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Study on Licker-In and Flat Speeds of Carding Machine and Its Effects on Quality of Cotton Spinning Process

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Abstract

Spinning has a significant influence on all textile processes. Combinations of all the capital equipment display the process' critical condition. By transforming unprocessed fibers into carded sliver and yarn, the carding machine serves a critical role in the textile industry. The carding machine's licker-in and flat speeds are crucial operational factors that have a big influence on the finished goods' quality. The purpose of this study is to examine the link between licker-in and flat speeds and how they affect the yarn and carded sliver quality. A thorough experimental examination on a carding machine was carried out to accomplish this. The carded sliver and yarn produced after experimenting with different licker-in and flat speed combinations were assessed for important quality factors including evenness, strength, and flaws. To account for changes in material qualities and machine settings, the study also took into consideration the impact of various fiber kinds and processing circumstances. The findings of the investigation showed a direct relationship between the quality of the carded sliver and yarn and the licker-in and flat speeds. Within a limited range, greater licker-in speeds were shown to increase carding efficiency and decrease fiber tangling. On the other hand, extremely high speeds led to more fiber breakage and neps. Higher flat speeds, on the other hand, helped to enhance fiber alignment, which increased the evenness and strength of the carded sliver and yarn. Additionally, it was discovered that the ideal blend of licker-in and flat rates varied based on the fiber type and processing circumstances. When being carded, various fibers displayed distinctive behaviors that necessitated adjusting the operating settings in order to provide the necessary quality results. The study also determined the crucial speed ratios between the licker-in and flat speeds that reduced fiber breakage and increased the caliber of the finished goods. The results of this study offer useful information for textile producers and process engineers to improve the quality of carded sliver and yarn while maximizing the performance of carding machines. Operators may choose machine settings and parameter adjustments wisely by knowing the impacts of licker-in and flat speeds, which will increase textile industry efficiency, productivity, and product quality.

Keywords

Spinning Process, Carding Machine, Yarn Count, Flat, Licker-In, Sliver Hank

1. Introduction

Carding, drawing, twisting, and spinning are the main processes involved in making yarn. The carding section of a mill is sometimes referred to as the "heart of a spinning" mill because of its central importance. Everybody in the spinning industry uses the phrase "to card well is to spin well" often [1] [2] [3]. The functioning of the card has been shown to have the strongest collaboration to both quality and productivity [4] [5]. The carding process is the most crucial step in the spinning process. It has a significant impact on the overall quality of the yarn. Controlling the speeds (flat speed, taker-in speed, and cylinder speed), as well as the settings (licker-in and feed plate, licker-in and under casing elements, cylinder and flat tops, between the cylinder and doffer, and so on), are examples of process parameters that need to be managed in order to produce yarn of high quality at a cost that is relatively affordable to manufacture [6].

During the carding process, the licker-in is responsible for doing significant opening and cleaning. More than half of the fibers pass onto the surface of the main cylinder as tufts and slightly less than half as individual fibers when the opening is conducted to this level in a carding machine with a single licker-in. As a result, the licker-in provides harsh, but unfortunately not very delicate, treatment [7].

Several studies have been conducted to analyze the licker-in and flat speeds of carding machines and their effects on the quality of the carded sliver and yarn. Here are some notable past studies in this field [8]. This study investigated the influence of licker-in speed on carding process parameters and fiber properties. Experimental results showed that an increase in licker-in speed improved carding efficiency and reduced fiber entanglement. However, excessive licker-in speed led to increased fiber breakage and Neps [9] [10]. This study explored the effects of licker-in and flat speeds on yarn quality. It revealed that higher licker-in speeds within a certain range improved fiber opening and separation, resulting in higher yarn strength and improved evenness. However, beyond a certain limit, the excessive licker-in speed negatively impacted the yarn quality [11] [12]. This study focused on the impact of flat speed on carded yarn quality. Experimental findings indicated that higher flat speeds enhanced fiber alignment during carding, leading to improved evenness and strength of the carded yarn. However, excessively high flat speeds caused fiber breakage and loss of fiber length [13]. In their research work, Z. Zhidan and S. Pengiz [14] conducted research to identify the speed of the licker-in cylinder and the layout between the fixed segments and the licker-in cylinder in the rear carding zone of the card. H. R. Sheikh [15] also in his research studied the influence of the fixed segments of the carding machine on the produced carding sliver. D. Simpson [16] and others looked at how the main drum's rotation and carding speed affected the productivity of the spinning process [17]. This study has identified that the quality of card slivers directly reflects the quality of yarns such as decreasing unevenness, imperfections and increasing strength. The higher the flat speed, and in this task, the highest flat speed, the better the quality of the yarn becomes, *i.e.* 320 mm/min is the optimum flat speed. The peculiarity of low-grade cotton fibers and fibrous waste is that they contain a large number of defective fibers and trash. Therefore, this kind of fiber must be given special attention during carding and intensive processing. On a card, the cleaning process is mostly carried out in the area of the licker-in cylinder. Licker-in cylinder speed is an important factor in maximizing fiber separation and cleaning. When studying the composition of fibrous waste, it was determined that they contain many tangled fibers and seed skins with fibers. Defects in fibrous waste led to the formation of a number of problems during the process of silver forming and spinning, as well as a decrease in the quality of the yarn produced.

2. Material & Methods

2.1. Materials

West African cotton originated from Benin and was utilized as the raw material to plan tests of sliver and yarn. The raw cotton fiber properties were tested with the assistance of USTER HVI 1000. The sliver and yarn properties were tested with the assistance of USTER AFIS PRO 2 and USTER EVENNESS TESTER-6 respectively as per the standard testing conditions that appeared in **Table 1**. Sliver fineness Ne 0.119 and one sort of yarn count (Ne 30) were produced and utilized as tested sample in Mondol Spinning Mills Ltd.

Table 1. Properties of Benin raw cotton recorded from USTER HVI 1000.

Properties	Value
SCI (Spinning Consistency Index)	123.17
Micronaire value (μg/in)	4.47
UHML (Upper half mean length)	28.47 mm
Strength	29.60 g/tex
Yellowness (+b)	10.35
Reflectance (Rd)	73.10

Continued

Color grade upland	12.2
Maturity index	0.87
Uniformity index (%)	81.50
Elongation (%)	4.90
Short fiber index (%)	9.80

2.2. Methods

2.2.1. Carding Process

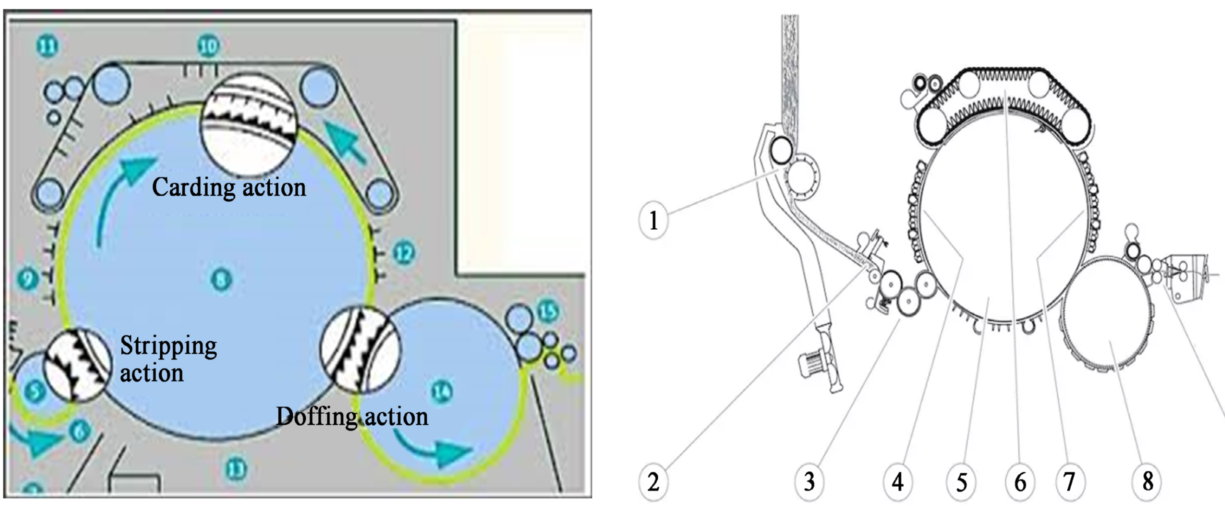
In this experiment, the licker-in and flat of Trutzschler carding machine (TC 19i) was driven at four different licker-in speeds, that is 960, 1020, 1100 and 1180 rpm and at three different flat speeds, that is 300, 340, and 380 mm/min, by keeping all other parameters unchanged. Table 2, Table 3 contains the carding machine's process parameters. In Figure 1 the diagram represents Various Parts of a Carding Machine. Four carded slivers were delivered for every level of licker-in speed to take care of the output of breaker draw frame. Three carded slivers were delivered for every level of flat speed to take care of the output of breaker draw frame.

Table 2. Process parameters of carding machine TC19i in Licker-in Speeds.

Technical Data	Settings	Technical Data	Settings
Sliver hank	418 - 422 grain/6 yds.	Feed roller to Licker-in	1.22 mm
DFK Feed roller diameter	200 mm	Licker-in to cylinder	0.30 mm
Licker in diameter	172.5 mm	Back stationary flat to cylinder	0.35 mm, 0.40 mm, 0.65 mm
Licker in speed $1^{st}/2^{nd}/3^{rd}$	960/1540/2040, 1020/1600/2100, 1100/1680/2180 and 1180/1760/2260 rpm	Revolving flat to cylinder (Auto-Monitor setting)	0.08 mm & Fixed-0.15 mm
Licker in PPSI	1) 66, 10˚	Front stationary flat to cylinder	0.35 mm
	2) 164, 20˚	Cylinder to doffer	0.30 mm
	3) 210, 20˚	Doffer. to take of Roller	0.25 mm
Cylinder diameter	1295 mm	Take-off roller to delivery roller	0.15 mm
Cylinder speed	560 rpm	Delivery speed	269 m/min
Cylinder PPSI	949, 40˚	Doffer dia.	700 mm
No. of flats	84	Doffer PPSI	367, 30˚
No. of flats in action	30	Doffer speed	(Around 286 m/min)
Flat PPSI	580	Flat speed	380 mm/min

Table 3. Process parameters of carding machine TC19i in flat speeds.

Technical Data	Settings	Technical Data	Settings
Sliver hank	418 - 422 grain/6 yds.	Feed roller to Licker-in	1.22 mm
DFK Feed roller diameter	200 mm	Licker-in to cylinder	0.30 mm
Licker in diameter	172.5 mm	Back stationary flat to cylinder	0.35 mm, 0.40 mm, 0.65 mm
Licker in speed $1^{st}/2^{nd}/3^{rd}$	1020/1600/2100 rpm	Revolving flat to cylinder (Auto-Monitor setting)	0.08 mm & Fixed-0.15 mm
Licker in PPSI	1) 66, 10˚	Front stationary flat to cylinder	0.35 mm
	2) 164, 20˚	Cylinder to doffer	0.30 mm
	3) 210, 20˚	Doffer. to take of Roller	0.25 mm
Cylinder diameter	1295 mm	Take-off roller to delivery roller	0.15 mm
Cylinder speed	560 rpm	Delivery speed	269 m/min
Cylinder PPSI	949, 40˚	Doffer diameter	700 mm
No. of flats	84	Doffer PPSI	367, 30˚
No. of flats in action	30	Doffer speed	(Around 286 m/min)
Flat PPSI	580	Flat speed	300, 340, 380 mm/min



1. DFK feed roller,
2. Card feed roller,
3. Licker-in unit (03 roller),
4. Pre carding area with fixed flats,
5. Main Cylinder,
6. Revolving flats (Magno tops),
7. Post carding area with fixed flats,
8. Doffer,
9. Web doffing zone.

Figure 1. Various parts of a carding machine.

2.2.2. Spinning Process

A ring outline machine, named Jingwei (JWF1566), was utilized for producing yarn. Ne 30 checked yarn was produced from Ne 0.80 roving. In ring frame, roving was placed on same spindle for every licker-in and flat speed. Important cycle characteristics for the experiment parameter of spinning process are given in Table 4.

Table 4. Important parameters of spinning process.

Name of the Parameters	30 Ne Yarn
Drawn sliver hank	0.119 Ne
Roving hank	0.80 Ne
Twist per inch (TPI)	20.73
Ring frame speed (RPM)	15,500
Drafting arrangement (ring frame)	3 over 3
Draft (ring frame)	39.43
Doubling (breaker draw frame)	6
Doubling (finisher draw frame)	8

2.2.3. Testing of Samples

The licker-in speed and flat speed variation has an effect on the end product. Short fibers content, sliver unevenness, yarn unevenness properties, thin places, thick places, neps are influenced by the licker-in speed and flat speed.

Neps: A Nep can be defined as a small knot (or cluster) of entangled fibers consisting either entirely of fibers (*i.e.*, a fiber nep) or of foreign matter (e.g., a seed-coat fragment) entangled with fibers. Neps are produced when fibers entangle during the harvesting, ginning, and other processes [18].

Neps content is measured in AFIS. The unit of neps content is neps content per gram in the material.

The characteristics are greatly influenced by the neps-to-neps ratio:

Yarn evenness, Co-efficient of variation handle of the product.

Neps Removal Efficiency (NRE%): The neps provided to the card determine how well they are removed. The efficiency of the neps elimination will be high if we feed more neps. What is more important is the neps level in the outgoing material [18].

$$\text{Neps removal efficiency} = \frac{\left(\text{Neps content of card mat} - \text{Neps content of card sliver}\right)}{\text{Neps content of card mat}} \times 100\%$$

Unevenness: Unevenness deals with the variation in yarn fineness. This characteristic is frequently assessed as the difference in mass per unit length along the yarn. For a complete analysis of the quality of fiber assembly, along with mass diagram, a numerical value of mass variation is also necessary. The irregularity or unevenness (U%) and the coefficient of variation (CV%) are used in mathematics to accomplish this [19].

Unevenness = Mean Deviation/Mean * 100

Co-efficient of variation (CV%) = Standard Deviation/Mean * 100

Imperfection Index (IPI): Imperfections are regarded as regularly occurring flaws that depend on the source material's fiber quality. The conditions of the production machinery strongly influence the amount of the imperfections in the yarn. The total imperfection of a yarn is simply expressed by imperfection index (IPI). The sensitivity settings for the detection of imperfections are −50%/km for thin places, +50%/km for thick places and +200%/km for neps.

IPI = Thick Place (+50%) + Thin Place (−50%) + Neps (+200%) [19]

Classimat Faults: USTER Company invented a chart to indicate yarn which thick, thin & neps faults/100km shown in specific class form is called Classimat faults chart. The classification of yarn defects according to their size and length into total 23 standards classes is used extensively to clarify yarn quality, to help control spinning processes and to optimize yarn clearing at the winding stage [20].

3. Results and Discussion

3.1. Effect of Licker-In Speed on Carded Sliver

Neps Removal Efficiency (NRE%) and Neps Content per Gramme Are Shown Graphically

Figure 2's left graph shows the fluctuation in neps content in the carded slice caused by changes in the carding machine's licker-in speed.

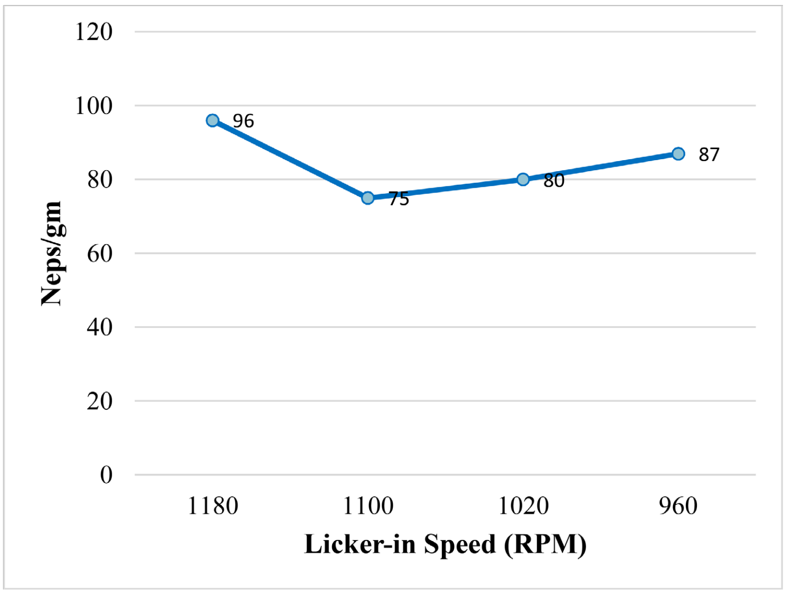


Figure 2. Effects of Licker-in speed on Neps/gm of the sliver.

By observing the graph, we can say that the variation in the licker-in speed has an effect on the variation of the neps content per gram of card sliver. When licker-in speed is raised, more flat come into touch with the fibre treatment process. So, the increase of licker-in speeds reduces the neps content per gram in the card sliver.

In the graph, we see that at licker-in speed 1180 rpm neps content per gram was 96 whereas at licker-in speed 1100 rpm neps content per gram was low 75 and then increases neps gradually with decreasing speed. So, we may conclude that with the medium licker-in speed neps content per gram of card sliver is reduced.

Figure 3 indicates the variation of NRE% in the carded sliver due to variation in licker-in speed of carding machine.

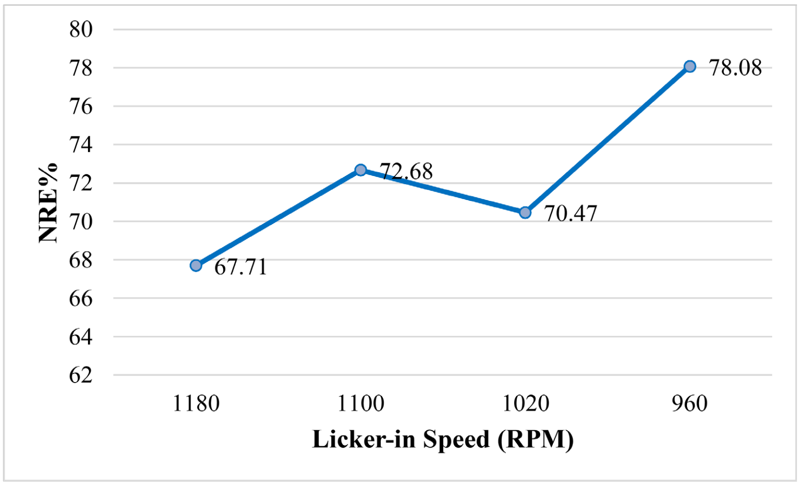


Figure 3. Effects of Licker-in speed on Neps Removal Efficiency (NRE%) of the sliver.

In the graph, we see that at licker-in speeds 960, 1020, 1100 and 1180 rpm, the NRE% are 78.08%, 70.47%, 72.68% and 67.71% respectively which is a decreasing trend.

According to the graph, the variation in licker-in speed does affect the variation in the NRE% of card sliver. There is more beating and opening of fiber flocks as licker-in speed is increased. So, the increase of licker-in speeds leads to decrease in the NRE% of the card sliver.

3.2. Effect of Licker-in Speed on 30 Ne Cotton

3.2.1. Graphical Representation of Unevenness (U%) and Co Efficient of Variance (CV%)

From the first part of Figure 4, it is much more observable that yarn unevenness increases with low and high licker-in speed. At both licker-in speed 1020 rpm and 1100 rpm, there is a steady decrease in the yarn unevenness 11.08% and 11.15% respectively.

Figure 5 makes it clear that yarn co-efficient of variation increases with low and high licker-in speed. At both licker-in speed 1020 rpm and 1100 rpm, there is a steady decrease in the yarn unevenness 14.08% and 14.18% respectively.

Hence, it can be said that at medium licker-in speed reduces the co-efficient of variation of yarn.

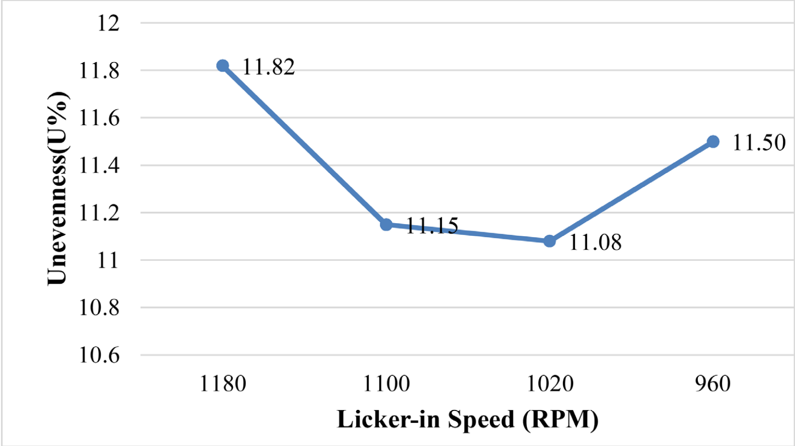


Figure 4. Effects of Licker-in speed on Unevenness (U%) of the yarn.

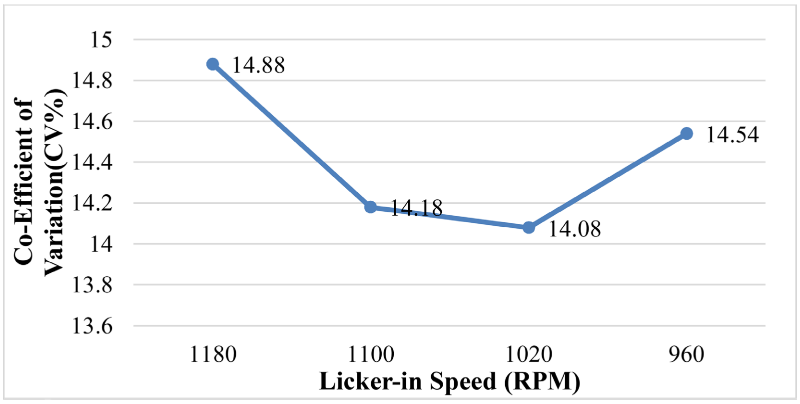


Figure 5. Effects of licker-in speed on Co-Efficient of Variation (CV%) of the yarn.

3.2.2. Graphical Representation of Thick Places (+50%/km) and Thin Places (+50%/km)

In the first graph of Figure 6, it was observed that at licker-in speed 1180, 1100 and 1020 rpm, thin places −50% are 5, 4 and 3 respectively which is a decreasing trend. But, thin places −50% is increased at 960 rpm. So, low and high licker-in speed are not suitable for decreasing thin places, optimum speed is 1020 rpm.

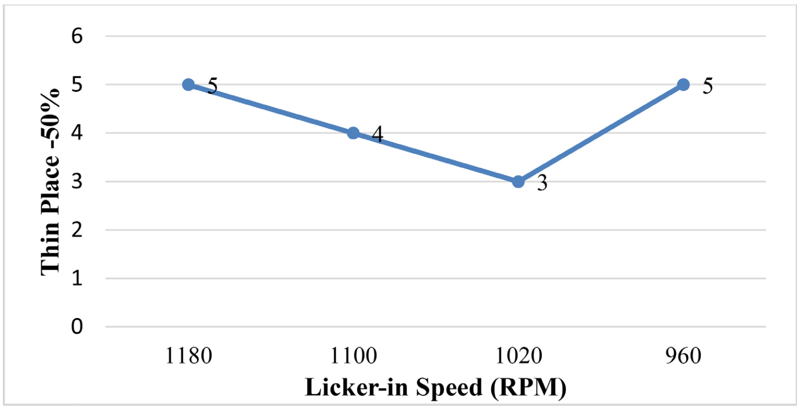


Figure 6. Effects of Licker-in speed on Thin Place −50% of the yarn.

In the first graph of Figure 7, it was observed that at licker-in speed 1180, 1100 and 1020 rpm, thick places +50% are 157, 123 and 104 respectively which is a decreasing trend. But, thick places +50% is increased at 960 rpm. So, low and high licker-in speed are not suitable for low thick places, optimum speed is 1020 rpm.

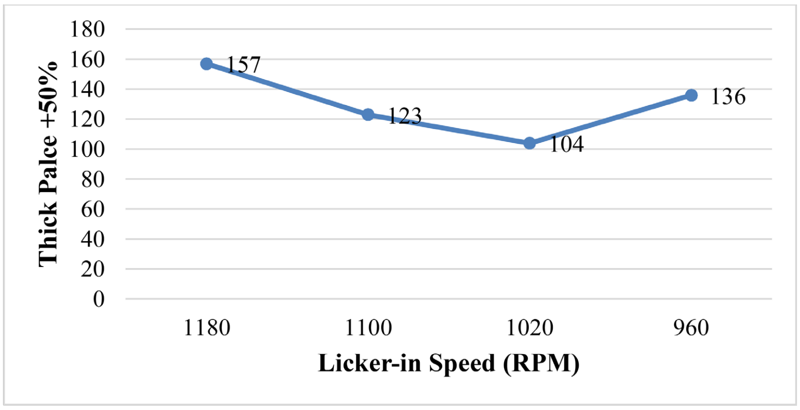


Figure 7. Effects of licker-in speed on Thick Place +50% of the yarn.

3.2.3. Graphical Representation of Neps (+200%/km) and Imperfection Index (IPI)

In left sided graph of Figure 8 it was seen that at licker-in speed 1180, rpm, neps +200% is 135 which is too high. Lowest neps have found at licker-in speed 1100 rpm which is 93, then neps is increasing with increasing speed.

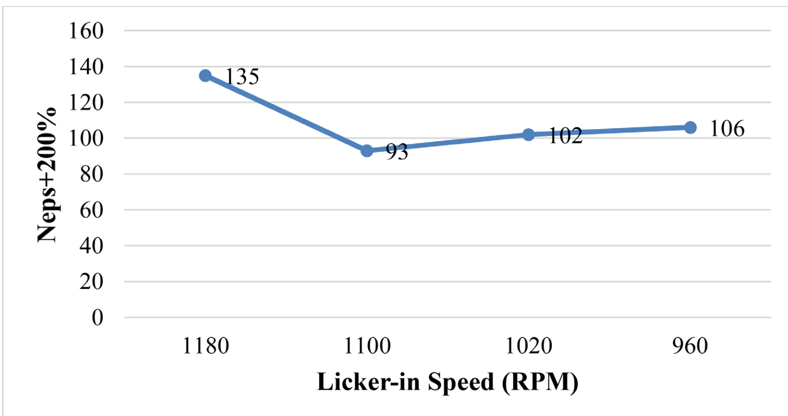


Figure 8. Effects of licker-in speed on Neps +200% of the yarn.

In Figure 9 the graph represents a significant Effects of licker-in speed on IPI. It is evident that at at licker-in speed 1180, 1100 and 1020 rpm, IPI are 297, 220 and 209 respectively which is a decreasing trend. But, IPI is increased at 960 rpm. So, low and high licker-in speed are not suitable for decreasing IPI, optimum speed is 1020 rpm.

3.2.4. Graphical Representation of Classimat Faults

In Figure 10 the graph represents a significant effect on the Classimat Faults, at licker-in speeds 960, 1020, 1100 and 1180 rpm, the Classimat Faults are 62,670.2, 63,853.3, 60,008.4 and 63,652.8 respectively which is a mixed trend. So, at licker-in speed 960 and 1100 Classimat Faults are increased and at 1020 and 1180 Classimat Faults are decreased.

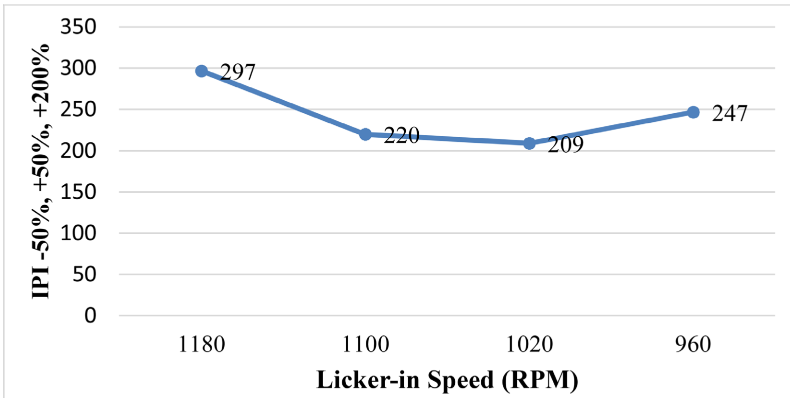


Figure 9. Effects of licker-in speed on IPI −50%, +50%, +200% of the yarn.

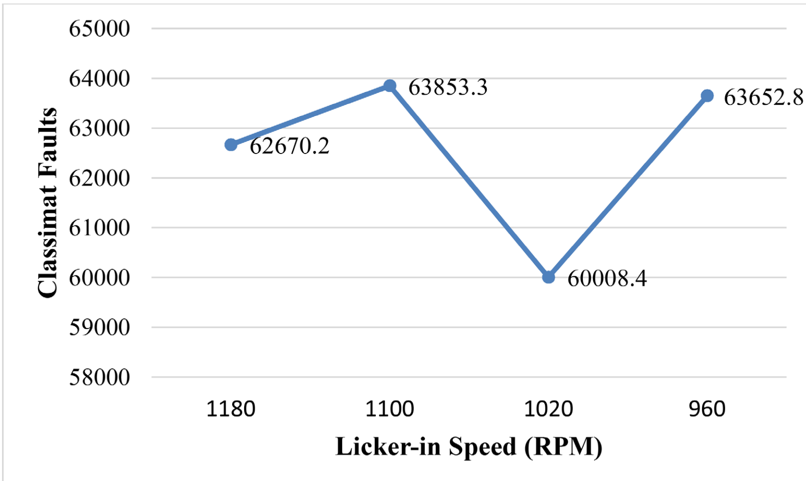


Figure 10. Effects of licker-in speed on Classimat Faults of the yarn.

3.3. Effect of Flat Speed on Carded Sliver

Graphical Representation of Neps Content per Gram and Neps Removal Efficiency (NRE%)

Figure 11's left graph shows the variation in neps content in the carded sliver caused by changes in the flat speed of the carding machine.

By looking at the graph, we may infer that the variation in flat speed affects the variation in neps content per gramme of card sliver. When flat speed is raised, more flat come into touch with the fibre treatment operation. So, the increase of flat speeds reduces the neps content per gram in the card sliver.

In the graph, we see that at flat speed 380 mm/min neps content per gram was 77 whereas at flat speed 300 mm/min neps content per gram was 77. Therefore, we can draw the conclusion that the amount of neps in a gram of card sliver decreases as flat speed increases.

Figure 12 indicates the variation of NRE% in the carded sliver due to variation in flat speed of carding machine.

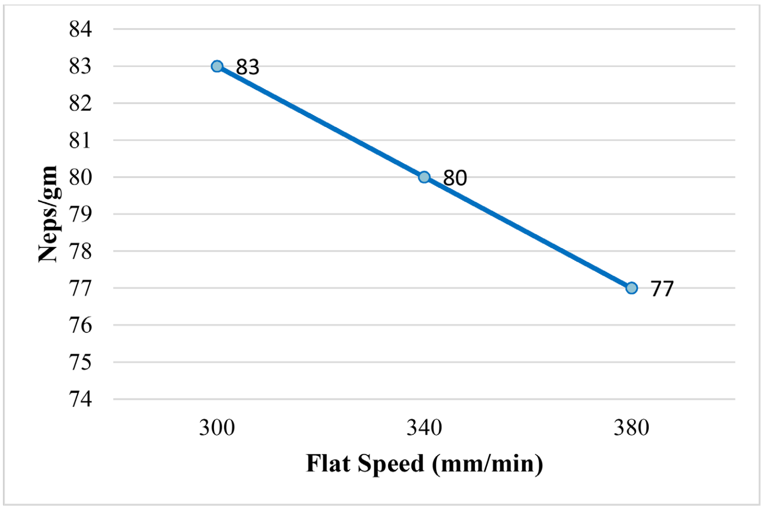


Figure 11. Effects of flat speed on Neps/gm of the sliver.

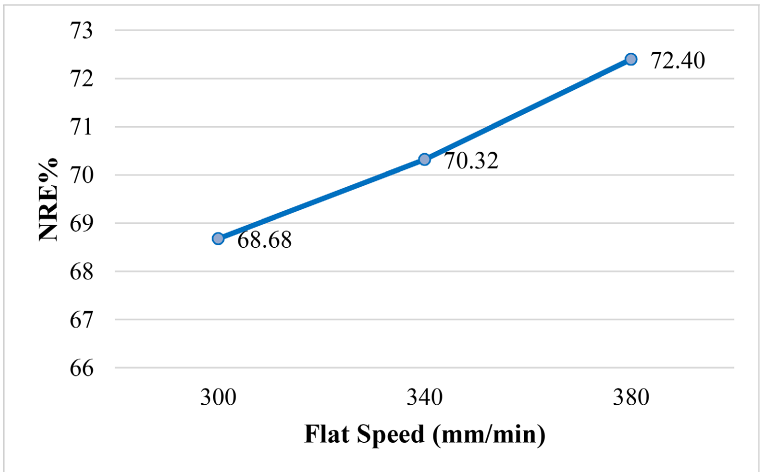


Figure 12. Effects of flat speed on Neps Removal Efficiency (NRE%) of the sliver.

In the graph, we see that at flat speeds 300 mm/min, 340 mm/min and 380 mm/min, the NRE% are 68.68%, 70.32% and 72.40% respectively which an increasing trend is.

We can infer from the graph that changes in flat speed do have an impact on changes in the NRE% of card sliver. When flat speed is increased, more number of flat comes to the contact with fiber treatment operation. So, the increase of flat speeds leads to increase in the NRE% of the card sliver.

3.4. Effect of Flat Speed on 30 Ne Cotton

3.4.1. Graphical Representation of Unevenness (U%) and Co Efficient of Variance (CV%)

The first portion of Figure 13 clearly shows that yarn unevenness diminishes as the card flat speed increases. As the card flat speed is increased from 300 mm/min to 380 mm/min, there is a steady decrease in the yarn unevenness from 11.52 at flat speed 300 mm/min to 11.06 at flat speed 380 mm/min. It is evident from the decreasing trend that the yarn unevenness is inversely proportional to the card flat speed.

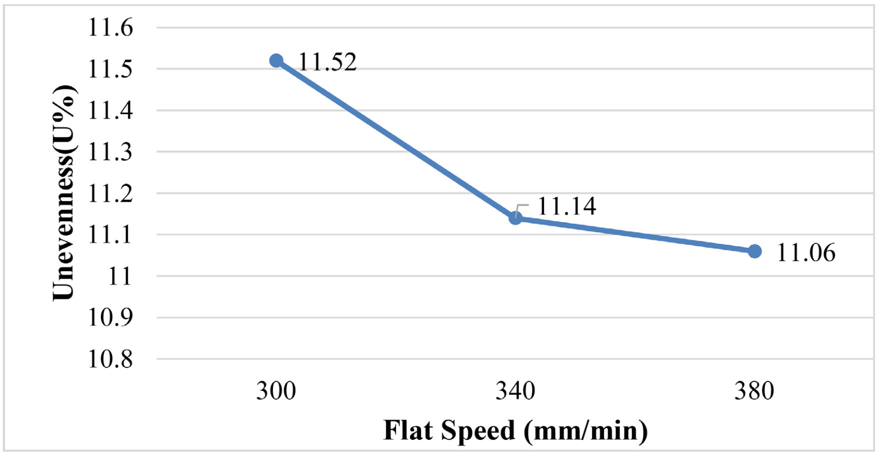


Figure 13. Effects of flat speed on Unevenness (U%) of the yarn.

Figure 14 makes it clear that yarn CV% decreases with an increase in the card flat speed. As the card flat speed is increased from 300 mm/min to 380 mm/min, there is a steady decrease in the yarn CV% from 14.55 at flat speed 300 mm/min to 14.01 at flat speed 380 mm/min. It is evident from the decreasing trend that the yarn CV% is inversely proportional to the card flat speed.

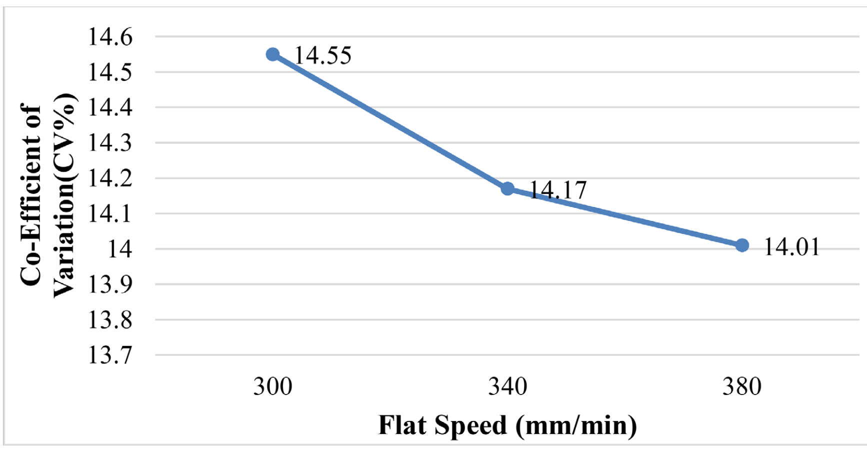


Figure 14. Effects of flat speed on Co-Efficient of Variation (CV%) of the yarn.

Hence, it can be said that the increase of flat speed reduces the co-efficient of variation of yarn.

3.4.2. Graphical Representation of Thick Places (+50%/km) and Thin Places (+50%/km)

In the first graph of Figure 15, it was observed that at flat speed 300, 340 and 380 mm/min thin places −50% are 2, 3 and 1 respectively which is a decreasing trend.

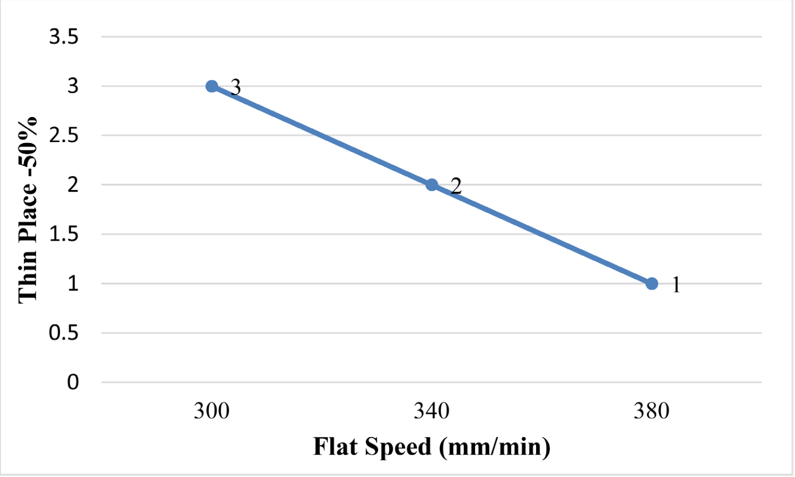


Figure 15. Effects of flat speed on Thin Place -50% of the yarn.

In the first graph of **Figure 16**, it was observed that at flat speed 300, 340 and 380 mm/min thick places +50% are 144, 114 and 95 respectively which is a decreasing trend.

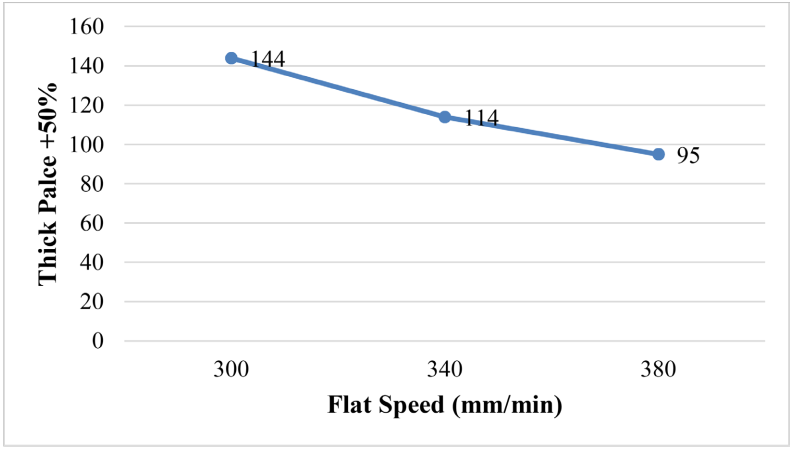


Figure 16. Effects of flat speed on Thick Place +50% of the yarn.

3.4.3. Graphical Representation of Neps (+200%/km) and Imperfection Index (IPI)

In left sided graph of **Figure 17** it was seen that at flat speed 300, 340 and 380 mm/min, neps +200% are 115, 112 and 82 respectively which is a decreasing trend.

It is clear that at flat speed of 300 mm/min, there are more neps, and at 380 mm/min, there are less neps. A decreasing trend of neps +200% is found with the increase of flat speed.

Figure 18 represents that the yarn spun at flat speed 380 mm/min gives lower IPI than yarn spun at flat speed 300 mm/min. The decrease in total yarn imperfections with the increase of flat speed can be explained by number of thick places, thin places and neps of yarn.

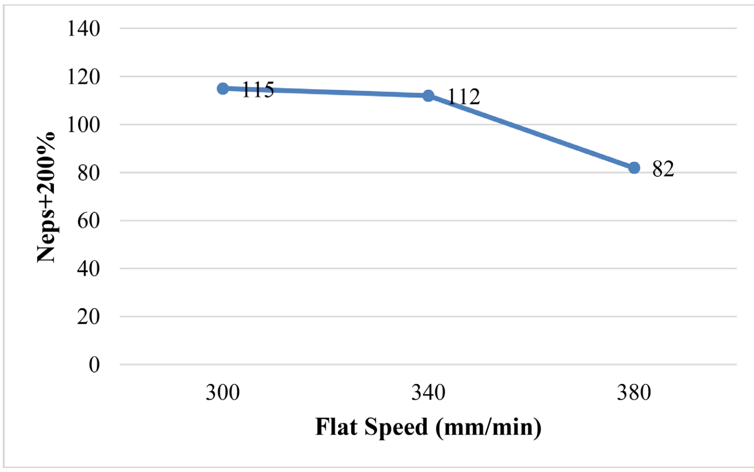


Figure 17. Effects of flat speed on Neps +200% of the yarn.

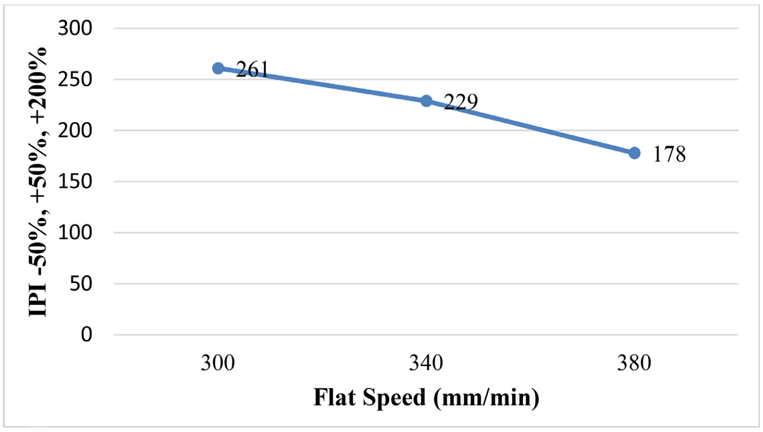


Figure 18. Effects of flat speed on IPI -50%, +50%, +200% of the yarn.

3.4.4. Graphical Representation of Classimat Faults

In Figure 19 the graph represents a significant effect on the Classimat Faults with the increase of flat speed. It can be seen that the yarn Classimat Faults decreases with the increase in flat speed.

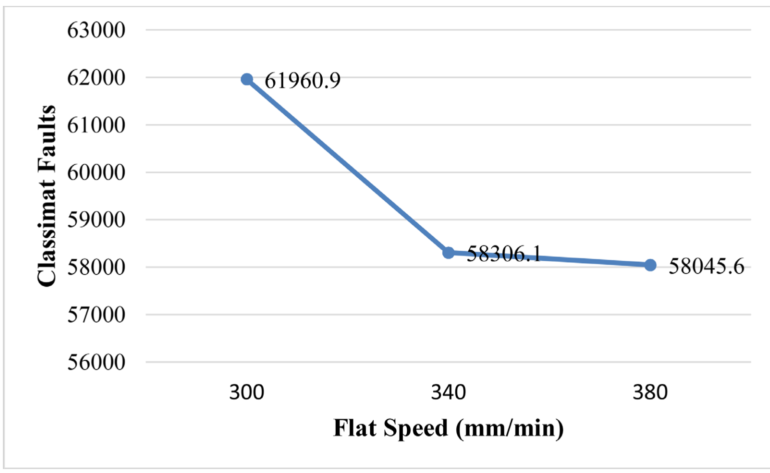


Figure 19. Effects of flat speed on Classimat Faults of the yarn.

4. Conclusions

As natural fibre like cotton which consumes about 30% of annual fibre consumption, its physical & chemical properties vary according to seed, plantation process, soil condition, natural resources, etc., so consistent quality in yarn is a crucial issue. In this project work, the actual relationship between the licker-in speed and flat speed of the yarn quality was studied. The graphical representations allow us to deduce that as the card is licked in faster, more neps and short fibers are removed, which results in less unevenness in the card sliver. Card slivers' quality, which includes diminishing unevenness, flaws, and yarn classimat faults, directly represents the quality of yarns. The quality of yarn improves with the decrease in licker-in speed and in this work; the medium licker-in speed *i.e.,* 1020 rpm is the optimum licker-in speed. There may be an optimum licker-in speed lower than 1020 rpm after that yarn quality will start to decrease. Since we have to employ the minimal licker-in speed of 960 rpm, finding the ideal licker-in speed might be the subject of future research.

This project effort examined the actual connection between flat speed and yarn quality. It may be inferred from the graphical representations that when flat speed of card increases, more neps and short fibers are eliminated, resulting in less unevenness of card sliver. The quality of card slivers directly reflects the quality of yarns such as decreasing unevenness, imperfections and yarn classimat fault. The quality of yarn improves as flat speed rises, and in this piece, the maximum flat speed is used. *i.e.,* 380 mm/min is the optimum flat speed. There may be an optimum flat speed higher than 380 mm/min after that yarn quality will start to decrease. Since we were restricted to use maximum flat speed at 380 mm/min, so obtaining optimum flat speed may be the topic of further research.

Author Statement

We certify that all named authors have read and approved the article and that no other individuals who meet the requirements for authorship but are not listed have done so. We also reaffirm that we all approved of the order in which the authors are listed in the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Rashid, M.M., Motaleb, K.A. and Khan, A.N. (2019) Effect of Flat Speed of Carding Machine on the Carded Sliver and Yarn Quality. *Journal of Engineered Fibers and*

Fabrics, **14**, Article ID: 1558925019845183.
https://doi.org/10.1177/1558925019845183

[2] Göktepe, F., *et al.* (2003) The Effect of the Licker-in Speed on Fibre Properties on Modern Carding Machines with a Triple Licker-In. *Journal of the Textile Institute*, **94**, 166-176. https://doi.org/10.1080/00405000308630605

[3] Bagwan, A., Salaam, A. and Jadhav, K. (2016) Card Setting: A Factor for Controlling Sliver Quality and Yarn. *Journal of Textile Science & Engineering*, **6**, 1-3.

[4] Lawrence, C.A. (2003) Fundamentals of Spun Yarn Technology. CRC Press, Boca Raton. https://doi.org/10.1201/9780203009581

[5] Lee, M.E. (2001) Mathematical Models of the Carding Process. Doctoral Dissertation, University of Oxford, Oxford.

[6] Teklehaimanot, M., Fisseha, K. and Ayele, M. (2022) Combined Effect of Carding Machine Process Parameters on Yarn Properties; Process Optimization. *Tekstilec*, **65**, 58-66. https://doi.org/10.14502/tekstilec.65.2021020

[7] Chaudhari, V.D., *et al.* (2017) Effect of Licker-In Speed on Yarn Quality. *Melliand International*, **4**, 193-195.

[8] Zhang, Y., Xu, B. and Shen, X. (2018) Effects of Licker-In Speed on the Carding Process and Fiber Properties. *Textile Research Journal*, **88**, 1276-1287.

[9] Ishtiaque, S.M., Mukhopadhyay, A. and Kumar, A. (2009) Impact of Carding Parameters and Draw Frame Speed on Fibre Axial Distribution in Ring-Spun Yarn. *Indian Journal of Fibre & Textile Research*, **34**, 231-238.

[10] Jia, Y., Wang, X. and Wang, X. (2019) Effects of Licker-In and Flat Speeds on Yarn Quality. *Journal of Textile Engineering & Fashion Technology*, **4**, 00091.

[11] Mazumder, M.C. and Bandyopadhyay, S.B. (1976) The Effects of the Cylinder Speed, Draft, and Delivery Rate in the Jute Breaker Card. *Journal of the Textile Institute*, **67**, 134-140. https://doi.org/10.1080/00405007608630555

[12] El-Sayed, M.A.M., Konig, G., Schaller, J. and Sanad, S.H. (2012) Effect of Carding Machine Delivery Speed on Production of Extra-Fine Egyptian Cotton Compact Spun Yarns. *International Journal of Textile Science*, **1**, 1-4.

[13] Ghosh, A. and Chatterjee, P. (2010) Prediction of Cotton Yarn Properties Using Support Vector Machine. *Fibers and Polymers*, **11**, 84-88.
https://doi.org/10.1007/s12221-010-0084-y

[14] Zhidan, Z. and Pengiz, S. (2007) Influences of Carding Machine Back Stationary Flat Gauge on Neps and Impurities. *Cotton Textile Technology*, **2**, 1-5.

[15] Sheikh, H.R. (2009) Impact of Carding Segments on Quality of Card Sliver. *Pakistan Textile Journal*.

[16] Simpson, J., DeLuca, L., Fiori, L. (1967) Effect of Carding Rate and Cylinder Speed on Fiber Hooks and Spinning Performance for an Irrigated Acala Cotton. *Textile Research Journal*, **37**, 504-510. https://doi.org/10.1177/004051756703700610

[17] Sayed, Z., Afrose, N. and Kabir, S. (2021) Impact of the Speed of Flat of a Typical Carding Machine on the Quality of Carded Sliver and 40 Ne Yarn. *Journal of Textile Science and Technology*, **7**, 66-76. https://doi.org/10.4236/jtst.2021.71006

[18] Purushothama, B. (2011) A Practical Guide to Quality Management in Spinning. Woodhead Publishing India, New Delhi. https://doi.org/10.1533/9780857093950

[19] Imtiaz, S. (n.d.) Yarn Unevenness and Its Impact on Quality.
https://www.academia.edu/1848499/Yarn_Unevenness_and_its_Impact_on_Quality

[20] Bihola, D. and Amin, H.N. (2015) Classimat Yarn Faults.
https://www.researchgate.net/publication/289916172_Classimat_Yarn_Faults