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Effects of Weft Count and Weft Density on Yarn Crimp% of Unbleached And Bleached 3/1(S) Twill Woven Fabrics

Atkı İplik Numarası ve Atkı Sıklığının Ham ve Ağartılmış Dimi 3/1(S) Dokuma Kumaşlarda İplik Kıvrımına Etkisi

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EFFECTS OF WEFT COUNT AND WEFT DENSITY ON YARN CRIMP% OF UNBLEACHED AND BLEACHED 3/1(S) TWILL WOVEN FABRICS

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ABSTRACT: In this study, the effects of weft yarn count and weft density on crimp% of unbleached and bleached 3/1(S) twill woven fabrics are investigated. The warp yarn properties (type, count and warp density) were kept constant while the effect of variation in weft count and weft density were studied. Crimp% of unbleached and bleached fabrics are calculated by dividing the difference between straightened yarn length and the distance between the ends of the yarn while in the fabric, by the distance between the ends of the yarn while in the fabric as percentage. It is observed that the crimp% of warp and weft yarn in woven fabric is effected by weft count and weft density statistically. Moreover weft and warp crimp% of bleached fabrics have higher values than unbleached fabrics as a result of the change in weft densities after bleaching process.

Keywords*:* Crimp, weft yarn, weft density, 3/1 twill weave, woven fabric geometry

ATKI İPLİK NUMARASI VE ATKI SIKLIĞININ HAM VE AĞARTILMIŞ DİMİ 3/1(S) DOKUMA KUMAŞLARDA İPLİK KIVRIMINA ETKİSİ

ÖZET*:* Bu çalışmada, dimi 3/1 (S) örgü yapısındaki ham ve ağartılmış dokuma kumaşlarda atkı iplik numarası ve atkı sıklığının kıvrım üzerindeki etkisi araştırılmıştır. Çözgü iplik özelliklerini değiştirmemek kaydıyla (tip, iplik numarası ve çözgü sıklığı), atkı iplik numarası ve atkı sıklığını değiştirmek suretiyle kumaş üretimi gerçekleştirilmiştir. Kıvrım yüzdesi, dokuma makinesi çıkışında ham ve ağartılmış kumaşlarda, kumaştan çıkarılarak ölçülen kıvrımsız gerçek iplik uzunluğu ile kumaş yapısındaki iplik uzunluğu arasındaki farkın, kumaş yapısındaki iplik uzunluğuna yüzdesel oranı olarak hesaplanmıştır. Atkı iplik numarası ve atkı sıklığının, dokuma kumaştaki çözgü ve atkı iplik kıvrımı üzerinde istatistiksel olarak anlamlı etkisinin olduğu gözlenmiştir. Ayrıca, ağartma işleminden sonra atkı sıklıklarında meydana gelen değişikliğin bir sonucu olarak, ağartılmış kumaşların atkı ve çözgü kıvrım yüzdelerinin ağartılmamış kumaşlardan daha yüksek değerlere sahip olduğu görülmüştür.

Anahtar Kelimeler: Kıvrım, atkı ipliği, atkı sıklığı, dimi 3/1 örgü, dokuma kumaş geometrisi

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1. INTRODUCTION

Warp and weft yarns follow a wavy path during the weaving process due to interlacing of warp and weft yarns. Originally straight yarn axes form a wavy shape and a certain amount of waviness called crimp is imparted to the warp and weft yarns in fabric [1,2]. Crimp is geometrically considered as the percentage excess of length of the straight yarn axis over the cloth length [3]. It is affected by various factors, such as loom setting, fabric structure, yarn count, weft and warp yarn bending rigidity, compression of yarns (at binding points) etc. The crimp of warp and weft yarn in woven fabrics is an important parameter which influences several fabric properties such as extensibility, thickness, compressibility, stress-strain relations, handle and creasing. Higher number of interlacements means more wavy yarns and increase in yarn crimp. The flexibility at small strains, is achieved by straightening of crimped yarns. If a load is apllied on a fabric, the initial load is consumed in straightenining crimped yarns. Because of the change of the compression of yarn at interlacement points, the compressibility and thickness properties are related with crimp level of yarn in fabric.Yarn crimp affect the permeability of fabric as it influences the shape and area of the spacing between yarns in fabric.The yarn crimp also influences the economics of the fabrics as it decides quantity of yarn required to weave a fabric during manufacturing and a difference in the weigth per unit area. As it provides a good basis for investigating such phenomena, measuring yarn crimp is essential [4-8]

A number of studies have been carried out to determine the constructional parameters which may affect the warp and weft crimp [9-11]. Some researchers carried out warp tension-crimp relation in woven fabrics theoretically and experimentally [12,13]. Siddika at all [14], found an indicative relationship between the yarn count and the crimp % of 2/1 (S) twill woven fabrics. Maqsood at all [15], developed statistical models for predicting the warp and weft yarn crimps in woven fabrics. Tan at all [16], presented two different ways to represent yarn crimp in numerical models of woven fabrics. Also researchers have reported the effect of crimp on mechanical and physical properties of woven fabrics [17-24]. Studies of fabric geometry have played an important role in the mathematical description or prediction of crimp and a variety of models have been used by investigators [25-30]. Moreover, mathematical models for yarn shape in fabric structure are used for simulating plain woven fabric appearance [31]. In this study warp and weft crimp% of 3/1(S) twill fabrics were investigated in terms of weft count and weft density.

2. MATERIALS AND METHOD

3/1(S) twill fabrics were produced by variation weft count and the weft density without changing the warp density.The fabric samples used in this study are produced with 100% cotton carded weft yarns spun as Ne 6/1, Ne 20/1 and Ne 30/1 yarn counts from the same cotton blend. Ne 20/1, 100% cotton warp sheet is used for all samples and fabrics were woven with dobby shedding rapier loom. The reed has a density of 110 dents per 10 cm and the loom was set up with 2 ends per dent. Constructional parameters of fabrics are given in Table 1. Subsequently, desizing and bleaching processes were applied respectively in the laboratory type haspel machine.

Table 1. Constructional parameters

Sample Code	Warp Yarn Count (Ne)	Weft Yarn Count (Ne)	Mechanical Weft Density (thread/cm)
F1	20/1	6/1	16
F2	20/1	6/1	20
F3	20/1	20/1	16
F4	20/1	20/1	20
F5	20/1	30/1	16
F6	20/1	30/1	20

Warp and weft yarns are removed from a strip of each unbleached and bleached fabric. The crimp percentages of the warp and weft are calculated from the values of straightened yarn length and the distance between the ends of the yarns while in the fabric by Equation 1.

$$C\% = \frac{(l - lo)}{lo} \times 100 \quad (1)$$

In Equation 1, C is crimp percentage, l is straightened yarn length and lo is the distance between the ends of the yarns while in the fabric [6,7].

3. RESULTS AND DISCUSSION

As seen in Figure 1 (a), the crimp% of the weft yarn is increased with the increase of weft yarn count at comparable weft densities for unbleached fabrics. It is seen from Figure 1 (b) that same situation is valid for bleached fabrics. It is probably related to the changing bending stiffness of the weft yarns. Due to the fact that coarser yarn is more rigid, finer weft yarns make more waviness resulting higher crimp%. Also warp crimp is significantly affected by the weft yarn count. It is obvious that thinner the weft yarn, lower the warp crimp%, probably as a result the warp yarns bend less than that occurred for coarser weft yarn [2].

Warp yarn crimp% is increased as the weft density increased depending on the change of yarn crimp as expected [17]. This increase could be result of that tight fabric will have high warp yarn crimp due to its maximum interlacement compared to slack fabric. Similarly, weft yarn crimp% of bleached fabrics is increased with the increase in weft density. However, weft yarn crimp% of unbleached fabrics increased as the weft density increased for fabrics woven with Ne 6/1 weft yarn and decreased as the weft density increased for fabrics woven with Ne 20/1 and Ne 30/1 weft yarns. It can be seen from Figure 1 that weft and warp crimp % of bleached fabrics have higher values than unbleached fabrics. This is probably because of the increase in weft densities due to the chemicals applied during the bleaching process and the temperature of the bleached fabric.

It is also seen from Figure 1, the yarn crimp% in warp direction is much higher compared to weft direction for fabrics woven with Ne 6/1 weft yarns, whereas the yarn crimp% in warp direction is much lower compared to weft direction for fabrics woven with Ne 30/1 weft yarns. However the crimp% values of the weft and warp yarns are getting closer each other with equal

counts (Ne 20/1) of yarn in warp and weft. The difference in yarn crimp percentage in warp and weft direction maybe due to change of interlacing, contact points and bending stiffness in the other direction. Because the woven fabric is manufactured by the interlacing of warp and weft yarn, at a warp and weft thread interlacing point, the location of the threads changes between the face and the back of the fabric where originally straight yarn axes form a wavy shape. More frequent interlacing increases the crimp of the two yarn systems. During the yarns of one direction are bending around their crossing neighbor yarns, finer yarns bend more than that occured for coarser yarns. This is probably due to the fact that coarser yarn is more rigid [1,2,32,33].

Normality of the crimp% data were determined based on skewness and kurtosis in descriptive statistics. It is evident that the values of skewness and kurtosis are significantly lower than the standard error of skewness and kurtosis for normal distribution. An inference may be drawn that the data of crimp% does not deviate from the normal distribution; hence parametric tests are applied [34,35].

The results of the pairwise comparison tests when weft crimp% is selected as the dependent variable are presented in Table 2.

It is seen that there is a significiant difference between weft crimp% values of fabrics comparing 16 thread/cm vs 20 thread/cm weft density and 19 thread/cm vs 23 thread/cm weft density. It is also seen that there is a significant difference between unbleached fabrics woven with weft yarns of Ne 6/1, Ne 20/1 and Ne 30/1 in terms of weft crimp%. When the pairwise comparison test results of bleached fabrics woven with different weft yarns are taken into consideration, there is significant difference between bleached fabrics woven with weft yarns of Ne 6/1 vs Ne 20/1 and Ne 6/1 vs Ne 30/1. But there isn't significant difference between bleached fabrics woven with weft yarns of Ne 20/1 vs Ne 30/1.

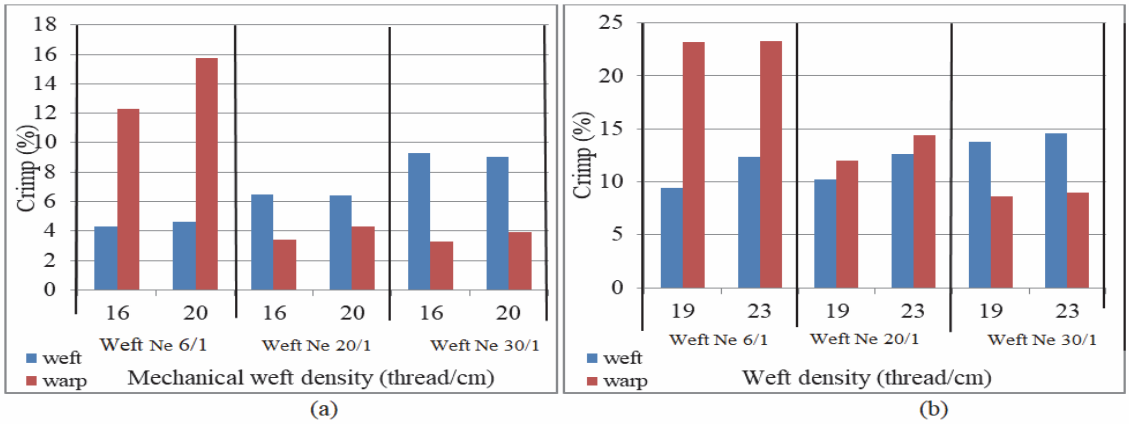

Figure 1. Crimp% a) Unbleached fabrics b) Bleached fabrics

Table 2. Pairwise comparisons test results (Dependent variable weft crimp%)

	WeftDensity (I)	WeftDensity (J)	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
						Lower Bound	Upper Bound
Unbleached fabrics	16 thread/cm	20 thread/cm	-3.118(*)	.117	.000	-3.352	-2.885
	20 thread/cm	16 thread/cm	3.118(*)	.117	.000	2.885	3.352
Bleached fabrics	19 thread/cm	23 thread/cm	-3.000(*)	.446	.000	-3.893	-2.107
	23 thread/cm	19 thread/cm	3.000(*)	.446	.000	2.107	3.893
	Weft Ne (I)	Weft Ne (J)	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
						Lower Bound	Upper Bound
Unbleached fabrcis	6/1	20/1	-1.628(*)	.143	.000	-1.914	-1.342
		30/1	-2.432(*)	.143	.000	-2.719	-2.146
	20/1	6/1	1.628(*)	.143	.000	1.342	1.914
		30/1	-.804(*)	.143	.000	-1.091	-.518
	30/1	6/1	2.432(*)	.143	.000	2.146	2.719
		20/1	.804(*)	.143	.000	.518	1.091
Bleached fabrics	6/1	20/1	-2.100(*)	.546	.000	-3.194	-1.006
		30/1	-1.400(*)	.546	.013	-2.494	-.306
	20/1	6/1	2.100(*)	.546	.000	1.006	3.194
		30/1	.700	.546	.205	-.394	1.794
	30/1	6/1	1.400(*)	.546	.013	.306	2.494
		20/1	-.700	.546	.205	-1.794	.394

Based on estimated marginal means, *The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

To investigate the effect of weft yarn count, weft density and the interaction between weft yarn count and weft density factors on weft crimp% general linear model analysis is conducted. Table 3 summarizes the results of the tests of between-subjects effects.

The results of general linear model analysis of unbleached fabrics show that, p-value (sig.) for weft yarn count, weft density and the interaction between weft yarn count and weft density groups are less than 0.025. Therefore, we can conclude that general linear model in which weft crimp% is selected as dependent variable is effected by weft yarn count, weft density and weft yarn count*weft density factors. Table 3 also shows that general linear model in which weft crimp% is selected as dependent variable is effected by weft yarn count and weft density factors for bleached fabrics.

The result of the pairwise comparison tests when warp crimp% is selected as the dependent variable is presented in Table 4.

Table 3. Tests of Between-Subjects Effects (Dependent variable weft crimp%)

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Unbleached fabrics	Corrected Model	226.416(a)	5	45.283	222.225	.000
	Intercept	2682.557	1	2682.557	13164.500	.000
	Weft Density	145.860	1	145.860	715.800	.000
	Weft Count	61.431	2	30.716	150.735	.000
	Weft Density* Weft Count	19.125	2	9.563	46.928	.000
	Error	11.004	54	.204		
	Total	2919.977	60			
	Corrected Total	237.420	59			
Bleached fabrics	Corrected Model	203.533(a)	5	40.707	13.670	.000
	Intercept	8881.667	1	8881.667	2982.649	.000
	Weft Density	135.000	1	135.000	45.336	.000
	Weft Count	45.733	2	22.867	7.679	.001
	Weft Density * Weft Count	22.800	2	11.400	3.828	.028
	Error	160.800	54	2.978		
	Total	9246.000	60			
	Corrected Total	364.333	59			

Table 4. Pairwise Comparisons (Dependent variable warp crimp%)

	WeftDensity (I)	WeftDensity (J)	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
						Lower Bound	Upper Bound
Unbleached fabrics	16 thread/cm	20 thread/cm	6.668(*)	.098	.000	6.471	6.865
	20 thread/cm	16 thread/cm	-6.668(*)	.098	.000	-6.865	-6.471
Bleached fabrics	19 thread/cm	23 thread/cm	8.833(*)	.319	.000	8.193	9.473
	23 thread/cm	19 thread/cm	-8.833(*)	.319	.000	-9.473	-8.193
	Weft Ne (I)	Weft Ne (J)	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
						Lower Bound	Upper Bound
Unbleached fabrics	6/1	20/1	-1.237(*)	.120	.000	-1.478	-.996
		30/1	4.607(*)	.120	.000	4.366	4.848
	20/1	6/1	1.237(*)	.120	.000	.996	1.478
		30/1	5.844(*)	.120	.000	5.603	6.085
	30/1	6/1	-4.607(*)	.120	.000	-4.848	-4.366
		20/1	-5.844(*)	.120	.000	-6.085	-5.603
Bleached fabrics	6/1	20/1	2.850(*)	.391	.000	2.066	3.634
		30/1	8.300(*)	.391	.000	7.516	9.084
	20/1	6/1	-2.850(*)	.391	.000	-3.634	-2.066
		30/1	5.450(*)	.391	.000	4.666	6.234
	30/1	6/1	-8.300(*)	.391	.000	-9.084	-7.516
		20/1	-5.450(*)	.391	.000	-6.234	-4.666

Based on estimated marginal means, *The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 5. Tests of Between-Subjects Effects (Dependent variable warp crimp%)

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Unbleached fabrics	Corrected Model	1482.165(a)	5	296.433	2053.492	.000
	Intercept	3066.206	1	3066.206	21240.652	.000
	Weft Density	666.933	1	666.933	4620.074	.000
	Weft Count	379.380	2	189.690	1314.046	.000
	WeftDensity * Weft Count	435.852	2	217.926	1509.646	.000
	Error	7.795	54	.144		
	Total	4556.166	60			
	Corrected Total	1489.960	59			
Bleached fabrics	Corrected Model	2224.083(a)	5	444.817	291.153	.000
	Intercept	13650.417	1	13650.417	8934.818	.000
	Weft Density	1170.417	1	1170.417	766.091	.000
	Weft Count	711.433	2	355.717	232.833	.000
	Weft Density * Weft Count	342.233	2	171.117	112.004	.000
	Error	82.500	54	1.528		
	Total	15957.000	60			
	Corrected Total	2306.583	59			

When the pairwise comparison test results of fabrics woven with different weft densities are taken into consideration, it is seen that there is a significiant difference between warp crimp% values of fabrics comparing 16 thread/cm vs 20 thread/cm weft density and 19 thread/cm vs 23 thread/cm weft density. Table 4 also shows that there is a significant difference between fabrics woven with weft yarns of Ne 6/1, Ne 20/1 and Ne 30/1 in terms of warp crimp% of both unbleached and bleached fabrics.

To investigate the effect of weft count, weft density and the interaction between weft count and weft density factors on warp crimp%, general linear model analysis is conducted. Table 5 summarizes the results of the tests of between-subjects effects.

As seen in Table 5, p-value (sig.) for weft yarn count, weft density and the interaction between weft yarn count and weft density groups are less than 0.025. Therefore, we can conclude that general linear model in which warp crimp% is selected as dependent variable is effected by weft yarn count, weft density and weft yarn count*weft density factors for both unbleached and bleached fabrics.

4. CONCLUSIONS

The warp and weft crimp% of 3/1 (S) Twill fabrics which produced by variation weft yarn count and the weft density without changing the warp density were analyzed. The crimp% of yarns is mainly determined by the weft yarn count and weft density. The study shows with the increase of weft yarn count, the crimp% of weft yarn is increased whereas it is reduced for the warp yarn at comparable weft densities. It is seen that one series of yarn of the woven fabric is directly related to the coarseness and density of the other series of yarn. It is obvious that lower the weft yarn count, higher the warp crimp and lower the weft crimp. This is probably because coarser weft yarn is more rigid and bends less at interlacement points. It was also observed that warp yarn crimp% increased with the increase of weft density. This is probably because, the increase in weft density resulted with more frequent interlacing in warp direction. Due to higher interlacing points the crimp% of warp yarn would be higher. As the weft density increased, weft yarn crimp% increased for fabrics woven with Ne 6/1 weft yarn and decreased for fabrics woven with Ne 20/1 and Ne 30/1 weft yarns. The crimp values of the weft and warp yarns are getting closer each other with equal counts (Ne 20/1) of yam in warp and weft. Weft densities of bleached fabrics increased due to the chemicals applied during the bleaching process and the temperature. Because of that weft and warp crimp % of bleached fabrics have higher values than unbleached fabrics. It is observed that the crimp% of warp and weft yarn in woven fabric is effected by weft count and weft density statistically.

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