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STATISTICAL ANALYSIS ON EFFECT OF TOP ROLLER LOADING AND TOTAL DRAFT ON THE PHYSICAL PROPERTIES OF POLYESTER/VISCOSE BLENDED RING-SPUN YARN

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Abstract: *Drafting in ring frame is the most important operation which influences the major quality parameters of yarn. Though bulk of literature is available on the effect of various parameters of ring frame on yarn quality, effect of top roller setting and the total draft on various quality parameters of yarn in actual mill setting is not studied systematically using statistical technique . In the present study, an attempt has been made to analyze statistically the response of various yarn properties to different top roller loading and total draft in actual mill conditions.*

Keywords- *Top roller loading, draft, friction field , roving hank, strength , elongation , hairiness, drafting faults, yarn imperfections,*

I. INTRODUCTION

Ring spinning system though invented more than 150 years ago, it is still the most widely used spinning machine all over the world despite of introduction of new spinning systems of higher productivity like rotor, air jet, air vortex etc. The ring spinning is considered to be unique spinning system as it is capable of spin all most all kind of textile fibres. The popularity of ring spinning comes from its flexibility and versatility with respect to type of material and count range it can spin. The yarn for any textile application can be made in ring frame by choosing appropriate parameters. It finds applications in wide ranging fields like apparels, hosiery, blankets, carpets, upholstery, terry cloths, geo textiles, agro textile, sports tech etc. to name a few. At present ring spun yarn sets the quality standards against which all others yarn types are judged. New generation high speed looms and knitting machines place more stringent demands on the quality of the yarn. The importance of yarn quality lies in the fact that they are a major factor responsible for rejection and down grading of fabrics and low productivity due to higher end breakage in downstream processes.

As ring frame contributes significantly towards the quality of the yarn, study on the effect of various ring frame process parameters on yarn quality has assumed considerable importance and every effort to optimize process parameters at this stage is worth exploring. Leaving aside twisting and winding, drafting is the most important operation which influences the major quality parameters of yarn. A bulk of literature is available on the effect of various parameters of ring frame on yarn quality [1, 2, 3, 4]. However, very limited systematic study using statistical technique has been carried out on effect of top roller loading and main draft on yarn properties. Furthermore, there is notable absence of literature on the influence of the aforesaid parameters on the various categories of yarn faults especially for polyester/viscose blended yarn. In the present work, effect of front roller loading and total draft on the physical properties of ring yarn is studied using statistical technique.

II. MATERIAL AND METHOD

2.1 Material

The specifications of polyester and viscose fibres used in the study are given in Table no 1

Table1 Specification of polyester and viscose

Fibre characteristics	Polyester	Viscose
Length (mm)	44	44
Fineness (denier)	1.4	1.5

2.1 Preparation of sample:

Standard sequence of operations and process parameters as adopted by the industry are followed for preparation of sample. Twenty roving bobbins are collected from the same doff of a roving frame and creeled on the same set spindles to rule out any variation in the experimental results due to machine conditions. It is ensured that all the parameters (other than the variable ones) are identical in the spindles (Table 2). Front top roller load was changed at three different stages namely 10 kg, 14 kg and 18 kg keeping total draft 30. In the next stage to assess the effect of draft, bobbins of three different hanks 0.8, 1.0 and 1.2 (each collected from same doff) are creeled to the same set of spindles and yarn count of 30^s is produced by applying total draft 37.5, 30 and 25. The front roller load is kept at 14 kg in each case .For each combination total 40 bobbins (2 complete doff) are prepared.

Table no 2 Process Parameters of ring frame

TM –	3.00
Spindle Speed (rpm)	17000
Count	30s
Roller Setting (mm) Front, Back	57.5/ 75
Break draft	1.17
Spacer size (mm)	3

2.2 Testing of Yarn

2.2.1 Yarn irregularity and imperfection:

Yarn unevenness and imperfection was tested by Evenness tester UT-4 (Zwellweger Uster) with under mentioned testing parameters
Yarn speed: 200 m/min
Duration (for each test): 1 min
Range: Thin Place: -50%; Thick Place: +50%; Neps: +200%
No of observation: 10

2.2.2 Hairiness Testing:

Yarn hairiness (number of hairs ≥3 mm per 100 m) measured with the help of uster tester (UT-6) working on photo electric principle. For each test - 400 m length of yarn was taken at draw-off speed of 800 m/min. Average of ten reading was taken for each sample

2.2.3 Tensile Testing:

All the yarns are tested for tensile strength and breaking elongation using PREMIER Tensomaxx 7000 V26 **working** on constant rate of elongation' principle**.**
Testing condition: Test length: 50m Speed of testing: 500m/min Number of tests performed: 50

2.2.4 Yarn Fault:

Measurement of seldom occurring yarn faults was done in Keisokki classifault tester at 500 m/min which classify the yarn faults in different categories e.g. slub, drafting faults total thick and thin faults. Total Length of yarn tested is approximately 150 km for each sample.

2.3 Statistical analysis of test results

The experimental results are analyzed by using one-way ANOVA carried out in statistical software package (SIGMAPLOT14). The conclusion for significant difference between the mean value is drawn on the basis of corresponding P values (generated by the software) which indicate the probability of being wrong in concluding that there is a true difference between the groups. The smaller the value of P greater is the probability that the sample means are statistically different. When $P < 0.05$, it can be concluded at 95% confidence level that at least one of the samples is significantly different from others. However, it does not provide information about exactly which sample(s) is (are) statistically different from the rest. To overcome this short coming, post hoc multiple comparison tests (Holm-Sidak test) was carried out.

III. RESULT AND DISCUSSION

Experimental results for properties of yarn spun under different level of top roller load are given in Table 3.

Table No.3: Effect of Top Roller Loading on yarn properties

	Front top Roller load stage			Results of Anova		
Properties	10 kg	14 kg	18 kg	F – value	P-value	**Remarks**
Yarn evenness (U%)	11.6 (0.420)	10.2 (0.240)	9.8 (0.180)	*100.6*	<0.05	Difference is significant at all the three-load level used in the study
Thick places per km	21.00 (8.20)	8.00 (4.6)	11.00 (3.9)	13.42	<0.05	Difference is significant except between load level 14 and18 kg.
Thin places per km	13.00 (6.3)	5.00 (3.5)	3.00 (2.7)	14.182	<0.05	Difference is significant except between load level 14 and18 kg
Neps per km	17.00 (16.3)	22.00 (11.2)	19.00 (9.1)	0.401	0.674	Difference is not significant at any load level used in the study

No of Hairs> 3mm / 100 m	4142 (326)	4391 276	3875 (372)	1.532	0.234	Difference is not significant at any load level used in the study
Strength (gm f)	478 (22.6)	517 (18.7)	521.5 (24.3)	59.16	<0.05	Difference is significant except between load level 14 and18 kg
Elongation (%)	12.8 (1.50)	13.1 (1.70)	11.8 (1.40)	1.901	0.153	Difference is not significant at any load level used in the study
Objectionable drafting Faults Per 100 km	52.00 (8.23)	37 (6.56)	19.00 (7.83)	21.2	<0.05	Difference is significant at all the three-load level used in the study
Total Slub Per 100 km	578 (102)	543 (87)	610 (116)	0.536	0.598	Difference is not significant at any load level used in the study
Total long thick Per 100 km	1240 (317)	1305 (239)	1185 (206)	0.034	0.96	Difference is not significant at any load level used in the study
Total Long Thin Per 100 km	2857 (307)	2786 (411)	2684 (421)	0.258	0.777	Difference is not significant at any load level used in the study

(*Values inside the parenthesis represent the standard deviation of the test results)

3.1 Results and discussion for effect of top roller load:

It can be seen from the Table 3 that, there is steady decrease in U% with increase in top roller loading. Multiple comparisons (Post hoc Holm-Sidak test at overall significance level = 0.05) confirms that the difference is significant at 95% confidence level.
Higher front top roller causes more flattening of front top roller cot therefore provide better guidance to the fibres. Furthermore, an increase in top roller load helps in spreading of rear end of frictional field created by front top roller [5]. This would reduce the gap between frictional field created by front and back roller pair. Thus, the movement of the fibres become more controlled which leads to reduction of U%. However; difference in imperfections (thick and thin place) beyond 14 kg load is not statistically significant. The effect of load on generation of neps is insignificant as evident from higher value of P (refer table 3). This is expected as neps are formed because of rolling of fibres which took place mainly at the earlier stages of spinning. Fig 1 represents the U% and imperfections (thick place, thin place and Neps) at various load stages.
Table 3 also reveals that number of hairs (≥ 3mm) is not affected by the change in front roller loading as the hairs is mainly formed either due to raw material or friction with the ring and traveler. The results are shown graphically in Fig no3.
Further, it can be seen from the Table3 that strength of the yarn increased significantly as the top roller increased from 10kg from 14 kg. This may be ascribed to reduction in thin place, which are potentially weak spot in the yarn. The reduction of thin place is direct consequence of controlled movement of fibres at the main draft zone. However, beyond this optimum level no significant difference can be seen. Front top roller load has no effect on breaking elongation of yarn. Fig 4 and fig 5 represents the strength and breaking elongation of yarn at various load stages.

Effect of top roller loading on the drafting fault is similar to that of unevenness %. However, the decrease in drafting fault is much prominent if the load is increased beyond 14 kg. This may be ascribed to the fact that heaver pressure on top roller prevent the slippage of fibre strand [6] and provides greater force for effective reduction of cohesion force between the small fibre cluster which would otherwise either pass on to the yarn or cause breaks during spinning.
No significant difference in number of total slub (Per 100 km) due to variation in front top roller loading has been observed. This is confirmed by results of one-way ANOVA. This may be because of the fact that the slubs apart from drafting in ring frame and / or speed frame are formed due to poor opening of the fibres at carding stage.
Results shown in Table no 3 further reveal that total long thin and thick faults are not affected by front top roller loading. This may be ascribed due to the fact that long thin places are formed due to splitting or stretching of sliver or roving at the creel whereas long thick place mainly attributed to spinners double, bad piecing etc [7]. Effect of different load stages on different categories of yarn fault is depicted in Fig no 2

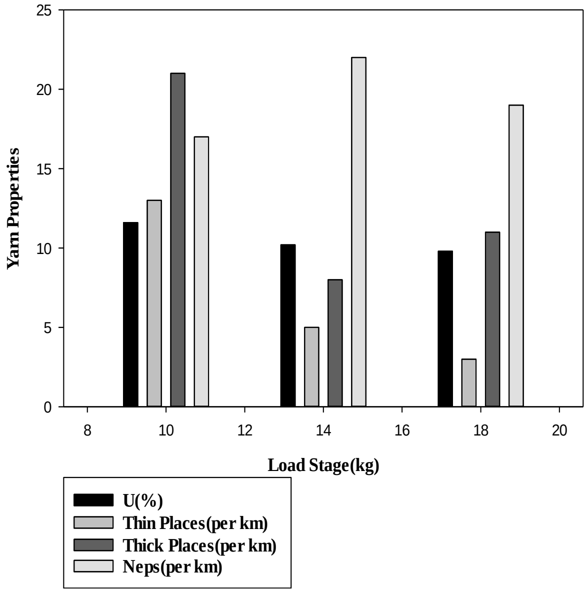

Fig 1 – effect of top roller loading on yarn U% and imperfections

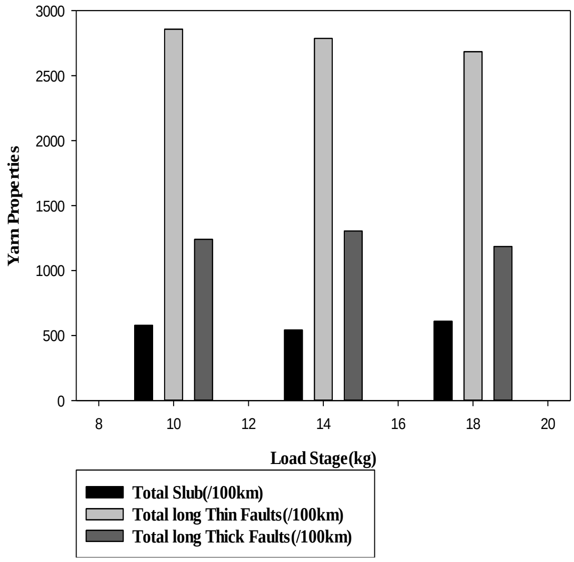

Fig 2 – effect of top roller loading on various yarn faults

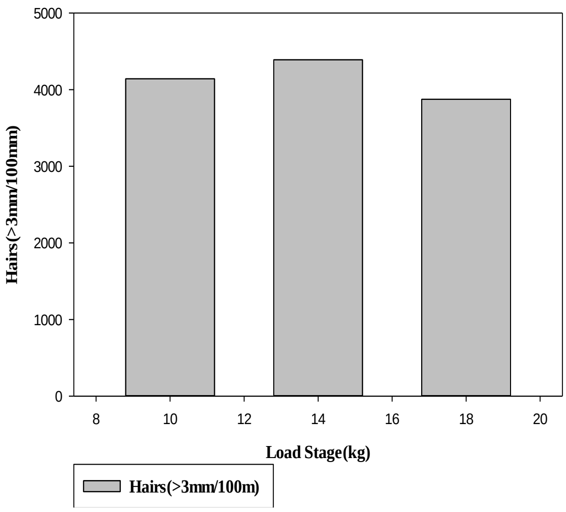

Fig 3 – effect of top roller loading on hairiness of the yarn

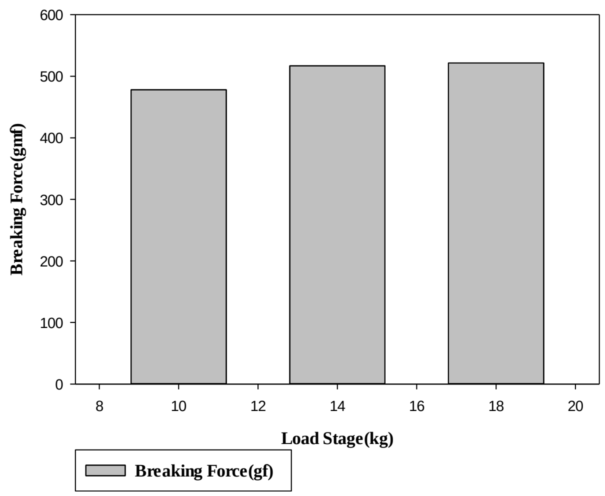

Fig 4 – effect of top roller loading on breaking force of yarn

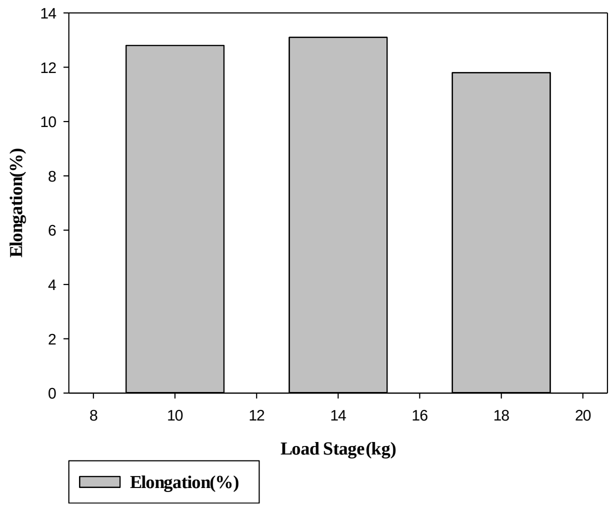

Fig 5 – effect of top roller loading on elongation of yarn

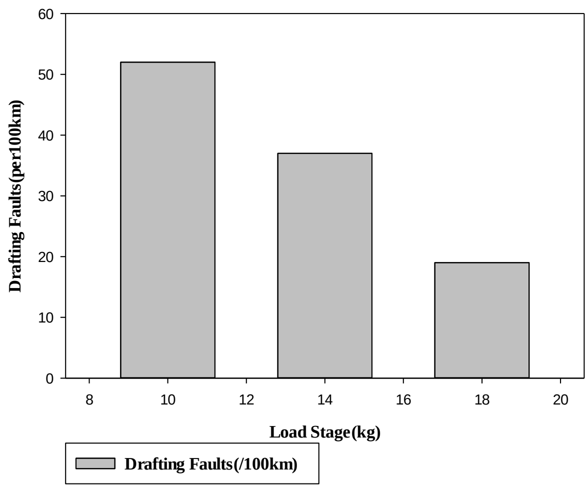

Fig 6 – effect of top roller loading on drafting faults of yarn

3.2 Result and Discussion for the Effect of Total Draft on Ring Spun Yarn

Experimental results for properties of yarn spun with different level of draft are given in Table 4.

Table No. 4. Effect of Total Draft

	Level of draft (hank of roving)			**Results of Anova**		
	37.5 [0.8] *	30 [1.0] *	25 [1.2] *			
Properties				F – value	P-value	**Remarks**
Yarn evenness (U%)	11.20 (0.670)	10.00 (0.22)	9.80 (0.430)	*25.213*	<0.05	Difference is significant except between 30 and 25
Thick places per km	17.00 (9.30)	8 (4.3)	6.0 (2.6)	9.218	<0.05	Difference is significant except between 30 and 25
Thin places per km	11.00 (3.40)	3 (3.80)	4 (2.10)	19.152	<0.05	Difference is significant except between 30 and 25
Neps per km	16.00 (13.4)	14 (15.7)	19.0 (14.2)	0.303	0.741	. Difference is not significant at any level.
No of Hairs> 3mm per 100 meters	6417 (342)	4591 (271)	3032 (154)	402.18	<0.05	Difference is significant at all levels of raft
Strength (gm f)	472 (21.3)	523.6 (27.8)	518.110 (22.60)	69.34	<0.05	Difference is significant except between 30 and 25
Elongation (%)	8.7 (0.70)	11.93 (1.40)	12.3 (1.10)	160.72 3	<0.05	Difference is significant except between 30 and 25
Drafting Faults Per 100 km	63 (13.5)	25 (17.5)	14 (18.6)	11.882	<0.05	Difference is significant except between 30 and 25
Total Slub Per 100 km	290 (73.00)	339 (102)	363 (97)	0.826	0.46	Difference is not significant at any level.
Total Thin faults Per 100 km	2470 (205)	1983 (394)	1543 (218)	13.176	<0.05	Difference is significant at all the three level of draft level used in the study
Total Thick faults Per 100 km	1542 (120)	1128 (245)	845 (113)	21.32	<0.05	Difference is significant at all the three level of draft level used in the study

(Values inside the parenthesis () represent the standard deviation of the test results)
(Values inside the parenthesis [] * represent the hank of the roving fed)

Increase in the number of fibres in the drafting zone because of coarser input material will cause the drafting force to increase disproportionately. This happens due to the greater cohesion force arising out of more frictional contact among the fibres. The front rollers at higher drafts have to accelerate the fibres to a greater extent which results in erratic movement of the fibres. This leads to higher short terms variation and generation of more imperfections (thick and thin place) at higher draft. However, improvement in this regard is not statistically significant if draft is further reduced to 25. Number Neps does not vary with draft (Table no. 4). The total number of imperfections per km and yarn U% is depicted in fig no 7

It can be inferred that number of hairs (≥ 3mm) reduces steadily as draft reduces. This is in line with the observation made earlier [8]. Higher draft necessitates coarser hanks of rove to be fed for the same count yarn to be spun. Thus, when yarn is spun with higher draft (37.5) at ring frame, higher degree of fibre spread took place between the rollers. Consequently, as the ribbon of the comes forward the fibres at the edge of the ribbon of greater width are more likely to protrude from or remain the fibre surface. Substantial decrease in hairiness observed further when the draft reduces to 25. This is depicted in fig no 9.

Table no. 4. reveals that strength of the yarn is increased when draft is reduced from 37.5 to 30. This may be attributed to fact that generation of a greater number of thin places at higher draft ratio resulted from uncontrolled movement of fibres at higher draft. However, no significant change in strength is observed with further reduction in draft. The trend of yarn elongation is similar to what is observed in case of strength. Higher draft is responsible for removal of hook and further straightening of the fibres thereby reducing the residual strain in the fibres resulting in reduction in the elongation of the yarn. The strength and elongation values of yarns spun at different draft levels are given in fig no 10 and fig no 11.

It can be seen from the Table no 4 that, there is steady increase in drafting fault with increase in draft. Analysis of variance followed by multiple comparisons (Post hoc Holm-Sidak test at overall significance level = 0.05) confirms that the difference is significant at 95% confidence level. This may be attributed to the fact that movement of fibres at the front zone becomes uncontrolled with higher draft [9]. Table 4 reveals that both the total long thick and long thin faults increase steadily with increase in total draft at ring frame. This is ascribed to the fact that the thick and thin faults which are introduced at earlier stages of spinning are elongated due to drafting at ring frame and counted as long thick and long thin faults. Higher the draft at ring frame more is the number of total longer length fault.

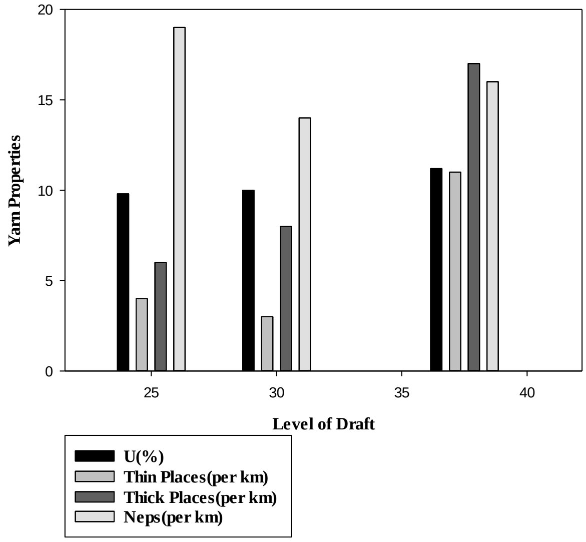

Fig 7 – effect of total draft on yarn U% and imperfections

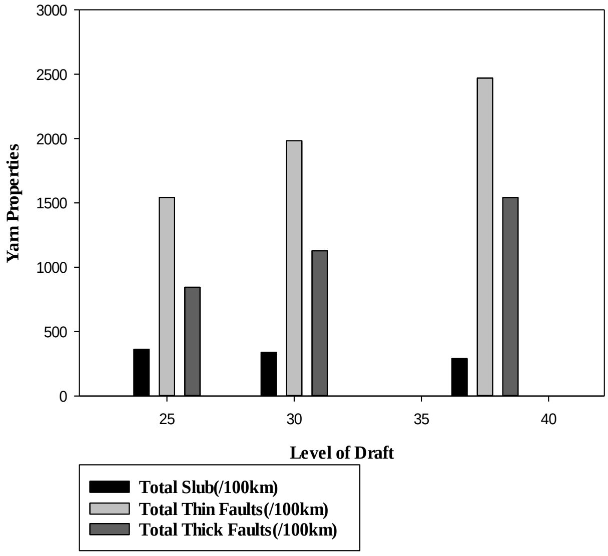

Fig 8 – effect of total draft on various yarn faults

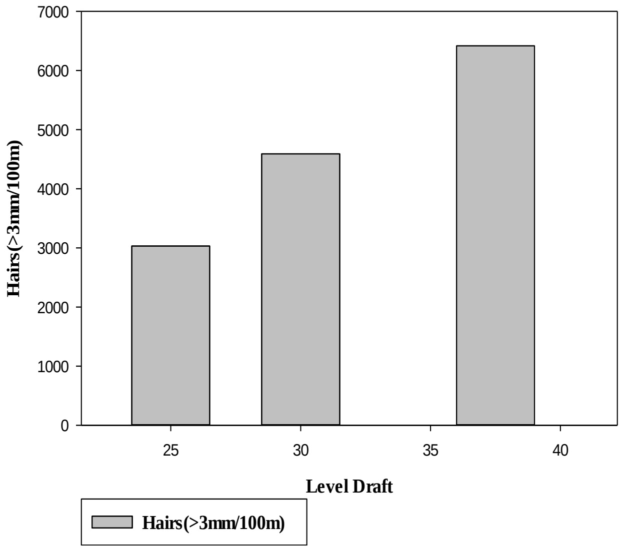

Fig 9 – effect of total draft on yarn hairiness

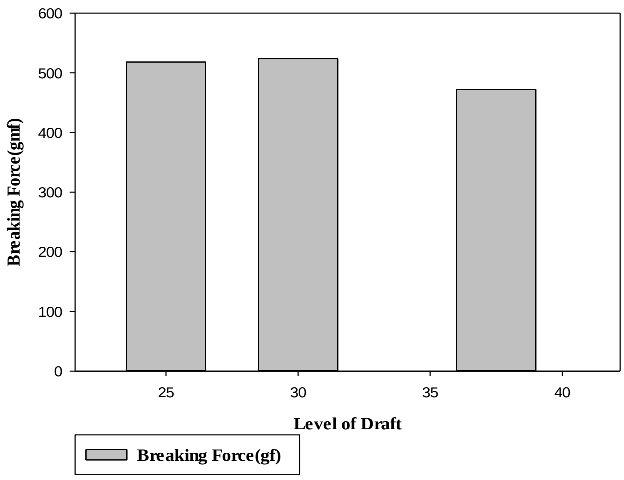

Fig 10 – effect of total draft on yarn breaking force

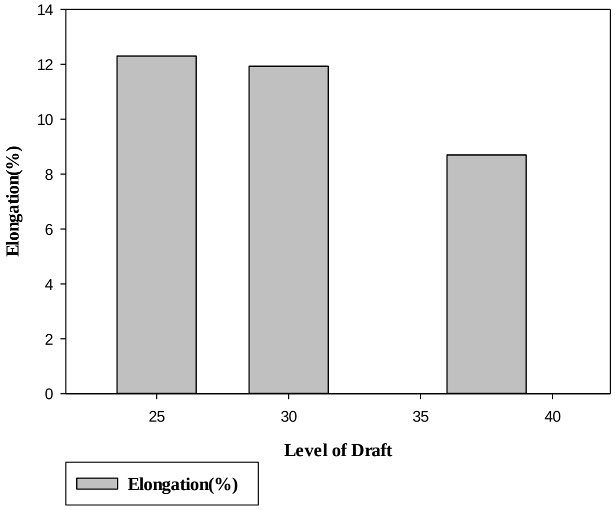

Fig 11 – effect of total draft on elongation

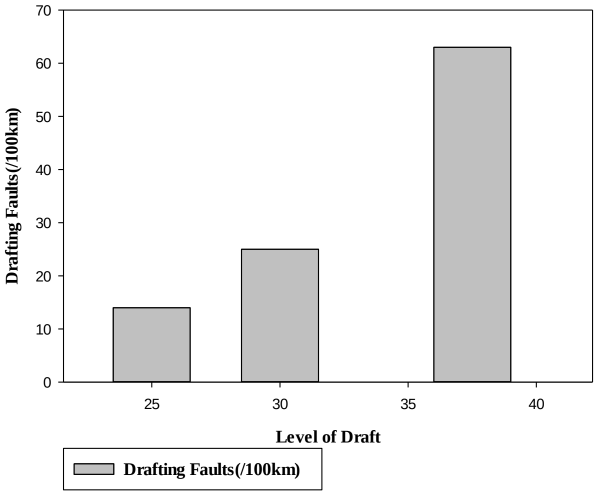

Fig 12 – effect of total draft on drafting faults

III. CONCLUSION

1. There is steady decrease in U%, thick and thin place and drafting fault with increase in top roller loading. However, difference in imperfections (thick and thin place) beyond 14 kg load is not statistically significant. It may be noted

that marginal improvement in U% at higher load of 18 kg may cost reduced life of cots because of more deformation and higher lapping tendency. Thus, roller loading of 14 kg which is usually adopted in industry may be considered as optimum

2. Total number of neps and hairs (≥3mm) are not affected by the change in front roller loading
3. Strength of the yarn increased significantly as the top roller increased from 10kg from 14 kg. But elongation remained unaffected with change in load.
4. Drafting faults decreases steadily with increase in top roller load but number total slub, total long thin and long thick place bare not affected by front top roller loading.
5. Significant reduction in U%, thick place and thin place and drafting fault is observed when draft total draft reduces from 37.5 to 30. However, further reduction of draft does improve the aforesaid properties.
6. There is steady and substantial decrease in number of hairs with decrease in total draft. But number of neps is not significantly influenced by draft.
7. Strength and elongation increase with reduction of draft. However, no further improvement could be observed in this regard.
8. Both total thick and total thin faults increase steadily with draft.

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