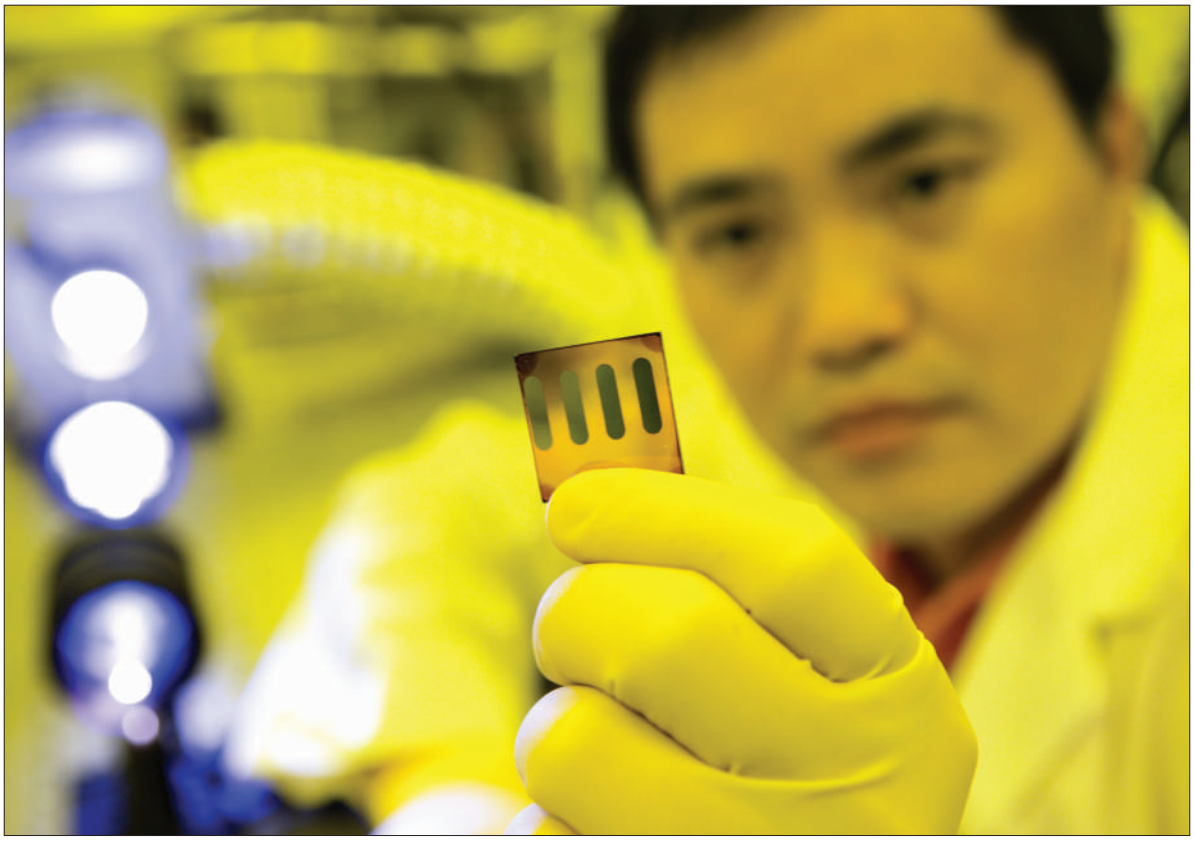

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Research Article
Effect of Feed Plate to Taker-in Distance of Carding Machine on the Quality of Cotton Card Sliver and CVC Ring-spun Yarn

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Abstract

Background and Objective: The setting parameters of the carding machine play a vital role and a small change in the setting is sufficient to produce inferior sliver quality. This experiment aimed to reveal a comparative analysis of the quality of cotton card sliver and CVC (60:40) yarn produced at different feed plate to taker-in distance in carding machine. In contrast, the other machine parameters remained fixed. **Materials and Methods:** Cotton (Sankar 6) from India and polyester (Indorama) from Thailand used as the raw material to prepare cotton card sliver and 30 Ne CVC (60:40) yarn. The experimental settings from feed plate to taker-in of carding machine were 12, 16, 20, 24 and 28 thou (1 thou = 0.001 inches). The quality parameters of cotton card sliver such as unevenness, NRE%, short fiber content and the quality parameters of CVC yarn like unevenness, thin place, thick place, neps, imperfection index, strength were tested and analyzed. **Results:** With the increase of feed plate to taker-in distance, the cotton card sliver showed a gradual increase in unevenness and short fiber content and decrease in NRE%. The results of cotton card sliver directly reflected on the quality of individual yarn, i.e., with the increase of mentioned distance yarn had higher unevenness and lower strength. **Conclusion:** The feed plate to taker-in distance 12 thou shows the significant improvements in cotton card sliver and CVC yarn quality. Further increasing of feed plate to taker-in distance causes considerable deterioration of cotton card sliver and CVC yarn quality.

Key words: Carding, feed plate, taker-in, thou, neps, CVC, unevenness, CSP

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The general operations for yarn manufacturing are blow room, carding, drawing, twisting and spinning[1]. In the processing sequence of spinning machinery, the blow room opens the fiber material to tufts or flocks. The proverbs of the experts "The Card is the heart of the Spinning Mill" and "Well Carded is half spun" demonstrate the vast significance of carding for the outcome of the spinning operation and is a term very extensively used by all those concerned with spinning technology[2-4]. After blow room, carding is the first and only machine (in card process), which can reduce neps (small knot of entangled fibers), seed coat neps and the remaining impurities which cannot be removed by blow room section. The carding machine is the first stage where the fibers start to be straightened and get some orientation in a common direction[5]. The well-cleaned material processed into a rope-like one called a sliver[6]. The better quality of the card sliver depends on several factors such as trash and neps content in fibers, card web evenness, fiber parallelization, fiber-to-fiber separation and minimizing short term variation in sliver thickness[7]. The setting parameters of a carding machine play an important role and a small change in the setting is enough to produce inferior sliver quality[4]. Usually, the quality of the produced yarn is very much dependent on the quality of the sliver. The carding machine consists of a feed plate, feed roller, cylinder, taker-in, doffer, flats, web-forming zone, calender rollers, coiler zone and other auxiliary components as shown in Fig. 1. The carding zone plays a major role in fiber individualization. Here fibers are picked apart by the cylinder from flats. Effective fiber opening is done by stationary flats which employed in the entry and exit of cylinder[8]. The function of the doffer is to deliver the fibrous web to the web-forming region. The coiler zone helps the web to condense and convert into sliver in the web-forming zone. The sliver then gets deposited in the can, which required for the subsequent process[9].

The taker-in zone comprises a feed plate, feed roller, taker-in and mote knives as shown in Fig. 2. Lap or fiber matt is held between the fluted feed roller and the smooth-curved surface of the feed plate under a particular load and is fed to the taker-in part by the revolutions of the feed roller. The feeding to the taker-in can be done in 2 ways, that is, counter feeding and concurrent feeding[10]. The following factors significantly influence the processing of the fiber tuft in the taker-in zone: feed roller speed, setting between the feed plate and the taker-in, feed fiber matt homogeneity and its parameters, feeding type-counter or concurrent, taker-in speed, number of taker-in, setting between taker-in and mote knife and taker-in wire specifications[5]. The position of the

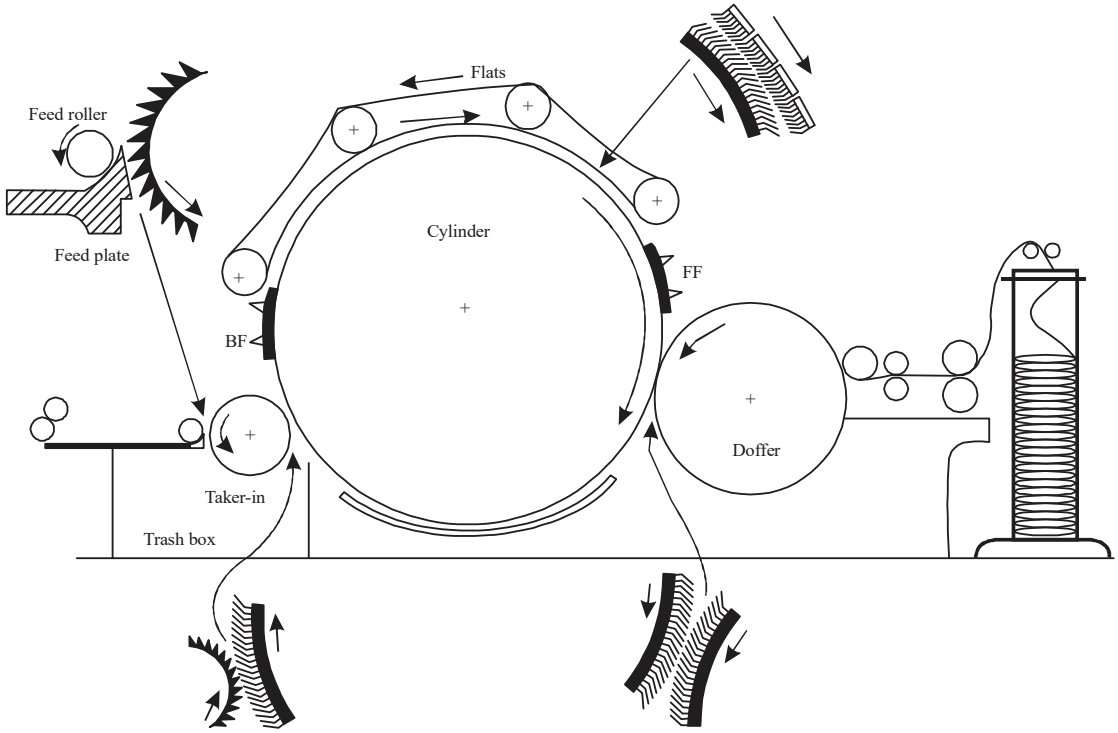

Fig. 1: Diagram of different elements of a carding machine
Source: Lawrence[6]

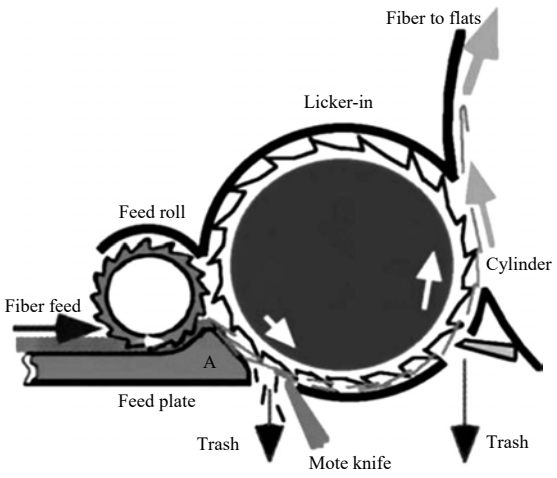

Fig. 2: Taker-in zone
Source: Lord[5]

fibers in the feed material and the contact point of taker-in wire play a crucial role in determining the fiber stress[11]. The setting between the feed plate and the taker-in is around 0.45-0.7 mm, depending upon the feed weight and fiber type. Fiber rupture often occurs when a closer setting kept between the feed plate and the taker-in[12].

For the last three decades,'cotton carding machine pass through several improvements[13]. Several numbers of research was done to find out the optimum setting parameter for a carding machine to produce a good quality card sliver. Sun and Shao[14] worked on the effect of wind flow of web cleaner in a carding on the quality of card sliver and found neither too large nor too small wind flow at backplate are favorable for card sliver quality. Sun *et al.*[15] studied on different cotton web cleaner position in the carding machine's back cover guard and its influence of the yarn quality. Many researchers studied the effect of elementary process variables on sliver and yarn properties. Bagwan and Jadhav[4] suggested various parameter settings of carding machines to get the optimum quality at carding. Some research evidenced that the improved carding can be done by reducing cylinder load, which in turn improves the yarn evenness[7]. Ghosh and Bhaduri[16] found that the card web is influenced mainly by cylinder and doffer speeds and the hank of the delivered sliver. Zhang and Sun[17] and Sun[18] studied on the influences of carding machine back stationary flat gauge and choice of taker-in speed. Simpson *et al.*[19] worked on the effect of carding rate and cylinder speed on fiber hooks and spinning performance and found increased carding rate increased minority and decreased majority hooks. The literature revealed that the process parameters of the carding machine have a significant impact on yarn quality. Although some research efforts have made on different process parameters, there is a lack of detailed research on the influence of feed plate to taker-in distance in the carding machine on the quality of card sliver and CVC yarn. In current research, an attempt has taken to investigate and analyze the effect of feed plate to taker-in distance on cotton card sliver and CVC (60:40) yarn properties.

MATERIALS AND METHODS

Experimental site: The study carried out at Prime Textile Mills Ltd., located at Nandalapur, Pagla, Narayanganj, Dhaka, Bangladesh. It took 20 days to do experimental study in August, 2019.

Materials: Cotton (Sankar 6) from India and polyester (Indorama) from Thailand were used as the raw materials to prepare cotton card sliver and CVC (60:40) yarn. The natural cotton fiber properties tested with the help of Uster HVI and AFIS Pro, according to the standard testing conditions[20] and the properties of polyester fiber provided by the suppliers. Properties of cotton and polyester fibers are shown in Table 1.

Research procedure: At first raw cotton was supplied in blow room line-1 and hand-mixed polyester/cotton fiber (PC) of 90:10 ratio supplied in blow room line-2. From line-1 carding machine, cotton slivers produced with 140 m min^{-1} delivery speed and 12 thou feed plate to taker-in distance, which fed to breaker draw frame to produce drawn cotton sliver. From line-2 carding machine, PC slivers produced, which supplied to breaker draw frame and provide drawn PC sliver. Then 4 can cotton drawn sliver of 440 grain/6 yd fed into 1st blending draw frame with 4 can PC sliver of 295 grain/6 yd and produce 60:40 ratio cotton/polyester drawn sliver. After that, the slivers passed through 2nd blending draw frame and finisher draw frame with 6 doublings. Finisher drawn slivers fed into simplex to produce rovings of 0.80 Ne from which 30 Ne (60:40) CVC (cotton/polyester) yarn manufactured in ring frame. The same procedure was carried out for 16, 20, 24 and 28 thou feed plate to taker-in distance in line-1 cotton carding machine to produce yarn keeping all other machine parameters fixed.

Data collection: Yarn samples conditioned at (20±3)°C temperature and (65±2) % RH according to the standard[20]. All cotton card sliver from line-1 and 30 Ne CVC (60:40) yarn produced from ring frame were taken for testing with Uster AFIS Pro, Uster Auto Sorter-5, Uster Tester-4. After then, tensile strength was done with the help of a lea strength tester machine.

Table 1: Important properties of cotton and polyester fibers

Fiber	Origin	Length (mm)	Strength (g den^{-1})	Fineness (μg inch^{-1})
Cotton	India	29-32	4	3.8
Polyester	Thailand	29-30	6	4.2

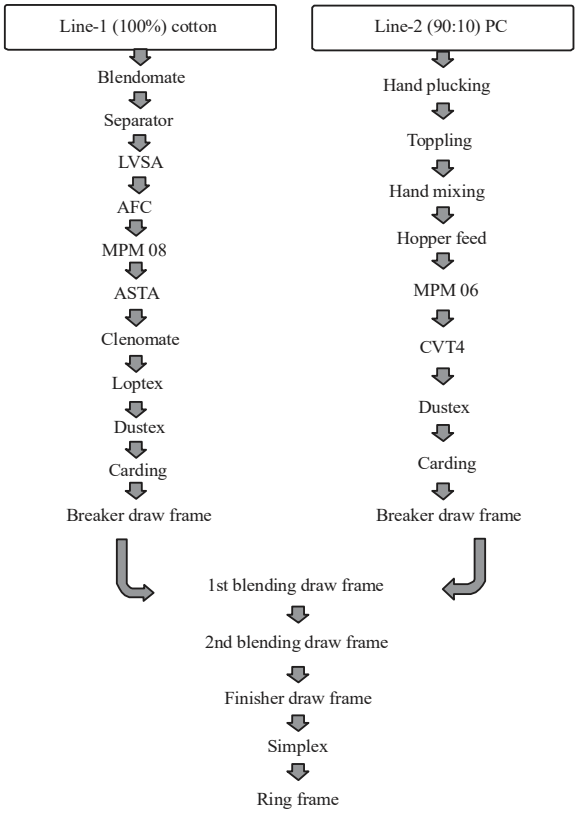

Fig. 3: Flowchart for CVC (60:40) yarn production

Experimental design: There are several ways to blend different fiber materials but over time, three ways have become established for blending manmade fibers in the modern spinning mill:tuft blending at the start of blow room process, tuft blending at the end of blow room process and sliver blending at drawing stage[21]. In this work combination of two blend processes used, one is tuft blending at the start of the blow room process (line-2) and another one is sliver blending at draw frame stage (blend line-1 and line-2 sliver). The process flowchart for producing CVC (60:40) yarn is shown in Fig. 3.

Parameter measured

Short fiber content and neps: Short fiber content by number and weight, neps content in cotton card sliver and neps removal efficiency (NRE%) of cotton carding was assessed using Uster AFIS Pro for different feed plate to taker-in distance. For each feed plate to taker-in distance, 5 readings were taken and then, averages calculated:

$$\text{NRE (\%)} = \frac{\text{Neps content of card matt} - \text{Neps content in card sliver}}{\text{Neps content of card matt}} \times 100 \quad (1)$$

Unevenness: The produced cotton card sliver samples from line-1 tested for their uniformity using Uster Tester-4. For sliver unevenness, 5 cans were selected randomly for each feed plate to taker-in distance. From each can, ten readings of unevenness (Um%) noted-the mean sliver unevenness (Um%) calculated from the 50 individual readings. For yarn unevenness, 10 ring bobbins tested for each feed plate to taker-in distance and the average was calculated.

Unevenness percentage is the mass deviation of the unit length of material. It is caused by uneven fiber distribution along the length of the sliver or yarn:

$$\text{Unevenness, Um (\%)} = \frac{\text{Mean deviation}}{\text{Mean}} \times 100 \quad (2)$$

The coefficient of variation (CVm%) is commonly used to define variability in handling large quantities of data statistically. It is currently possibly the most widely known way of quantifying unevenness:

$$\text{Coefficient of variation CVm (\%)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100 \quad (3)$$

Imperfection index: Imperfection index is the sum of thick places, thin places and neps per km of yarn:

$$\text{Imperfection index} = \text{Thick places (+50\%) km}^{-1} + \text{Thin places (-50\%) km}^{-1} + \text{Neps (200\%) km}^{-1} \quad (4)$$

Thin place (-50%): A place in the yarn exceeds -50% with respect to mean yarn cross-section and length is 10 mm.

Thick place (+50%): A place in the yarn exceeds +50% with respect to mean yarn cross-section and length is 10 mm.

Neps (+200%): A place in the yarn exceeds +200% with respect to mean yarn cross-section and length is up to 4 mm.

Hairiness: Hairiness is measured using Uster Tester-4. Hairiness is the total length of protruding fibers within the measurement field of 1 cm length.

Count and strength: Yarn count was determined using Auto Sorter-5 and it gave direct reading. Lea strength of yarn was calculated using lea strength tester:

$$\text{Yarn strength} = \text{yarn count (Ne)} \times \text{lea strength (pound)} \quad (5)$$

Statistical analysis: Data were evaluated and summarized by using Microsoft excel and necessary statistical equations were used to determine frequencies of variation in cotton card sliver and CVC (60:40) yarn thickness to identify the quality parameter.

RESULTS

The results after testing the cotton card sliver produced from the line-1 carding machine with changing feed plate to taker-in distance on Uster AFIS Pro and Uster Tester-4 have been shown in Table 2. Yarn test results found from Uster Tester-4 and lea strength tester have been shown in Table 3.

Unevenness of sliver: From Fig. 4a, b, it is observed that at feed plate to taker-in distances 12, 16, 20, 24 and 28 thou, the corresponding Um (%) and CVm% of cotton card sliver are 2.25, 2.33, 2.92, 3.05 and 3.37 and 2.85, 2.93, 3.67, 3.82 and 4.24, respectively, which shows an increasing trend. The Um and CVm% were gradually increased up to 49% when feed plate to taker-in distance increased from 12-28 thou.

Neps content and NRE% of carding: In Fig. 4c, it is presented that when feed plate to taker-in distance was 12 thou, neps content per gram was 82, whereas at 28 thou neps content g^{-1} was 117. From Fig. 4d, it can be said that the

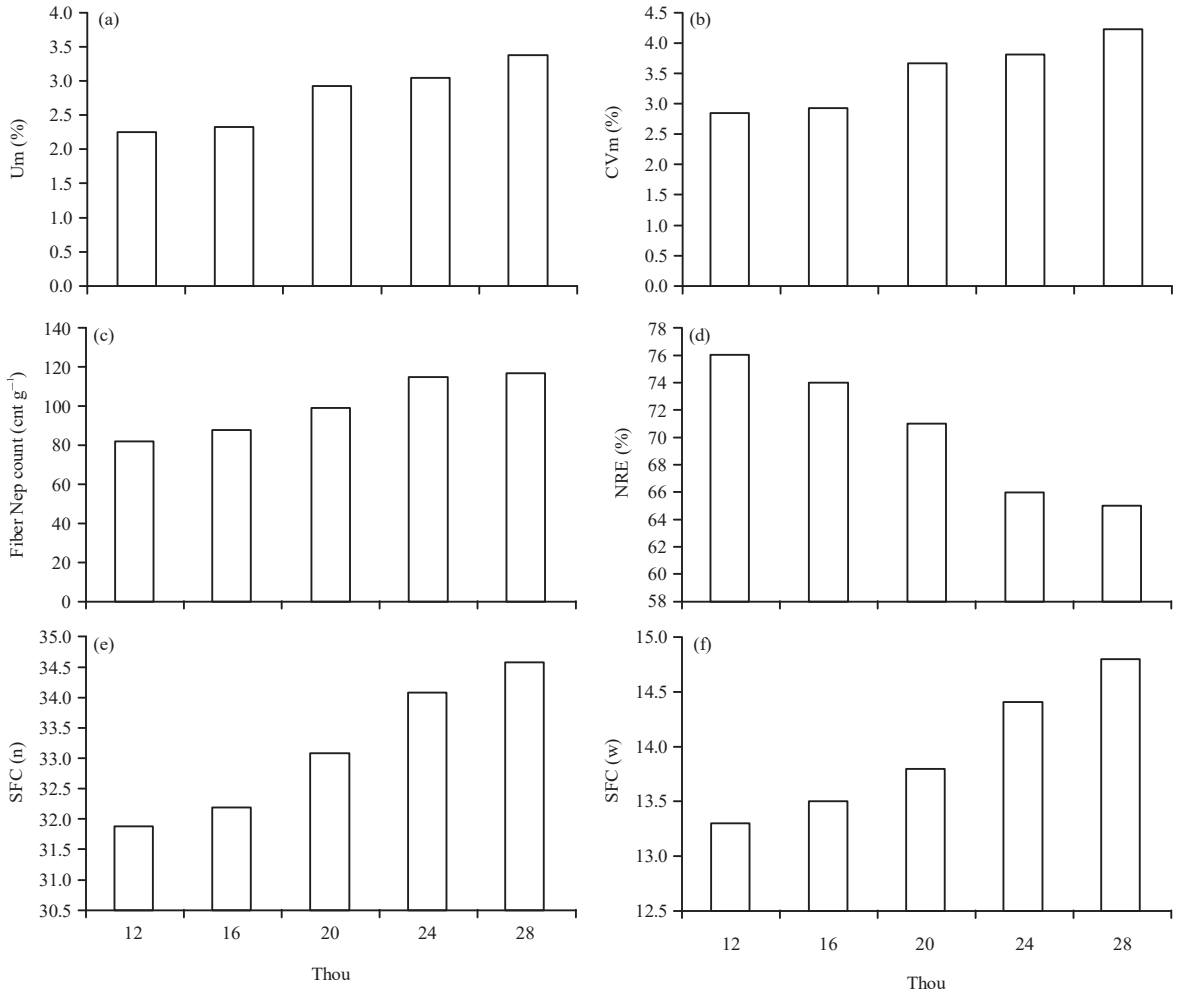

Fig. 4(a-f): Effect of feed plate to taker-in distance on (a) Um%, (b) CVm%, (c) Neps content g^{-1} (d) Neps removal efficiency (NRE%), (e) Short fiber content by number and (f) Short fiber content by weight of cotton card sliver

Table 2: Test result for line-1 cotton card sliver

	Feed plate to taker-in distance (thou)				
Quality parameters	12	16	20	24	28
Um (%)	2.25	2.33	2.92	3.05	3.37
CVm (%)	2.85	2.93	3.67	3.82	4.24
Fiber nep count (Cnt g^{-1})	82.00	88.00	99.00	115.00	117.00
Neps removal efficiency (NRE%)	76.00	74.00	71.00	66.00	65.00
Short fiber content by number ((SFC (n))	31.90	32.20	33.10	34.10	34.60
Short fiber content by weight ((SFC (w))	13.30	13.50	13.80	14.40	14.80

Table 3: Tests results for 30 Ne CVC (60:40) yarn

	Feed plate to taker-in distance (thou)				
Quality parameters	12	16	20	24	28
Um (%)	12.24	12.40	12.55	12.80	13.01
CVm (%)	15.76	16.40	16.60	16.72	16.79
Thin places (-50%) km^{-1}	3.00	7.00	8.00	11.00	12.00
Thick places (+50%) km^{-1}	391.00	449.00	496.00	538.00	564.00
Neps (+200%) km^{-1}	506.00	570.00	692.00	767.00	855.00
Imperfection index	900.00	1026.00	1196.00	1316.00	1431.00
Hairiness	5.12	5.29	5.42	5.50	5.57
CSP	2624.00	2623.00	2616.00	2600.00	2590.00

variation in the feed plate to taker-in distance affects the NRE% of carding. When the range is too close, cotton comes into action and neps removal efficiency increased.

Short fiber content of sliver: Figure 4e, f reveal that there has been a significant increase in short fiber content of cotton card sliver with the rise in feed plate to taker-in distance. When feed plate to taker-in distance was 12 thou, short fiber content by number SFC (n) was 31.9 and short fiber content by weight SFC (w) was 13.3. Whereas, when feed plate to taker-in distance increased to 28 thou, SFC (n) was increased to 0.08% as 34.6 and SFC (w) also increased to 0.11% as 14.8.

Unevenness of CVC (60:40) yarn: The Um (%) and CVm% of 30 Ne CVC (60:40) yarn highlighted in Fig. 5a, b. A clear increasing trend is seen in the unevenness of yarn with the increase of feed plate to taker-in distance. The Um (%) and CVm% were increased near about 6.3% when feed plate to taker-in distance increased from 12-28 thou.

Imperfections of CVC yarn: Figure 5c-f depicts the imperfections of CVC (60:40) yarn. In all cases, CVC (60:40) yarn imperfections ((thick places (+50%), thin places (-50%) and neps (+200%)) increase with the increase of feed plate to taker-in distance. The imperfections index value was increased tremendously to 59%, by increasing the feed plate to taker-in distance from 12-28 thou.

Hairiness of CVC (60:40) yarn: In Fig. 5g, it is revealed that when feed plate to taker-in distance was 12 thou, the hairiness was 5.12, whereas at 28 thou hairiness was 5.57. By observing the graph, it can be said that the variation in the feed plate to taker-in distance affects the hairiness of the CVC (60:40) yarn.

Strength of CVC (60:40) yarn: Figure 5h provides a significant impact on the yarn strength with the increase of feed plate to taker-in distance. From this graph, it is observed that with the increase of feed plate to taker-in distance of carding machine, count strength product(CSP) of the CVC (60:40) yarn were decreased.

DISCUSSION

The quality of the cotton card sliver and CVC (60:40) yarn improved with the closer setting of feed plate to taker-in distance in the cotton carding machine. The Um (%) and CVm% of cotton card sliver (Fig. 4a, b) and CVC (60:40) yarn (Fig. 5a, b) were increased by 49% and 6.3%, respectively with the rise in feed plate to taker-in distance. The wider setting of feed plate to taker-in distance increased the neps content and short fiber content[19] and the degree of parallelization of fiber became lower because of weak carding action. As a result, the unevenness of cotton card sliver increased and this sliver unevenness directly affected the yarn unevenness. The variation in the feed plate to taker-in distance affected the change of the neps content per gram of cotton card sliver (Fig. 4c) and NRE% of carding (Fig. 4d). When feed plate to taker-in distance was too close, less cotton number of cotton fiber came into the carding action and a large number of neps content removed by taker-in action[5]. That's why with the

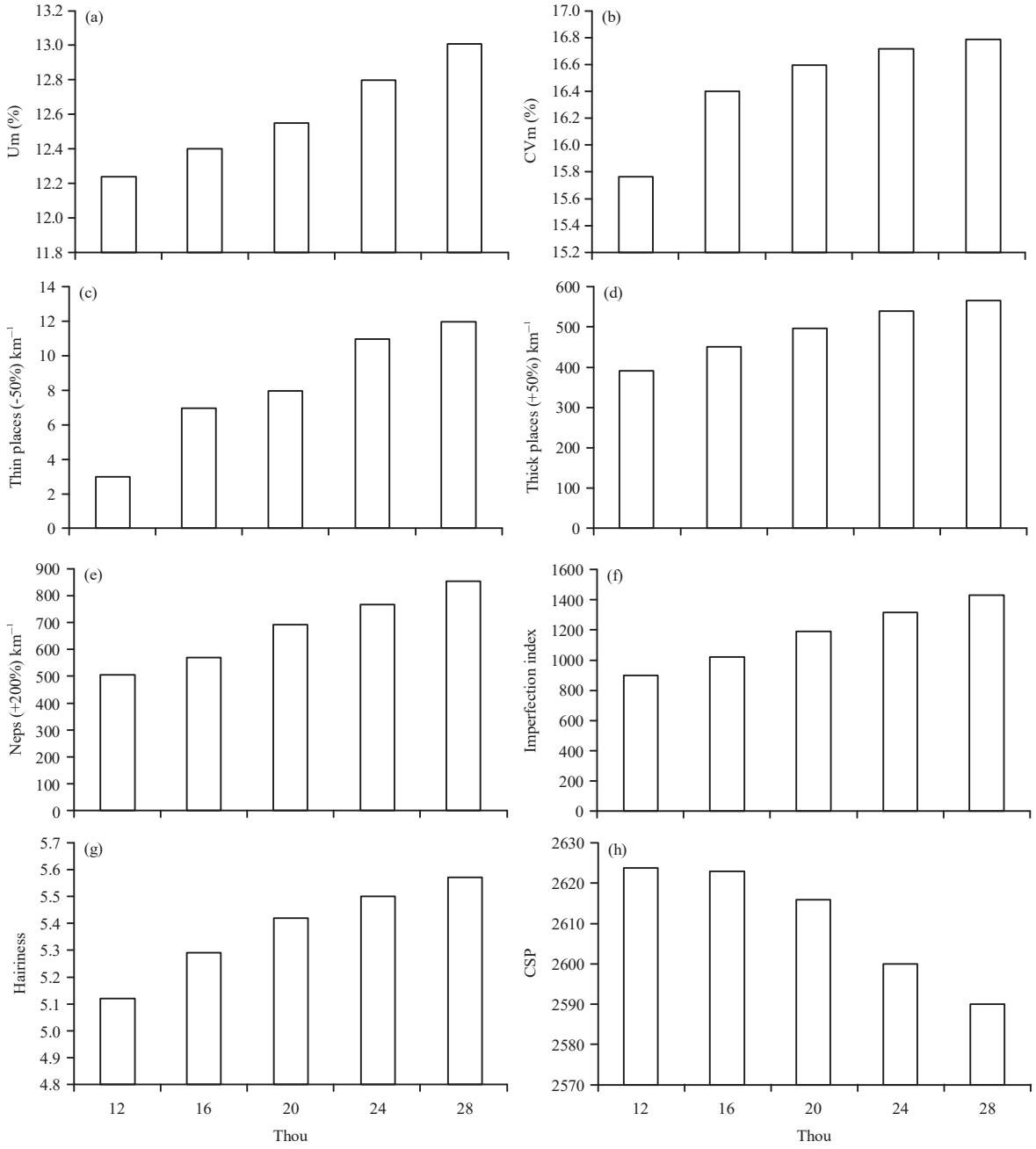

Fig. 5(a-h): Effect of feed plate to taker-in distance on the (a) Um%, (b) CVm%, (c) Thin places (-50%) km^{-1}, (d) Thick places (+50%) km^{-1} (e) Neps (+200%) km^{-1}, (f) Imperfection index, (g) Hairiness and (h) Strength(CSP) of CVC (60:40) yarn

increase of feed plate to taker-in distance, the neps content per gram of cotton card sliver increased and neps removal efficiency decreased.

There had been a significant increase in short fiber content (Fig. 4e, f) of cotton card sliver with the wider setting in feed plate to taker-in distance. In a closer setting, less amount of fiber feed and the wire of taker-in penetrated deeply into the fiber, which removed more short fibers[6]. The imperfections of CVC (60:40) yarn increased tremendously to 59% (Fig. 5c-f), by increasing the feed plate to taker-in distance from 12-28 thou. The number of short fibers and neps content proportionally related to the quality parameters of yarn[22]. With the increase of feed plate to taker-in distance of the carding machine, removing of trash, neps, short fiber, etc. became less. As a result, the degree of fiber parallelization became less, which increased the variation in sliver as well as

yarn thickness. Short fibers were the leading cause of hairiness. At closer feed plate to taker-in distance, more short fibers were removed (Fig. 5g) because of precise carding action. There is an association between feed plate to taker-in distance and yarn strength (Fig. 5h). A possible elucidation for this might be that by increasing the feed plate to taker-in distance of carding machine, short fibers and unevenness increased. Hence, the addition of floating fiber, less twist insertion and less fiber migration occurred, which resulted in decreasing of in yarn strength. From the all graphical representation, it might be conclude that if feed plate to taker-in distance increase, less amount of short fibers and neps removed that resulted in higher Um (%) and CVm% of cotton card sliver. The quality of the cotton card sliver reflected the quality of the CVC (60:40) yarn, such as increasing the unevenness, imperfections, hairiness and decreasing the strength. This research recommends 12 thou as the appropriate feed plate to taker-in distance because of further increasing of distance causes considerable deterioration of cotton card sliver and CVC (60:40) yarn quality. The key finding of this study suggests that better quality CVC (60:40) yarn in the spinning mill can be achieved through lower feed plate to taker-in distance in the cotton carding machine.

CONCLUSION

The study demonstrates the quality of cotton card sliver and 30 Ne CVC (60:40) yarn produced from different feed plate to taker-in distance in the cotton carding machine. The quality of cotton card sliver and CVC (60:40) yarn improved at closer feed plate to taker-in distance. All the quality parameters of cotton card sliver and CVC (60:40) yarn investigated in this research. With the increase of feed plate to taker-in distance, the cotton card sliver showed a gradual increase in unevenness, short fiber content and a decrease in NRE%. The results of cotton card sliver were directly reflected on the quality of individual yarn, i.e., with the increase of feed plate to taker-in distance CVC (60:40) yarn had higher unevenness and lower strength. Feed plate to taker-in distance 12 thou shows the significant improvements in cotton card sliver and CVC (60:40) yarn quality.

SIGNIFICANCE STATEMENT

This article has concentrated on the changes in elementary process parameters of the carding machine for producing better quality card sliver as well as yarn. Among many variables of the machine parameters, such as feed speed, take-in speed, cylinder speed, flat speed, delivery speed, chute feed speed, we worked on feed plate to taker-in distance. Although some research efforts have made on other process parameters, there is a lack of detailed research regarding the influence of feed plate to taker-in distance in the carding machine. Hence, in this work, an attempt has been taken to investigate and analyze the effect of feed plate to taker-in distance on card sliver and CVC (60:40) yarn properties.

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REFERENCES

1. Rashid, M.M., K.A. Motaleb and A.N. Khan, 2019. Effect of flat speed of carding machine on the carded sliver and yarn quality. J. Engineered Fibers Fabrics, Vol. 14. 10.1177/1558925019845183.
2. Chaudhari, V.D., P.P. Kolte and A.D. Chaudhari, 2017. Effect of card delivery speed on ring yarn quality. Int. J. Text. Eng. Process, 3: 13-18.
3. Goktepe, F., O. Goktepe and T. Suleymanov, 2003. The effect of the licker-in speed on fibre properties on modern carding machines with a triple licker-in. J. Text. Inst., 94: 166-176.
4. Bagwan, A.S.A. and K. Jadhav, 2016. Card setting: A factor for controlling sliver quality and yarn. J. Text. Sci. Eng., Vol. 6, No. 2. 10.4172/2165-8064.1000246.
5. Lord, P.R., 2003. Handbook of Yarn Production: Technology, Science and Economics. Woodhead Publishing Limited, Cambridge, UK., ISBN: 978-1-85573-696-2, Pages: 504.
6. Lawrence, C.A., 2003. Fundamentals of Spun Yarn Technology. CRC Press, Boca Raton, FL., USA., ISBN-13: 9781566768214, Pages: 552.
7. Nerurkar, S.K., 1979. Detailed analysis of carding quality and its influence on processing and yarn properties. Indian J. Text. Res., 4: 63-70.
8. Lee, M.E.M. and H. Ockendon, 2006. The transfer of fibres in the carding machine. J. Eng. Math., 54: 261-271.
9. Manohar, J.S., A.K. Rakshit and N. Balasubramanian, 1983. Influence of rotor speed, rotor diameter and carding conditions on yarn quality in open-end spinning. Text. Res. J., 53: 497-503.
10. Kumar, R.S., 2014. Process Management in Spinning. CRC Press, Boca Raton, FL., USA., ISBN-13: 9781482208368, Pages: 416.

11. Sengupta, A.K., N. Vijayaraghavan and A. Singh, 1983. Studies on carding force between cylinder and flats in a card: Part I-Effect of machine variables on carding force. Indian J. Text. Res., 8: 59-63.
12. Alagirusamy, R., 2013. Process Control in Blowroom and Carding Operations. In: Process Control in Textile Manufacturing, Majumdar, A., A. Das, R. Alagirusamy and V.K. Kothari (Eds.). Chapter 6, Woodhead Publishing, Cambridge, UK., ISBN: 978-0-85709-027-0, pp: 132-157.
13. Lawrence, C.A., A. Dehghani, M. Mahmoudi, B. Greenwood and C. Iype, 2000. Fibre dynamics in the revolvingflats card, part 1: A critical review. AUTEX Res. J., 1: 64-77.
14. Sun, P.Z. and J.D. Shao, 2006. Influence of wind's flow of web cleaner in a carding machine on the quality of card sliver. J. Text. Res., 27: 74-76.
15. Sun, P.Z., X.C. Yu, J.D. Shao, L.J. Xu and X.Z. Yu, 2005. Influence on yarn quality of the cotton web cleaner position in carding machine back cover guard. Cotton Text. Technol., 1: 13-16.
16. Ghosh, G.C. and S.N. Bhaduri, 1968. Studies on hook formation and cylinder loading on the cotton card. Text. Res. J., 38: 535-543.
17. Zhang, Z.D. and P.Z. Sun, 2007. Influences of carding machine back stationary flat gauge on neps and impurities. Cotton Text. Technol., 2: 1-5.
18. Sun, P.Z., 2005. Research and choice of licker-in speed of carding machine. Cotton Text. Technol., 10: 15-19.
19. Simpson, J., L.B. DeLuca and L.A. Fiori, 1967. Effect of carding rate and cylinder speed on fiber hooks and spinning performance for an irrigated acala cotton. Text. Res. J., 37: 504-510.
20. ASTM., 2004. Standard practice for conditioning and testing textiles. ASTM D1776-04, ASTM International, West Conshohocken, PA., USA. https://www.astm.org/DATABASE.CART/HISTORICAL/D1776-04.htm
21. Klein, W., 2014. The Rieter manual of spinning. Rieter Machine Works Ltd., Switzerland. https://www.rieter.com/services/expertise-new/the-rieter-manual-of-spinning
22. Ochola, J., J. Kisato, L. Kinuthia, J. Mwasiagi and A. Waithaka, 2012. Study on the influence of fiber properties on yarn imperfections in ring spun yarns. Asian J. Textile, 2: 32-43.