OPTIMIZING FIBER TO ROLLER INTERACTION, FINISHER SPEED AND LEVELLING ACTION POINT VIA SPECTROGRAM ANALYSIS FOR IMPROVED YARN QUALITY

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ABSTRACT: The main objective of the present research is to improve yarn quality by improving yarn evenness and strength while increasing the finisher speed. In this study, using spectrogram analysis, the drafting wave behavior in the finisher sliver was examined on the RSBD-35 drawing frame. The polyester-cotton blend (80:20) was developed at the varying delivery speeds (400, 500, and 600 meter/min) drawing frame to evaluate changes in sliver evenness and yarn characteristics. Based on the spectrogram analysis, the processing parameters were optimized and the sliver for the yarn preparation was developed at drawing frame at the optimized leveling action point (LAP; 984 mm) and 65.5 grains/yards. The yarn of 30/1 (Ne) was developed from the prepared sliver using the conventional ring spinning process. The coefficient of variation of mass (CV%) of the prepared sliver samples was determined by the UsterTester-3 (UT-3). The fineness/count (Nec) of the prepared samples was determined by following the standard test method ASTM-D1907. The quality parameters of the yarn including thick imperfection index (IPI;), U%, CV%, hairiness were determined by UsterTester by following the standard test method (ASTM D1425). The results indicated that increasing the finisher speed (600 m/min) reduced the LAP (984 mm) for PC yarn without compromising yarn quality indicators; U% (9.63), CV% (12.22), IPI (133), hairiness (4.27), and strength (CLSP: 4953). These results demonstrate the effectiveness of optimizing draw frame parameters in balancing productivity with yarn quality.

Keywords: Finisher Speed, Levelling Action Point, Spectrogram Analysis, Drafting Waves, Yarn Evenness, Yarn Strength

İPLİK KALİTESİNİN İYİLEŞTİRİLMESİ İÇİN LİF–SİLİNDİR ETKİLEŞİMİ, CER HIZI VE DÜZGÜNLEŞTİRME ETKİ NOKTASININ SPEKTROGRAM ANALİZİ İLE OPTİMİZASYONU

ÖZ: Araştırmanın temel amacı, iplik düzgünlüğü ve mukavemetini geliştirerek iplik kalitesini iyileştirmek, aynı zamanda son pasaj cer hızını artırmaktır. Bu çalışmada, Spektrogram analizi kullanılarak RSBD-35 cer makinesinde son pasaj cer şeridindeki çekim dalgası davranışı incelenmiştir. Şerit düzgünlüğündeki ve iplik özelliklerindeki değişimleri değerlendirmek üzere polyester-pamuk karışımlı iplik (%80:%20) farklı çıkış hızlarında (400, 500 ve 600 m/dak) çalışan cer makinesinde üretilmiştir. İşlem parametreleri spektrogram analizine dayanarak optimize edilmiş ve cer makinesinde optimize edilmiş seviyeleme etki noktasında (SEN; 984 mm) ve 65.5 grain/yards ile iplik hazırlığı için kullanılacak şerit üretilmiştir. Hazırlanan şeritten konvansiyonel ring iplik eğirme prosesi kullanılarak 30/1 (Ne) numara iplik üretilmiştir. UsterTester-3 (UT-3) ile hazırlanan şerit numunelerin kütle değişim katsayısı (CV%), tespit edilmiştir. ASTM-D1907 standart test metodu izlenerek hazırlanan numunelerin incelik/numara (Ne) değeri tespit edilmiştir. ASTM D1425 standart test metodu izlenerek UsterTester cihazı ile ipliğin kalın yer kusur indeksi (IPI), U%, CV%, tüylülük gibi kalite parametreleri ölçülmüştür. Sonuçlar, finişer hızının artırılmasının (600 m/dak), iplik kalite göstergelerinden; U% (9.63), CV% (12.22), IPI (133), tüylülük (4.27) ve mukavemet (CLSP: 4953) değerlerinden ödün vermeden Polyester-Pamuk ipliği için seviyeleme etki noktasını (SEN) (984 mm) düşürdüğünü göstermiştir. Bu sonuçlar, cer makinesi parametrelerinin optimize edilmesinin, verimlilik ve iplik kalitesi arasında denge kurmadaki etkinliğini ortaya koymaktadır.

Anahtar Kelimeler: Son Pasaj Cer Hızı, Seviyeleme Etki Noktası, Spektrogram Analizi, Çekim Dalgaları, İplik düzgünsüzlüğü, İplik Mukavemeti

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1. INTRODUCTION

The quality of yarn plays a pivotal role in the performance characteristics and final acceptability of the finished textile products [1,2]. Development of uniform and good strength yarns has long been a focus for textile engineers, technologists, and researchers [3]. Among the various stages of yarn manufacturing, the draw frame plays a key role in every spinning mill to improve the quality of the yarn by influencing fiber alignment and distribution [4,5]. The various actions at draw frame, including doubling, blending, drafting, parallelizing, leveling action point (LAP) and auto-levelling considerably improves the quality parameters of the sliver fibers [6–9]. These tasks ensure the best possible sliver quality and ensure optimum subsequent processing. The interaction between fibers and rollers during the drafting process is a key determinant of yarn characteristics, and optimizing this interaction can significantly improve yarn properties [10, 11].

Drafting waves, a common phenomenon during the drawing process, pose challenges in achieving consistent yarn quality [12]. These waves result from differences in the movement and alignment of the fibers, which alter the evenness of the sliver and, ultimately, the uniformity of the yarn [12]. Improving the physical characteristics of slivers and the resulting yarns requires an understanding and commitment to reducing drafting waves [13]. A thorough investigation of fiber-to-roller interactions is made possible by the effective analysis and visualization of these drafting wave characteristics provided by spectrogram analysis [14]. The spectrogram is an illustration of the mass deviations of the sliver, in reference to wavelength, designed for identification and analysis of the periodic faults [14,15].

Recent research highlights that optimizing the LAP is key to reducing drafting waves and sliver CV%, incorrect LAP leads to periodic faults [8, 16]. Furthermore, spectrogram analysis also helps for the detection of sliver faults and LAP adjustment by linking drafting wave frequencies to machine components. Both; optimized LAP and proper monitoring of spectrogram helps to ensure the quality of the resultant yarn [6]. However, the spectrogram determined by the draw frame is not reliable, a real time monitoring of sliver spectrogram determined by the UsterTester is more reliable.

Despite the significant research work that has been reported regarding the understanding relationship between draw frame processing parameters and their impact on the resultant yarn [17,18], a crucial gap still exists in connecting the optimization of finisher speed and LAP with the subsequent conversion of sliver quality into resultant yarn performance. Although sliver CV% is frequently employed as a direct measure of yarn quality, research indicates that various factors such as drafting multiplication, fiber migration, and twist insertion during yarn manufacturing process, yarn CV% is generally higher than sliver CV% [19–21]. However, there is limited research that has systematically quantified how drafting waves and short fiber irregularities can be controlled by the optimization of draw frame processing parameters [8,13], and how these improvements in sliver evenness are consistently translated into yarn. Furthermore, it is important to note that UsterTester spectrogram tool has been used for the detection of draft waves, but their integration into a practical optimization framework for industrial-scale ring spinning is still underexplored. It is very important to fill this gap for deeper understanding of the fiber-to-roller interaction and to ensure improvements at the draw frame translate into quantifiable and sustainable gains in yarn quality.

In order to reduce drafting waves and improve yarn quality, this study focuses on improving important draw frame (finisher) parameters. For short-staple fibers, the leveling action point (LAP), grains/yard, and other crucial characteristics were systematically examined using the RSBD-35 drawing frame. Polyester and cotton were blended to produce PC (PC 80:20) and operational parameters were optimized using the UsterTester results. The yarn of said composition was prepared from the slivers developed at the optimized parameters (Speed: 600 meter/minute, LAP: 984 mm, and grain/yard: 65.5). The focus was on striking a balance between higher finisher speeds and preserved yarn properties including tensile strength, imperfection index (IPI), and evenness (U%, CV%). The proposed research work indicates that optimizing draw frame parameters, particularly finisher speed and LAP, can improve yarn quality without reducing efficiency, while providing a framework for future research on enhancing fiber-to-roller interactions in blended yarns.

2. MATERIAL AND METHODS

The raw cotton with upper half mean length of 25 mm, uniformity index of 81.5%, short fiber index of 11.3 %, strength of 29.3 g/tex, elongations 6.7%, and fineness of 4.6 mic (microgram/inch) was obtained from the local market. The polyester with staple length of 38 mm, strength 49.5 g/tex, elongation of 22.8, and fineness of 1.2 denier was purchased from Ibrahim Fibers, Pakistan. The raw material was stored in the godowns under standards condition for further use. The yarn of Polyester-Cotton (PC 80:20, polyester 80: cotton 20) blend was prepared using the conventional ring spinning process. The Rieter Draw frame (RSB-D35) equipped with auto leveler was used. Card slivers of cotton (78 grains/yard) were produced by the Rieter C-70 card while card slivers of polyester (68 grains/yard) were produced by the Cross-roll MK-4 Rieter. The slivers for the desired compositions of blended fiber were manufactured by Toyoda breaker drawing 500C.

The finisher drawing parameters were optimized using the spectrogram analysis. For this, the spectrogram of the prepared slivers was determined by UsterTester-3 and drafting waves (peaks) and coefficient of variation (CV %) of the sliver were recorded and analyzed. The LAP was also optimized without an autoleveller, then the close loop autoleveller was turned on and the corresponding LAP was found with the help of spectrogram. For close loop auto-levelling, the variations of the incoming sliver

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were detected by the scanning rollers (gauge; 6.5 mm) and an electronic signal was generated and transmitted to a digital control unit. The dynamic servo drive system controlled them by giving the required draft at the LAP. A Rieter Quality Monitor after delivery; feedback loop ensured the variations such as CV% (1.65-1.90%) and spectrogram peaks stay within the limits.

In the first step, by hit and trial, optimized LAP at different delivery speeds (400 MPM, 500MPM, and 600 MPM) of the finisher drawing frame for PC (PC 80:20) by analyzing the sliver through spectrogram analysis. The sliver used for the yarn manufacturing (65 grain/yard) was developed under optimized draw frame (Rieter RSB-D 35) conditions, operating at the speed of 600 meter/min with a LAP of 984 mm, front and back bottom gauge settings of 45mm, and a break draft of 1.41. The roving of 1.05 hanks was prepared by the simplex (FL-16) machine. The prepared roving was processed in the conventional ring frame machine (EJM 168) and it was drafted, twisted, and wound on ring cops as yarn of 30s count (Nec).

It is important to note that all the testing of the samples was carried out at standards environmental conditions temperature 20 ± 2 °C and relative humidity at 65 ± 2 %. For the authenticity of the results, each test was carried out 5 times and their average was taken. The yarn quality characteristics such as count (Nec), unevenness (U %), coefficient of variation (CV %), imperfections, hairiness, and CLSP were determined and analyzed.

CV% of sliver and yarn: The various prepared slivers prepared were tested for drafting waves and coefficient of variation (CV%). For this, sliver sample of 6 yards was analyzed by the UT-3 according to standard test method ASTM D1425.

Sliver, roving and yarn count (Nec): The linear density: count (numerical English count) of the prepared sliver, roving, and yarn was determined using a wrapping drum/wrap reel and weigh scale in accordance with ASTM D1907. The test lengths for sliver,

roving, and yarn were 6 yards 15 yards and 120 yards, respectively after which the skeins were weighed and the count calculated. The operating speed of UT-3 for sliver and roving was 25 m/min while yarn testing was carried out at 400 m/min.

Yarn imperfections: The yarn hairiness (H) and imperfections (IPI) including thin places (-50%), thick places (+50%), and neps (+200%) were determined using the UT-3 operating at 400 m/min by following the standard Test method (ASTM D1425)

Lea strength (yarn bundle strength): A lea strength tester was used to determine the CLSP of the yarn. For this, a skein of 120 yards on a wrap reel according to ASTM (D1578) and determined its breaking strength (Newton) of yarn using tensile testing machine working on the constant rate of traverse principle. The product of count (Nec) and lea strength (CLSP) of the yarn was obtained. It is important to note that for the authenticity of the results, each test was carried out 5 times, and their average was taken.

For clarity, Least Significant Difference (LSD) test was applied after the two-way Analysis of Variance (ANOVA) to compare the interaction means of finisher speed (m/min), LAP on sliver CV%, and yarn quality parameters including CV%, imperfection index (IPI), hairiness and strength. So, it was identified which specific combination have a significant effect on the performance of the materials. The LSD was calculated from the mean square error of ANOVA, and pairwise comparisons were made.

3. RESULT AND DISCUSSION

The research plan was comprised of two phases to conduct this study. In the first phase, trial observations were made to optimize the levelling action point to develop the minimum drafting wave sliver at different delivery speeds of the finisher drawing at different blends. In the first step, the quality results of sliver prepared for PC 80:20 such as drafting waves (peaks) and CV% are given in Table 1.

Table 1: Speed, LAP interaction and the corresponding quality parameters of resultant slivers

Delivery Speed (MPM)	Levelling action point (mm)	Sliver CV%	Results
S1= 400	L1=996	1.70	Minimum drafting peaks in sliver
	L2=987	1.76	Maximum drafting peaks in sliver
	L3=984	1.92	Maximum drafting peaks in sliver
S2= 500	L1=996	1.85	Maximum drafting peaks in sliver
	L2=987	1.69	Minimum drafting peaks in sliver
	L3=984	1.84	Maximum drafting peaks in sliver
S3= 600	L1=996	1.89	Maximum drafting peaks in sliver
	L2=987	1.78	Maximum drafting peaks in sliver
	L3=984	1.63	Minimum drafting peaks in sliver

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3.1. Characterization of prepared Sliver

Coefficient of variation of the sliver (CV%): The sliver irregularities increased due to uncontrol of short fibers in the drafting zone and high drafting peaks in draw frame sliver. The quality parameters of the finisher drawing such as CV % and high drafting waves can be optimized through parallelization of the fibers. The incoming irregularities in the card sliver are minimized through bottom roll gauge and break draft. The results of the analysis of variance for the sliver CV% demonstrated that the influence of delivery speed (S) and LAP, were significant in this study as shown in Table 1. The sliver CV% values of interactions S1×L1, S1×L2, S1×L3, S2×L1, S2×L2, S2×L3, S3×L1, S3×L2, S3×L3, are 1.70%, 1.76%, 1.92%, 1.85%, 1.69%, 1.84%, 1.89%, 1.78% and 1.63%, respectively. The sliver CV% values of interactions range from 1.63% to 1.92%. S3×L3 had the lowest value of 1.63% while S1×L3 had the highest value of 1.92%.

The result of the present study shows that at 400 MPM, the CV % of the finisher draw frame sliver was considerably reduced in the range from 1.92 % to 1.70 % which was done by the optimization of levelling action point (996 mm) as shown in Table 1. The result of the study shows that at 500 MPM, CV % of the finisher draw frame sliver was considerably reduced in the range from 1.85% to 1.69 % which was done by the optimization of LAP (987mm) as shown in Table 1. It was also found that at 600 MPM, CV % of the finisher draw frame sliver was considerably reduced in the range from 1.89% to 1.63 % which was done by the optimization of LAP (984 mm) as shown in Table 1. So, the control of short fibers and fiber parallelization during the drafting process significantly affect the quality of the sliver [22].

Spectrogram analysis proved to be a valuable tool for optimizing sliver evenness by minimizing drafting waves. At the finisher speed of 400 MPM, the optimized LAP of 996mm resulted in minimal drafting peaks (Fig. 1(a)) and a low CV% of 1.70% (Table 1). This indicates good control over short fibers within the drafting zone. Conversely, lower LAP (987mm and 984mm) led to an increase in drafting peaks (Fig. 1 (b & c)) and higher CV% values (1.76% and 1.92%, respectively) as shown in Table 1.

Similarly, at 500 MPM and optimized LAP of 987mm, minimized drafting peaks (Fig. 1(e)) with a sliver CV% of 1.69% (Table 1) were observed, demonstrating effective short fiber control. Higher and lower LAP at 500 MPM (Fig. 1 (d & f)) resulted in increased drafting peaks and higher CV% values (1.84% and 1.85%, respectively) in Table 1.

Interestingly, even at 600 MPM, the optimized LAP of 984 mm minimized drafting peaks (Fig. 1(i)) and maintained good sliver evenness (CV% of 1.63%, Table 1), signifying improved evenness despite the increased speed. Higher LAP at 600 MPM (Fig. 1 (g & h)) led to an increase in drafting peaks and higher CV% values (1.89% and 1.78%, respectively) in Table 1.

These findings support the notion that chimney-type periodic faults (draft waves) arise due to uncontrolled short fibers, improper drafting zone settings, and suboptimal LAP. Effective LAP optimization minimizes peak height (chimney) above the baseline spectrogram, ensuring proper short fiber control. The chimney type periodic faults are called draft waves. The cause of such faults is due to uncontrolled short fibers, improper settings in the drafting zone, and LAP. The height of the peak, known as the chimney, above the basic spectrogram at any wavelength must equal or exceed by 50% the height of the basic spectrum at that wavelength.
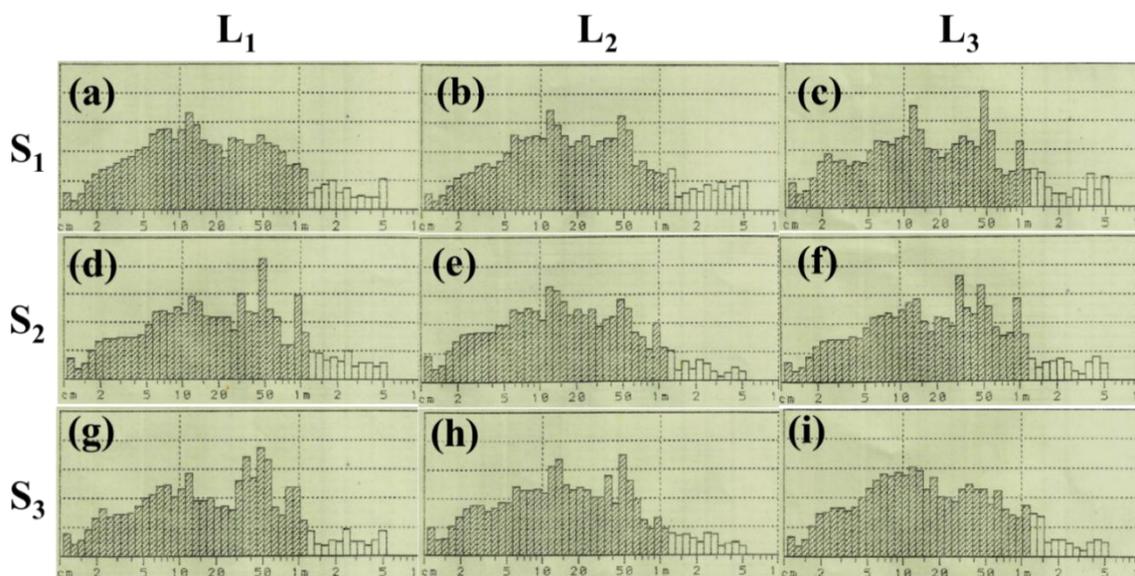

Fig.1: Sliver drafting waves (peaks) of at various delivery speeds and levelling action points

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3.2. Yarn Characterization

In the second step, the slivers which were developed at various speeds (S1, S2, and S3) and LAP (996, 987, 984 mm) were successfully converted into the hank roving of 1.04 (Nec). The yarns of 30s (Nec) were prepared and their results including uniformity (U%), CV%, yarn imperfections (IPI), hairiness (H), and count lea strength product (CLSP) were determined and analyzed (Table 2).

Coefficient of Variation of yarn (CV %): It is obvious from Tables 1&2, that the CV% of the resultant yarns is higher than their parent slivers. It is attributed to the draft given to the fibers at roving and ring frame [25]. Additionally, fiber migration and fiber twisting mechanism also results in the increased CV% of the resultant yarns [26]. In the present study, the yarn irregularities (CV%) increased due to uncontrol of short fibers in the drafting zone and high drafting peaks in draw frame sliver [25]. However, incoming sliver irregularities were minimized through optimized bottom roll gauge and break draft settings [24]. The optimized drafting system, minimal drafting waves, and low CV% in the finisher draw frame contributed to reduced CV% of the resultant yarn [25], [27]. At 500 MPM (S1) yarn CV% decreased from 13.22% to 12.47% (Table 2) after optimizing the LAP on the draw frame. Similar improvements were observed at 500 MPM (S2) and 600 MPM (S3). At 500 MPM (Table 2), the CV% of the yarn was reduced from 13.22% to 12.34%. At 600 MPM, yarn CV% was reduced from 13.51% to 12.22%. It is important to note that yarn and sliver results follow the same trends (Table 1&2). The results of the analysis of variance of data related to yarn CV%

demonstrated that the influence of S and LAP were significant in this study, as shown in (Table 2). The LSD test was used in the context of the analysis of variance, and the comparison of interaction means for S and LAP. The yarn CV% values of interactions S1×L1, S1×L2, S1×L3, S2×L1, S2×L2, S2×L3, S3×L1, S3×L2, S3×L3, are 12.47%, 12.76%, 13.22%, 13.02%, 12.34%, 13.22%, 13.51%, 13.18% and 12.22%, respectively (Table 2). The yarn CV% values of interactions range from 12.22% to 13.51%. S3×L3 had the lowest value of 12.22% while S3×L1 had the highest value of 13.51%.

Fig. 2(a) illustrates that optimized LAP at higher speeds contributes to improving sliver evenness. Conversely, uncontrolled drafting waves in slivers lead to increase yarn unevenness, as evidenced by the highest yarn CV% at S3×L1. These findings suggest that optimized LAP enhance fiber orientation within the sliver [28], leading to fewer short- and medium-term variations and improved yarn CV%.

Imperfection of yarn: Yarn imperfections (IPI) significantly influence the quality of the resultant product, with excessive IPI resulting in a cloudy fabric appearance [29]. Similar to CV%, yarn IPI also exhibits a comparable trend (Table 2). Uncontrolled short fibers within the drafting zone are a common cause of IPI. The periodic irregularities in drawing slivers, often attributed to uncontrolled short fibers during drafting, lead to thick and thin places in yarn. The periodic irregularities in drawing slivers, which may possibly be caused by uncontrollable short fibers during drafting, cause thick and thin places in yarn. The drafting force effect the yarn imperfection [27].

Table 2: Speed, LAP interaction and the corresponding quality parameters of resultant Yarn (PC yarn of 30s Nec)

Speed (MPM)	Optimized/Normal point	Finisher LAP (mm)	Yarn results					
			Yarn Count (Nec)	U%	CV%	IPI	Hairiness	CLSP
S1=400	Opt. point	L1=996	29.16	9.82	12.47	135	4.16	4941
	Normal point	L2=987	29.38	10.03	12.76	160	4.14	4850
	Normal point	L3=984	29.30	10.76	13.22	193	4.17	4790
S2=500	Normal point	L1=996	29.45	10.23	13.02	200	4.12	4823
	Opt. point	L2=987	29.52	9.70	12.34	143	4.18	4913
	Normal point	L3=984	29.17	10.41	13.22	154	4.23	4816
S3=600	Normal point	L1=996	29.27	10.59	13.51	193	4.32	4850
	Normal point	L2=987	29.27	10.64	13.18	180	4.20	4807
	Opt. point	L3=984	29.21	9.63	12.22	133	4.27	4953

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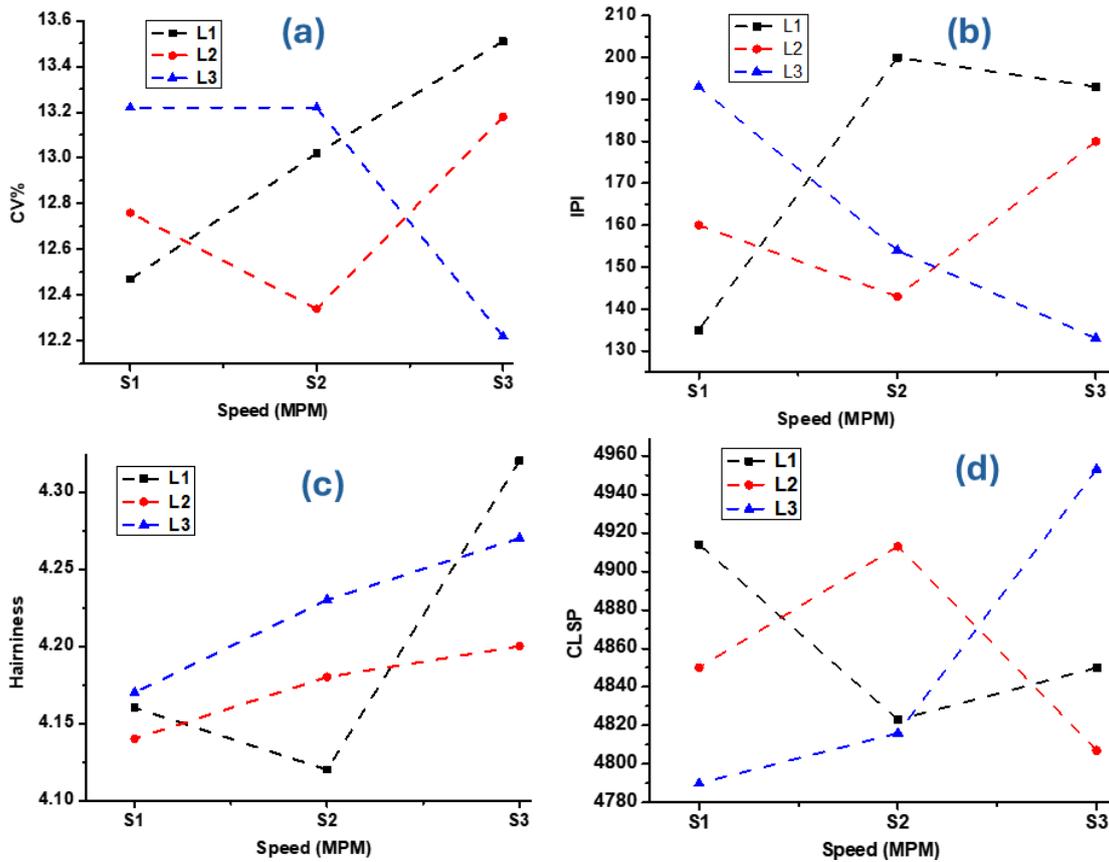**Fig. 2:** Main effects of LAP and delivery speed on (a) CV%, (b) IPI, (c) Hairiness, and (d) CLSP

The IPI values of interactions S1×L1, S1×L2, S1×L3, S2×L1, S2×L2, S2×L3, S3×L1, S3×L2, S3×L3, are 135, 160, 193, 200, 143, 154, 193, 180 and 133, respectively (Table 2). IPI values for the interactions ranged from 133 to 200, with S3×L3 exhibiting the lowest value 133 and S2×L1 displaying the highest value 200. As demonstrated in previous sections, optimizing the LAP significantly reduced sliver CV% and drafting waves at all finisher speeds. This is translated to a substantial reduction in yarn imperfections. For example, at 400 MPM (S1), optimizing the LAP decreased yarn imperfections from 193 to 135 (Table 2). Similar improvements were observed at 500 MPM (S2) and 600 MPM (S3).

Fig. 2(b) clearly illustrates that controlling drafting waves through LAP optimization effectively minimizes yarn imperfections, even at higher finisher speeds. Conversely, uncontrolled drafting waves in slivers, regardless of delivery speed, lead to increased yarn imperfections. As shown in (Table 2), the IPI value of 193 at S1×L3 highlights the negative impact of uncontrolled drafting waves on yarn quality. In conclusion, this study emphasizes the critical role of drafting wave control in optimizing yarn quality. By effectively managing drafting waves through LAP optimization, it is possible to significantly reduce yarn imperfections and enhance overall product quality.

Hairiness of the yarn: Hairiness means protruding fibers from the yarn body. Hairiness plays a major role in fabric quality in knitting

as well as in weaving [3,17]. The results of the analysis of variance of data related to yarn hairiness demonstrated that both S and LAP influence yarn hairiness (Table 2). The LSD test was used in the context of the analysis of variance, and the comparison of interaction means for S and LAP. The H values of interactions S1×L1, S1×L2, S1×L3, S2×L1, S2×L2, S2×L3, S3×L1, S3×L2, S3×L3, are 4.16, 4.14, 4.17, 4.12, 4.18, 4.23, 4.32, 4.20, and 4.27, respectively (Table 2). The H values of interactions range from 4.12 to 4.32. S2×L1 had the lowest value of 4.12 while S3×L1 had the highest value of 4.32.

CLSP of the yarn: The CLSP is one of the key factors of yarn that directly influences the fabric manufacturing, and mechanical performance of the resultant fabric. CLSP is directly influenced by the fiber length, fiber mic, fiber strength, doubling, sliver leveling, and yarn twist [30, 31]. In finisher drawing, optimizing the LAP promotes short fiber control, leading to improved fiber length and orientation, ultimately resulting in stronger yarn. This study's analysis of variance revealed that both S and LAP significantly influenced CLSP (Table 2).

At 400 MPM (S1), optimizing LAP reduced sliver CV% from 1.92% to 1.70% (Table 1) and minimized drafting waves. This resulted in a significant improvement in yarn CLSP from 4790 to 4941 (Table 2). Similar trends were observed at 500 MPM (S2) and 600 MPM (S3), where optimized LAP led to improvements in yarn CLSP. In conclusion, this study highlights the pivotal role of

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LAP optimization in enhancing yarn strength and CLSP. By effectively controlling short fibers and improving fiber orientation, optimizing LAP settings contributes to stronger yarns, ultimately improving weaving machine efficiency. From Fig 2(d), it is seen that due to an uncontrolled sliver drafting wave, the ultimate yarn strength at S1 and L3 decreased to 4790 while S3×L3 had the highest value of 4953 at the optimized LAP (984mm). The CLSP of the yarn after optimization of LAP on the draw frame at 600 MPM has been significantly improved from 4807 to 4953 (Table 4). It is obvious from the results that optimizing the LAP at higher finisher speed (600 MPM) improves the fiber orientation and improves the CLSP and other quality parameters of the resultant yarn [24, 32].

4. CONCLUSIONS

This work provides a deeper understanding of the optimization of fiber-to roller interaction at the finisher draw frame by the help of real time analysis of UsterTester spectrogram, with focus on the impacts of the draw frame speed and LAP on the quality of resultant sliver and yarn. As finisher speed increased (400 to 600 MPM), the optimum LAP decreased (996 to 984 mm), resulting in reduced drafting peaks and improved sliver evenness. The present research showed that the quality parameters of yarn including CV%, U%, IPI, H, and CLSP can be effectively controlled by minimizing the drafting waves using spectrogram, without compromising the machine efficiency. The findings indicated that after optimization of LAP (984 mm) at higher speed (600 MPM), the U%, CV%, IPI, hairiness, and CLSP can be improved to 9.63%, 12.22%, 133, 4.27, 4953, respectively. Furthermore, this study also highlighted the importance of the optimization of draw frame parameters to balance productivity with quality. The reported methodology and results of our work establish a foundation for future studies aiming to refine drafting processes and improve the overall efficiency of yarn manufacturing.

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