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Research Article

The Effect of Weave Structure on Mechanical Property of Denim Fabric

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Abstract

Fabrics are designed to fit different projected demands in order to be suitable for their end use. Strength and abrasion resistance of fabric is very important for the end use of the fabric for its performance. The mechanical and physical properties of the fabric are affected by different factors. The study conducted focuses preliminarily on the effect of weave structure on the strength and abrasion resistance of the fabric. An investigation was undertaken to determine the effects that affect the mechanical and physical properties of fabric which is strength and abrasion resistance of the fabric by taking sample fabrics with different construction and testing the required property. The effects are studied were carried out by using laboratory testing with suitable testing equipment's.

Keywords: Fabric structures; Denim fabric; Tensile strength; Tear strength; Abrasion resistance.

Introduction

Weaving is the interlacing of two systems of yarns, which interlaced at right angle to each other. The lengthwise threads are called warp while the crosswise threads are called weft. In order to interlace warp and weft threads to produce fabric on any type of weaving machine, three operations are necessary: shading, picking and beating [1]. Plain fabric pattern in which each yarn of the filling passes alternately over and under a yarn of warp and each yarn of the warp passes alternately over and under a yarn of the filling [2].It plain weave, each weft thread (filling) passes alternatively over and under each ways yarn in a square pattern. It is also known as tabby, homespun or taffeta weave. During Manufacturing, on the loom, the plain weave requires only two healed shafts. Plain weave requires only two harnesses. Each weft yarn goes alternately underhand over the warp yarns [3].

Twill weave, a weave characterized by diagonal lines produced by a series of floats staggered in the warp or filling direction [2]. The surface of the cloth consist almost entirely either of warp or weft float. It is so because in each repeat, each thread of one series (i.e. either warp or weft) passer over all except one thread of the other series [8]. The interlacing points are so arranged as to allow the floating treads to over the binding points of one thread by the float of another. This results in the production of fabrics with a maximum degree of smoothness and luster and without any prominent weave features. Sateen indicates a weft faced construction, while satin is used with reference to a warp faced structure. Thus sateen's are constructed with a greater number of picks/inch than ends per inch and satins have more ends than picks per inch [3].Strength and elongation are the most important performance properties of fabrics governing the fabric performance in use. Thus; the focus is on the end use application such as protective clothing, perform materials for composites etc. [4]. The aim of this study is to determine the important mechanical properties including tensile strength and abrasion resistance of denim fabric and compare them for further end use application.

Fabric strength is the performance of the fabric which resists the applying of force. The strength tests covered tensile, tear, and burst strength. These mechanical properties are important for all textile users including fabric processors, garment manufacturers, designers and customers [7]. There are three fabric strengths which are occurred in different manner. Those are tensile strength, abrasion strength. The tensile strength deals with the force required to break a large number of yarn simultaneously in either warp or weft direction. The force at which

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the material breaks is directly proportional to cross-section. The tensile force recorded at moment of rupture is termed as the tensile strength at break tenacity [6]. Most of the time after denim fabric manufactured some problems is occurred on the serviceability, appearance, slippage of the fabric, yarn mobility, fitness, weight and large number of threads broken together [10]. When maximum force applied to a material carried to break. Fabrics are subjected to abrasion during their life-times and this may result in wear, deterioration, damage and a loss of performance [11]. Contact of the denim fabric with sharp object lead to the formation of tear. And most common types of failure in textile materials, causes to terminate their service life, give practically direct assessment of serviceability and a fabric with low tearing strength is generally an inferior product [9]. Abrasion of fabric is done by rubbing against parts of the body or external surfaces.

By understanding those problems we want to study the effect of weave structure on the tensile strength, tear strength and abrasion resistance of denim fabrics by selecting two type of construction that are satin and twill structure. There are different researches and journals that are concerned on the study of the effect of different factors which affect the mechanical property of fabric. But there is no more concerned on the effect of weave structure on the mechanical properties which are tensile strength and abrasion resistance of denim fabric. This thesis work study the effects of weave structure on such properties of fabric.

Materials and methods

Materials

For doing this thesis work, 75% Cotton/23% Poly/2% Spandex denim fabric is used, the sample fabrics are twill and (3/1) and satin (4/1). For testing, universal tensile strength testing machine, and abrasion (Martindale) tester machine were used.

Methods

Sampling and data collection

The material used for this thesis work is different weave structure of 75% Cotton/23% Poly/2% Spandex denim fabrics. Which is came from kanoria Africa textile plc. Those fabrics have the same fabric density and the same count.

Fabric property testing

After the samples are collected for different weave structure the tensile tear and abrasion resistance of fabrics were tested (Table 1).

Table 1. Fabric property testing for each parameter

Weave	Count (Ne)		Density		End/ dent	Composition	Machine specification		
	Warp	Weft	EPI	PPI			M/c Name	rpm	tension (Kgf)
Satin 4/1RHT	16	32	80	64	4	75%Cotton/23%Polyster /% Spandex	Air jet	850	360
Twill 3/1RHT	16	32	80	64	4	75%Cotton 23%Polyster/2% Spandex	Air jet	850	360

Results and discussion

Warp yarn breakage, and average weaving efficiency

The influence of weave on properties of denim fabric will be studied. The results of tests of selected properties of fabric have been analyzed to find the most suitable weave structure to get optimum mechanical and comfort property. The effect of weave on critical properties of fabric (Abrasion strength, breaking strength and breaking extension) are reported

The effect of weaving structure on fabric tensile (breaking) strength and elongation

The tested results of breaking strength found from the experiments. The effect of weave structure (twill and satin) on fabric's breaking strength in warp and weft direction is presented.

As shown in the figure 1 Twill weave provided best strength than satin. Having higher interlacement, twill weave fabrics have the maximum crimp, so very little amount slippage of fibers happened in the yarn. This is the reason,

why satin weaves show low strength. When fabric is stretched in lone direction (uniaxial load) first the crimp in that direction declines. Fabric is relatively easy to expand during crimp diminish. After that, the yarn material initiates bearing the load which would trim down the extension tempo of the fabric.

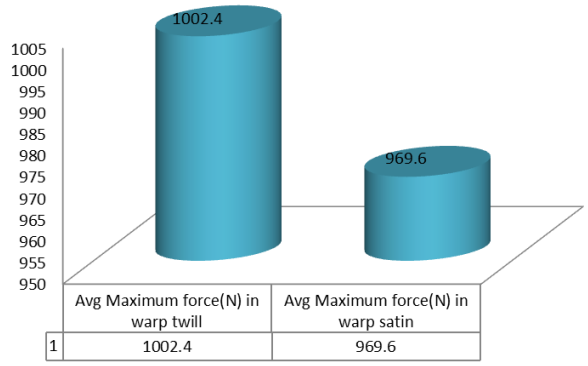

Figure 1. Shows the comparative analysis of Tensile Strength for different weave

There is a statistically insignificant difference between groups means of breaking strength as determined by one-way ANOVA (F= 4.167, p-value = 0.76 in the warp direction twill and satin) and (F=1.557, p-value = 0.247 in weft direction). According to the statistical analysis, those weave structure has insignificant effect on fabric's breaking strength in warp and weft direction (ANOVA table 2 and table 3). This indicates a strong relationship between tensile in warp direction twill and satin and tensile in weft direction twill and satin.

Table 2. ANOVA table of tensile in warp direction twill and satin

	Sum of Squares	Df	Mean Square	F-value	Sig.
Between Groups	6451	1	6451.600	4.167	0.076
Within Groups	12386	8	1548.300		
Total	18838	9			

There is a statistically significant difference between groups means of elongation at break in warp direction twill and satin as determined by one-way ANOVA (F=6.300, p-value = 0.036 in the warp direction twill and satin) and insignificant difference (F=0.194, p-value = 0.671 in weft direction). According to the statistical analysis, weave structure has insignificant effect on fabric's elongation at break in warp direction twill and satin. From table 4 and table 5 show that, in general breaking strength in weft way were better in twill structure than that of satin.

Table 3. ANOVA table of tensile in weft direction twill and satin

	Sum of Squares	Df	Mean Square	F-value	Sig.
Between Groups	1849.6	1	1849.60	1.557	0.247
Within Groups	9502.8	8	1187.85		
Total	11352.4	9			

Table 4. ANOVA table of elongation at break in warp direction twill and satin

	Sum of Squares	Df	Mean Square	F-value	Sig.
Between Groups	2.304	1	2.304	6.300	0.036
Within Groups	2.926	8	0.366		
Total	5.230	9			

Table 5. ANOVA for elongation in weft direction twill and satin

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3.733	1	3.733	0.194	0.671
Within Groups	153.955	8	19.244		
Total	157.688	9			

As shown in figure 2 Twill weave have Abrasion resistance than satin. Having higher interlacement, twill weave fabrics have the maximum crimp, so very little amount slippage of fibers happened in the yarn. This is the reason, why satin weaves show low strength and too much larger floats also cause lower breaking strength due of looser structure. When we compare the abrasion resistance of twill weave is greater than satin weave due to their structure flexibility and their crimp effect. Abrasion mostly affected by weaves structure.

There is a statistically insignificant difference between groups means of Abrasion resistance of twill and satin denim fabric as determined by one-way ANOVA (F=0.707, p-value = 0.433). According to the statistical analysis, weave structure has insignificant effect

on Abrasion resistance of twill and satin fabric's (ANOVA table 4.9). From 6 show that, in general Abrasion resistance of denim fabric was better in twill structure than that of satin.

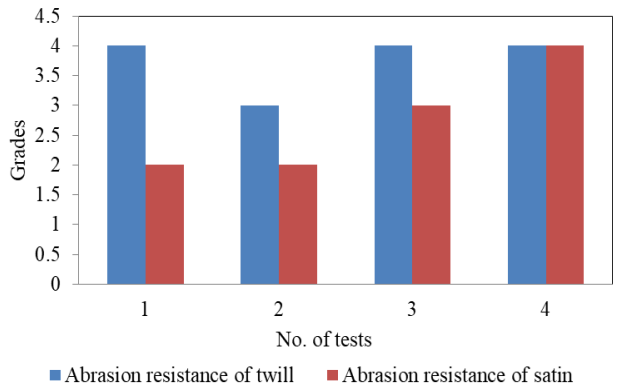

Figure 2. Shows the comparative analysis of Abrasion resistance of twill and satin denim fabric

Table 6. ANOVA table of abrasion resistance of twill and satin denim fabric

	Sum of Squares	Df	Mean Square	F-value	Sig.
Between Groups	0.408	1	0.408	0.707	0.433
Within Groups	3.467	6	0.578		
Total	3.875	7			

Conclusions

The properties of denim woven fabric due to the variation of weave structure were found when the other factors (EPI, PPI, Warp Count, Weft Count and Tension) remain constant. Finally it can be concluded that tensile strength and abrasion resistance are high in twill weave compared to satin weave because these mechanical properties improved with the increasing no. of interlacement of warp & weft yarns also by decreasing the no. of floating in the weave.

Conflict of interest

The authors declare no conflict of interests.

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