Influence of Plain and Twill (3/1) Weave Designs on the Tensile Strength of PC Blended Fabrics

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ABSTRACT

A study was carried out to investigate the effects of plain and 3/1 twill weave designs on the tensile strength of polyester-cotton blended fabrics. For this purpose five fabric samples, each of plain and twill designs, were made on projectile weaving machine from 15 tex polyester-cotton (52:48%) yarn. The fabric count was increased from 80 (40+40) to 160 (80+80) with equal increment of 10 threads per 25mm both in warp and weft directions to obtained fabrics of different weights. After enzymatic desizing, tensile strength of fabric samples was determined as per standard test method. Comparison of test results shows that plain fabric samples have considerable high tensile strength as compared to twill fabric samples at the same fabric counts.

Key Words: **Tensile Strength, PC Blended Fabrics, Fabric Count, Plain Weave, 3/1 Twill Weave.**

1. INTRODUCTION

Tensile strength has been accepted as one of the most important attributes of woven textiles [1]. It is the main characteristic of woven fabric that distinguishes it from non-woven and knitted fabric. It provides a comprehensive check on most of the specifications of cloth construction. Due to this reason, a demand for minimum strength is added to the usual structural particulars of a fabric in order to ensure the quality of fabric, yarn as well as fiber [2]. Tensile strength is defined as a maximum load that a test specimen will endure when subjected to uniaxial tensile loading [3].

The strength of a fabric depends not only on the strength of constituent yarns, but also on the yarn and fabric structure and many other factors [3-4]. The woven fabrics are made up of warp and weft yarns, interlaced perpendicular to each other in a specific way. There are a particular number of yarns per unit length in each direction. Warp and weft yarns are of specific linear density or fineness. These yarns are made up of fibers or filaments which are spun with or without twist. Fibers are of different material such as cotton, linen, polyester, acrylic and viscose etc. Thus the factors, which have influence on the tensile strength of fabric other than yarn strength, are yarn material, yarn fineness, number of ends and picks per unit length and weave design. In this study, an attempt has been made to explore the effect of weave design on PC (Polyester Cotton) blended woven fabrics.

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Previous literature reveals that weave design is a factor which has influence on the tensile strength of woven fabric. General conclusions of different researchers with respect to effect of weave design on tensile strength of woven fabric can be summarized as under:

Taylor concluded that the strongest weaves would be those, which had greatest number of intersections in the weave repeat and thus had more fiber-binding effect from the mutual pressure of the yarns. Simple weaves (plain, twill, etc.) therefore, would be strongest due to large number of intersections [2]. Ping and Greenwood stated that all fabric properties were not equally influenced by the weave. The tensile strength in either the warp or weft direction, for instance, was primarily the function of yarn strength, with the weave playing only a minor part [5].

It was concluded by Essam that the relation between strength and fabric structure was one of correlation between the strength and the frequency of interlacing and to a smaller extent between the strength and character of weave [6-7]. Hamilton described that the structural tightness of a woven fabric governed by three basic factors which were the number of warp and weft threads per inch; the effective thickness of these threads in fabric; and the way the warp and weft threads interlace to form the actual cloth, i.e. weave design [8].

2. MATERIALS AND METHOD

Ring spun PC (52:48) yarn of 15 tex was arranged from AA Spinning Mills Faisalabad. One hundred cones were selected randomly out of 600 cones and conditioned in standard atmosphere for 48 hours. Linear density of yarn was determined from one hundred leas of these cones according to ISO 2060:1994 test method [9]. Test skeins of 120 yards were made on wrap reel and then conditioned for 24 hours in standard environment. After weighing of these skeins, linear density was calculated by using the following formula:

Tex = Mean weight of skeins (g)x1000x1.0936/length of skein in yards

Tensile properties of yarn were measured by Uster Tensorapid-4 according to ISO 2062:1993 test method [10]. Pretension was adjusted at 0.5cN/tex. Gauge length of 500mm was used at a rate of extension of 5000 mm/min. From each cone, twenty tests were conducted. Thus total of 2000 tests were carried out to get a mean value of tensile properties of yarn.

Uster tester-4 was used to determine Um%, total imperfections (Thin places, thick places and neps) and hairiness at a speed of 400m/min from twenty five conditioned cones according to ISO 16549:2004 test method [11]. Testing length was kept 400 meters from each cone. Thin and thick places were counted at sensitivity levels of -50 and +50 % below and above the mean thickness of yarn respectively while neps at +200 %.

Semi-automatic twist tester was used to measure the twist per meter in the yarn according to ISO 17202:2002 [12]. Gauge length of this equipment was 500 mm while spindle speed was kept at 990 revolutions/min. Testing was conducted in mode A which is suitable for ring spun single yarns. For pretension of 0.50cN/tex, respective pretension weight was placed in the pretension holder. Ten packages were selected randomly and twenty tests per package were conducted. Thus two hundred tests were conducted to get a mean value of yarn twist.

For making fabric samples in plain and twill (3/1) designs, yarn material and yarn linear density in both directions was kept same i.e. 15 tex. Similarly, warp, weft density and even ends per dent were kept same with the intention that samples would have square constructions with only one difference of weave design. Thus fabric count was selected from 80-160 with equal increment of 10 threads per 25mm both in warp and weft directions to make light, medium and heavy fabrics. Warping and sizing was done for above warp densities in AL-Karam Textile Mills Karachi. TB starch, PVA, ACB, and F-311 (softener) were used for making sizing solution. Size percentage of 12.50 was applied on the warp yarn so that yarn could withstand friction during the weaving process.

These fabric samples were woven on projectile weaving machine P 7150 in the Department of Textile Engineering, Mehran University of Engineering and Technology, Jamshoro, Pakistan. Adjustments of shedding, picking, weft detector, warp and weft tension, temples, take-up, let-off and tuck-in were done according to machine manual with the assistance of skilled technician. Settings of warp and weft densities were done by using different reeds and pick gears keeping in view the contraction of the fabric after weaving and desizing. Weave design was kept only the difference between both sets i.e. samples of one set were made in plain 1/1 design while the samples of second set in twill 3/1 design.

In order to remove the sizing materials from fabric without any strength loss, Alpha amylase enzymes were used as desizing agent in a winch dyeing machine. Clariant desizing chemicals (Bactosol PHC Liquid, Imerol PCJ Liquid, Sirrix 2UD Liquid) were used for a desizing grade of six to seven. Exhaust method was used for desizing at a temperature of 80°C while pH was kept within 6-7. After hot and cold wash, fabric was dried at room temperature under roof in order to avoid the effects of sunlight on strength. To determine the tensile strength, samples were first preconditioned at a temperature of 47°C and relative humidity of 10-25% for 4 hours in a hot air oven and then conditioned for 24 hours in standard atmosphere. Test specimens were prepared according to ISO Standard test method 13934-1. Calibrated universal strength tester working on CRE principle was used for breaking of these specimens as per international standards in Al-Rehmat Textile Mills Faisalabad [13]. A gauge length of 200mm was used at an extension speed of 100 mm/min.

3. RESULTS AND DISCUSSION

The quality parameters of 15 tex PC (52:48) yarn measured on different equipments are summarized in Table 1. Tensile strength mean values based on seven readings for each mean value are consolidated in Table 2. To study the effect

TABLE 1. YARN PARAMETERS AND MEASURED QUALITY SPECIFICATIONS

Yarn Quality Parameters	Measured Values
Linear Density	14.66 tex
CV	1.23%
Breaking Force	272.47 cN
CV	9.45%
Breaking Elongation	7.25%
CV	9.85%
Unevenness	12.59%
Total Imperfection Index	956
Hairiness	5.79
Twists per Meter	1049.20
CV	3.22%

TABLE 2. WARP AND WEFT WISE TENSILE STRENGTH OF FABRICS

Sample	Threads in	Warp Strip Strength (N)		Weft Strip Strength (N)	
Construction	the Strip	Plain Design	Twill Design	Plain Design	Twill Design
15x15/40x40	80	179	170	167	160
15x15/50x50	100	240	226	224	212
15x15/60x60	120	310	277	287	269
15x15/70x70	140	370	324	359	319
15x15/80x80	160	446	381	437	376

of weave design on warp wise tensile strength of fabric, comparison is made between tensile strength of plain and twill fabrics and shown in Fig. 1. Similarly, Fig. 2 presents the comparison between tensile strength of plain and twill fabric in weft direction.

It is evident from Fig. 1 that warp-wise tensile strength of plain weave is higher than the twill weave. Similarly, weft-wise tensile strength of plain weave is also higher than twill weave. This effect becomes gradually visible as fabric count increases from 80-160.

These results are analyzed statistically by using ANOVA through Minitab software to assess the significance difference between the strength of plain and 3/1 twill fabrics. As each mean value of warp and weft strip strength given in Table 2 was obtained from seven single values, so seventy single values of warp direction and seventy of weft direction were fed to Minitab work sheet separately. First thirty five values are related to plain weave, while next thirty five are related to twill weave. Analysis of the data is given in Tables 3-4. These results suggest that weave design has highly significant influence on the tensile strength of pc blended fabric.

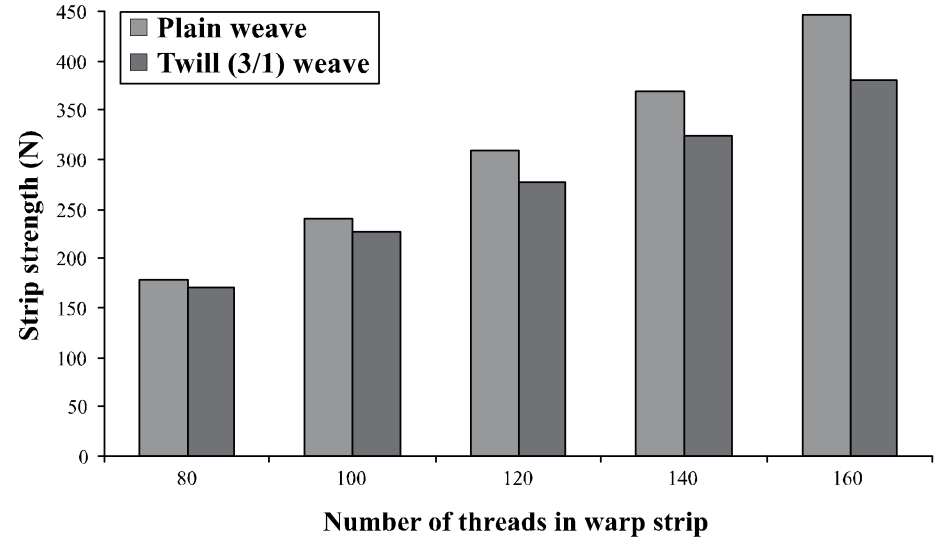

FIG. 1. COMPARISON OF WARP WISE TENSILE STRENGTH FOR PC BLENDED FABRICS

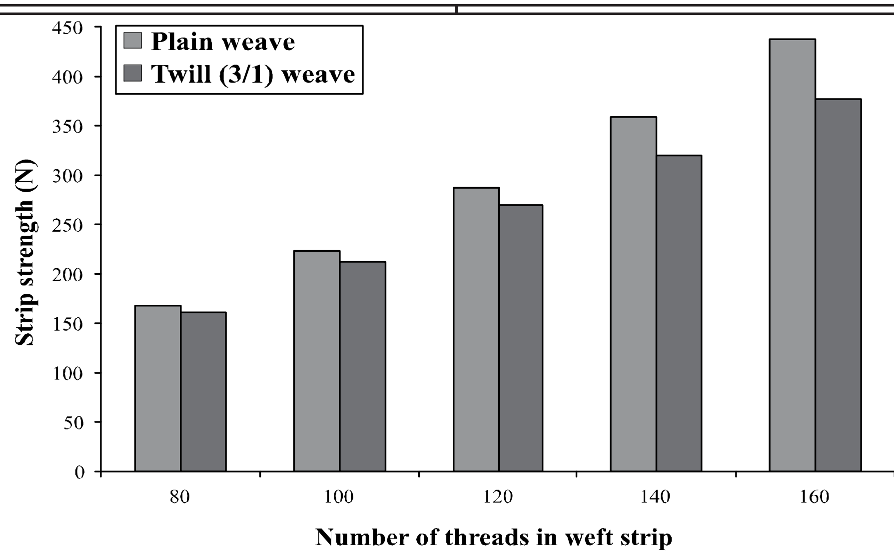

FIG. 2. COMPARISON OF WEFT WISE TENSILE STRENGTH FOR PC BLENDED FABRICS

Reasons behind this loss in the tensile strength of fabric can be explained as: There is only one difference between both sets of fabric samples i.e. the interlacing of warp and weft yarns. In plain design, warp and weft yarns are interlaced one up and one down, while in twill 3/1 design both yarns are interlaced by the order of three up and one down in the face and back of fabric. This difference of interlacement changes the contact area between warp and weft yarns. This contact area of warp and weft yarns in plain weave is about forty percent greater than 3/1 twill weave as it is clear from Fig. 3.

So contact friction between warp and weft yarns of plain samples is more than twill samples. This higher friction provides more resistance to tensile load. It means structure of twill samples having same construction as plain samples is loose and has less binding effect of cross yarns due to float length. Thus yarn failure mechanism in the fabric is dominated with slippage of more number of yarns in twill samples as compared to plain samples. Hence tensile strength of twill weave design is less than plain weave.

4. CONCLUSION

The results of this study show that weave design plays a significant role in the tensile strength of woven fabrics. PC plain fabrics show significantly higher strength in both warp and weft directions than 3/1 twill fabrics at the same construction parameters. This difference in strength of plain and 3/1 twill samples ranges from 4-14 % with respect to light, medium and heavy construction. There is a difference of 65 N in warp direction and 61 N in weft direction at fabric count of 160 which is highly significant. Thus, weave design is an important parameter which has remarkable influence on the tensile strength of woven fabrics.

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TABLE 3. WARP WISE STRENGTH DATA ANALYSIS

Source	DF	SS	MS	F	P
Experiments	9	519657	57740	392.57	0.000
Error	60	8825	147		
Total	69	528482			

TABLE 4. WEFT WISE STRENGTH DATA ANALYSIS

Source	DF	SS	MS	F	P
Experiments	9	539388	59932	465.17	0.000
Error	60	7730	129		
Total	69	547118			

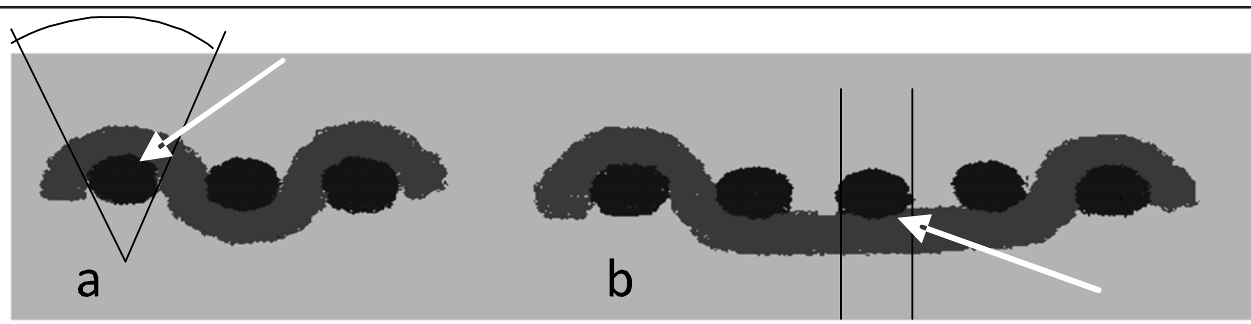

FIG. 3. CONTACT DIFFERENCE IN (A) PLAIN WEAVE (B) TWILL WEAVE

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