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An Investigation about Abrasion Resistance and Seam Stretchability Properties of Weft Knitted Fabrics made from Conventional Ring and Compact Spun Yarn

Md. Rafiqur Rashid[1], Farid Ahmed[2], Abul Kalam Azad[3]

[1] Department of Textile Engineering, Ahsanullah University of Science and Technology, Dhaka,
[2] Departments of Physics, Jahangirnagar University, Dhaka,
[3] Bangladesh Jute Research Institute, Dhaka

Abstract- Compact Spinning is a new version of ring spinning and distinct features of these yarns are their high strength and elongation values and low hairiness. In this research work cotton yarns, produced from same cotton blend were spun according to compact and conventional ring spinning principles in three different counts. Three different knitting structures single jersey, rib and interlock were produced from these yarns. The physical properties of those fabrics were investigated and compared with each other before and after reactive dyeing processes. When the results were studied, it was observed that higher abrasion resistance and lower mass loss after 10,000 cycles was found in all knitted fabrics made from compact yarn. Compact yarn based knitted fabrics showed higher seam stretchability and higher extension percentages compared to knitted fabrics made from conventional ring yarn.

Index Terms- compact yarn, abrasion resistance, seam stretchability and weft knitted fabric.

I. Introduction

A revolutionary version of ring spinning process is called compact spinning achieves remarkable improvement in yarn quality through better utilization of fibre properties which gives benefit in the downstream. So the fabric made from compact spun yarn gives better look and feel [1].Compact spinning produces a novel yarn structures and the development of compact spinning has set new standards in yarn structures [2, 3].

Compact yarns are uniformly oriented and having better tenacity, elongation and hairiness properties. The better tenacity properties of compact yarn provide opportunities to work with lower twist coefficients result in an increase in production rate and also better handling properties of end product [4].

Many textile scientists have studied factors that have an effect on pilling and abrasion resistance [5, 6, 7]

Ortlek and Ulku found that the material type, twist level and pile length have a significant effect on the abrasion resistance of cotton chenille yarns is higher than that of acrylic or viscose chenille yarns [8].

Nergis and Candan proved that the over feed ratio, the binding yarn in the twist direction and the twist amount affected the stitch density, thickness and abrasion behavior of knitted fabrics from boucle fancy yarns [9].

Kaynak and Topalbekirroglu observed that the weave pattern and number of rubbing cycles have a significant effect on the abrasion resistance property of woven fabrics [10].

The performance assessment of ring and compact yarns in knitted fabrics with single jersey knit fabrics have been studied and reported that plain knitted fabric made out of compact spun yarn having better pilling resistance and abrasion resistance when compact or ring spun knitted [11].

In this research work was carried out to investigate the abrasion resistance and seam stretchabilty of knitted fabrics using ring and compact spun yarn on various knit structures such as single jersey, rib and interlock.

II. Material and Methods

In this study, 100% cotton yarns of 40/1 and 30/1 and 20/1 Ne were spun according to combed and compact spinning methods from the roving produced by using the same cotton blend (CIS Uzbekistan cotton).The compact yarns were produced on suessen EliTe compact system and Toyota Rx-240 ring frame was used to produce the conventional yarn. The quality parameters of these yarns are given in Table-2. Experimental samples from these conventional ring (combed)and compact yarns were knitted into Single Jersey, Rib (1×1) and Plain Interlock fabric. Knitting Machine specification are given in Table-1.

Table 1: Knitting Machines specifications

Machine Specification	Single Jersey	Rib	Interlock
Manufacturer	Mayer & Cie	Mayer & Cie	Mayer & Cie
Country of origin	Germany	Germany	Germany
Machine Diameter	30”	40”	40”
Gauge	24	18	24

Table 2: Quality parameter of Conventional ring and Compact yarn made from 100% cotton fibres produced on Conventional ring (Toyota –Rx240) and Suessen Elite compact system.

Test parameter	40/1Ne		30/1 Ne		20/1Ne	
	Conventional Ring Yarn	Compact Yarn	Conventional Ring Yarn	Compact Yarn	Conventional Ring Yarn	Compact Yarn
Yarn count	39.89	39.7	29.95	29.92	19.83	19.8
Count CV%	0.35	0.6	0.61	0.55	0.93	0.65
Uster U%	9.76	9.02	8.97	8.73	7.5	7.13
Uster CVm%	12.33	11.4	11.32	11.01	9.76	9
Thin place/km(-50%)	1	0	0	0	0	0
Thick places/km(+50%)	24	14	12	5	4	2
Neps/km(+200%	35	37	20	21	8	3
IPI	60	51	32	26	12	5
CSP	2549	2789	2411	2473	2722	2862
RKM(CN/Tex)	17.01	19.93	18.29	19.29	19.82	20.07
RKM CV%	11.56	9.08	7.13	9.75	5.91	9.24
Elongation%	4.6	4.81	4.21	4.62	5.03	4.86
Elongation CV%	8.66	8.63	8.06	11.2	5.92	10.62
TPI	23.74	23.19	20.28	19.46	16.59	16.38
Hairiness(H-index)	4.47	3.12	4.79	3.33	5.59	3.98
Hairiness(CVHb%)	3	3	2.2	3.3	3.4	2.3

III. SAMPLE PREPARATION

All the grey fabrics of compact and ring spun yarn were processed in same bath to eliminate any variation during the process. Scouring and bleaching was applied to all the knitted fabrics in same bath as the first step to finishing process. The scouring and bleaching was done in the same bath with liquor ration 1:20 using Theis winch dyeing machine. The scoured and bleached fabrics were rinsed at 80^{o} C for 20 minutes. After drop the bath fabric were neutralization with peroxide killer and Acetic acid. After this all the fabrics were dyed with medium brand reactive dyes (red color) in Theis Winch dyeing machine. The scouring & bleaching and dyeing process condition are given in following Table-3 and 4.Digital picture of Theis Winch dyeing machine(Germany) is given in figure-1.

Table 3: Scouring and Bleaching Recipe

Scouring and bleaching recipe	
Felosan RGN (Detergent)	0.7 g/l
Denquist HYN (Sequestering agent)	0.25 g/l
Windcrease WL (Anticreasing)	0.7 g/l
Soda ash Light (Alkali)	5 g/l
Hydrogen Peroxide (oxidizing agent)	2.5 g/l
Setabiocal A_4 (Stabilizer)	0.5 g/l
Geizyme APB (Peroxide Killer)	0.5 g/l
Acetic Acid (Neutralizing agent)	1 g/l
Time	60 min
Temperature	98° C
Liquor ratio	1/20

Table 4: Dyeing Recipe

Dyeing Recipe	
Sarabid LDR (leveling agent)	0.5 g/l
Setazol Red 3BS (dyestuff)	%3.0 owf
Sodium Sulphate (glauber salt)	80 g/l
Soda ash light (alkali)	20 g/l
Liquor ratio	1/50
Temperature Time	60° C 60 min
After Treatment	
Cotoblance NSR (soaping)	0.3 g/l
Acetic acid (Neutralizer) Time	0.8 g/l 45min

Fig. 1: Thies Winch Dyeing Machine (Germany)

IV. FABRIC TESTING

Following tests were carried out for all knitted fabric samples. All the tests were performed after the fabrics had been conditioned for 24 hours. (Atmosphere conditions of 65% R.H .and 27^{o} C).

A. *Abrasion resistance*

Martindale tester is designed to give a controlled amount of abrasion between fabric surfaces at comparatively low pressures in continuously changing direction. The abrasion resistances of the fabrics were tested on the Martindale pilling and abrasion tester at 9 kPa pressure according to BS EN ISO 12947-2(Determination of specimen break down and mass loss.)[12]A circular specimen(38mm), mounted in a specimen holder and subjected to a defined load, is rubbed against an abrasive medium in a translational movement tracing a lissajous figure, the specimen holder being additionally freely rotatable around its own axis perpendicular to the plane of the specimen. The evaluation of the abrasion resistance is determined from the inspection of specimen break down and mass loss of specimen after specific amount(10,000 cycles) of rubs. Experimental data of breaking cycle for Grey and bleached Sample are given in table-5, 6,7and 8. Figure-2shows the abrasion resistance tester.

Fig. 2: Martindale pilling and abrasion tester

Fig. 3: Seam strength tester, Tinius Olsen, SDL

B. Experimental Data

Table 5: Data of breaking cycle for Grey Sample

40/1 Knitted Fabrics		
Sample	Sample Type	Number of Cycle
Single Jersey	Combed	17000
	Compact	17500
Rib	Combed	21000
	Compact	25000
Interlock	Combed	30000
	Compact	35000
30/1 Knitted Fabrics		
Single Jersey	Combed	20500
	Compact	22000
Rib	Combed	38000
	Compact	42000
Interlock	Combed	35000
	Compact	35500
20/1 Knitted Fabrics		
Single Jersey	Combed	29500
	Compact	30500
Rib	Combed	33000
	Compact	35000
Interlock	Combed	62000
	Compact	72000

Table 6: Data of breaking cycle for Bleached Sample

40/1 Knitted Fabrics		
Sample	Sample Type	Number of Cycle
Single Jersey	Combed	32,000
	Compact	40,000
Rib	Combed	32,000
	Compact	33,000
Interlock	Combed	34,000
	Compact	62,000
30/1 Knitted Fabrics		
Single Jersey	Combed	36,000
	Compact	40,000
Rib	Combed	28,000
	Compact	30,000
Interlock	Combed	46,000
	Compact	66,000
20/1 Knitted Fabrics		
Single Jersey	Combed	38,000
	Compact	40,000
Rib	Combed	47,000
	Compact	48,000
Interlock	Combed	65,000
	Compact	72,000

Table 7: Data for Abrasion resistance (Mass Loss) in grey stage

40/1 Knitted Fabrics		
Sample	Sample Type	Mass loss after 10,000 cycles
Single Jersey	Combed	10.9 %
	Compact	10.2 %
Rib	Combed	6.2 %
	Compact	5.8 %
Interlock	Combed	4.4 %
	Compact	4 %
30/1 Knitted Fabrics		
Single Jersey	Combed	9.2 %
	Compact	7.8 %
Rib	Combed	4.1 %
	Compact	3.7 %
Interlock	Combed	3.7 %
	Compact	3.6 %
20/1 Knitted Fabrics		
Single Jersey	Combed	5.2 %
	Compact	4.8 %
Rib	Combed	3.8 %
	Compact	3.6 %
Interlock	Combed	2.8 %
	Compact	1.6 %

Table 8: Data for Abrasion resistance (Mass Loss) in For Bleached Sample

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40/1 Knitted Fabrics		
Sample	Sample Type	Mass loss after 10,000 cycles
Single Jersey	Combed	5.3 %
	Compact	3.2 %
Rib	Combed	2.8 %
	Compact	2.8 %
Interlock	Combed	2.6 %
	Compact	1.5 %
30/1 Knitted Fabrics		
Single Jersey	Combed	1.182 %
	Compact	1.10. %
Rib	Combed	4.4 %
	Compact	3.2 %
Interlock	Combed	0.80 %
	Compact	0.60 %
20/1 Knitted Fabrics		
Single Jersey	Combed	3.5 %
	Compact	3.2 %
Rib	Combed	3.6 %
	Compact	2.3 %
Interlock	Combed	3.1 %
	Compact	2.3 %

C. Seam Stretchability of knitted Garments

This method covers the measurement of breaking force and elongation at break of seams from different areas of garment when stretching. TS -015 was followed to test Seam Stretchability of knitted Garments [13]. Tinius Olsen,SDL was used to test the samples. Side seam (super imposed) was produced for every knitted fabric. Four thread over lock machine and 50/2 Nm sewing thread was used to produce those seam.

All the testing of knitted fabric was carried out in standard atmospheric condition of 65% RH and 27±2 ° C. Finally load value recorded in pounds and as well as elongation at break in percentage.

Experimental data for Seam Stretchability for Grey and dyed Sample are given in table-9 and 10. Digital picture of Seam strength tester (Tinus Olsen,SDL) is given in figure-3.

Table 9: Data for Seam Stretchabilityfor Grey Sample

40/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
40/1 Single Jersey	Combed	32.84	99.8
	Compact	36.82	114.3
40/1 Rib	Combed	40.78	80.0
	Compact	65.80	87.0
40/1 Interlock	Combed	67.00	83.9
	Compact	81.00	101.9
30/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
30/1 Single Jersey	Combed	41.55	119.4
	Compact	51.3	131.0
30/1 Rib	Combed	72.3	74.0
	Compact	78.8	92.6
30/1 Interlock	Combed	81.9	87.1
	Compact	110.2	79.2
20/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
20/1 Single Jersey	Combed	67.8	87.1
	Compact	80.4	106
20/1 Rib	Combed	116.8	70.8
	Compact	140.4	82.9
20/1 Interlock	Combed	167.3	86.4
	Compact	171.9	89.7

Table 10: Data for Seam Stretchability for Dyed Sample:

40/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
40/1 Single Jersey	Combed	28.56	52.6
	Compact	31.80	77.9
40/1 Rib	Combed	37.14	61.8
	Compact	42.40	53.3
40/1 Interlock	Combed	53.3	62.9
	Compact	80.9	77.0
30/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
30/1 Single Jersey	Combed	33.98	68.8
	Compact	37.12	75.4
30/1 Rib	Combed	53.5	53.7
	Compact	56.8	55.9
30/1 Interlock	Combed	66.8	46.21
	Compact	86.6	70.0
20/1 Knitted Fabric			
Sample Name	Sample Type	Stretching Force (lbf)	Extension (%)
20/1 Single Jersey	Combed	46.31	65.2
	Compact	54.9	75.3
20/1 Rib	Combed	64.8	65.2
	Compact	72.5	70.5
20/1 Interlock	Combed	84.1	91.2
	Compact	84.8	89.5

V. RESULTS AND DISCUSSION

A. Abrasion resistance

i. Specimens break down

In order to evaluate the resistance of the samples to abrasion, the fabrics were subjected to 100000 rubs or until a hole occurs. Abrasion tests were performed for all knitted fabrics in grey and bleached stages. The weight loss percent of the fabrics were also measured after 10,000 cycles. In figure 4 and 5 showed that the production process (Compact or conventional ring) have a significant effect on the abrasion resistant values on Knitted fabrics. Fabric made from compact yarn shows higher abrasion than fabric made from conventional ring yarn. Compact yarns based fabrics are expected to have lower friction values because of their uniform and less hairy structures and as a result higher abrasion resistance in expected.

It was also seen that knitting structure had an important effect on the abrasion values on knitted fabric. The abrasion resistance values (breaking cycles) of interlock and rib are higher than single jersey fabric. Highest breaking cycles was found in 20/1 interlock fabric due to its compact structures. It was 62,000(grey stage) for fabric made from conventional ring yarn. In compact it was increased to 72,000 cycles.

In bleached stage abrasion resistance was increased due the removal of impurities of fabrics after bleaching.

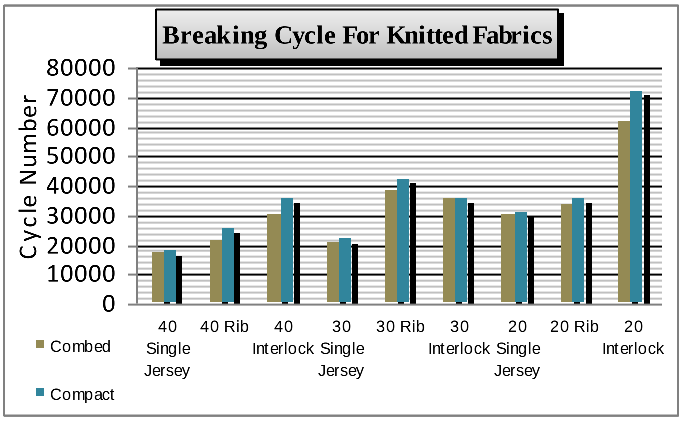

Fig. 4: Abrasion resistance (specimen breakdown) for all knitted fabric in grey stage.

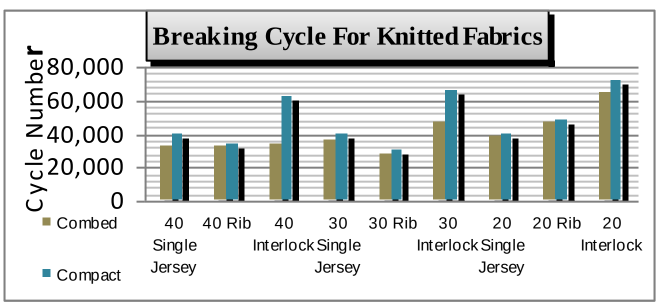

Fig. 5: Abrasion resistance (specimen breakdown) for all knitted fabric in bleached stage.

ii. Mass loss

In figure 6 and 7 it was clearly showed that Knitted fabric made from Compact yarn showed less mass loss after 10,000 cycles than the conventional ring based fabric in both grey and bleached stages. Fabric structures had in important effect on mass loss percentages. Higher mass are found Single jersey knitted fabric compare to rib and interlock structures. Less hairiness and higher strength of compact yarn have caused this difference.

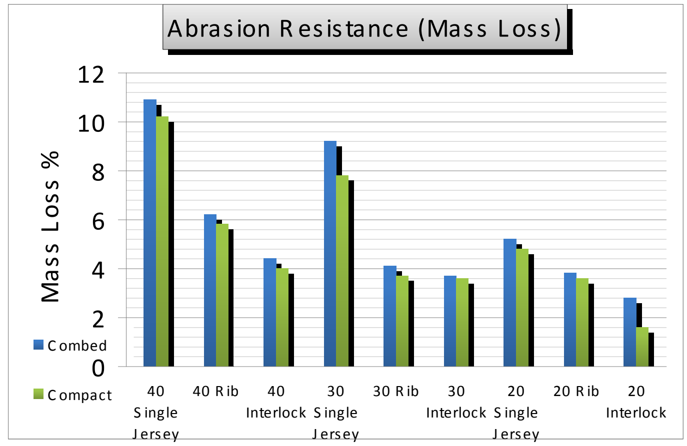

Fig. 6: Abrasion resistance (Mass loss) for all knitted fabric in grey stage.

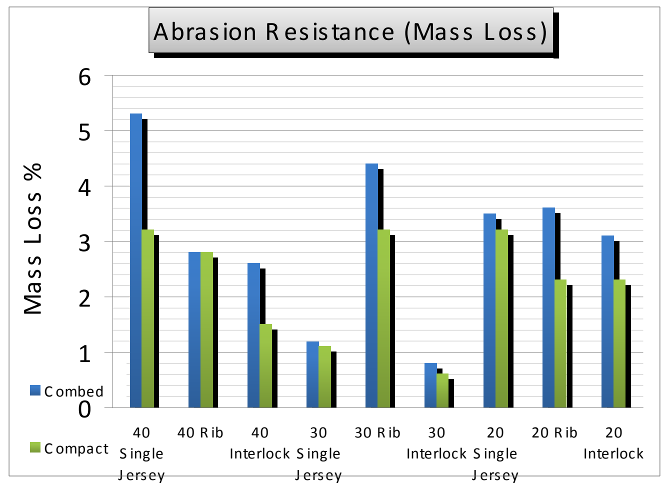

Fig. 7: Abrasion resistance (Mass loss) for all knitted fabric in bleached stage.

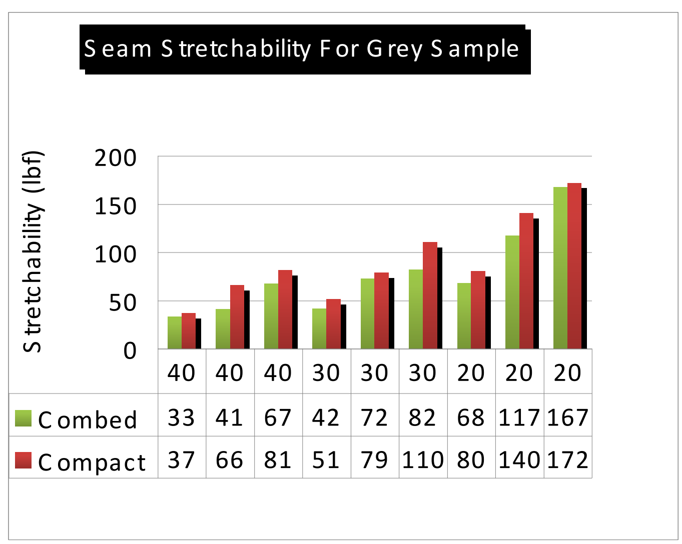

Fig. 8: Seam stretchability for all knitted fabric in grey stage.

iii. Seam stretchability of knitted garments

In graphical representation(Figure8 and 9) showed that Compact yarn based garment show the better seam stretchabilty than the conventional ring yarn based knitted fabric. 40/1 fabric has less stretch ability than 20/1 knitted fabric and Interlock fabrics showed higher seam stretchability. These results are due to higher bursting strength, lesser hariness and the more parallel state of fibre in yarn of compact yarn based. In grey stage seam stretchability was higher than the dyed stages. But in all stages fabric made from compact yarn showed higher seam strength and extension percentages compared to fabrics made from conventional ring yarns.

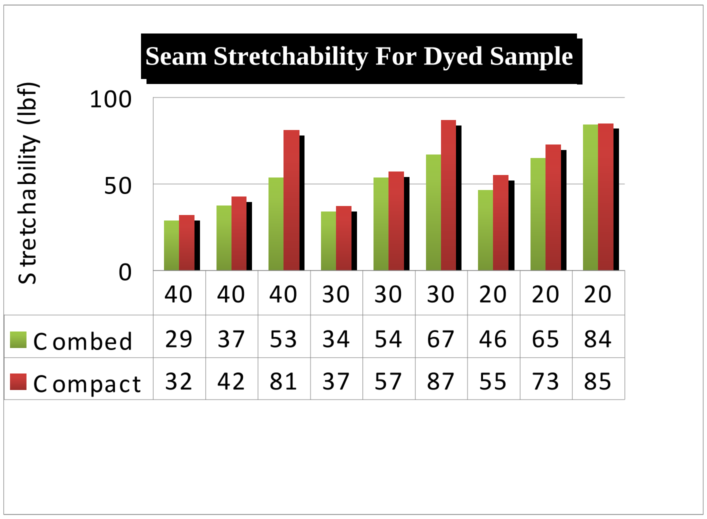

Fig. 9: Seam stretchability for all knitted fabric in grey stage.

VI. CONCLUSION

It was established that knitted fabric made from compact yarn have better physical properties than the fabric made from conventional ring(combed) yarn from the viewpoint of hairiness, neps, Unevenness, strength and elongation etc. Abrasion Resistance and seam stretchability are the two important properties of knitted garments. Compact yarn based fabric have abrasion resistance and seam stretchability which means they are more durable than conventional ring(combed) yarn based fabric. So knitted fabrics made of compact yarn can be used to make high quality garments with higher productivity.

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AUTHORS

First Author – Md. Rafiqur Rashid, Msc in Textile studies, University of Bolton,UK Associate Professor, Department of Textile Engineering, Ahsanullah University of Science and Technology, Dhaka,
Email id - rafiqurrashid@yahoo.com
Second Author – Farid Ahmed, PhD, Japan, Departments of Physics, Jahangirnagar University, Dhaka,
Third Author – Abul Kalam Azad, PhD, JU, Bangladesh Jute Research Institute, Dhaka