A Study of Yarn Breaks on Warping Machines

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Abstract: The present study was conducted to determine the impact of cotton / polyester blending ratio, cotton type, yarn twist and yarn count on yarn breaks on warping machine. Two-way ANOVA technique was used to detect the significant effects of these variables on yarn breaks. Regression analysis was used to predict the number of yarn breaks at different levels of each independent variable. The findings of this study revealed that Blending ratio of polyester in cotton:polyester blended yarns has a significant effect on yarn breaks and the breaks associated with carded yarns were more than that accompanied the combed ones. The number of yarn breaks varies directly with single and plied yarn counts. Whereas twist multipliers inversely affect the number of yarn breaks. For warp yarns of count 20 Ne, Yarns spun from Giza 70 exhibited higher breaks number, while for yarns of count 40 Ne, Giza 83 showed higher yarn breaks. Singeing process enhanced warp yarn breaks on warping machine by approximately 25%.

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Key words: blending techniques; cotton/polyester ratio, yarn count, yarn twist, combed yarn, carded yarn, warping process.

1. Introduction

During processing, textile materials are subjected to various stresses not only during the machine operation but also during its stoppage. If these stresses exceeded a given limits it will adversely affect the quality of the produced yarns, fabrics and the efficiency of the machines **[1].**

The end breakage rate is a critical spinning parameter that not only affects the maximum spindle speed but may also indicate the quality of yarn, the mechanical condition of the machine and the quality of raw materials **[2].** An end break will occur in spinning when the tension in the balloon exceeds the strength at the weakest point in the yarn, which is at the point of twist insertion and before the fibers are fully twisted together **[3].**

In weaving process, the strains on warp ends can lead to thread breaks, loss of quality and shutdowns **[4, 5].** Warp breaks still represent major problem especially for today's high – speed weaving machines **[6].** Generally, warp yarn break occurs due to excessive tension greater than the strength of the yarn. Also, friction on the warp yarns and repeating beat-up are factors to reduce the yarn strength as warp yarn passes from the beam into the cloth fell **[7]. Lord [8]** compared the warp yarn properties before and after weaving. Considering the yarn evenness, the two cases seem to be similar, but there is a reduction in yarn mass after weaving. In his subsequent research, **Lord [9]** noted that the most important change was the change in load-elongation characteristics, and benefits of sizing would be removed as long as the excessive tensions are loaded on the warp yarn.

Brown [10] classified the warp break into eight categories (knots, impurities, chopped ends, abrasion, soft yarn, twisted ends, taped ends and unknown), and observed what type mostly caused the warp break, and assessed each categories to establish the causes of warp breaks. **Morton and Pollard** [11] also classified the causes of warp breaks into six similar categories. The number of warp break was recorded for the different twist constants. The position of warp breaks was classified and it was noted that most of the breaks took place between the stop motion and the fell of the cloth. Here, it was found that the abrasion by harness and reed was the main cause for breaks. The tension in shedding is not uniform on a warp sheet. Therefore, uniformity of tension would be obtained by eliminating all friction between the yarn and the heald-eye, drop wires and back rest. The effect of twist on warp breaks was also studied by **Morton and Pollard [11]** and they found out that warp twist affect warp break rate and hence weaving efficiency. During insertion, weft yarns on weaving machines are exposed to bending and tensile stresses which cause high tension. This tension upon weft yarns causes longer insertion times and thus lower yarn velocities. High tension also causes weak yarns to break **[12,13].**

Most researchers in the past two decades concerned with yarn breaks on weaving and spinning machines. But there was a shortage research with respect to yarn breaks on warping machines. So, this study aimed at investigating the effects of warp yarn characteristics on its breakage rate on warping machines. The effects of cotton type, yarn count, yarn type, twist multipliers and blending ratio on yarn breaks on warping machine were intended to be studied.

2. Materials

Five different Egyptian cotton types namely, Giza 70, Giza 80, Giza 83, Giza 86 and Giza 89 were used in this study. These types of cotton were blended with polyester fibers. From the blended cotton and polyester fibers, different carded and combed yarns were spun with different blending ratios and twist factors. The produced materials were single and plied yarns. The single yarn counts were 20, 40, 50 and 60 Ne. While the plied ones were 80/2, 90/2, 100/2 and 120/2 Ne. Table 1 shows the characteristics of the five cotton types used in this study. However, the characteristics of polyester fibers were presented in table 2. The different levels of yarn counts, blending ratios and twist multipliers for carded and combed spun yarns were listed in table 3.

Table 1. Characteristics of cotton types used in the study

	Giza 70	Giza 80	Giza 83	Giza 86	Giza 89
Fiber length, mm	35.7	30.3	29.7	32.8	31
Uniformity,%	51	47.8	47.8	50.4	49.2
Fiber strength, g/tex	34.1	28.3	27.6	31.8	29
Fiber elongation,%	6.9	7.8	7.1	7.1	7
Micronair value	4.1	4.4	4.4	3.9	4.3
Maturity ,%	93	83	85	88	90
Fineness, mtex	147	175	168	152	150

Table 2. Properties of the used polyester fibers

Denier	1.4
Tenacity, g/denier	5.9
Elongation, %	22
Shrinkage, %	4.2
Crimp	9/cm
Moisture content	0.4
Additives, (oil,--etc) %	0.12

Table 3. Levels of yarn counts, blending ratios and twist multipliers for carded and combed yarns.

Yarn count (Ne)		Blending ratio (%)	Twist multiplier
Single	Plied yarn		
20	80/2	25	4
40	90/2	35	4.2
50	100/2	50	4.5
60	120/2	65	

Singeing Process

In the course of this study, some yarns of count 120/2 which spun from Egyptian cotton of Giza 70 were singed to study its effects on the number of breaks on warping machine. The singeing process was performed on SSM-singeing machine with the following specifications:

- M/c speed: 550 mpm.
- Singeing type: Gas burner
- Gas to air ratio: 1:3
- Relative humidity: 60%
- Temperature at gas burner: 800^{o}C

Warping Process

In general terms, warping is transferring many yarns from a creel of single – end packages forming a parallel sheet of yarns wound onto a beam or a section beam. Today's warping machines can process all kinds of materials including coarse and fine filament and staple yarns, monofilaments, textured and smooth yarns, silk and other synthetic yarns such as glass. The warp beam that is installed on weaving machines is called a weaver's beam. A weaver's beam can contain several thousand ends and for different reasons it is rarely produced in one operation. There are several types of warping processes, of which the common types are direct warping and sectional warping **[14].**

The performance of warping process is judged mainly by the end breakage rate at this process. To get a reliable estimate of the end breakage rate, the average for each count and on a machine should be based on observation of about 1,000,000 meters × 400 ends for super speed warping and 60,000 × 400 ends for high speed warping over a month's period.

In this study, Benninger warping machine was used. The general characteristics of this machine are tabulated in table 4. The general view of this machine was also shown in figure 1.

Throughout this study, the number of end breaks for each type of the yarns was calculated for one million meters of the warp yarn processed on the Benninger warping machine.

Table 4. Characteristics of warping machine used in the study

Machine Name	Benninger – direct warping m/c
Useful width	180 cm
Air pressure	5- 8 bar
Power consumption	15 KW
Operating speed	300-1200 m/min
Crawl speed	20 m/min
Over all yarn tension	450 Newton
Max. beam diameter	101.6 cm
Oil file	Approx. 3 Lit
Yarn types	Natural- Synthetic- Blended
Total number of ends	768

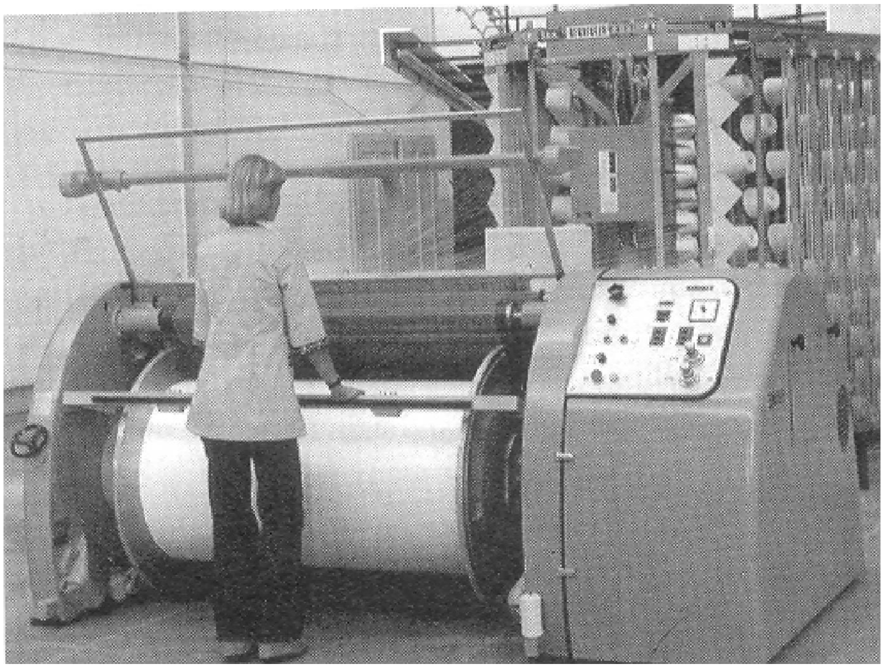

Figure 1: General view of the warping machine used in the study

Statistical Analysis

Throughout this study, all data results were assessed statistically at significance level 0.01 for the effects of independent variables on the number of yarn breaks on warping machine. Two-Way and One - Way Analysis of Variance (Two-Way and One-Way ANOVA) are used to detect the significant effects of these variables. SPSS Statistical package was used to perform all data analysis. A regression analysis was also used to predict the number of yarn breaks at different levels of the independent variables. The validation for these regression models was conducted using the coefficient of determination, i.e. R^2 value, which ranges between zero and 1. When the R^2 value approaches 1, the regression model fits the data results very well and it becomes reliable to be used in predicting.

3. Results and Discussion

Effect of blending ratio on the number of yarn breaks

During this study, four different blending ratios of cotton and polyester fibers were studied, namely 25%, 35%, 50% and 65% of weight of polyester. From these blending ratios, carded and combed yarns were spun. The effect of these variables on the number of yarn breaks on warping machine was plotted in figure 2. From the statistical analysis shown in table 5 it is noticed that both variables have a significant influence on the number of yarn breaks at 0.01 significance level. As seen from this figure, a decreasing trend for both carded and combed yarns was detected. Assuring that as the blending ratio increases the number of yarn breaks decreases. This is because the higher strength of polyester fibers. It is also shown that the higher number of yarn breaks was associated with carded yarns than combed one. The lower yarn breaks accompanied carded yarns may be attributed to lower strength and higher hairiness of this yarn than combed one. The effect of blending ratio on yarn breaks is more pronounced for carded yarn than combed yarn. The statistical analysis proved that increasing the blend ratio from 25% to 65% leads to a reduction of yarn breaks on warping machine from 766 to 270 breaks/one million meters of carded yarns and from 522 to 180 breaks/ one million meter of combed yarns.

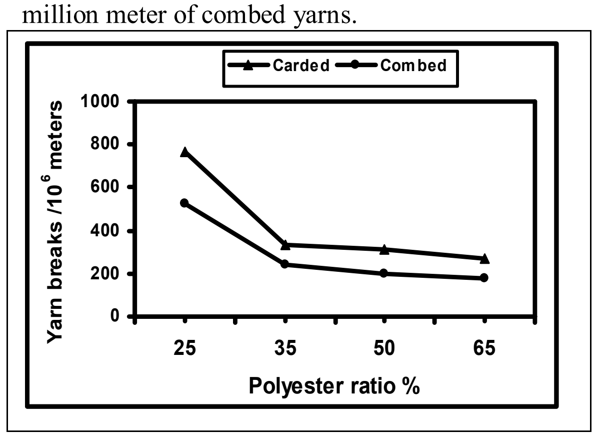

Figure 2. Effect of cotton/polyester blending ratio on yarn breaks on warping machine for carded and combed yarns.

Table 5. Anova results for the effects of blending ratio and yarn type on yarn breaks on warping machine

Source of Variation	SS	df	MS	F	P-value	
Blending ratio	230972	3	76990.667	28.071	0.011	significant
yarn type	35912	1	35912.000	13.094	0.036	significant
Error	8228	3	2742.667			
Total	275112	7				

To predict the number of yarn breaks at different blending ratios of carded and combed cotton:polyester blended yarns the following formulas were used.

Number of combed yarn breaks= $66x^2$- 436.2x +882

Number of carded yarn breaks= $99x^2$- 645.8x +1291

Where, X= % polyester. The statistical analysis proved that the coefficients of determination of these models are 0.96 and 0.94 for combed and carded yarns respectively. This means that these models fit the data very well.

Effect of yarn count on the number of yarn breaks

The effects of plied and single yarn counts spun from Giza 70 and Giza 89 respectively on the number of yarn breaks on warping machines were depicted in figures 3 and 4. The statistical analysis shown in table 6 and table 7 proved that yarn count has a profound influence on the number of yarn breaks.

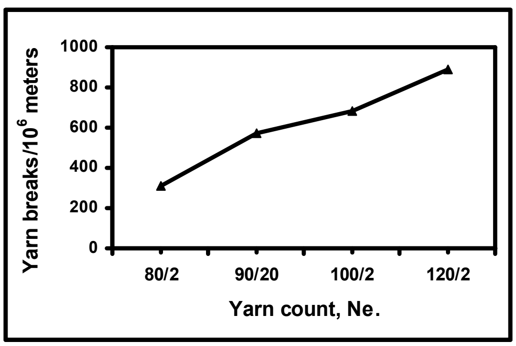

Figure 3. Effect of count on the number of yarn breaks for plied yarns spun from cotton of type Giza 70

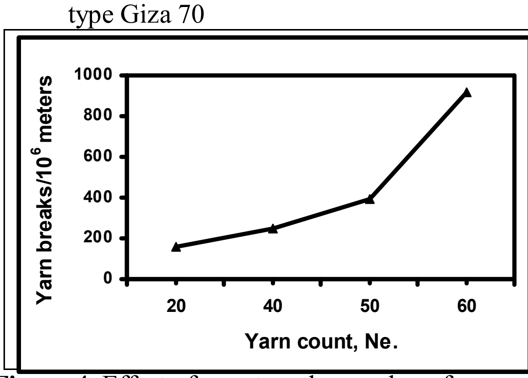

Figure 4. Effect of count on the number of yarn breaks for single yarns spun from cotton of type Giza 89

Table 6. One – Way ANOVA for the effect of plied yarn count on the number of yarn breaks.

Source of Variation	SS	df	MS	F	P-value	
Between Groups	525750	3	175250	775.4425	0.000	significant
Within Groups	1808	8	226			
Total	527558	11				

Table 7 One – Way ANOVA for the effect of single yarn count on the number of yarn breaks

Source of Variation	SS	df	MS	F	P-value	
Between Groups	1025396	3	341798.8	6801.965	0.000	significant
Within Groups	402	8	50.25			
Total	1025798	11				

From figure 3 it is noticed that the number of yarn breaks was affected linearly with the variation of plied yarn count. As the plied yarn count increases the breakage rate of yarns spun from Giza 70 also increases. The statistical analysis showed that increasing plied yarn count from 80/2 Ne to 120/2 Ne leads to an increase of breaks on warping machine from 312 to 893 breaks/10^6 meters of the yarn.

The relationship between plied yarn count and the number of breaks on warping machine has the following linear form:

Number of yarn breaks=185.2x +151

Where, X= plied yarn count. The R^2 value for this model equals 0.97 which means that this model fits the data very well.

Number of breaks on warping machine at different single yarn counts spun from cotton of type Giza 89 was depicted in figure 4. An increasing trend is detected assuring that as the single yarn count increases the number of yarn breaks increases. Increasing yarn count from 20 to 60 Ne leads to an increase of yarn breaks from150 to 910 per one million meters of the yarn.

The regression relationship between single yarn count and the number of yarn breaks for yarns spun from Giza 89 is a parabola of the following form:

Number of combed yarn breaks= $107x^2$- 297.7x +365

The coefficient of determination of this model is 0.98 which means that it fits data very well.

By comparing figure 3 with figure 4 at net yarn count 40 Ne, we observed that the number of yarn breaks which accompanied Cotton of type Giza 70 and Giza 89 were 312 and 247 breaks. This is an odd result, because of the higher strength of cotton Giza 70 than cotton of Giza 89.

Effect of cotton type on the number of yarn breaks

Breaks on warping machine of spun yarns of count 20 and 40 Ne which produced form different cotton types were illustrated in figures 5 and 6. The ANOVA analysis in tables 8 and 9 showed a significant impact for the cotton type on the yarn breaks at 0.01 significance level for both type of yarns.

Table 8 One – Way ANOVA for the effect of cotton type on the number of breaks for yarn count 40 Ne.

Source of Variation	SS	df	MS	F	P-value	
Between Groups	10338	2	5169	78.31818	0.000	significant
Within Groups	396	6	66			
Total	10734	8				

Table 9 One – Way ANOVA for the effect of cotton type on the number of breaks for yarn count 20 Ne.

Source of Variation	SS	df	MS	F	P-value	
Between Groups	2419518	2	1209759	675.9268	0.000	significant
Within Groups	10738.67	6	1789.778			
Total	2430256	8				

Figure 5 depicts the relation between cotton type and the number of breaks on warping machine for yarn of count 20 Ne. From this figure it is seen that there is a significant difference between Egyptian cotton types with respect to the number of yarn breaks on warping machine. It is also shown that cotton of type Giza 70 gave the higher yarn breaks followed by cotton of type Giza 86 and cotton of type Giza 89. The average yarn breaks were 340,287 and 247 for Giza 70, Giza 86 and Giza 89 respectively.

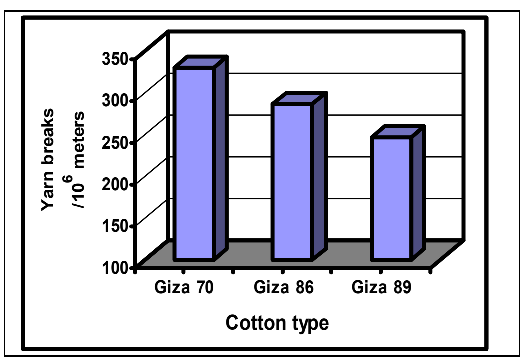

Figure 5. Effect of cotton type on breaks on warping machine for yarns of count 20 Ne.

Figure 6 shows the effect of cotton type (Giza 80, Giza 83 and Giza 89) of yarn count 40 Ne on its breakage rate on warping machine. The statistical analysis assured the significant difference between cotton types in relation to average yarn breaks. Yarn spun from Giza 83 showed higher yarn breaks followed by cotton of Giza 80 and Giza 89. The average values of yarn break are 444, 1419 and 260 for yarns spun from Giza 80, Giza 83 and Giza 89 respectively.

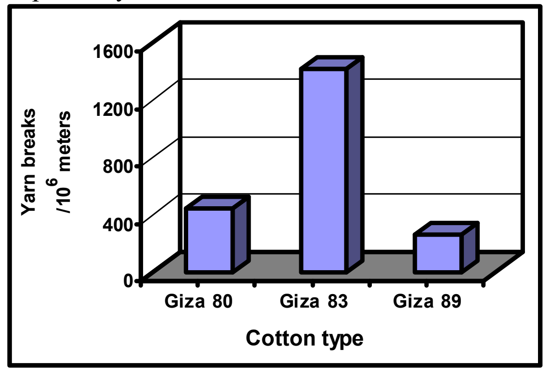

Figure 6. Effect of cotton type on breaks on arping machine for yarns of count 40 Ne**.**

By comparing the above two figures we can conclude that for cotton of type Giza 89, The yarns of count 40 showed higher number of breaks more than that of count 20 Ne. This is a natural result because of the higher strength of spun yarns of count 20 Ne compared to the former one.

Effect of twist multiplier on yarn breaks

Breaks on warping machine of yarns spun from Giza 70 and Giza 80 at different twist multipliers were plotted in figure 7. The statistical analysis in table 10 shows the significant influence of twist multiplier and cotton type on warp breaks. Form this figure it is noticed that the number of yarn breaks varies inversely with the twist multipliers for both types of Egyptian cotton. As the twist multiplier increases the number of yarn breaks decreases.

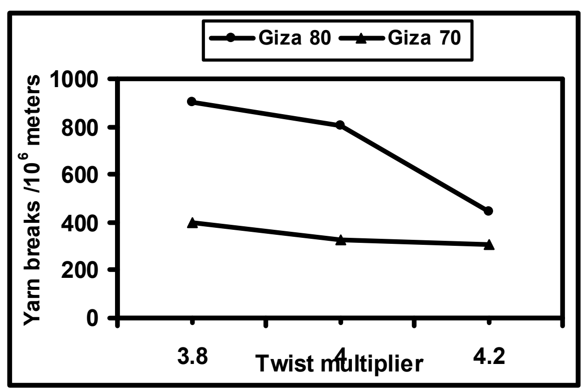

Figure 7. Effect of twist multiplier on breaks on warping machine for yarns spun from Giza 70 and Giza80.

The statistical analysis proved that increasing the twist multiplier from 3.8 to 4.2 leads to a reduction in the warp breaks from 900 to 444 breaks and from 400 to 310 breaks for cotton of type Giza 80 and Giza 70 respectively. It is also shown that the effect of twist multiplier on the yarn breaks is more pronounced in the case of Giza 80 than Giza 70. The inversely effect of twist multiplier on warp breaks is due to the increase of yarn strength with twist multiplier. The lower yarn breaks associated with yarns spun from cotton of Giza 70 compared to Giza 80 may be related to the higher strength for this type of cotton as shown in table 1.

Table 10. Two–Way ANOVA for the effects o twist multiplier and cotton type on the number of breaks .

The regression model which can be used to predict the number of yarn breaks at different twist multipliers for the cotton of type Giza 70 has the following linear form:

Number of yarn breaks= -45x +436

Source of Variation	SS	df	MS	F	P-value	
Twist multiplier	490000	2	245000	49	0.02	significant
Cotton type	135000	1	135000	27	0.035	significant
Error	10000	2	5000			
Total	635000	5				

Where, x is twist multiplier. For cotton of type Giza 80, the relation between the number of yarn breaks and twist multiplier is as follows:

Number of yarn breaks= -228x +1173

The R^2 values for the above two models equal 0.9 which means that these models fit the data very well.

Effect of singeing process on the number of yarn breaks

The number of yarn breaks on warping machine for singed and un-singed cotton yarns of Giza 70 and count 120/2 was shown in figure 8.

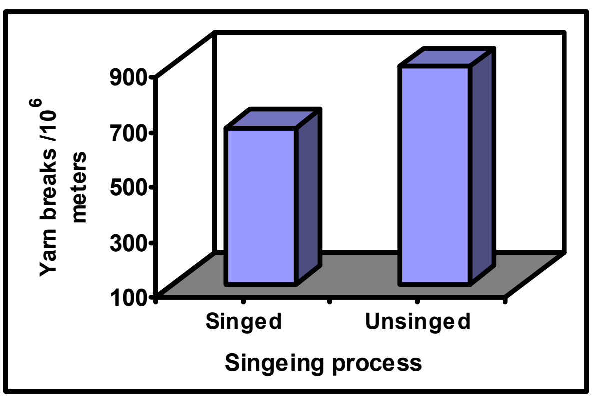

Figure 8. Effect of singeing process on breaks on warping machine for yarns spun from Giza 70 and count 120/2 Ne.

Table 11. Results of t-test for the effect of singeing process on the number of yarn breaks.

	Singed	Un-singed
Mean	666.6667	892.5
Variance	108.2667	8.7
Observations	6	6
Pearson Correlation	0.443131	
Hypothesized Mean Difference	0.05	
df	5	
t Stat	-58.399	
P(T<=t) one-tail	0.000	
t Critical one-tail	2.015	
P(T<=t) two-tail	0.000	
t Critical two-tail	2.571	

The results of t-test shown in table 11 illustrates that there is a significant difference between singed and un-singed yarns regarding the number of yarn breaks on warping machine at significance level 0.01. From figure 8, it is shown that the number of breaks associated with un-singed yarns is higher than that associated with singed one. The statistical analysis proved that singeing process reduced breaks on warping machine by approximately 25%. The significant influence of singeing process may be due to removing hairs on the yarns surface, and then increases yarn smoothness, which in turn reduces the friction between yarns and metal guides.

Conclusion

Reducing warp breaks on warping machines uplift the efficiency of this process and the efficiency of weaving machines, and finally enhances the quality of yarns and produced fabrics. In this study, the effects of Egyptian cotton types, yarn counts and type, twist multipliers blending ratio of cotton: polyester yarns, and singing process on the number of yarn breaks per one million meters on warping machine was investigated. The following conclusion can be drawn:

- The statistical analysis proved that the polyester ratio in cotton: polyester blended yarns have a significant effect on yarn breaks for carded and combed yarn. A decreasing trend was detected, and combed yarn exhibited lower breaks than carded one.
- For single and plied yarns, the number of breaks varied directly with the yarn count.
- Yarns of count 20 Ne and spun from Giza 70 showed higher breaks on warping machines followed by those spun from Giza 86 and Giza 89 respectively. While for yarns of count 40 Ne, yarn

breaks has the following order Giza 83 > Giza 80 > Giza 89.
- For Giza 89, yarns spun with count 20 Ne exhibited lower breaks than those spun with count 40Ne
-An inversely relationship between twist factor and yarn breaks was detected for yarns spun from Giza 70 and Giza 80. Giza 70 showed lower breaks than Giza 80.
- Singing process enhanced yarn breaks on warping machine by 25%.

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