology. Woodhead Publishing Limited, USA, pp: 125-128.
21. Klein W (2016-2017) Manual of Textile Technology. The Textile Institute UK 5: 289.
22. USTER® laboratory systems Application Report (2020).
23. Neps in Textiles (2014).
24. Siddique AB, Begum HA (2014) Introduction to Textile Engineering, Books Fair Publications. Dhaka, p 43.

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726

25. Leslie AB (2020) How Can Industrial Thread and Yarn Twist Affect Your Process?

26. Ochola J, Kisato J, Kinuthia L, Mwasiagi J, Waithaka A (2012) Study on the Influence of Fiber Properties on Yarn Imperfections in Ring Spun Yarns. Asian J of Textile 2: 32-43.

27. Klein W (2016-2017) Manual of Textile Technology. The Textile Institute, UK 4: 192-193.

28. Sheikh HR (2020) Textile Institute of Pakistan. Development of open end rotor spinning system.

29. Lawrence AC (2010) Advances in yarn spinning technology. In: Woodhead Publishing Limited, USA, pp. 121-126.

30. Wikipedia (2020) https://en.wikipedia.org/wiki/Machine.

31. Kassu JS (2019) Research Design and Methodology. In: Evon AT, Abdelkrim ElM, Issam HAlH, Cyberspace, Intech Open.

How to cite this article: MD Rakib H G, Hasan Mazharul H, Mushfiqur R. Investigating the Relationship between Yarn Structure and Mechanical Properties in Ring and Rotor Spun Yarns. JOJ Material Sci. 2023; 8(1): 555726. DOI: 10.19080/JOJMS.2023.08.555726