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Impact of Finisher Drawframe Storage Variables on Combed Yarn Quality

Vpliv dejavnikov shranjevanja raztezanega pramena na kakovost česane preje

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Abstract

The cotton ring spinning preparatory is confronting the serious issue of combed sliver handling during sliver storage and processing. Combed sliver is more liable to stretching and failure due to low interfibre cohesion during the processing on a drawframe and speedframe. The combed sliver quality deteriorates if stored in older storage cans of decreased spring stiffness due to prolonged fatigue loading. The bottom position combed sliver processed from older cans results in sliver stretching and sometimes failures at speedframe creel due to high inter-sliver coils adhesion with adjacent sliver coils. The study deals with investigating the influence of the sliver coils position, storage can-spring stiffness and finisher drawframe delivery speed on combed cotton yarn unevenness, imperfections, breaking tenacity, breaking elongation and S3 hairiness. The experimental work and statistical analysis suggest that the sliver coils position and can-spring stiffness play a vital role in deciding combed yarn quality characteristics.
Keywords: combed sliver, can-spring stiffness, coils position, storage time

Izvleček

Pri pripravi na predenje prstanske bombažne preje se soočamo s pomembnimi problemi, povezanimi z ravnanjem s česanim pramenom med skladiščenjem in predenjem. Zaradi slabe kohezije med vlakni v česanem pramenu hitro pride do neželenih nekontroliranih raztegov, predpreja in preja postaneta bolj neenakomerni. Kakovost česanega pramena se poslabša, če ga skladiščimo v starejših loncih z zmanjšano togostjo vzmeti, ki je posledica preutrujenosti materiala. Predelava spodnjih plasti česanega pramena iz starejših loncev lahko vodi do neželenih raztegov in občasno pretrgov pramena na krilniku zaradi povečanega medsebojnega sprijemanja sosednjih ovojev. Študija se ukvarja s proučevanjem vpliva položaja ovojev, togostjo vzmeti v loncu in odvajalno hitrostjo raztezalnika na neenakomernost česane bombažne preje, količino napak, pretržno trdnost, pretržni raztezek in kosmatost preje. Eksperimentalno delo in statistična analiza sta pokazala, da položaj ovojev pramena in togosti vzmeti loncev močno vpliva na končno kakovost bombažne česane preje.
Ključne besede: česani pramen, togost vzmeti v loncu, položaj ovojev, čas shranjevanja

1 Introduction

At the finisher drawframe section in a combed ring spinning preparatory, hundreds of storage cans are used for sliver storage. The main component of a sliver storage container, which is also termed as the heart of the storage can, is its spring. The spring stiffness of these storage cans decreases with

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time due to fatigue loading and surface crack formation [1–2]. These older storage cans of reduced spring stiffness are extensively used in the spinning preparatory in India. In the last few years, there has been a growing interest in combed sliver handling during sliver deposition and withdrawal from storage cans. Moreover, combed sliver handling is an unavoidable quality issue while using older storage cans of reduced spring stiffness for combed sliver storage. Older can-springs deform more against the applied sliver load as compared to new springs due to the can-spring stiffness variation. The optimum spring pressure should be maintained for smoother operations and for fault-free sliver handling [3]. Furthermore, older can-springs can deteriorate stored combed sliver quality caused by sliver stretching during sliver deposition and withdrawal at a drawframe and speedframe, respectively. Previous studies showed that the storage can-spring condition should be monitored regularly after some prescribed time for fault-free roving and yarn [4–7].

The finisher drawframe machine holds a crucial position in quality improvement through fibre alignment in sliver and by producing a uniform sliver free from thick and thin places [8–10]. The improved fibre alignment in combed sliver is responsible for low interfibre cohesion, making combed sliver liable to stretching at the time of sliver deposition on a drawframe and during sliver withdrawal on a speedframe [11]. Previous research has documented that the fibre configuration in combed sliver is primarily affected by the drawframe speed [12]. The weight of the sliver is the major source of sliver stress during sliver deposition and can achieve about one-third of the combed sliver strength in a modern high-speed drawframe [13–14]. The imperfection free combed yarn can be produced at a ringframe by feeding consistent quality sliver at a finisher drawframe machine. For that, we need a correct sliver handling system [15–17]. However, to the authors' best knowledge, very few studies are available in the literature that discuss the issue of poor combed sliver handling due to improper can-spring stiffness. Previous studies also lack detailed explanations of the cause of variation in combed sliver quality at different sliver coils position in a storage can. Furthermore, the effect of allowing combed sliver storage time on the resultant yarn quality has not yet been studied. Combed sliver storage time is considered as a quality-reducing factor among the spinners and is a result of poor preparatory planning, maintenance loss and power loss.

Hence, a comprehensive study is required to examine the effect of a few imperative sliver storage variables at a finisher drawframe on combed yarn quality characteristics. The present research work is focused on studying the effect of few scarcely investigated finisher drawframe variables, such as sliver coils position, can-spring stiffness and delivery speed, on combed yarn unevenness, imperfections, tenacity, elongation and S3 hairiness.

2 Materials and methods

2.1 Material

Combed cotton extra-long variety from the south Indian states MCU-5 100% was used to produce sliver samples on a twin delivery finisher drawframe machine. The fibre properties were measured using a high volume instrument HVI900-spinlab. The cotton fibre specifications with 2.5% span length were 30.9 mm, fibre strength 24.61cN/tex and fibre fineness in micronaire was 4.2, used for the combed sliver sample preparation. The finisher drawframe sliver liner density 5.319 ktex was processed on a speedframe at the twist multiplier 1.34 to produce 0.641 ktex roving. Furthermore, the roving samples were fed to the ringframe machine to manufacture 14.22 tex yarn at the twist multiplier 4.2.

2.2 Methods

In order to investigate the effect of sliver coils position, can-spring stiffness and finisher drawframe delivery rate on combed yarn quality parameters, the three-factor and three-level Box-Behnken design was used to prepare the combed yarn samples to determine yarn unevenness, imperfections/km, breaking tenacity, breaking elongation and S3 hairiness index. The detail of levels is given in Table 1. A suitable randomization and replication technique was adopted at the time of sample preparation for an effective statistical analysis and to reduce the chances of error occurrence.

2.2.1 Experimental plan and yarn sample preparation

In order to optimise the number of runs, the Box-Behnken design was adopted for sample planning with coded and real values, as shown in Tables 1

Table 1: Box-Behnkenexperimental design

Standard runs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sliver coils position	–1	1	–1	1	–1	1	–1	1	0	0	0	0	0	0	0
Spring stiffness [N/m]	–1	–1	1	1	0	0	0	0	–1	1	–1	1	0	0	0
Delivery speed [m/min]	0	0	0	0	–1	–1	1	1	–1	–1	1	1	0	0	0

Table 2: Factors and corresponding levels of variation

Variables	–1	0	+1
Sliver coils position	Low	Middle	Top
Spring stiffness [N/m]	170	190	210
Delivery speed [m/min]	250	400	550

and 2. Initially, older storage can-spring stiffness was measured using predetermined dead weights and then categorized into three different groups of spring stiffness after prolonged scrutiny, as indicated in Table 2. Spring stiffness was measured in N/m. It is observed that the deformation is higher against the applied load in the case of older cans compared to the new cans. The main cause for higher deformation in older cans against applied sliver load was a decrease in spring stiffness due to fatigue loading over the years.

Combed drawn sliver samples were deposited in storage cans of different spring stiffness at 250 m/min, 400 m/min and 550 m/min delivery rates at the finisher drawframe machine. In order to assess the quality of stored combed sliver at different coil positions, the top, middle and bottom sliver coils position were considered. Each sliver coils position contained an equal length of combed sliver as the total length of deposited combed sliver was divided into three equal parts, representing each sliver coils position. In order to access the effect of sliver storage time, two cases were considered after consulting with industry experts, i.e. with 8 hours of sliver storage time after a full can being ejected from the finisher drawframe and without allowing any sliver storage time or 0 hour storage time.

2.2.2 Yarn testing

The yarn sample was conditioned under standard atmospheric conditions, in a tropical atmosphere of 27 °C± 2 °C temperature and 65 ± 2% relative humidity, while the number of readings was determined according to the variation in a sample in order to achieve a 95% confidence interval. Appropriate numbers of combed yarn samples were tested by calculating and considering the coefficient of variation in all cases. Yarn unevenness and imperfections/km were measured on an Uster® Tester 4-S according to ASTM D 1425-96. The total combed yarn imperfection/km was calculated by adding –50% thin, +50% thick and +200% neps. The Zweigle hairiness index (S3) was measured using a Zweigle G565 instrument, considering the hairiness parameter "S3" (number of hairs equal or greater than 3 mm) as per ASTM D 5647-01. Yarn breaking tenacity and breaking elongation were measured on a Premier TensoMaxx at 500 mm gauge length and according to ASTM D 2256-02.

3 Results and discussion

The detail of all observed response yarn test results is shown in Table 3.

Statistical analysis

The influence of independent control variables was statistically investigated using ANOVA at 95% confidence level using statistical software. The p-value helped determining the significance of the results. A low p-value (≤ 0.05) indicates a strong effect of the control factor on the observed response, whereas a high p-value (> 0.05) indicates a weak effect. The independent control factors, i.e. sliver coils position, spring stiffness and finisher drawframe delivery speed, were considered to check any statistical significance. The analysis of variance summary is as shown in Tables 4a and 4b.

Table 3: Control factors and corresponding observed responses

Runs	Variables			Responses without allowing any storage time					Responses at 8 hours of storage time				
	Sliver coils position	Spring stiffness [N/m]	Delivery speed [m/min]	U [%]	Imperfection [1/km]	Breaking tenacity [cN/tex]	Breaking elongation [%]	Hairiness, S3	U [%]	Imperfections [1/km]	Breaking tenacity [cN/tex]	Breaking elongation [%]	Hairiness, S3
1	–1	–1	0	11.41	135	15.89	3.75	1770	11.73	152	15.36	3.56	1864
2	1	–1	0	10.75	105	16.89	4.11	1149	11.38	141	16.30	3.88	1461
3	–1	1	0	10.69	111	17.05	4.37	1422	10.94	139	16.64	4.16	1678
4	1	1	0	10.59	93	18.68	4.41	711	10.77	112	17.09	4.47	957
5	–1	0	–1	11.34	131	16.29	3.68	1580	11.58	126	16.51	3.73	1640
6	1	0	–1	10.66	104	17.52	4.53	1050	10.61	104	17.67	4.44	1015
7	–1	0	1	11.31	92	16.73	4.08	1495	11.41	133	16.73	3.97	1523
8	1	0	1	10.57	98	18.23	4.41	780	11.19	101	16.78	4.32	1035
9	0	–1	–1	11.21	114	16.22	3.98	1561	11.28	130	16.28	3.95	1131
10	0	1	–1	10.59	102	16.97	4.62	887	11.32	89	17.39	4.41	1011
11	0	–1	1	11.11	96	16.65	4.43	1295	11.23	119	16.50	4.36	1107
12	0	1	1	10.57	94	18.77	4.92	891	10.57	99	17.52	4.86	927
13	0	0	0	10.57	97	17.93	4.71	845	10.62	97	17.04	4.52	895
14	0	0	0	10.61	91	18.06	5.05	861	10.59	110	16.93	4.89	861
15	0	0	0	10.58	89	17.96	4.81	877	10.65	116	16.87	4.78	1004

Table 4a: ANOVA general linear model summary through p-value analysis: Effects without any sliver storage time

Spinning variables	U [%]	Imperfec-tions [1/km]	Breaking tenacity [cN/tex]	Breaking elongation [%]	Hairiness, S3
Sliver coils position	0.00[a)], s [b)]	0.01, s	0.00, s	0.00, s	0.00, s
Spring stiffness [N/m]	0.00, s	0.08, ns	0.00, s	0.00, s	0.00, s
Delivery speed [m/min]	0.05, ns [c)]	0.04, s	0.00, s	0.07, ns	0.00, s

Table 4b: ANOVA general linear model summary through p-value analysis: Effects after 8 hours of sliver storage

Spinning variables	U [%]	Imperfec-tions [1/km]	Breaking tenacity [cN/tex]	Breaking elongation [%]	Hairiness, S3
Sliver coils position	0.03, s	0.00, s	0.00, s	0.00, s	0.00, s
Spring stiffness [N/m]	0.04, s	0.00, s	0.00, s	0.00, s	0.00, s
Delivery speed [m/min]	0.27, ns	0.12, ns	0.16, ns	0.08, ns	0.58, ns

[a)] p-value
[b)] s-significant if $p < 0.05$ at 95% confidence interval
[c)] ns-not significant if $p > 0.05$

3.1 Effect of control factors on combed yarn unevenness

It was observed that the combed yarn samples produced from sliver stored in older storage cans of can-spring stiffness 170 N/m and the yarn samples produced from the bottom position sliver coils result in higher unevenness as compared to the samples produced from the middle and top position sliver coils using 190 N/m and 210 N/m stiffness storage can-springs, as shown in the contour plots in Figure 1.The samples prepared without allowing any sliver storage time produced from the bottom sliver coils position using 170 N/m can-spring stiffness showed by 11.41% higher observed mean unevenness, which further increased after 8 hours of sliver storage time to 11.73%, as shown in the contour plots in Figure 1. At a lower delivery speed, relatively higher unevenness was observed in both cases as is indicated in Figure 1.

The main reason for stored sliver quality deterioration were poor sliver handling in older storage cans, older can-spring buckling, sliver contact with the rough

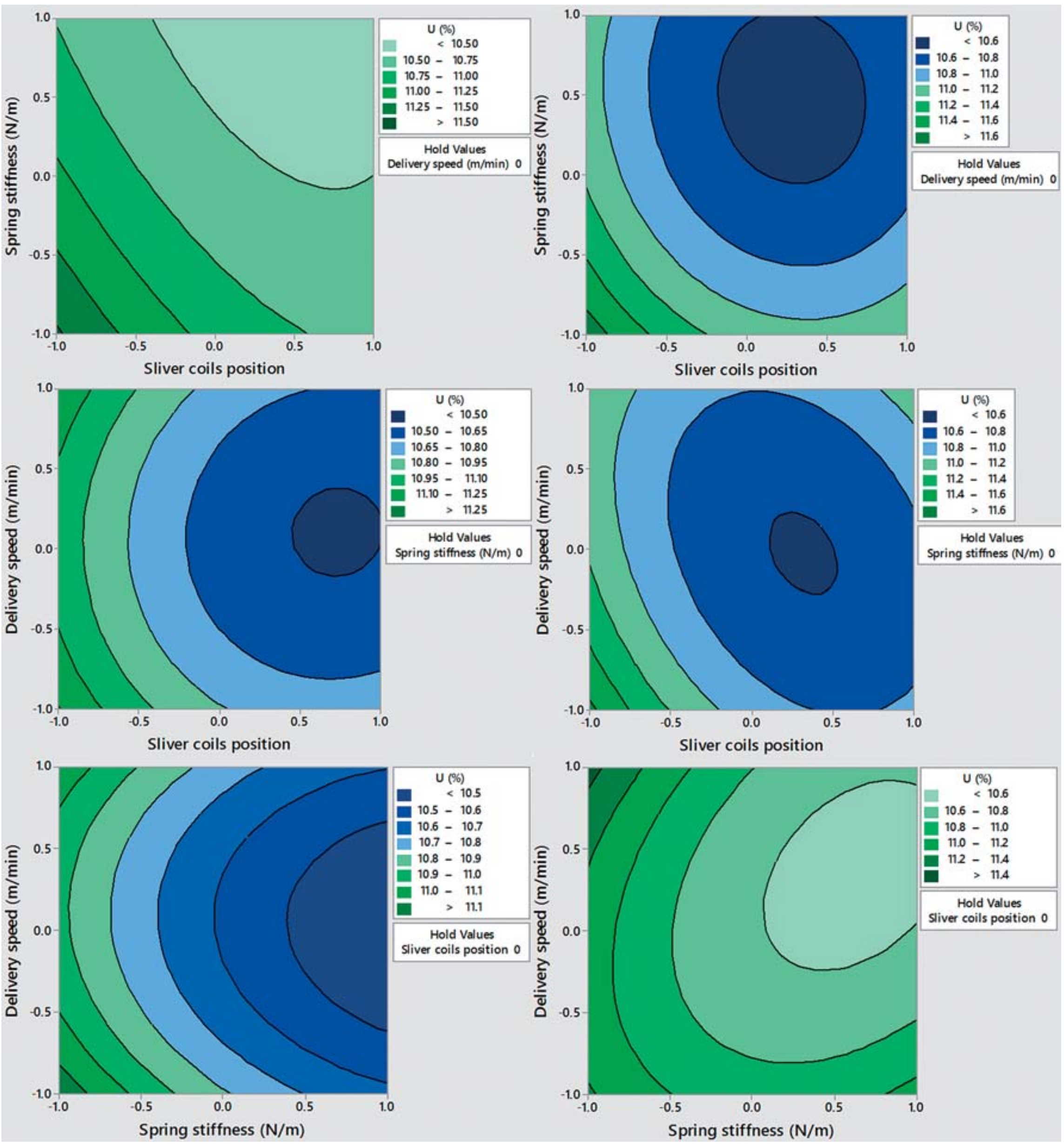

Figure 1: Effect of control factors on yarn unevenness at 0 hr (left) and 8 hrs (right) storage time

side wall of the container and frequent sliver failure at the speedframe creel due to the presence of higher inter-sliver coils adhesion at the bottom sliver coils position as shown in Figures 2–4. Due to the variation in force experienced by different sliver coils, the bottom sliver coils became flattened and experienced more adhesion with adjacent sliver coils at the time of sliver withdrawal at the speedframe, as shown in Figure 2. Consequently, higher sliver stretching and even sliver failure was observed at the speedframe creel and more frequent start-up breakage at the ringframe. The combined action of poor combed sliver handling in older storage cans and yarn samples produced from the bottom position sliver coils resulted in higher unevenness in the resultant yarn. The combed sliver stored in older storage cans of decreased can-spring stiffness experienced sliver rubbing against the container's rough wall due to can-spring buckling, as shown in Figure 4, and resulted in a relatively weaker, hairy and uneven roving, and yarn which also contributed to higher combed yarn unevenness. Furthermore, the combed yarn unevenness percentage was found higher at the samples produced from the bottom position sliver coils allowing 8 hours of sliver storage time, which is due to improved sliver coils adhesion with adjacent coils at the speedframe creel. However, relatively lower inter-sliver coils adhesion was observed at the bottom position sliver coils samples produced without allowing any storage time.

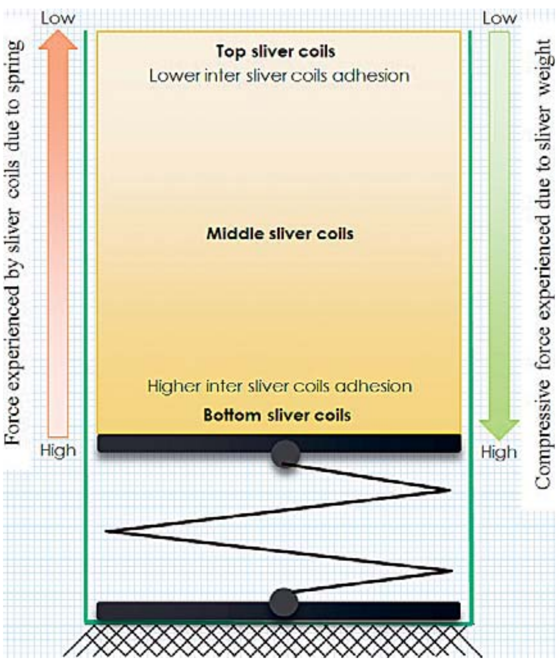

Figure 2: Forces experienced by different sliver coils position

Figure 3: Flattened bottom sliver coils at speedframe creel

Figure 4: Can-spring buckling on sliver storage in older can

Based on the statistical analysis conducted with a general linear ANOVA model and experimental results, it was found that the effect of the sliver coils position and can-spring stiffness is significant for yarn unevenness at 8 hours of storage time as well as without allowing any storage time; however, the effect of the delivery speed is marginal in both cases, as shown in the contour plots in Figure 1 and as vindicated in Table 4. Overall, the combed yarn unevenness was found higher at 8 hours storage of time as compared to the samples produced without allowing any storage time.

3.2 Effect of control factors on combed yarn imperfections

The uneven sliver results in faulty roving and yarn. The statistical analysis and experimental results reveal that the yarn produced from the bottom position sliver coils using older storage cans of spring stiffness 170 N/m showed a higher imperfection level with 135 imperfections/km at the yarn samples produced without allowing any storage time. A further increase in the imperfection level was observed at 8 hours of storage time with the highest mean value of 152 imperfections/km observed at the lowest spring stiffness and at the samples produced from the bottom position sliver coils, as shown in the contour plots in Figure 5.

The reason for a higher imperfection level in the resultant yarn was improved stickiness in the bottom sliver coils, and hairy and weak combed sliver, which results in more sliver stretching and sliver failure at the time of sliver withdrawal from older storage cans. As discussed earlier, older can-spring buckling resulted in combed sliver contact with the rough side wall of the storage container and deteriorated stored sliver quality by producing weaker and hairy sliver. The yarn samples produced from the bottom position sliver coils showed a higher imperfection level as these sliver coils experienced the highest compressive force, resulting in more contact with adjacent sliver coils and improved adhesion. Consequently, sliver splitting, stretching, the formation of thick & thin places, and even failure was observed at the time of sliver processing at the speedframe. Finally, the combed yarn samples produced from such hairy and weaker roving samples showed more imperfections in the resultant yarn.

In the case of samples produced without allowing any storage time, it was observed that total

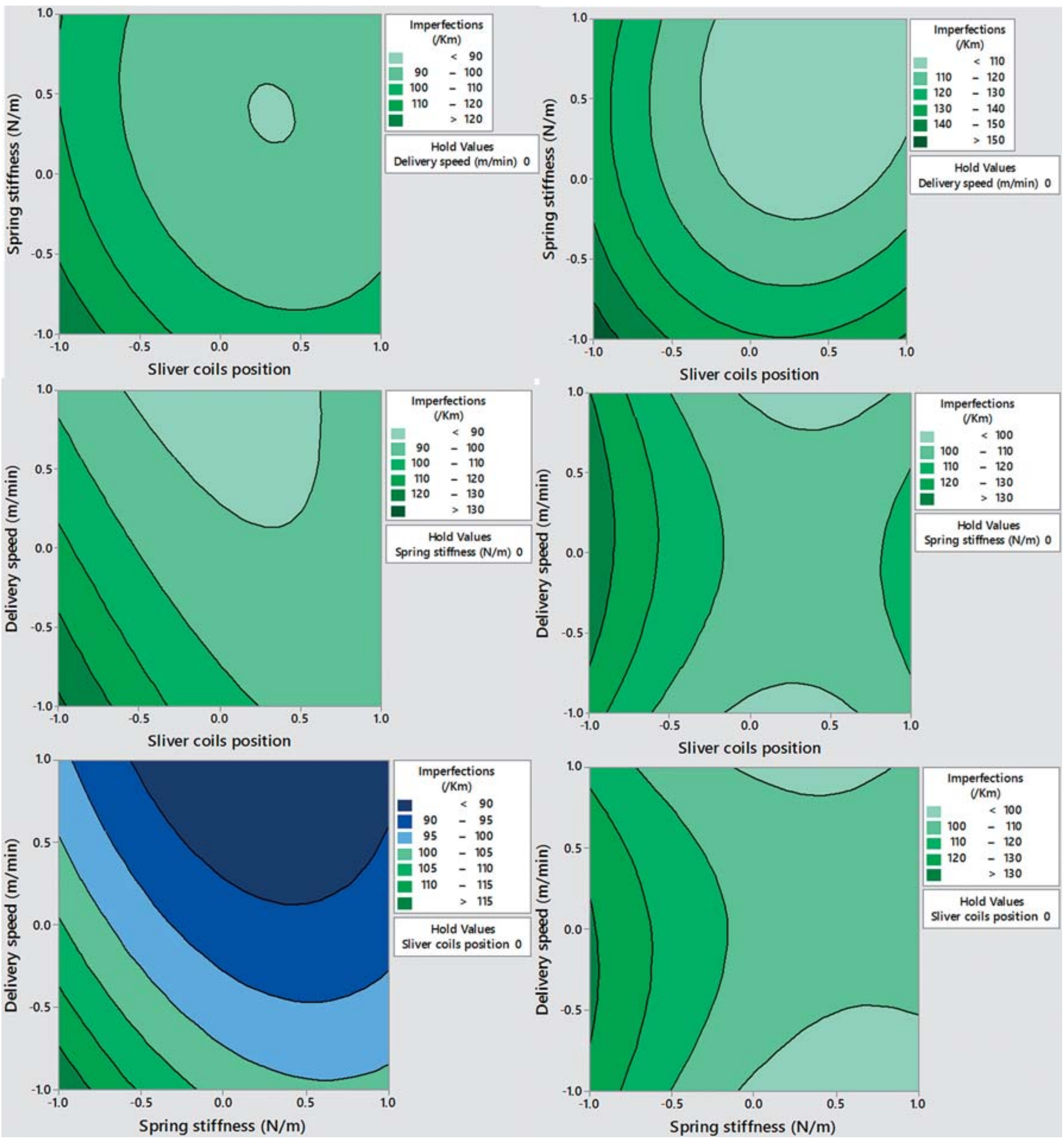

Figure 5: Effect of control factors on yarn imperfections at 0 hr (left) and 8 hrs (right) storage time

imperfections are lower at a higher finisher drawframe delivery speed, i.e. 550 m/min, and higher at a lower delivery speed, i.e. 250 m/min, which is a consequence of ineffective straightening of hooked fibres in the drafting zone at a higher delivery speed. A general linear ANOVA analysis suggested that the effect of the sliver coil position and delivery rate is significant for imperfection, whereas the observed effect is insignificant for can-spring stiffness at the samples produced without allowing any sliver storage time. Moreover, the effect of the sliver coils position and can-spring stiffness was found significant, whereas the effect of the delivery rate is insignificant for the samples produced by allowing 8 hours of sliver storage time.

3.3 Effect of control factors on combed yarn breaking tenacity

It was found that the resultant combed yarn breaking tenacity was higher at the samples produced

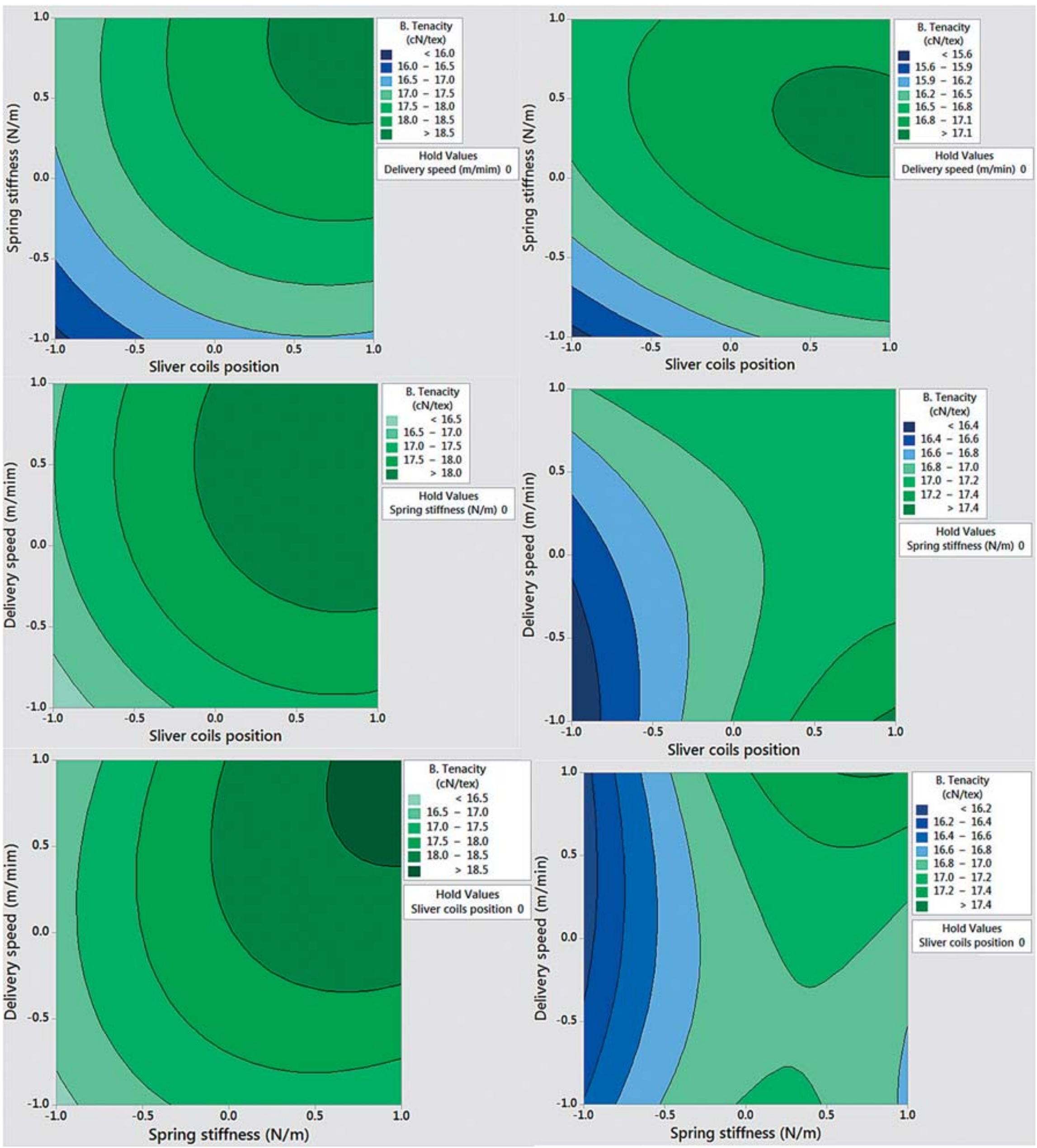

Figure 6: Effect of control factors on yarn breaking tenacity at 0 hr (left) and 8 hrs (right) storage time

from the storage cans of spring stiffness 210 N/m and the top position sliver coils compared to the samples produced from older storage cans. The contour plots in Figure 6 confirm the same, as at the samples produced without allowing any storage time, the upper range of breaking tenacity mean values was between 17 cN/tex and18.5 cN/tex, and at the samples produced by allowing 8 hours of sliver storage time, relatively lower breaking tenacity was observed with the upper mean values being between 16.6 cN/tex and17.4 cN/tex. Yarn breaking tenacity was found higher at a higher finisher drawframe delivery speed, i.e. 550 m/min, which is a consequence of less effective straightening of hooked fibres in the drafting zone, and higher centrifugal force inside the coiler at a higher delivery speed. Thus, the sliver, roving and yarn failure rate decreased and resulted in stronger and fault-free yarn with higher breaking tenacity. The weaker, hairy, flattened and stretched bottom position sliver coils from older storage cans resulted in weaker and irregular roving, and yarn of low breaking tenacity. Furthermore, it was observed that yarn breaking tenacity was relatively lower at the yarn samples produced at the 8 hours combed sliver storage time, which is a consequence of an additional improvement in the bottom sliver coils adhesion with adjacent coils, resulting in more sliver stretching and failure at the time of sliver withdrawal at the speedframe creel. This caused uneven resultant yarn with more imperfections (thick and thin places), resulting in a decrease in breaking tenacity of yarn samples produced from such roving samples.

The statistical analysis with ANOVA summary reveals that the effect of all control factors was found significant on combed yarn breaking tenacity in both cases of sliver storage time, except for the effect of the delivery rate, which was found insignificant for the samples produced by allowing 8 hours of sliver storage time.

3.4 Effect of control factors on combed yarn breaking elongation

The experimental results reveal that combed yarn samples produced from older storage cans of can-spring stiffness 170 N/m, bottom position sliver coils and at the finisher drawframe speed of 250 m/min showed lower breaking elongation, which is 3.68% with the lowest observed mean value in the case of samples produced without allowing any storage time compared to other yarn samples, as shown in Figure 7. Furthermore, it was found that the samples produced by allowing 8 hours of storage time showed a marginal decrease in breaking elongation with the lowest observed mean value of 3.56%, as shown in Figure 7. The causes of low breaking elongation are similar to that of low breaking tenacity due to the presence of higher unevenness and higher imperfections present in the yarn samples produced from older cans bottom sliver coils position at the 250 m/min drawframe delivery speed. Weaker, hairy and flattened sliver from the bottom sliver position resulted in weaker roving and resultant yarn with low breaking elongation. The analysis of variance showed that the effect of sliver coils position and can-spring stiffness is significant for combed yarn breaking elongation, whereas the effect of the delivery rate on breaking elongation is insignificant.

3.5 Effect of control factors on combed yarn hairiness

Lower S3 hairiness was observed at the samples produced at the 550 m/min finisher drawframe delivery rate using storage cans of spring stiffness 210 N/m and from the middle and top sliver coils positions. For the samples produced without allowing any storage time, the highest S3 hairiness with the S3 mean value 1770 was observed at 170 N/m can-spring stiffness and the bottom sliver coils position. In addition, the samples produced by allowing 8 hours of storage time encountered a further improvement in S3 hairiness at 170N/m spring stiffness, as well as the samples produced from the bottom sliver coils position with the S3 mean values 1864, as shown in the contour plots in Figure 8. Higher S3 hairiness observed in the case of samples produced from the bottom position sliver coils resulted from various reasons, including sliver rubbing with the rough side wall, can-spring buckling, sticky & flattened bottom sliver coils, and hairy sliver & roving. The bottom position sliver coils experienced the highest compressive force as discussed earlier and stickiness increased further at 8 hours of sliver storage time, resulting in weak, hairy and uneven combed sliver during the withdrawal at the speedframe. Older storage cans caused sliver quality deterioration as a result of can-spring buckling and

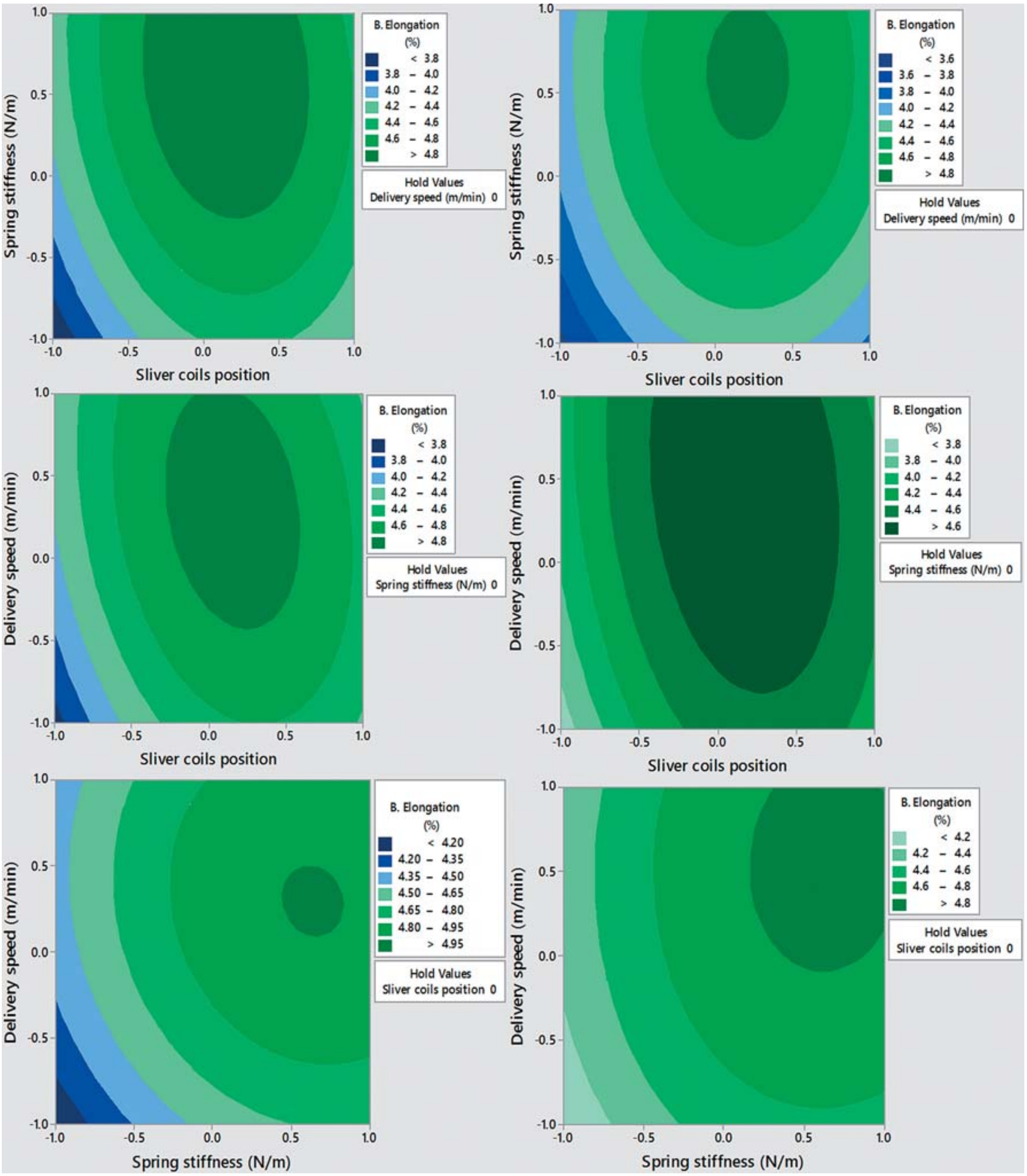

Figure 7: Effect of control factors on yarn elongation at 0 hr (left) and 8 hrs (right) storage time

sliver contact with the side wall of the container and experienced sliver splitting/stretching at the speedframe during the sliver withdrawal. The experimental results and analysis of variance revealed that the combed yarn S3 hairiness is significantly influenced by the sliver coils position, can-spring stiffness and delivery rate for the samples produced without allowing any storage time. At 8 hours of sliver storage time, the effect of the delivery rate was found insignificant, whereas the effect of the sliver coils position and can-spring stiffness was found significant at S3 hairiness. It was established that the overall combed yarn hairiness improved at 8 hours of sliver storage time as compared to that of samples where no sliver storage time was allowed, as shown in Figure 8 and vindicated by ANOVA summary.

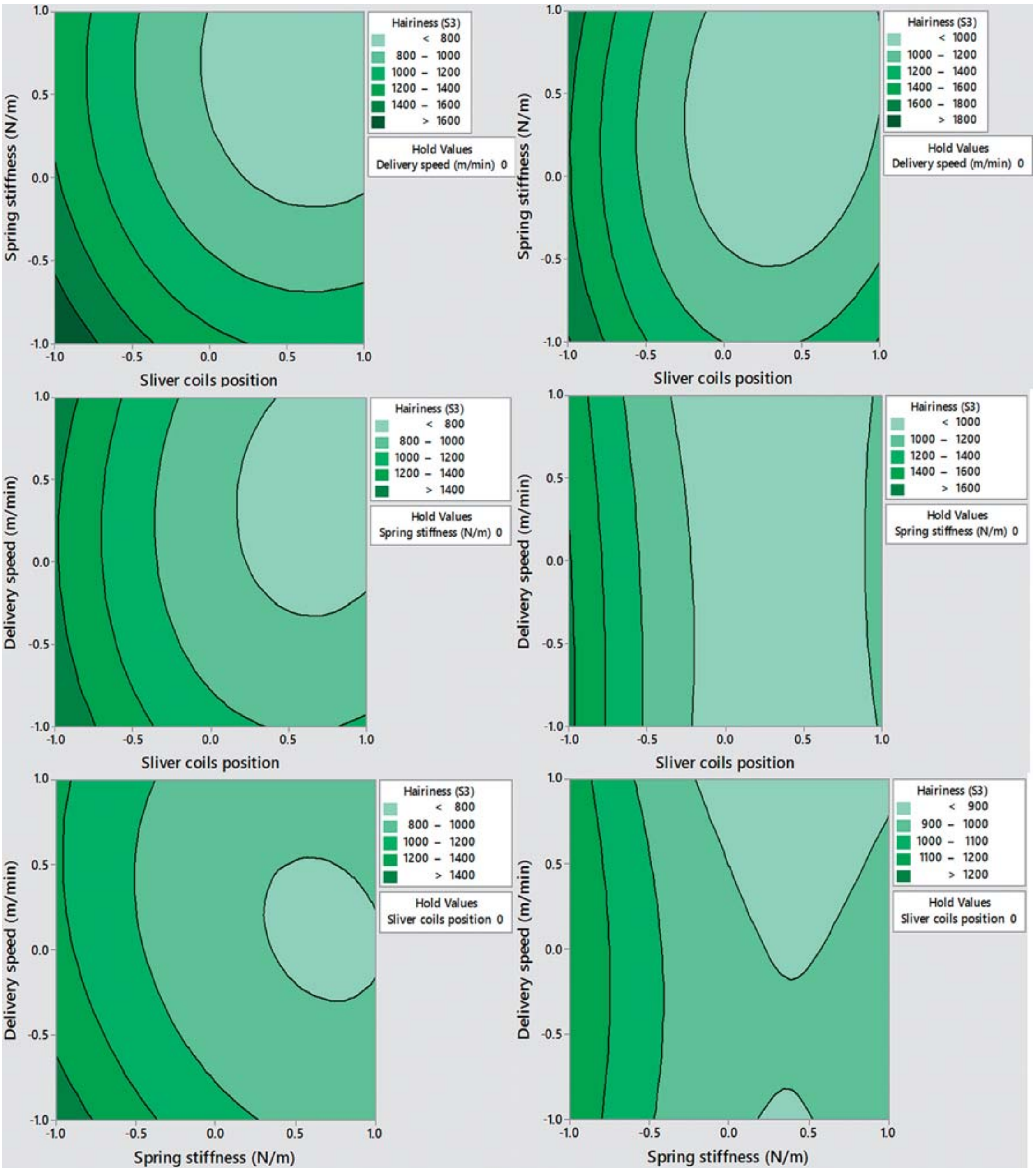

Figure 8: Effect of control factors on S3 yarn hairiness at 0 hr (left) and 8 hrs (right) storage time

3.5 Analysis of predicted versus actual values responses

The predicted versus actual value plots are merely a graphical interpretation of the analysis of variance or ANOVA, respectively. For a good fit, the actual points should be located close to the fitted line. It was found that the actual values are in a better alignment with respect to the predicted values in the case of breaking tenacity, breaking elongation and S3 hairiness for the samples produced without allowing any storage time, as shown in Figure 9. However, the predicted versus actual value plots confront non-uniform actual values distribution in the case of unevenness and imperfection for the samples produced without allowing any storage time, as shown in Figure 9.

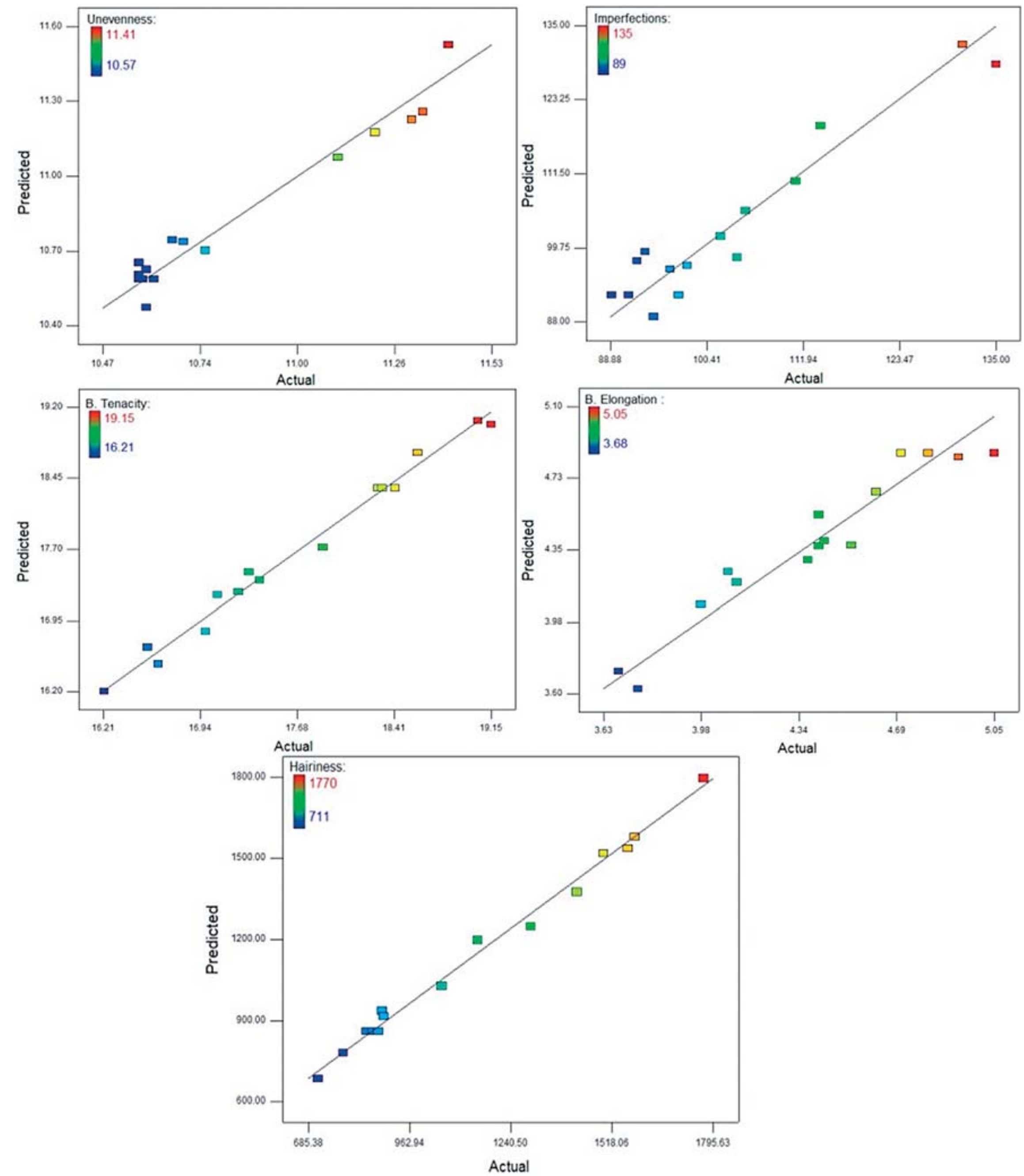

Figure 9: Actual versus predicted values of responses without allowing any storage time

The predicted versus actual value plots for the samples produced at 8 hours of storage time showed a good fit along with uniformly distributed actual values in the case of imperfections and breaking elongation, as shown in Figure 10. However, in the case of unevenness, breaking tenacity and hairiness, unevenly distributed actual values and the lack of fit was observed, which can be seen in Figure 10.

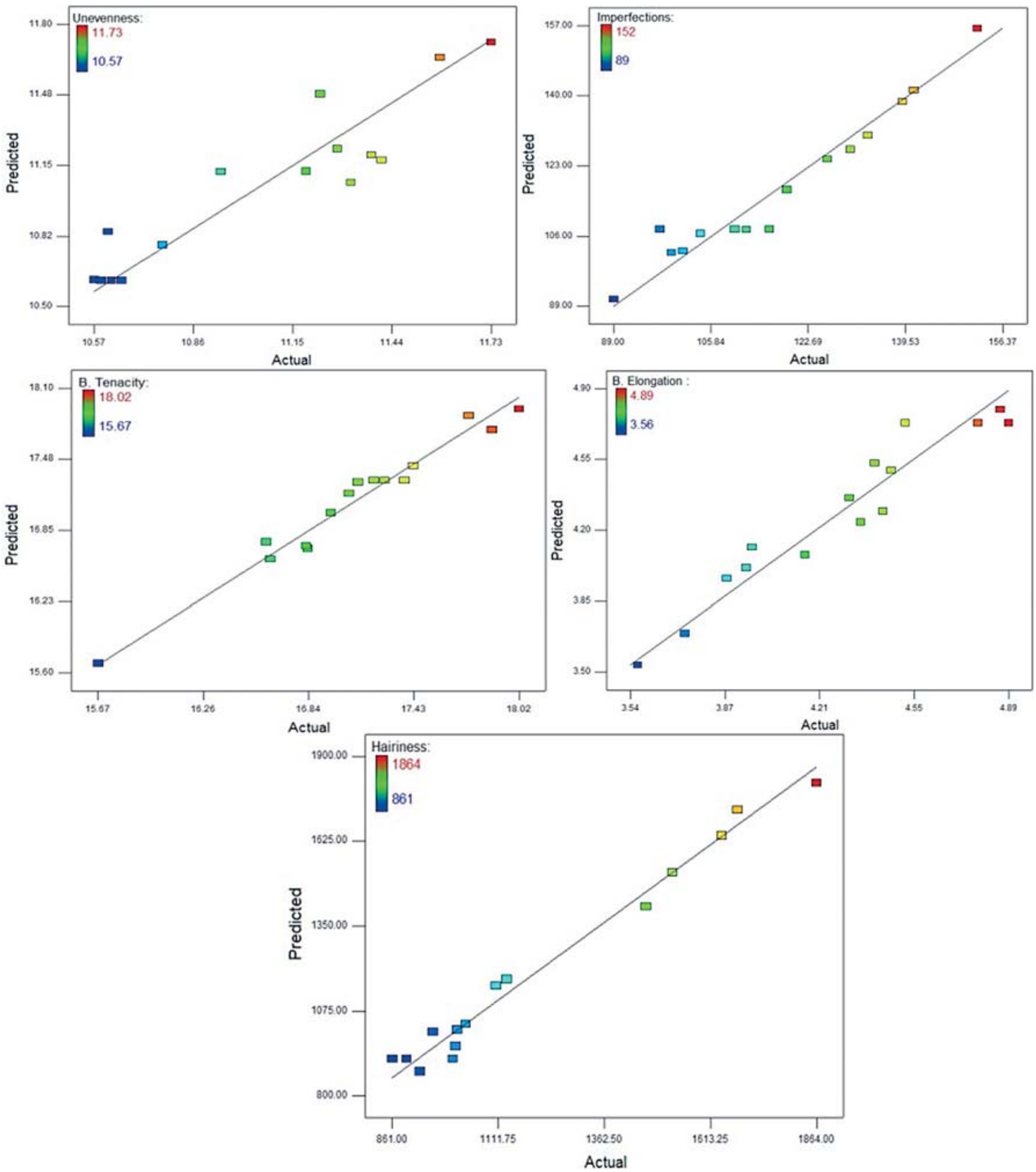

Figure 10: Actual versus predicted values of responses at 8 hours storage time

4 Conclusion

The present study was focused on investigating the effect of sliver coils position, can-spring stiffness and finisher drawframe delivery speed on combed yarn quality parameters, including unevenness, imperfections, breaking tenacity, breaking elongation and S3 hairiness index. The experimental results revealed that the combed yarn samples produced from older storage cans with the spring stiffness of 170 N/m, bottom position sliver coils, produced at 250 m/min finisher drawframe delivery speed, showed higher combed yarn unevenness, a higher number of total imperfections/km, lower breaking tenacity, relatively lower breaking elongation and higher S3 hairiness. The main reason for combed sliver quality deterioration was sliver stretching and sliver failures at the time of sliver withdrawal at the speedframe. Furthermore, the storage can-spring buckling in older cans resulted in a non-uniform distribution of the load, experienced by different position of sliver coils. The storage can-spring buckling in older storage cans was found responsible for sliver rubbing against the rough container side wall, producing hairy and weaker sliver, roving and yarn. It was found out that the samples produced from the bottom sliver coils position showed higher unevenness, more imperfections, hairy and relatively weaker resultant yarn due to improved adhesion with adjacent sliver coils, and sliver stretching and more sliver failure at the speedframe creel during sliver withdrawal. Hence, the role of sliver coils position and spring stiffness was found significant for combed yarn unevenness, imperfections, breaking tenacity and S3 yarn hairiness index. The effect of the finisher drawframe delivery rate was found insignificant for yarn unevenness and breaking elongation for the samples produced without allowing any storage time. Moreover, the effect of the delivery rate on all observed responses was found insignificant at 8 hours of storage time. Additionally, combed yarn samples produced by allowing 8 hours of sliver storage time showed higher unevenness, imperfection and S3 hairiness, and lower breaking tenacity and breaking elongation than the yarn samples produced without allowing any sliver storage time.

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