A Comparative Analysis on the Physical Property of Different Types of Yarn and Their Relation with Knitting Productivity and Knitted Fabric Quality

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Abstract—At the very beginning of this research work we have done a comparative study among the property of card yarn, combed yarn, mechanical compact yarn and pneumatic compact yarn. To make a fair comparison, all the yarns are produced with same linear density, same raw material and nearly about same TPI. Among all the yarns pneumatic compact yarn shows superior quality in terms of evenness, hairiness, strength etc. Then all types of yarn are knitted to make fabric by keeping same knitting parameters and same fabric construction. Then the knitting production per day is calculated. Investigation shows that pneumatic compact yarn gives higher production per day and it has the higher quality among all type of yarns and production per day decreases with the decreasing in yarn quality. Finally, we have investigated the bursting strength, weight loss due to abrasion and pilling resistance of the four fabrics. Test results show that all these properties are completely depends on the quality of yarn. Pneumatic compact yarn exhibits higher bursting strength, abrasion resistance and pilling resistance property and consecutively decreases for mechanical compact, combed yarn and card yarn.

Index Terms—Mechanical compact, pneumatic compact, knitting productivity, process loss, abrasive property.

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1 Introduction

THEtechnology of ring spinning is the widely used technology for the production of yarn as it can spin almost all sorts of natural and synthetic staple fiber[1, 2]. Both card and combed yarn are very well known types of yarn which are produced by ring spinning technology[3]. The quantity of combed yarn is superior to the quality of card yarn through the raw material, linear density TPI all are same for the both yarn. Combed yarn is characterized by higher strength, less hairiness, more uniformity as compared to card yarn[4, 5]. Though the quality of combed is superior but it still not satisfactory the end users. For achieving the better quality compact spinning technology is introduced which minimize the negative effect at the spinning triangle through reengineering the as usual ring spinning frame by inducing a small condensing device[6]. This condensing device assisted fiber from the surface to incorporate into the yarn structure[7].

Researchers show that to conventional ring yarn the strength of compact yarn is improved by 15-20%, elongation by 20% and hairiness lowered by 50%[8]. Nowadays different compact spinning system has been found and they can be divided into mechanical and pneumatic compact system[9, 10]. In this work, several research works shows the comparison between the conventional ring spinning technology and the newly developed yarn spinning technology but in this research work we have tried to make a comparison among the yarn produced from all theabove mentioned technology of same linear density.

Different research shows that yarn produced from above mentioned advanced technology shows greater strength, less hairiness etc[11, 12]. The excellent abrasion resistance helps the smooth running of yarn during knitting. In this study, we have also tried to figure out the relation between yarn quality and productivity of knitting and also the relationship between yarn quality and process loss during knitting. The resulted yarns from different spinning technology are different from each other in terms of their structure, bulk mechanical and surface properties. The quality of knitted fabric very much affected by the quality of yarn used to make the fabric[13, 14]. For the aforementioned reason we have tried to make a comparison among the knitted fabric produced from the card yarn, combed yarn, mechanical compact yarn and pneumatic yarn.

2 Methodology

2.1 Yarn Production and Testing

In this study, four types of single yarn are used and they are pneumatic compact yarn, mechanical compact yarn, combed yarn and card yarn. Carded and combed yarn are produced from 100% cotton by using conventional ring spinning frame. For producing pneumatic compact yarn, Rieter K44 pneumatic compact spinning system is used and for producing mechanical compact yarn ZinserImpact 71 compact spinning farme is used. For all the cases one type of raw material is used and the linear density of all yarns was same so that we could compare the properties of all types of yarn. The properties of all yarns were tested by using Uster Tester5-S400. For each yarn the sample was tested for 5 times at a speed of 400 m/min. All the above mentioned works were done at CMC Kamal Textile Mills Ltd., in Bangladesh. Table 1, gives the detailed properties of all types of yarn.

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TABLE 1
COMPARISON AMONG THE PROPERTIES OF DIFFERENT TYPES YARN

Yarn type	U%	Thin - 50% /Km	Thick +50% /Km	Neps +200% /Km	H	IPI	Average TPI	CSP
Pneumatic compact	9.41	0.2	9.8	17	4.14	27	20.05	3063.12
Mechanical compact	9.54	0.4	18.6	22.8	4.69	41.8	20.56	2838.77
Combed	10.28	0.6	25.2	80.6	6.39	106.4	20.01	2505.15
Card	12.22	5.2	229.2	402	7.6	636.4	20.35	2391.88

2.2 Knitted Fabric production

All the yarns were knitted to produce single jersey knit fabric. The fabrics were knitted in a Pailung single jersey circular knitting machine with a gauge of 24, diameter of 32inches, at speed of 26 rpm. After knitting the construction of all types of grey fabrics were investigated. Table represents the construction of fabric knitted from all types of yarn. For all the cases 200 kg of yarn is used and the stitch was same. The time required to knit all the yarns is measured to calculate the per day production of fabric for each cases. All the fabrics are weighted after conditioning to calculate the process loss percentage during knitting.

2.3 Fabric testing

TABLE 2
COMPARISION AMONG THE PROPERTIES OF DIFFERENT TYPES YARN

Yarn type	Stitch length	WPI	CPI	GSM
Pneumatic Compact	2.8	29	51	138
Mechanical compact	2.8	29	51	136
Combed	2.8	29	51	139
Card	2.8	29	51	136

After knitting, the fabrics are prepared for the testing. The fabric is prepared by scouring and bleaching which is carried out in the process of normal industrial practice. Then the the fabrics are dried and allowed to become in a stable state. After full relaxation and conditioned the bursting strength is measured by the bursting strength tester. For each sample the test is carried out for 10 times and average value is taken. The value is expressed in kg/cm2.Then abrasion property of all the fabrics is measured by Martindale Abrasion Tester to calculate the abrasion resistance. For testing the pilling property of all the fabrics ICI pilling box tester was used. A standard of 3000 revolutions were given and assessed with the standard to get the pilling grades.

3 RESULTS AND DISCUSSION

3.1Yarn properties

According to experimental data, the linear density for all types of yarn is 30 Ne and the TPI value of all types of yarn is nearly same. From the Fig. 1, it is seen that both the two compact yarn has higher evenness quality than the other two types of yarn. Among the pneumatic compact and mechanical compact yarn, pneumatic compact has shown superior quality. Card yarn shows very poor evenness quality as it was expected.

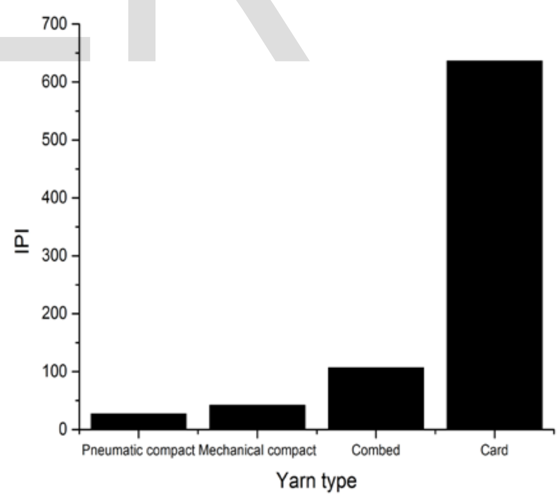

Fig. 1 Comparison among the evenness of different types of yarn

The test results of yarn hairiness are given on Fig. 2. The data represent the effect of spinning system on the quality the yarn. Among all the yarns pneumatic compact shows very low hairiness and card yarn shows higher yarn hairiness. This is the direct result of the elimination of spinning triangle in the compact spinning system. Due to lower spinning triangle higher amount of fibers are inserted into the yarn structures under the same tension.

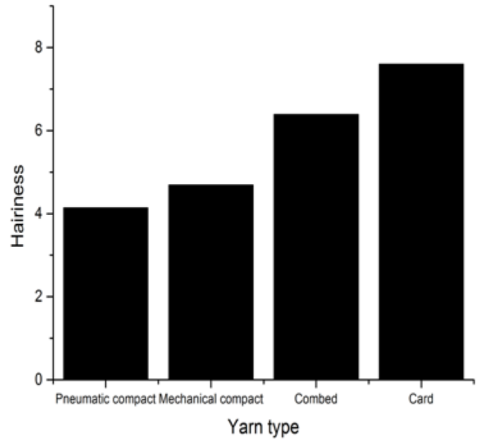

Fig. 2 Hairiness of different types of yarn

Fig. 3represents the CSP values of all types of yarn. According to the data analysis, it can be said that there is a significant effect of the spinning system on the strength of the yarn. The CSP of pneumatic compact yarn is higher than the other types of yarn used in this investigation though the liner density is same and TPI is nearly same for all types of yarns. This is also because of the incorporation of higher amount of fiber into the fiber structures.

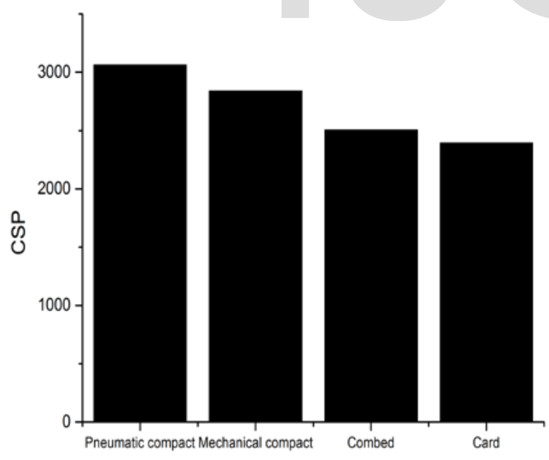

Fig. 3 Comparison among strength of different types of yarn

3.2Knitting productivity

As mentioned early, count of all types of yarn is same. All the yarn is knitted in the same machine and all the knitting parameters were also same. But from Fig. 4, it is seen that there is a variation of per day production among all the types of yarn. In case of pneumatic compact per day production is higher than any other types. The variation of production occurs due to the following reasons:

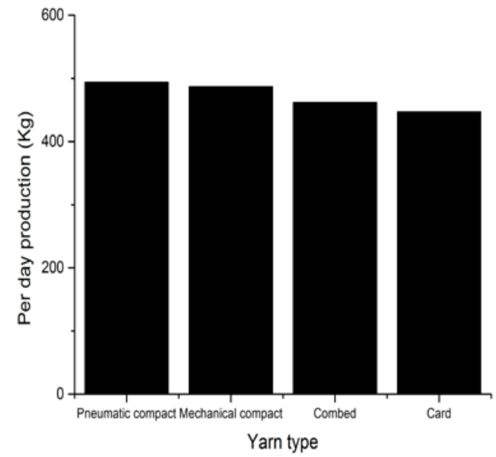

Fig. 4 Per day production for different types of yarn

- Yarn breakage during knitting causes machine stoppage. Higher the machine stoppage time lower the production. In case of card yarn breakage is higher among all types of yarn and the production is lower among all the yarns and breakage rate of yarn in case of card yarn is very high which causes lower production.
- Yarn which contains more hairiness causes more dust in the knitting area. As a result, more time required for cleaning of machine which causes lower production. Among all types of yarn pneumatic compact has lower hairiness and higher production and card yarn has higher hairiness and lower production.

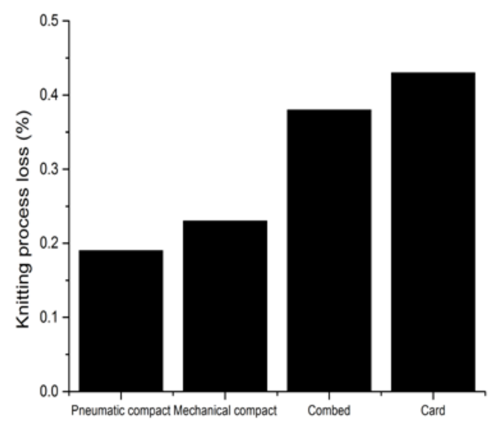

Fig. 5 Knitting process loss for all types of yarn

- It is well established that good quality yarn, less hairiness, less yarn breakage, less dust resulting less process loss in knitting. From Fig. 5, it is seen that process loss percentage for pneumatic compact is lower among the all types of yarn and then mechanical compact. Compared to both compact yarn process loss percentages in knitting of combed yarn and card yarn is very high and among these two yarn card yarn shows higher process loss percentage.

3.3Fabric properties

From the Fig. 6, it is seen that fabric made from pneumatic compact yarn shows higher bursting strength due to higher CSP of yarn which is the result of higher incorporation and uniform fiber arrangement into the yarn. Fabric made from mechanical compact also shows high bursting strength as compared to fabric made from combed yarn and card yarn

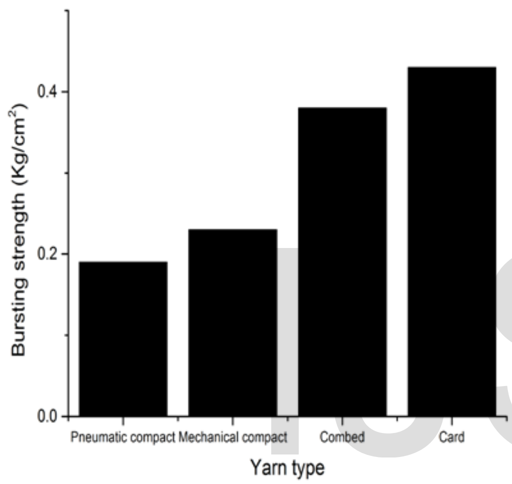

Fig. 6 Bursting strength for for all types of knit fabric

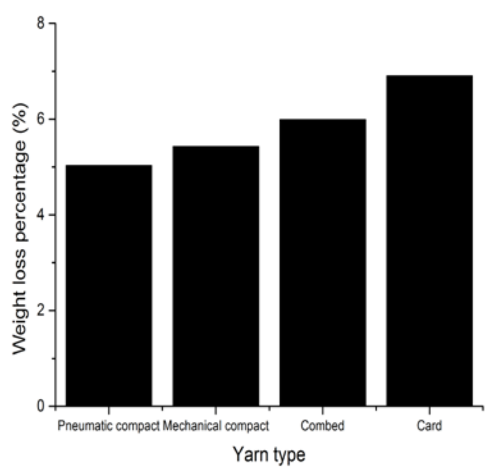

Fig. 8 Weight loss percentage for all knit fabrics

The abrasion property of a fabric depends on the construction of yarn and fabric structure. As in this work construction of all types of fabric is same so the difference between the abrasion properties among all the fabrics completely depends on the yarn structures. From the Fig. 7, it is seen that fabric made from pneumatic compact yarn shows higher abrasion resistance, followed by mechanical compact and then combed yarn. The fabric made from card yarn shows lower abrasion resistance. The reason behind the higher abrasion resistance of both compact yarns made fabric is the less fiber loss during abrasion the fibers are strongly bound to the structures of yarn

When fabrics made from all types of yarn are in terms pilling resistance, we can see that from the Fig. 8, both pneumatic compact yarn and mechanical compact made fabric shows higher pilling resistance as the yarns contain lower hairiness than the combed and card yarn.

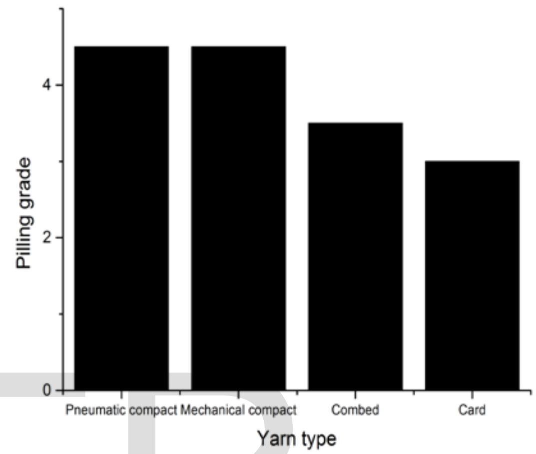

Fig. 7 Pilling grade for different types of knitted fabric

4 Conclusion

This investigation mainly consists of three parts. At the very beginning we have studied the properties of four different types of yarns; pneumatic compact yarn, mechanical compact yarn, combed yarn and carded yarn. Yarns produced from compact spinning technology provided lot of advantages over conventional ring spinning technology. We have found every test result outcome comparatively better for pneumatic yarn and gradually worse for mechanical compact yarn, combed yarn and carded yarn. Then the knit fabric was produced with constant stitch length, WPI, CPI from all the yarns and we have got variation for knit fabric production. Result shows that the knitting productivity in case of the pneumatic yarn is higher for its better quality and serially lowers for others types of yarn. The main reasons behind the lower production are yarn breakage due to lower strength, more machine cleaning time due to more dust for the higher hairiness in the yarn and higher process loss due to the loss of surface hair for the abrasion occurs during knitting.

Finally, we have studied the quality of knit fabric produced from the all types of yarn. We have tested Bursting strength, weight loss percentage and pilling grade which are related to the properties of yarn. Fabric produced from pneumatic compact yarn shows higher bursting strength compared to the others and fabric produced from card yarn shows lower bursting strength. The investigation shows that fabrics made from both two compact yarns shows higher abrasion property compared to combed and card yarn. The weight loss percentage and pilling for card yarn is higher compared to other yarn.

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Reference

1. Padaki, N.V., R. Alagirusamy, and B. Sugun, *Knitted preforms for composite applications.* Journal of industrial textiles, 2006. **35**(4): p. 295-321.
2. Spencer, D.J., *Knitting technology: a comprehensive handbook and practical guide*. Vol. 16. 2001: CRC Press.
3. Gordon, S. and Y.-l. Hsieh, *Cotton: Science and technology*. 2006: Woodhead Publishing.
4. Spink, A., et al., *Purls of wisdom: A collectivist study of human information behaviour in a public library knitting group.* Journal of Documentation, 2007. **63**(1): p. 90-114.
5. Ganesan, S., A. Venkatachalam, and V. Subramaniam, *Fibre migration in compact spun yarns: Part II–Mechanical compact yarn.* 2007.
6. Barella, A. and A. Manich, *Yarn hairiness: a further update.* Textile Progress, 2002. **31**(4): p. 1-44.
7. Hunter, L., *Mohair: a review of its properties, processing and applications*. 1993.
8. Manonmani, G., et al., *Effect of Ring and compact cotton spun yarn characteristics on physical and comfort properties of knitted fabrics.* Research Journal of Textile and Apparel, 2013. **17**(3): p. 68-82.
9. Altas, S. and H. Kadoğlu, *Comparison of conventional ring, mechanical compact and pneumatic compact yarn spinning systems.* Journal of Engineered Fibers and Fabrics, 2012. **7**(1): p. 87-100.
10. Lewandowski, S., R. Drobina, and I. Józkowicz, *Comparative analysis of the ring spinning process, both classic and compact: theoretical reflections. Part 1: Elaboration of the statistical model based on multiple regression.* Fibres & Textiles in Eastern Europe, 2010. **18**(4): p. 81.
11. Huang, Z.-M. and S. Ramakrishna, *Modeling mechanical properties of knitted fabric composites-Part I: Overview and Geometric Description.* Science & Engineering of Composite Materials, 2002. **10**(3): p. 163-188.
12. de Araujo, M. and R. Fangueiro, *Weft knitted structures for industrial applications.* Advances in Knitting Technology. Oxford: Woodhead, 2011: p. 136-170.
13. HASSAN, N., *An investigation about spirality angle of cotton single jersey knitted fabrics made from conventional ring and compact spun yarn.* Journal of American Science, 2013. **9**(11): p. 402-416.
14. YILMAZ, D., L. BÜYÜK, and Z. TOPUZ, *The Analysis of Yarn and Fabric Properties of Second Generation Compact Spinning Systems.* Tekstil Teknolojileri Elektronik Dergisi, 2013. **7**(3): p. 15-29.