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Effect of Single End Strength of Various Doubled Yarns on Tearing Strength of Double Weft Fabric

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Abstract: Yarns reflect the characteristics of its constituent fibres, and the characteristics of the fabric arise from the structure of the yarns, from which it is composed. PC blended yarn of 24^s were prepared at five TM levels for both S and Z twists and then doubled in S and Z directions. Finally fabric samples were prepared at power loom using the doubled yarn weft. It was concluded from this study that the yarn with TM 4 at SS combination in folding was the best to achieve optimum fabric tearing strength.

Key Words: Carded Yarn 24^s, Twist Multiplier, S and Z Twist, Doubling, Fabric Tearing Strength, Double Weft Fabric

Introduction

A woven fabric, as it is ultimately presented to the user is the assembly of fibres in the form of warp and weft in different form and design of weaves. Using combinations of different twist levels and directions in the warp and weft, different appearances and mechanical effects can be produced in the fabric due to changes in orientation of the fibres.

The plied yarn strength is usually more than double of the component yarn strength. The effects of folding twist on yarn strength follows almost the same pattern to the effect of twist on single end strength.

Majority of the folded yarns has the folded twist in the opposite direction to the spinning twist. This situation is subsequently referred to as 'S' folding twist on 'Z' twisted component yarns or simply 'S' on 'Z' yarns and vice versa. Besides the S on Z twist yarns, there are folded yarns with folding twist in the same direction as the spinning twist. Such yarns are referred to as 'Z' folding twist on 'Z' component yarns or simply 'Z' on 'Z' yarns. Also the same applied to S on S twisted yarns. A third kind of folded yarn is also manufactured, in which the direction of twist of one component yarn is same as the direction of folding twist but opposite to the twist direction of second component yarn, which may be referred as S on SZ yarns or Z on SZ yarns.

Treloar (1956) described that the relation between the single yarn twist (before cording) and the twist in the ply (after cording) is dealt with, and is shown to depend on change in the length of ply axis on cording. Harrison (1960) found that an increase in the twist factor of the component thread of a fabric would generally increase the thread strength and reduce the yarn diameter. Both these effects tend to increase the tearing strength, the later doing so because of the greater freedom of the thread movement attainable. He further concluded that since the structure of two-fold yarn is more compact, which may allow the more space between the threads, the consequent increase in the ease of thread slippage leading to an enhanced, tearing strength. Taylor (1972) remarked that if in tearing the threads slip, they would bunch together to some extent and support each other. Hence, more easily the yarns slip the greater the tearing strength. Lord and Mohamed (1973) described that the tear strength of a woven fabric is very important, since it is more closely related to serviceability than is the tensile strength. In tear loading only one, two or a few yarns share the load. Lord and Radhakrishnaiah (1987) found that the Z on Z yarns felt harder and smoother than the S on Z yarns. Booth (1996) described that threads break singly or in very small groups during tear, therefore the single-thread strength of the component yarns is of great importance. Also in plied yarns the grouping of the thread becomes easier as the yarns are smooth and can slip over each other so tearing strength of the fabric is high.

Materials and Methods

The present research work was initiated in the Department of Fibre Technology, University of Agriculture, Faisalabad and was mainly conducted in Koh-i-Noor Industries Faisalabad.

Samples of polyester-cotton blend (52:48) were spun in both S and Z twist directions at 24^s count. Their quality parameters were measured and evaluated then yarn samples were doubled under following process and programme.

Doubling Process: Doubling was done on Two-for-One unit, by combining the singles yarns in three combinations of twist directions viz. TDzz, TDsz and TDss in both the doubling directions i.e. S and Z. Five different twist levels i.e. TM=3, TM=4, TM=5, TM=6 and TM=7 were employed for each yarn sample.

Weaving: The doubled yarns were then used in the weft of the fabric on a power loom. The fabric construction was as under:

$$\frac{\text{Warp count} \times \text{Weft count}}{\text{No. of end/inch} \times \text{No. of picks/inch}}$$

Warp yarn count	24s
Weft yarn counts	24/2
No. of ends per inch	50
No. of picks per inch	35
Loom width	60 inches

These plain-woven fabrics thus obtained were evaluated for their physical characteristics to observe the effect of these of doubled yarns in the weft of the fabric.

Single End Strength: Single end strength was measured with the help of "Uster Tensorapid-3". The procedure was adopted as laid down in its operational manual supplied by M/S Zellweger Uster Limited Switzerland (1992) and according to the ASTM standards (1997 a).

Tearing Strength: In tear strength testing of the fabric the yarns are broken singly or in very small groups, therefore the single end strength has a great importance. The Heavy-Duty Elmendorf Tear Tester was used for the tear strength testing. The method was adopted as mentioned in ASTM standards (1997 b).

Statistical Analysis: Three factors factorial Completely Randomized Design was applied in the analysis of variance for testing differences among the various quality characteristics studied in these investigations. M-Stat Computer package devised by Freed (1992) was employed for statistical manipulation of the results.

Results and Discussion

Single End Strength: The data of single end strength as observed under two types of doublings, three types of twist directions and five twist multipliers with quadruplicate observations was subjected to analysis of variance which reveals a very highly statistically significant differences of all the mean values for main effects, second order interactions as well as third order interactions. The results are presented in the Table-1 (a). The overall co-efficient of variation of experimental data on single end strength was as low as 0.23, which means that the quality of the experiment was highly satisfactory. The performance in mechanical operations seems to be almost in perfect control.

The average values along with the letters showing the differences among values is of main interest because of the highly significant interactions of TDxDxTM i.e. the three factor interaction. The table depicts the variation in responses due to one-factor levels in the presence of other factors. For this reason it is not possible to explain explicitly the overall comparison of different levels of the same factor.

In view of above facts the specific results for single end strength are discussed for data given in Table-1 (b). The table reveals a comparison among means for all the thirty treatments, i.e. the variables design for investigation by using two doublings, three twist directions and five twist multiplier levels. The best single end strength is observed under TM4, TDzz and Ds combination i.e. 1230.47 g, followed by the same TM, i.e. TM4, TDss and Dz combination with a value of 1218.75 g. The best strength at TM4 is because at this level the ply yarn structure is balanced. Lord also explained this and Radhakrishnaiah (1987) who found that when yarns are plied S on Z the best tenacity appeared to be obtained at 4.2 TM confirms this result. The single end strength under TDss xDs and TDzz x Dz is higher under TM3 which are 1102 and 1088 respectively, where as it decreases when twist multipliers increases. As Lord and Radhakrishnaiah (1987) explained that when ring spun yarns are plied Z on Z the outer fibres have a steeper helix angle, which reduces the tenacity of the plied yarns. The single end strength values were lower for all the twist multipliers under combination TDsz xDs as well as TDsz x Dz with values ranging from 1131 to 802.7 and 1128.9 to 8.10g respectively. The poor values for single end strength were observed under the higher TM at TDsz for both doublings. This is again due to the fact of untwisting of one component yarn and the over twisting of the other one.

Tearing Strength: The data of tearing strength as observed under two types of doublings, three types of twist directions and five twist multipliers with quadruplicate observations was subjected to analysis of variance which reveals a very highly statistically significant differences of all the mean values for main effects, second order interactions as well as third order interactions. The results are presented in the table-2 (a).

The overall co-efficient of variation of experimental data on tearing strength was as low as 0.45, which means that the quality of the experiment was highly satisfactory. The performance in mechanical operations seems to be almost in perfect control. The average values along with the letters showing the differences among values is of main interest because of the highly significant interactions of TDxDxTM i.e. the three factor interaction. The table depicts the variation in responses due to one-factor levels in the presence of other factors. For this reason it is not possible to explain explicitly the overall comparison of different levels of the same factor.

In view of above facts the specific results for tearing strength are discussed for data given in Table-2 (b). The table reveals a comparison among means for all the thirty treatments, i.e. the variables design for investigation by using two doublings, three twist directions and five twist multiplier levels.

The best tearing strength is observed under TM4, TDss and Ds combination which is 10944.33g, followed by the same TM, i.e. TM4, TDzz and Dz having the value of 10624g. In order to have the better tearing strength the yarns should have good single end strength because against tearing

Table 1 a: Analysis of Variance Table for Single Yarn Strength

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F.Ratio	Prob	Standard Error
D	1	669.297	669.297	133.8991**	0.0000	0.2886
TD	2	328091.325	164045.662	32818.884**	0.0000	0.3535
TD X D	4	564160.474	282090.227	56434.816**	0.0000	0.4999
TM	2	361899.999	90475.000	18100.378**	0.0000	0.4564
D X TM	4	163.404	40.851	8.1726**	0.0000	0.6454
TD X TM	8	463036.509	57879.564	11579.3533**	0.0000	0.7905
TD X D X TM	8	858527.23	107315.904	21469.5601**	0.0000	1.1179
ERROR	90	449.866	4.999			
TOTAL	119	2577018.1				

Coefficient Of Variation = 0.23 %

** Highly significant * Significant NS Non Significant

Individual Comparison of Treatments Means at P = 0.05

Table 1b:Average Single Yarn Strength As Effected By Various Doubling, Twist Directions And Twist Multipliers

	DS			DZ		
	TDzz	TDsz	TDss	TDzz	TDsz	TDss
TM—3	864.74 R	1131.25 H	1102.55 I	1088.47 J	1128.9 H	855.17 T
TM -4	1230.47 A	957.28 N	1051.95 K	1039.72 L	966.58 M	1218.75 B
TM—5	1191.95 C	853.45 T	899.43 O	889.72 P	860.05 S	1189.42 C
TM—6	1157.63 D	836.03 U	871.10 Q	862.1 RS	837.97 U	1148.05 E
TM—7	1141.95 F	802.70 Y	829.20 V	820.63 W	810.28 X	1134.63 G
AVERAGE	1117.30 A	916.14 F	950.85 C	940.14 D	920.77 E	1109.20 B

TABLE 2a: Analysis Of Variance Table For Tear Strength

Source Of Variation	Degrees Of Freedom	Sum Of Squares	Mean Squares	F.Ratio	Prob	Standard Error
D	1	181980.1	181980.1	95.1259**	0.0000	6.5201
TD	2	842464.867	421232.433	220.1896**	0.0000	7.9855
TM	4	19335775.7	4833943.93	2526.833**	0.0000	10.3092
TD X D	2	200047.267	100023.633	52.2851**	0.0000	11.2932
D X TM	4	236957.178	59239.294	30.966**	0.0000	14.5795
TD X TM	8	3659647.02	457455.878	239.1245**	0.0000	17.8561
TD X D X TM	8	8272915.29	1034114.41	540.5595**	0.0000	25.2524
ERROR	60	114782.667	1913.044			
TOTAL	89	32844570.1				

COEFFICIENT OF VARIATION = 0.45 %

** Highly significant * Significant NS Non Significant

Individual Comparison of Treatments Means at P = 0.05

TABLE 2b: Average Tear Stregth of Fabric as Effected by Various Doubling, Twist Directions And Twist Multipliers

	DS			DZ		
	TDzz	TDsz	TDss	TDzz	TDsz	TDss
TM—3	8250.33 Q	9260.0 LM	8810.0 P	9182.0 N	8912.33 O	8301.0 Q
TM -4	9941.67 F	9865.6 GH	S10944.33 A	10624.0 B	9497.0 J	9817.67 GH
TM—5	10026.00 E	10096.6 DE	9793.3 H	10023.0 E	9875.0 FG	9935.00 F
TM—6	10150.67 D	9641 I.0	9616.67 I	9519.0 J	9598.6 I	10154.0 D
TM—7	10435.0 C	9358.0 K	9502.67 J	9306.0KL	9214.0 MN	10375.33 C
AVERAGE	9760.73 A	9642.47 C	9733.40 AB	9730.80 AB	9419.40 D	9716.60 B

Any two means not sharing a letter differ significantly at 5% level of probability a,b,c are used separately for each column.

strength the yarns break singly. Also the yarns should be compact to have freedom of movement in the fabric so that they may group together and offer a bunch of yarns against the tearing force. In this twist direction i.e. TDss x Ds and TDzz x Dz and twist multiplier i.e. TM 4 the yarns are more compact in comparison to other two directions, due to the addition of folding twist to the spinning twist and yarns have sufficient single end strength. These facts get support from Taylor (1974) who remarked that if in tearing the threads slip, they would bunch together to some extent and support each other. Hence, more easily the yarns slip the greater the tearing strength.
The tearing strength under TDzz xDs and TDss x Dz is lower under TM3 where as it increases when twist multipliers increases and highest value is for TM7. The values range from 8250 to 10435 and 8301 to 10375 respectively. The reason is that as the TM increases the yarn becomes compact and group together therefore tearing strength increases with the increase of twist multiplier. The agreement of this result comes from Harrison (1960) who found that an increase in the twist factor of the component thread of a fabric would generally increase the thread strength and reduce the yarn diameter. Both these effects tend to increase the tearing strength, the latter doing so because of the greater freedom of the thread movement attainable. The tearing strength values are lower for all the twist multipliers under combination TDsz xDs as well as TDsz x Dz in comparison to other two directions. This might be due to the fact that these yarns do not possess a good combination of compactness and single end strength.

Conclusion

- The yarn strength, either lea-strength or single yarn, increase with doubling and it touches an optimum value when the ply twist is balance.
- The tear strength of the fabric produce from yarns of same spinning and folding twist and also SZ combination of yarns, increase up to a certain level and then decreases for higher twist multipliers. While for the fabric made from yarns of same spinning but opposite folding twist it increases with the increase of the twist multiplier.
- It was concluded from this study that the yarn with TM 4 at SS combination in folding was the best to achieve optimum fabric tearing strength.

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