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An Experimental Investigation of the Effects of Some Process Conditions on Ring Yarn Breakage

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Abstract : *End breakage has a great effect on ring spinning productivity and also on yarn quality. In this study, it was aimed to analyze the statistically significant processing parameters of ring spinning that have an effect on the end breakage during the formation of ring spun yarn using the plackett burman experimental design. In addition, the effects of the significant parameters on the end breakage of ring frame were investigated. Our eight selected independent processing conditions were mixing ratio (CIS cotton/ Shankar-6); Waste extraction% at blow room and carding; roving twist; break draft; spacer size; top roller pressure; spindle speed and yarn count .Two levels for each independent variable were selected to conduct the study. For this study, 100% cotton carded yarn samples were produced by Marzoli ring spinning frame and the results of end breakage /100 spindles/hour were calculated and analyzed for all samples produced according to the design of experiment. As a result, the parameters that have most significant effect on the end breakage during the formation of ring spun yarn were obtained as waste extraction percentage at fiber preparatory stages viz. blow room and carding, amount of roving twist, front top roller pressure and spindle speed of ring frame. Finally, all the results of the statistical analysis were discussed and evaluated.*

Keywords: *End breakage, plackett burman design, process parameters, ring spinning, statistical significance*

I. Introduction

In today's spinning technology, ring spinning still dominates over other modern spinning system in terms of yarn quality and flexibility. Ring spinning stands alone as the primary reference to high quality yarn suitable for any type of textile end product. But in comparison with the new spinning processes the production of ring spinning is almost 10 times smaller. R S Rengasamy et al. reported that the performance of a ring machine is evaluated by productivity, end breakage rate and quality of yarn produced [1]. One of the limitations of modern ring frame is end breakage. As a result, decreasing end breakage of ring frame in consideration of running performance is the cherished goal consistently sought by every spinner in order to minimize the yarn cost. Ends down rate are directly connected with percentage of pneumafil wastages and cost of yarn production.

In ring spinning, from an operational point of view, the end breakage rate is a symptom of how well a plant is running. A high end breakage rate points to a combination of machine, material and human faults [2]. Control of end breakage rate at the ring frame is the first step for improving the ring frame productivity [3].

The end breakage in ring spinning not only reduces the production of the plant but also deteriorates the quality of yarn in terms of presence of piecing. End breakage during yarn winding in cops may lead to formation of lean cops. These lean cops will surely reduce the production of auto-coner machine. Yarn ends down rate have direct effect on fabric production and final product quality. Higher the end breakage rate in spinning leads to higher the end breakage rate in weaving. It might be worth commenting that, generally speaking, controlling yarn ends down rate in spinning process will surely improve the running performance of subsequent processes and the quality of fabric.

However, end breakage occur during spinning depends on various processing conditions of spinning. The permutation and combination of different processing conditions during ring spun yarn production can reduce the end breakage.

Design of Experiment (DOE) is an experimental or analytical method that is commonly used to statistically signify the relationship between input parameters to output responses, where by a systematic way of planning of experiments, collection and analysis of data is executed [4]. In practical use, Plackett-Burman design is often used to screen for the important factors that influence process output measures.

In this investigation, we have tried to identify and analyzed the statistically significant factors among various processing conditions of ring spun yarn namely blend ratio, total waste extraction% of blow room and carding, roving twist per inch, break draft, spacer size, top roller pressure, spindle speed and yarn count for predicting the end breakage of ring spun yarn. For this purposes, we have used plackett burman design of eight independent variables having two levels for each variables.

Table I: Selected independent and dependent variables with level values

Variable Qualification	Variables	Symbol	Unit	Levels (Low-High)
Dependent	End breakage		per 100 sp./hr	-
Independent	Blend ratio (CIS/S-6)	A	%	60/40-50/50
	Waste extraction	B	%	8-9
	Roving twist	C	per inch	1.02-1.06
	Break draft	D	-	1.19-1.24
	Spacer size	E	mm	2.75-3.25
	Top roller pressure	F	kgf	12-14
	Spindle speed	G	rpm	15000-17000
	Yarn count	H	Ne	30-36

II. Materials And Methods

2.1 Experimental design

Firstly the eight processing conditions of spinning that may have an effect on yarn end breakage were selected to use in the experimental design as independent variables. The dependent variable is end breakage of ring frame during formation of ring spun yarn. Two levels of each independent variable are given in Table-1. The plackett burman design method used to screen the selected processing conditions for their effect on yarn end breakage. Total 12 experiments of different combinations were carried out. All statistical analyses were performed by reliasoft design software. Analysis of variance (ANOVA) was applied to the data obtained from the tests in order to define the statistically significant parameters affecting yarn breakage and significance tests were applied at α= 0.1 level.

Table II: Experimental results of ends down rate

Expt. No.	Blend Ratio (CIS/S-6)	Waste Extracti-on %	Roving twist/inch	Break draft	Spacer size (mm)	Top roller pressure (kgf)	Spindle speed (rpm)	Yarn count (Ne)	Ends down /100sp./hr
1	50/50	8	1.06	1.24	2.75	14	17000	36	28.5
2	50/50	9	1.02	1.19	2.75	14	15000	36	13.5
3	50/50	8	1.06	1.24	3.25	12	15000	30	15.7
4	60/40	8	1.02	1.19	2.75	12	15000	30	8.7
5	60/40	9	1.06	1.19	3.25	14	17000	30	24.1
6	60/40	9	1.06	1.24	2.75	12	15000	36	9.8
7	60/40	8	1.06	1.19	3.25	14	15000	36	21.2
8	60/40	9	1.02	1.24	3.25	12	17000	36	10.5
9	50/50	9	1.06	1.19	2.75	12	17000	30	11.8
10	50/50	9	1.02	1.24	3.25	14	15000	30	14.1
11	50/50	8	1.02	1.19	3.25	12	17000	36	20.4
12	60/40	8	1.02	1.24	2.75	14	17000	30	19.7

2.2 Raw materials and production conditions

Two types of cotton were used namely CIS cotton having average fiber fineness of 4.42 Mic, length of 30.6 mm, strength of 29.4 g/tex, trash area% of 0.19 and Shankar-6 (S-6) cotton having average fiber fineness of 4.15 Mic, length of 27.4mm, strength of 29.6 g/tex. CIS cotton and Shankar-6 were blended at two different ratios (60/40 and 50/50). Fibers of two types were mixed by hand as per ratios of experiment and were fed to CL-P machine of Truetzschler by pipe opening. Slivers were produced using modern blow room line of Truetzschler and TC-6 (Truetzschler) carding machine. Total waste extraction percentage of blow room and carding were kept 8% and 9% by changing winch settings of card. Two passage drawing was applied using Rieter SB-D45 and RSBD-22 drawframe and slivers of 75.5 grain per yard were obtained. A Toyota FL-100 roving frame was used for producing rovings of Ne0.72. Yarn .Two levels of roving twist per inch were 1.02 and 1.06. Yarns were spun as Ne 30 and Ne 36 with TPI of 20.06 and 21.78 respectively. The climate conditions were 28-29 degree Celsius and 48-52 % Rh. Throughout the production of yarn samples. Travellers were used 3/0 for Ne 30 and 5/0 for Ne 36 and two levels of break draft for both yarn counts were 1.19 and 1.24.

2.3 Measurements of end breakage

For counting yarn end breakage rate/100 spindles/hour, two skilled operators per frame (504 spindles) have been engaged for yarn piecing just after breakage and one quality officers for marking spindles of breakage. Spindles were marked after piecing because of identifying the mechanical related causes. However, ends down rate were calculated by observing ring frame two hours continuously for each combinations of experiment. Four ring frames were used to produce all of our yarn samples as per design combinations.

Table III: ANOVA Table for Yarn End Breakage

Source of Variation	Degrees of Freedom	Sum of Squares [Partial]	Mean Squares [Partial]	F Ratio	P Value
Model	8	406.7867	50.8483	7.0189	0.0684*
Main Effects	8	406.7867	50.8483	7.0189	0.0684*
Residual	3	21.7333	7.2444		
Lack of Fit	3	21.7333	7.2444		
Total	11	428.52			

Table IV: Regression Table for Yarn End breakage

Term	Coefficient	T Value	P Value
Intercept	16.5	21.236	0.0002*
A: Blend Ratio	0.8333	1.0725	0.3621
B: Blow Room & Carding Waste	-2.5333	-3.2605	0.0471*
C: Roving Twist	2.0167	2.5955	0.0807*
D: Break Draft	-0.1167	-0.1502	0.8902
E: Spacer Size	1.1667	1.5015	0.2302
F: Top Roller Pressure	3.6833	4.7406	0.0178*
G: Spindle Speed	2.6667	3.4321	0.0415*
H: Yarn Count	0.8167	1.0511	0.3704

*Significant at 90% confidence level.

III. Results And Discussion

Results of end breakage rate of different combinations of experiment are given in Table-2.The p-value and regression co-efficient values are given in Table-4. From ANOVA Table-3, it is seen that p value of the model less than 0.1 indicating significance of the design model. The coefficient of determination R^2prediction is obtained as 0.949 and R^2adj as 0.814 which indicating that selected model is significant for this study. The p-value marked with an asterisk (*) indicates that the term is considered to be significant due to having p-value lower than 0.1. The Table-4 shows that the effect of the waste extraction%, roving twist, top roller pressure and spindle speed are statistically significant whereas the effect of blend proportion, break draft, spacer size and yarn count are statistically insignificant at α= 0.1 level. Normal probability plot of effect has been given in fig-2 based on T value of our selected independent variables.

The effects of the main significant factors are examined by observing the fig-1. It shows that the end breakage rate decreases significantly with an increase in the total waste extraction percentage at blow room and carding. The reason may be due to higher waste extraction% means more clean cotton will remain in sliver. As a result, chance of yarn breakage at spinning triangle of ring spinning will be low because of decreased probability of interruption, caused by trash particles, in fiber movement from drafting roller to participation in twisting mechanism. From figure-1, it is also seen that end breakage rate increases with an increase in roving twist, indicating the importance of roving twist for yarn breakage at ring frame. High twisted roving not only leads to fiber breakage at back draft zone but also hampers the total drafting operation of ring frame. Because of using high twisted roving, undrafted fibers bunch can emerge from front roller. As a result, yarn breakage will occur undoubtedly along with the disturbance of yarn formation at neighboring spindle of ring frame. Ultimately, the incidence of series of end breakage will be occurred.

On the other hand, end breakage rate have been increased surprisingly with the increase of top roller pressure. This result may be explained in such a way that higher the top roller pressure, greater will be the strain on the fibers in the nip point, leading to the increasing normal force over fibers and resistance to drafting which will result in undrafted ends in the yarn. Undrafted fiber bunch will create yarn breakage during spinning. Fig-1 indicates that there is a strong effect of spindle speed on yarn breakage. Unsurprisingly, breakage rate have been increased with the increase of spindle speed. This finding can be explained on the basis of fact that the increase in spindle speed resulted in higher spinning tension. It is reported that an end break occurs whenever the spinning tension exceeds the yarn breaking force [5].

However, end breakage rate increases with the increase of spindle speed irrespective of yarn count (shown in fig-3).Figure-3, in which there is the interaction plot of AB factors, shows that the end breakage rate has been decreased with an increase of waste extraction% for both type of mixing ratios of CIS cotton and Shankar-6. However, an increase in the percentage of CIS cotton in mixing has a tendency to decrease the end breakage rate of yarn at low level of waste extraction but at high level of waste extraction% the end breakage rate has been slightly increased. From figure-3, it is seen that with an increase of waste extraction% leads to decrease the end breakage rate at higher spindle speed.

On the other hand, higher break draft at ring frame decrease the end breakage rate of ring spun yarn produced from relatively higher roving twist. From the interaction plot of BH, it seems that for producing finer count of yarn with less number of ends breakage needs more clean cotton. It is also understood from interaction plot of FC that high amount of top roller pressure gives negative effect on end breakage rate of ring spun yarn produced from high twisted roving. The probable reason of this trend in results has been already discussed above. To spin yarn at high spindle speed, it is necessary to extract more waste% in blow room and carding (shown in fig-3). From interaction plot of AH factors, it is seen that with respect to production of finer yarn count, it is recommended to use more long fibers in mixing. This finding is well established in ring spinning system.

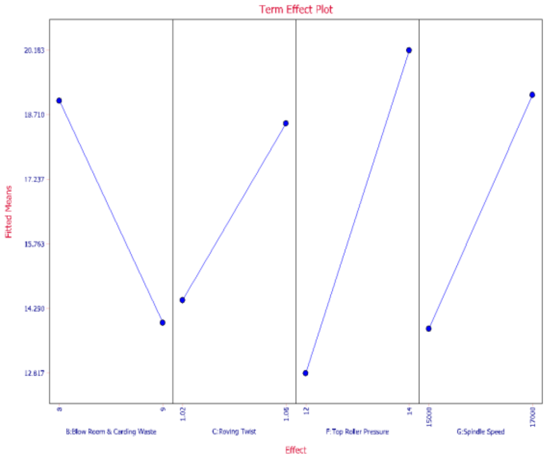

Fig:1 Main effect plots of significant factors

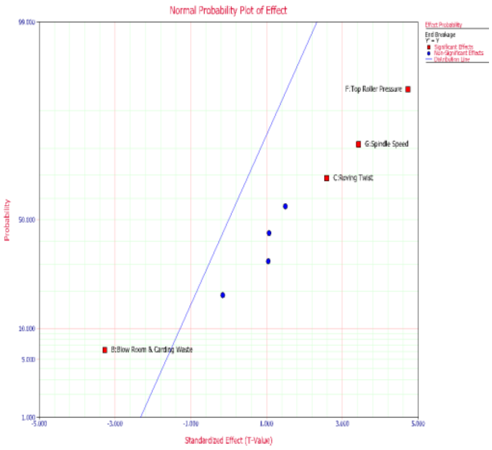

Fig:2 Normal Probability Plot of Effect

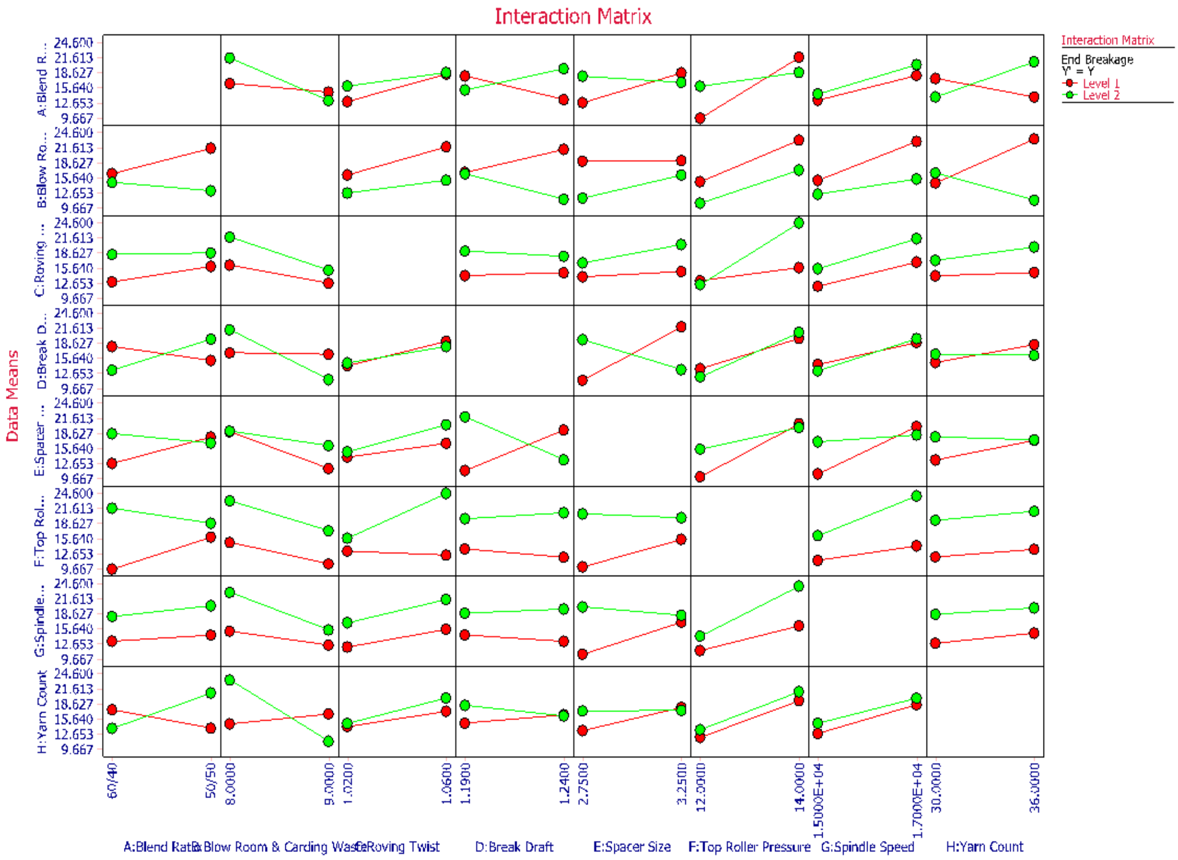

Fig. 3. Interactive effect of independent variables on ends down rate/100sp./hour.

IV. Conclusion

Our objective in this work was to understand the trend of some spinning processing conditions on end breakage of ring spun yarn using placket burman design of experiment. Waste extraction percentage (B) before sliver preparation, roving twist (C), and top roller pressure (F) and spindle speed (G) are statistically significant for the breakage rate of ring spun yarn. The relationship between the end breakage and our selected spinning conditions were explained by a significant regression model at risk level of 0.1. It is concluded that for producing ring spun yarn with increasing spindle speed, it is recommended to prepare clean sliver by extracting waste in blow room and carding as much as possible to get maximum production in ring frame. However, roving twist and spindle speed, influencing parameters, affect yarn breakage negatively whereas the introduction of 10% CIS cotton, comparatively longer fibers, in mixing improves the formation of yarn positively with less number of end breakages. Excessive top roller pressure can deteriorates the result of yarn breakage rate during ring spun yarn production. Although high break draft can minimize the effect of high roving twist on yarn breakage rate but it is recommended to insert very small amount of roving twist for getting higher production in ring frame. Results from this study can provide some insight into the understanding of the trend of yarn breakage rate with the change of various processing conditions of ring spun yarn.

References

[1] R S Rengasamy, S M Ishtiaque, A Ghosh, A Patnaik & M Bharati,"Analysis of spinning tension in ring spinning", Indian Journal of Fibre & Textile Research, December 2004, Vol. 29, pp. 440-442

[2] Peter R. Lord, Handbook of Yarn Production: Technology, Science and Economics (page-298, August 5, 2003, published in North America by CRC press).

[3] R. Senthil Kumar, Process Management in Spinning (page- 189, September 23, 2014, CRC press, Taylor and Francis Group).

[4] Siva Prasad Kondapalli, Srinvasa Rao Chalamalasetti, Nageswara Rao Damera "Application of Taguchi based Design of Experiments to Fusion Arc Weld Processes: A Review", International Journal of Technology and Management.Vol. 2 No. 1, pp. 1-8 (2013).

[5] EL-SAYED M. A. M., "Optimizing ring spinning variables and a proposed procedure to determine the Egyptian cotton spinning potential ", Journal of Textile and Apparel, Technology and Management, Spring2009, Volume 6, Issue 1.