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A Study on the Effect of Pin Density on Stationary Flats and its Setting on Carding Quality

Raziskava vpliva gostote obloge na stacionarnih mikalnih pokrovčkih in njene nastavitve na kakovost mikanja

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Abstract
Carding is the most vital process in spinning, which influences the sliver quality and the resulting yarn characteristics. The effect of carding on single fibre and bundle fibre properties were studied by employing advanced fibre information system (AFIS) and differences in properties are reported. For a good quality yarn, the process parameters and setting in the carding are needed to be selected properly. The paper presents the results due to the effect of points per square inch (PPSI) in stationary flats of licker-in side (SFL). The effect of setting between the flats and cylinder was also studied. The sample was prepared using LMW spinning line using LC-333 carding machine. After regulatory changing the PPSI in SFL, the neps in the carded sliver were reduced. The experimentation led to the reductions in the total imperfection in yarn.
Keywords: carding, stationary flats of licker-in side, SFL, PPSI, neps, total imperfection

Izvleček
Mikanje je najpomembnejši postopek predenja, ki vpliva na kakovost pramena in s tem na lastnosti preje. Vpliv mikanja tako na lastnosti posamičnega vlakna kot na lastnosti snopičev vlaken v kopreni smo raziskovali s pomočjo naprednega informacijskega sistema (AFIS); razlike v lastnostih predstavljamo v članku. Za dobro kakovost preje je potrebno skrbno izbrati procesne parametre in nastavitve mikanja. V članku so predstavljeni rezultati raziskovanja vpliva gostote obloge mikalnih pokrovčkov (PPSI: število zobcev na kvadratnem inču) na stacionarnih mikalnih pokrovčkih rahljalnega valja. Proučili smo tudi vpliv nastavitve med mikalnimi pokrovčki in valjem. Vzorec smo pripravili na predilni liniji LMW z uporabo mikalnega stroja LC-333. Po spremembi PPSI na SFL se je število vozličkov (nopkov) v mikanem pramenu zmanjšalo. S pomočjo eksperimentov smo zmanjšali skupne nepravilnosti v preji.
Ključne besede: mikanje, gostota obloge na stacionarnih mikalnih pokrovčkih, PPSI, nopki, neenakomernost preje

1 Introduction

The process of converting fibre tufts into sliver involves processing over several zones in a carding machine. The first zone is a feeding zone which involves feeding section of the carding machine. In the feeding zone, fibre tufts are fed into the carding machine by means of two methods: one is via a lap-sheet feeding and the other is via a chute feed [1]. The method used for study in this research paper deals with the chute feed system. After getting through the feeding zone, fibre tufts come under the action of licker-in, and from there, they enter into a carding section. The activity in the carding section is observed and analysed for the purpose of the study.

Carding action can be described as the combing of fibres between two wired surfaces (card clothing), oriented in opposing directions, with their relative speed greater than zero. This action individualises the fibres and gives parallelism to the fibre mass flow [2].

Carding machine performs the following task: opening of individual fibres, elimination of impurities,

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elimination of dust, disentangling of neps, elimination of short fibres, fibre blending, fibre orientation and sliver formation. The number of neps increases from machine to machine in the blow-room, the card reduces the remaining number to a small fraction. Improvement in disentangling of neps is obtained by a closer spacing between clothing, sharper clothing, optimal speed of licker-in, low doffer speeds, lower throughput. To achieve a good quality of carded sliver, the pre-carding, carding and post-carding operations are important [3].

"The card is the heart of the spinning mill" and "Well carded is half spun" are two well-known proverbs of the experts. These proverbs apprise the immense significance of carding in the spinning process [4, 5].

The carding quality is primarily determined in the cylinder region, where the revolving flat is of high importance [6]. With an optimal number of flat bars, it is responsible for cleaning as well as extracting neps and short fibres. The purpose of high-speed carding is to increase the card productivity without reducing carding quality or even improving it to some extent. However, it had been assumed that increasing the carding speed would also increase the fibre breakage [7].

High production carding machine economises the spinning process and leads to the reduction in yarn quality. Hence, higher the rate of production, the more sensitive becomes the carding operation and the greater is the danger of a negative influence on quality. Since 1965, the production rate has been increased from about 5 kg/h to about 100 kg/h, a rate of increase not matched by any other machine except the draw frame. The technological changes that have taken place in the process of carding are remarkable compared to any other technology in textile processing [8, 9].

The opening or individualization of fibres achieved by the carding action between the cylinder and flats is expressed by the number of wire points [10]. With an increase in the production rate in carding, the points per fibre decrease leading to the reduction of the carding action. In the carding zone, if any fibre bundle is not opened up in the first few flats, it is difficult to open it in the last flats. The rolling action after the 5th flat or so, when no more carding is possible and leads to neps formation. This deficiency can be rectified by the following:

– increase in wire point density
– increase in cylinder speed
– increase in carding surface

The increase in the density of wire points in cylinder and the increase in the speed of cylinder have certain limitations, both technologically and mechanically. The only possibility is to increase the carding surface or changing the carding position. After some prior researches in this field, it was found that the increase in carding surface could be considered as the best alternative. Therefore, it seems to be the creation of additional carding position or introduction of the stationary flats of licker-in side (SFL) and stationary flats of doffer side (SFD). By introducing SFL, the pre-carding action has been substantially improved.

Modern carding machines are equipped with several stationary flats of licker-in side (Fig. 1). The SFL encounters tufts. The setting should be close enough so that the fibre tufts get pre-carded thoroughly before reaching the flats. It leads to the liberation of dust and short fibres which are immediately sucked away.

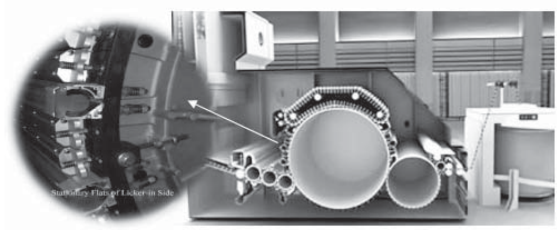

Figure 1: Side view of LC-333 (left: zoomed view of stationary flats of licker-in side)

The setting in the pre-carding zone has a strong influence on nep level, cleanliness and short fibre level. If the pre-carding action is better, then it will reduce the cylinder load resulting in better carding action on fibre. The carding action also depends upon the setting between the cylinders and flats. The setting between the cylinder and flat is optimum for the quality of fibre (fibre fineness, dust level, tenacity) over the entire flat zone, the setting is gradually reduced in the material flow direction in order to gradually increase the intensity of opening [11, 12]. If the setting is too close, it would lead to the thorough opening of fibres with the liberation of dust and trash, but neps and short fibre may increase due to higher stress on fibres. The yarn neppiness is influenced by the number of neps in the raw material [13]. As the PPSI (points per square inch)[1] is increased on the cylinder, the nep removal efficiency also increases [15]. The reduction

[1] PPSI = 1.550 points/m^2

in card sliver neps with variable density cylinder wires is fully reflected in the quality of corresponding yarns. The nep removal efficiency of card increases with the sharpness of flat and cylinder wires. New (sharper) wires were found to produce slivers with fewer neps [14, 15].

The present paper studies the effect by changing the point per square inch in stationary flats of licker-in side and the observations are analysed. The mechanical properties of the yarns before and after changing the SFL and gauge setting is an area for future work and this study has been limited and focused on physical properties.

2 Material and methods

2.1 Material

The properties of the fibres used to produce the yarn are given below in Tab. 1.

Table 1: Specification of fibre used

Fibre's specification	Value
Fibre type	cotton (H-4)
Fineness [mtex]	176.67
Fibre length [mm]	30
Neps [g]	203
Neps size [µm]	822
Seed coat neps (SCN) [g]	35
Uster 5% length [mm]	35
Maturity [%]	87

For the yarn samples preparation, the following process parameters were used (Tab. 2).

Table 2: Process parameters for yarn production

Process parameter	Model	Sliver/ roving/yarn count [tex]
Card	LC-333	4724
Breaker draw frame	LD-2	4920.83
Lap former	LH-15	–
Comber (noil % 19.50)	LK-64	5134.78
Finisher draw frame	RSB-851	5134.78
Speed frame	LF-4200	590.5
Ring frame	LR-9AXL	18.45

Carding setting parameter PPSI of SFL was changed in carding machine (Tab. 3).

Table 3: Carding setting parameters

Parameter		Before[a)]	After[b)]
Card speed [m/min]		160,170,180	160,170,180
Cylinder wire		R2030 × 0.5	R2030 × 0.5
SFL	1st strip set (PPSI[1])	140, 140	90, 140
	2nd strip set (PPSI)	240, 240, 240	90, 140, 140
	3rd strip set (PPSI)	340, 340, 340	240, 240, 240
SFL setting – bottom [mm]		0.4	0.45
SFL setting – middle [mm]		0.375	0.4
SFL setting – top [mm]		0.35	0.35
Flat gauge [mm]		0.25, 0.25, 0.225, 0.225, 0.225	0.25, 0.25, 0.225, 0.225, 0.225
Feed roll to licker [mm]		0.75	0.75

a) Before changing the PPSI on SFL and gauge setting
b) After changing the PPSI on SFL and gauge setting

2.2 Testing methods

The yarns were conditioned at the standard tropical atmospheric condition of 65±2% RH and 27±2°C temperature for 24 hours. The number of tests for each parameter were taken to ensure the result to attain 95% confidence limit.

2.2.1 Neps

The neps study was carried out on the advanced fibre information system (AFIS). For neps testing, 100 gm of fibre sample were taken from the feed material on carding, the same amount of sliver sample was taken after the carding operation.

2.2.2 Nep removal efficiency

The parameter characterising the carding machine effectiveness in the aspect of nep reduction is the Nep Removal Efficiency (NRE), which is expressed by the equation:

$$NRE\ (\%) = \frac{Nep\ Cnt/g_{feed} - Nep\ Cnt/g_{\ delivery}}{Nep\ Cnt/g_{feed}} \times 100 \quad (1),$$

where *NRE* is nep removal efficiency, $Nep\ Cnt/g_{feed}$ is the nep number per gram in fibre stream feeding the machine and $Nep\ Cnt/g_{\ delivery}$ is the nep number per gram in the fibre stream delivered by the machine.

2.2.3 Unevenness and imperfection

The evenness was measured on Uster Evenness Tester-5, which simultaneously measures the hairiness and imperfections. Yarn imperfections refer to the total number of thin places (–50%), thick places (+50%) and neps (+200%) present per 1000 metre of yarn.

3 Results and discussion

The number of neps/gram in sliver, unevenness and imperfection values of the yarns are given in Tab. 4. The yarn is produced before and after changing the SFL and gauge setting.

3.1 Effect of SFL PPSI and gauge setting on sliver properties

Stationary flats in licker-in side and doffer side are the recent introductions in the spinning industry for improving card sliver quality. The graphical representation of the effect of carding delivery speed and SFL PPSI on neps, short fibre content (SFC), and NRE in sliver are shown in Fig. 2.

It is inferred from the graph (Fig. 2a) that the neps per grams in sliver are reduced after reducing the point per square inch on SFL. The chances of fibre damage increase when the number of wire points on SFL increases hence more will be the nep formation. The point per square inch on the 1st set of the plate in SFL side is reduced from 140, 140 to 90, 140. With this particular experimental setup, the fibre is initially in contact with a lesser contact point so the opening of tufts started and then from the 2nd plate, the points per fibre increased. Similarly, PPSI in the 2nd set of SFL is changed from (240, 240, 240 to 90, 140, 140) and in the 3rd set of SFL 340, 340, 340 to 240, 240, 240.

The feeding of fibres to the carding zone increases with increase in the card delivery rate. This, in turn, affects the carding action as with an increase in input fibres, the number of fibres per wire point is increased. Hence the resulting neps per grams are increased by increasing the delivery speed.

The Short Fibre Content is defined as the percentage of fibres less than 12.7 mm in length. It is again inferred from Fig. 2b that the SFC/grams have reduced with the change in the setting in the pre-carding zone. Before the change in PPSI on SFL plats, the seed fibre coat is more due to similar points per square inch on tufts. When a fibre enters the pre-carding zone, the opening up operation may suffer due to a similar trend of wire density. As a result, the points per square are reduced resulting in the better opening up. It is evident from Fig. 2 that with an increase in the delivery speed, a short fibre content tends to increase in the card sliver. This is

Table 4 Effect of changing the PPSI on SFL, gauge setting and delivery speed on yarn and sliver properties

Delivery speed [m/min]	Place of yarn sampling	Neps [g]	Short fibre content, SFC [g]	Nep removal efficiency, NRE	Unevenness, U [%]	Total imperfection IPI	Hairiness
160	Before[a)]	130.7	27	53.83	9.73	139	4.94
	After[b)]	96	14	66.89	9.08	67	4.92
170	Before[a)]	161.2	27.9	43.09	9.84	128	4.99
	After[b)]	102	14.3	63.95	9.43	61	4.98
180	Before[a)]	186.3	29	34.19	9.9	133	5.05
	After[b)]	130	15	54.06	9.9	63	5.5

[a)] Before changing the PPSI on SFL and gauge setting
[b)] After changing the PPSI on SFL and gauge setting

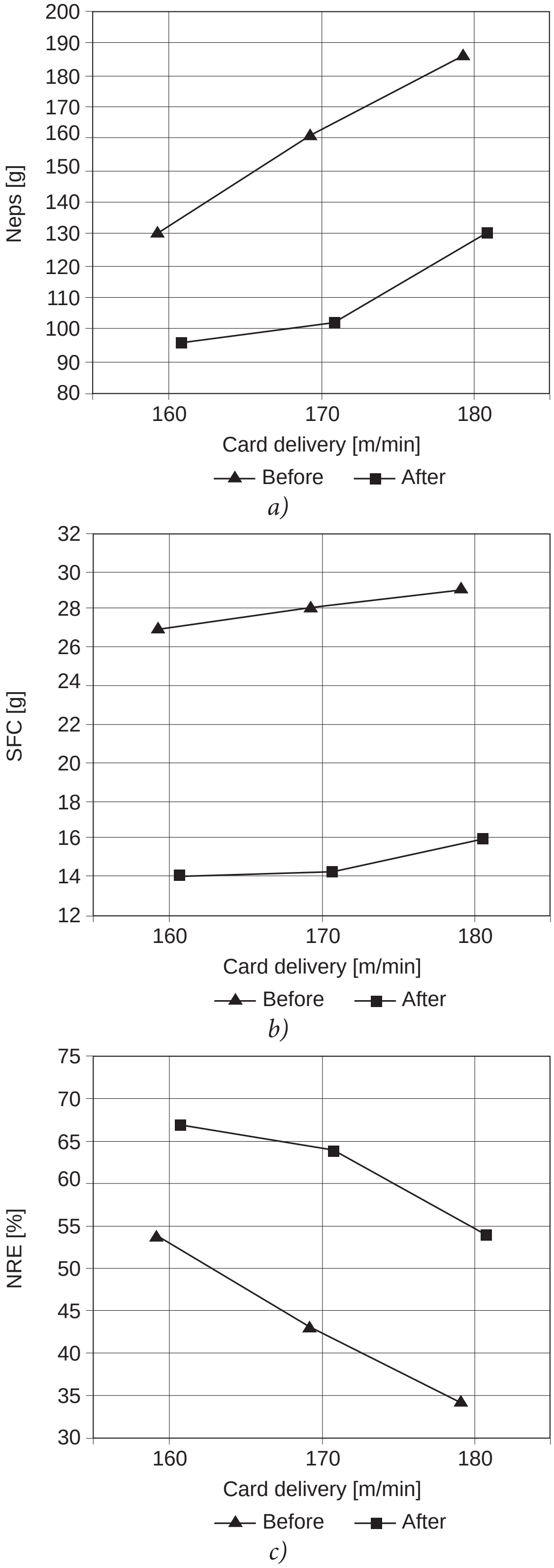

Figure 2: Effect of PPSI of SFL and card delivery rate on: (a) neps, (b) SFC and (c) NRE

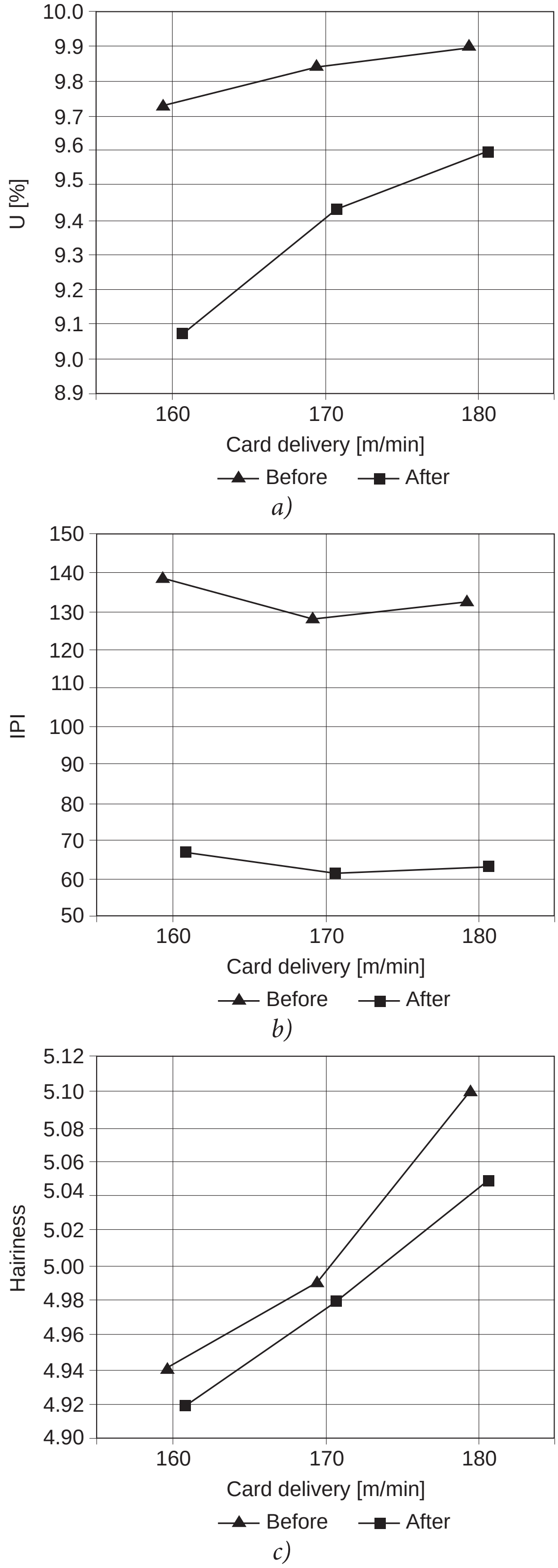

Figure 3: Effect of PPSI of SFL and card delivery rate on yarn parameters

due to fibre breakage at higher tensions. It is likely that when the flat's speed is kept constant, the fibres are stretched by the higher doffer speed which results in maximum fibre breakage.

It is also inferred from Fig. 2c that the nep removal efficiency (NRE) is increased after the change in pre-carding setting and PPSI on SFL with respect to carding delivery. Neps are created by the mechanical handling, cleaning of the cotton fibre. Neps increase throughout the ginning, opening and cleaning process. The nep removal efficiency depends on the number of neps present in a feed fibre and settings in carding. After changing the SFL and its setting, it directly influences the NRE. The NRE decreases with increase in the delivery speed of carding. When the delivery speed is increased, it reduces the time for the carding operation and hence due to the reduction in time, the neps could not be opened up properly. The formation of neps may also be possible due to high speed.

3.2 Effect of SFL PPSI and gauge setting on yarn properties

The raw materials and the technological process influence the final yarn quality. The graphical representation of the effect of carding delivery speed and SFL PPSI on unevenness, total IPI, and hairiness of yarn are shown in Fig. 3. The value of unevenness, U, and total imperfection are also shown in Tab. 4. Fig. 3a depicts the effect of PPSI of SFL and card delivery rate on yarn unevenness. It is clear from Fig. 3a that yarn unevenness decreases after changing the PPSI of SFL. As the points per square inch of the stationary flat are reduced, the opening up of neps is better in the pre-carding zone and hence it is directly reflected in the final yarn properties. It is also evident from Fig. 3a that yarn unevenness increases with an increase in the delivery rate of the card. As the card delivery rate is increased from 160 to 170 m/min, there is a steady increase in the yarn unevenness (U) from an average value of 9.07 at 160 m/min delivery rate to 9.6 at 170 m/min delivery rate. The trend indicates that the yarn unevenness is directly proportional to the card delivery. The trend in the result can be explained as follows: the higher delivery rate results in poor carding, higher cylinder loading and more leading fibre-hooks in the carded sliver. Ultimately, roving with higher leading fibre-hooks is forwarded to the ring frame contributing to an increase in yarn unevenness.

Fig. 3b depicts the effect of PPSI of SFL and card delivery rate on total imperfection. There is a tremendous reduction (139 to 67 at 160m/min) in total imperfection after the change in points per square inch of SFL. The decrease in the total imperfections with the decrease in points per square inch of SFL can be explained by good pre-carding and nep removal at the carding stage. A yarn with the higher number of yarn imperfections will ultimately result in poor fabric appearance. The points per square inch of SFL is playing the vital role in the pre-carding zone. As discussed earlier, the similar trend of wire density is not improving the sliver quality and by avoiding the similar trend the nep removal efficiency is increased and ultimately its reduces the total imperfection.

Mean plot depicting the effect of card delivery rate and PPSI of SFL on yarn hairiness are given in Fig. 3c. It is inferred from the Fig. 3c that yarn hairiness increases with the increase in card delivery and it also reduces after reducing the wire density on SFL. The average hairiness before the change in wire point density was 4.94 at 160m/min and after the change, the hairiness is reduced to 4.92 at the same delivery speed. The difference between before and after the change of hairiness is not so great at 160m/min but the difference is high for 180m/min. The yarns with high hairiness may result in a greater amount of fabric pilling and surface fuzziness as compared to the yarns with lower hairiness.

4 Conclusion

The analysis of the study presents an overview of the effect of changing the point per square inch in stationary flats of licker-in side (SFL) on sliver and yarn properties. It has been found that by reducing the point per square inch in stationary flats of licker-in side (SFL), the number of neps per grams in sliver is reduced. Also, the SFC/grams has decreased with the change in the setting in the pre-carding zone.

The yarn unevenness was found to be directly proportional to the card delivery rate. The increase in the card delivery rate results in poor carding since it leads to higher cylinder loading and more leading fibre-hooks in the carded sliver.

A considerable reduction in total imperfection was found with the decrease in points per square inch of SFL. Further, the reduction in yarn hairiness was found with the reduction in pin density on SFL at different rates of card delivery speed. The results obtained on the basis of experimentation may be used in a customised yarn production for different applicability. Even various customization may be achieved automatically by programming the carding mechanisation. The programmable design of such mechanisation can be obtained by suitable hardware and software interaction that has not been dealt in the paper. However, the prospect of such design can be investigated further in the future course of action. The mechanical properties of the yarns before and after changing the SFL and gauge setting is an area for the future work and this study has been limited and focused on physical properties.

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