(REFEREED RESEARCH)

WARP TENSION DISTRIBUTION OVER THE WARP WIDTH AND ITS EFFECT ON FABRIC'S BREAKING STRENGTH DISTRIBUTION OVER THE FABRIC WIDTH IN WOVEN FABRICS

DOKUMA KUMAŞLARDA ÇÖZGÜ GENİŞLİĞİ BOYUNCA ÇÖZGÜ GERGİNLİK DAĞILIMININ KUMAŞ GENİŞLİĞİ BOYUNCA KUMAŞIN KOPMA MUKAVEMETİ DAĞILIMINA ETKİSİ

Gülcan SÜLE
Uludağ University
Textile Engineering Department
e-mail: gulcan@uludag.edu.tr

Mine AKGUN
Uludağ University
Textile Engineering Department

Halil Rifat ALPAY
Uludağ University
Textile Engineering Department

Recep EREN
Uludağ University
Textile Engineering Department

ABSTRACT

This paper assesses warp tension distribution over the warp width and its effect on fabric's breaking strength distribution over the fabric width in plain woven fabrics. Different fabric constructions were woven by changing weft density, weft yarn count and warp tension during weaving on an air jet loom. Warp tension was measured for nine warp ends over the warp width. Then, fabric's breaking strength in warp and weft directions over the fabric width were measured for nine and three measurement points, respectively. It was found that warp tension was lower in the edge zones and increases towards the middle of the loom. There was no uniform change of fabric's breaking strength in warp and weft directions over the fabric width. Warp tension and fabric's breaking strength variation increased when weft density and weft yarn thickness decreased and warp tension increased. These results showed that denser fabrics woven with lower warp tension had less fabric's breaking strength variation in warp direction.

Key Words: Warp tension, Warp tension distribution, Fabric's breaking strength, Fabric's breaking strength distribution, Weaving.

ÖZET

Bu makalede, bezayağı dokuma kumaşlarda çözgü genişliği boyunca çözgü gerginlik dağılımının kumaş eni boyunca kumaşın kopma mukavemeti dağılımına etkisi araştırılmaktadır. Farklı kumaş konstrüksiyonları atkı sıklığı, atkı ipliği numarası ve çözgü gerginliği değiştirilerek hava jetli dokuma makinasında dokunmuştur. Çözgü gerginliği çözgü genişliği boyunca dokuz çözgü ipliği üzerinde ölçülmüştür. Dokuma kumaşların çözgü yönündeki kopma mukavemetleri kumaş genişliği boyunca dokuz bölgede, atkı yönündeki kopma mukavemetleri kumaş genişliği boyunca üç bölgede ölçülmüştür. Sonuçlar, çözgü gerginliğinin tezgahın kenar bölgelerinde orta bölgeye gore daha düşük olduğunu göstermiştir. Kumaşın çözgü ve atkı yönündeki kopma mukavemeti kumaş genişliği boyunca uniform bir değişim göstermemiştir. Çözgü gerginliğindeki ve kumaşın çözgü yönündeki kopma mukavemetindeki değişimin atkı sıklığı ve atkı iplik numarası azaldığında ve çözgü gerginliği arttığında arttığı görülmüştür. Bu sonuçlar, düşük çözü gerginliği altında kalın atkı iplikleri ile ve/veya yüksek atkı sıklıkları ile dokunan kumaşların çözgü yönündeki kopma mukavemeti değişiminin daha az olduğunu göstermiştir.

Anahtar Kelimeler: Çözgü gerginliği, Çözgü gerginlik dağılımı, Kumaşın kopma mukavemeti, Kumaşın kopma mukavemet dağılımı, Dokuma.

Received: 03.12.2009 Accepted: 04.11.2010

1. INTRODUCTION

Breaking strength is the maximum tensile force recorded in extending a test piece to breaking point. It is generally referred to as strength. The fabric strength in either the warp or weft direction is primarily determined by the strength of the yarn. The important fabric variables effecting strength of woven fabrics are fiber properties, yarn properties, warp and weft densities, fabric weave, crimp and finishing process. Therefore, the tensile qualities of woven fabric are closely dependent on the structure of the fabric (1-8).

There seems no doubt that tension during weaving has an important effect on the quality of the fabric. Uneven warp tension over the fabric width may cause unevenness in fabric properties over the width. Previous researchs show that warp tension over the fabric width is not uniform and it is higher in the middle of the warp width than in edge zones. The unequal distribution of the warp end tension over the warp width also affects fabric quality (9-14). The unequal distribution of the warp end tension over the warp width causes varying warp and weft crimps over the warp width in both the fabric on the loom and grey fabric (12,13).

The effect of weft tension on physical properties of woven fabrics has been researched by Nosraty et al. (15). In this study, a weft yarn tension controller was implemented in a single nozzle air-jet loom for controlling the weft yarn tension variations during weft insertion. The fabric samples were woven with and without controlled weft yarn tension and their physical properties were measured. The results show that control of the weft yarn tension decreased the coefficient of variation (CV %) of the fabric's breaking strength in warp and weft direction.

Previous researchs have investigated woven fabric's strength, warp tension distribution over the fabric width and how it is influenced by weaving machine settings and fabric construction. In this research, we investigated experimentally warp tension distribution over the warp width and its effect on fabric's breaking strength distribution over the fabric width for different fabric constructions.

2. MATERIALS AND METHODS

The breaking strength of plain woven fabrics over the fabric width were investigated experimentally for two different warp tensions, three different weft densities and two different weft yarn counts. Different fabric constructions were woven on a Picanol OMNI air jet loom with the warp width of 168 cm. Type of warp and weft yarn, warp density and warp yarn count (150 denier/36 filaments) remained the same. Twisted polyester (yarn twist of 350 turns/metre in the Z direction) warp yarn and textured polyester weft yarns were used in weaving fabrics. The values of parameters changed for weaving different fabric constructions were presented in Table 1.

Warp tension was measured by Schmidth make single end tension sensor which has a measurement interval of 0-200 cN. Loom main shaft angle was measured by an inductive sensor. Tension sensor and inductive sensor were interfaced to a personal computer and warp tension was read with respect to loom main shaft angle by a computer program developed for this purpose using Turbo C programming language. Adjusted total warp tension was a parameter representing the warp tension of all ends measured by loom tension sensor. This parameter was entered from machine computer and used to adjust warp tension by the tension control system of the air jet loom. The adjusted total warp tension was changed for two different values. For each fabric construction, warp tension measurement was carried out over 20 loom revolutions for 9 warp ends over the warp width and average warp tensions were calculated for all warp ends. Then, fabric's breaking strength in warp and weft directions over the fabric width were measured for each fabric construction. Warp tension and fabric's breaking strength measurement points on the loom and fabric were given in Table 2.

The fabric's breaking strength experiments were carried out according to standard ASTMD 1682-64 (16) for grey woven fabrics. The experiments were performed with a tensile tester Instron 4301 in standard laboratuary conditions (25 ^{o}C, 65 %RH). Tests were performed in warp and weft directions and five samples were taken from both directions of each type of fabric. For each fabric construction, fabric's breaking strength measurement in warp and weft directions was carried out for 9 and 3 measurement points, respectively.

Table 1. Constructional parameters of the woven fabrics

Weft Count (denier / filaments)	Adjusted Total Warp Tension (kN)	Weft Density (thread / cm)	Warp Density (thread / cm)
70/72	1	18-22-26	34
	1,75	18-22-26	34
150/96	1	18-22-26	34
	1,75	18-22-26	34

Table 2. Warp tension and fabric's breaking strength measuring points

Measuring points of warp tension over the warp width (As from left temple - cm)		Measuring points of fabric's breaking strength over the fabric width (As from left fabric selvedge - cm)		
Measuring no	Measuring point	Measuring no	Measuring point	
			Warp direction	Weft direction
1	6	1	6	20
2	19	2	20	60
3	31	3	41	100
4	54	4	63	-
5	72	5	71	-
6	96	6	94	-
7	128	7	120	-
8	142	8	139	-
9	160	9	158	-

3. RESULTS AND DISCUSSION

3.1. Warp tension distribution over the warp width

Warp tension distribution over the warp width according to warp tension, weft density and weft yarn count was presented in Figures 1 and 2.

In Figures 1 and 2, warp tension did not have a uniform distribution over the warp width. Warp tension was lower in the edge zones and increased towards the middle of the loom. It took the highest values around the middle of the loom width. We considered that main reason for warp tension variation over the warp width was the slip of the weft yarn inwards at the edge zones. When a weft yarn was inserted and pushed towards the cloth fell by the reed, it took on crimp due to interlacing with the warp ends. As fabric was hold from both sides by the temples, the straight weft laid to the shed was beaten up to the fabric at the same length but in a crimped form. Therefore, weft yarn elongated during beat up due to crimp formation and weft yarn tension inside the fabric increased. As the weft yarn tension inside the fabric exceeded the tension of the weft outside the ground warp width, the weft from outside ground warp was drawn inwards. This caused some slip and relaxation of weft yarn between warp ends at edge zones. Towards the middle of the fabric, the slip of the weft yarn between warp yarns decreased progressively due to the increased in interlacing point. In the middle, the weft was hold firmly by the warp ends and no slip occurs. As a result, weft crimp at edge zones of the fabric became higher than middle zone of the fabric and in contrast to this, warp crimp at edge zones was expected to be lower than the middle zone. Same amount of warp was fed from the beam for all ends but less was taken up by the fabric at edge zones than middle part of the fabric because of lower warp crimp. This caused lower warp yarn tension at edge zones and higher warp yarn tension at the middle zone of the fabric.

The CV % was used to evaluate the effect of warp tension, weft yarn count and weft density on warp tension distribution over the warp width. This effect was presented in Figure 3. According to Figure 3, as the level of warp tension increased warp tension variation over the warp width increased. This was because higher warp tension forces weft yarn to take on more crimp during beat up and weft yarn inside fabric elongated and induced more tension. This caused more slip of weft yarn from outside the ground warp towards inside the fabric. As a result of this, weft yarn relaxed more at the edge zones compared to weaving at a lower warp tension. This effect caused higher warp tension variation over the warp width. Both increasing weft density and increasing weft yarn thickness decreased warp tension variation over the warp width because both effects warp crimp. An increase in warp crimp increased wrapping angle of warp yarn around the weft yarn. This increased friction forces between warp and weft yarns reduced the slip of the weft yarn towards inside the fabric and the weft relaxes less. Because of this, less warp tension variation occurred over the warp width. These results showed that a denser fabric woven with a lower warp tension had less warp tension variation over the warp width.

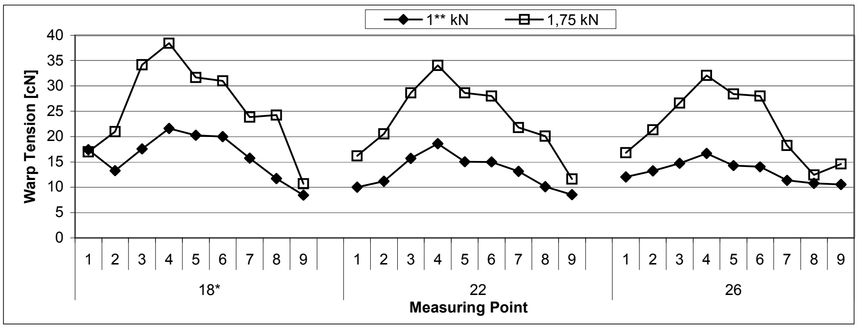

Figure 1. Warp tension distribution over the warp width with 70 denier weft yarn [*weft density (weft /cm) and ** adjusted total warp tension (kN)]

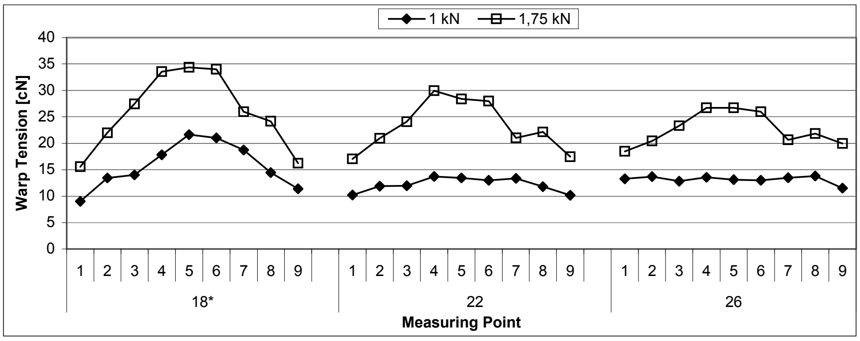

Figure 2. Warp tension distribution over the warp width with 150 denier weft yarn [*weft density (weft /cm) and **adjusted total warp tension (kN)]

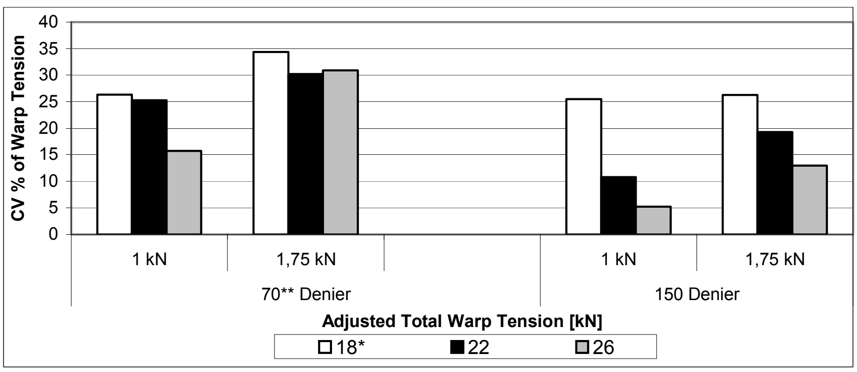

Figure 3. The coefficient of variation of the warp tension over the warp width [*weft density (weft /cm) and **weft yarn count (denier)]

3.2. Fabric's breaking strength distribution in warp direction over the fabric width

Fabric's breaking strength distribution in warp direction over the fabric width according to warp tension, weft density and weft yarn count was presented in Figures 4 and 5.

In Figures 4 and 5, fabric's breaking strength in warp direction changed over the fabric width. The CV % values over the width for every fabric were calculated in order to comment better on this variation of the fabric's breaking strength in warp direction.

To compare the effect of warp tension, weft density and weft yarn count on the fabric's breaking strength in warp direction, the coefficient of variation of the experimental results for nine measuring points were presented graphically in Figure 6.

Figure 6 showed that, the CV % of the fabric's breaking strength in warp direction decreased with decreasing warp tension, increasing weft density and weft yarn thickness. This meant that reducing warp tension and increasing weft density and weft yarn thickness increased the uniformity of fabric's breaking strength in warp direction over the fabric width.

The effect of the warp tension, weft density and weft yarn count on fabric's breaking strength variation over the fabric width was similar to the effect of warp tension, weft density and weft yarn count on warp tension variation over the warp width. These results showed that the greater CV % of warp tension distribution over the warp width, the greater was CV % of fabric's breaking strength distribution over the fabric width. Based on above discussion, it was thought that a denser fabric woven with a lower warp tension had less fabric's breaking strength variation in warp direction over the fabric width. This might cause improving the fabric's tensile qualities.

3.3. Fabric's breaking strength distribution in weft direction over the fabric width

In Figure 7, fabric's breaking strength in weft direction did not have a uniform change over the fabric width and as the weft yarn count and weft density increased the breaking strength in weft direction increased as expected. There was no significant effect of warp tension on the breaking strength in weft direction. To compare the effect of warp tension, weft density and weft yarn count on the fabric's breaking strength in weft direction, the coefficient of variation of the experimental results for three measuring points were presented graphically in Figure 8. Figure 8 showed that the CV % of the fabric's breaking strength in weft direction in all fabrics were different and did not have regular change with warp tension, weft density and weft yarn thickness.

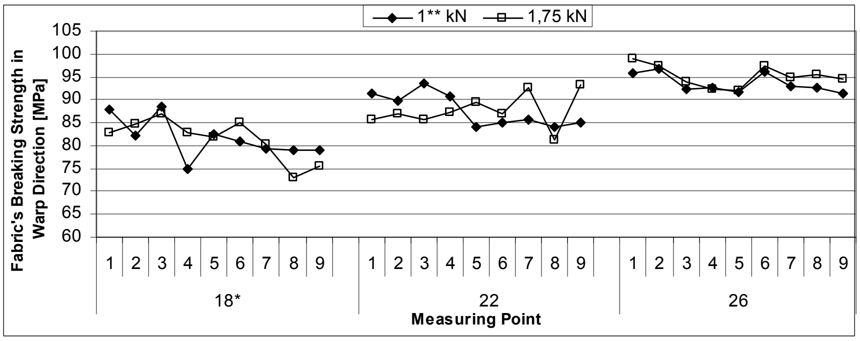

Figure 4. The effect of warp tension changed over the warp width on fabric's breaking strength in warp direction with 70 denier weft yarn [*weft density (weft /cm) and **adjusted total warp tension (kN)]

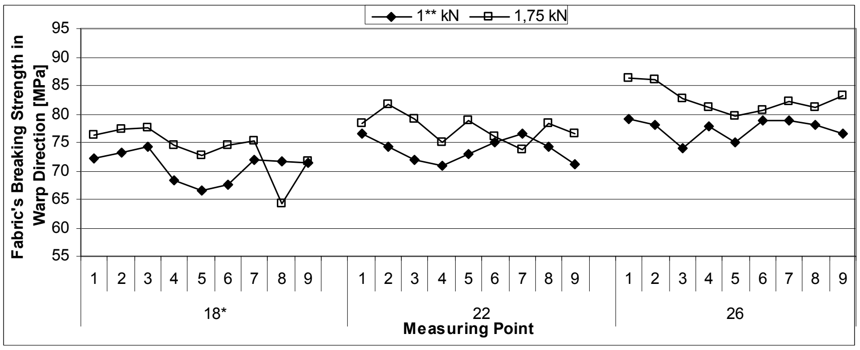

Figure 5. The effect of warp tension changed over the warp width on fabric's breaking strength in warp direction with 150 denier weft yarn [*weft density (weft /cm) and **adjusted total warp tension (kN)]

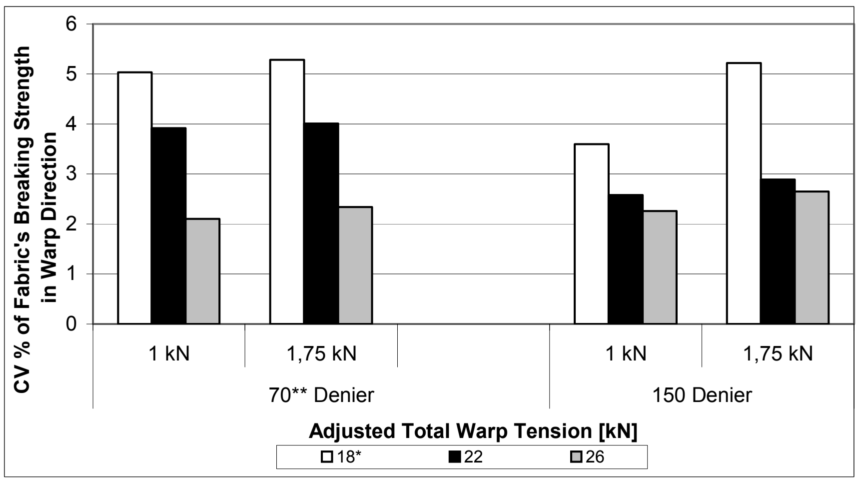

Figure 6. The coefficient of variation of the fabric's breaking strength in warp direction over the fabric width [*weft density (weft /cm) and **weft yarn count]

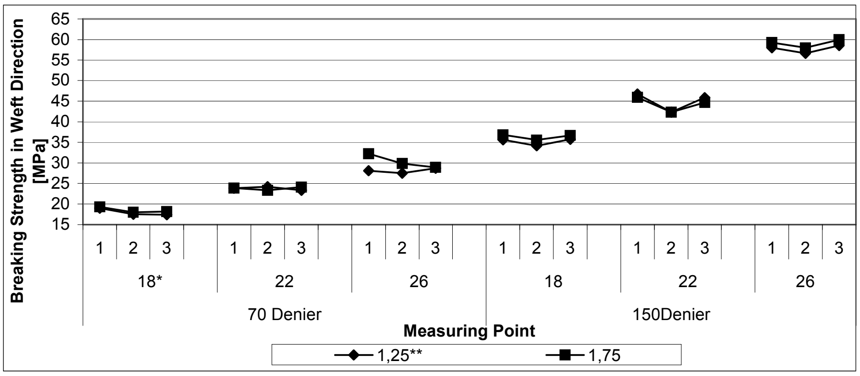

Figure 7. The effect of warp tension changed over the warp width on fabric's breaking strength in weft direction [*weft density (weft /cm) and **adjusted total warp tension (kN)]

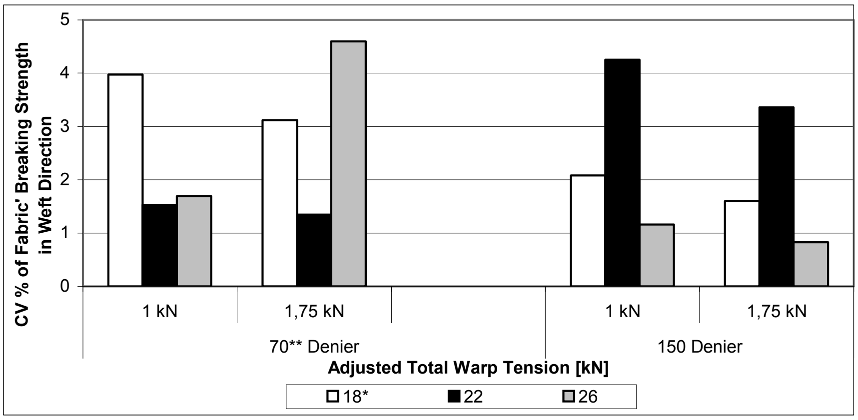

Figure 8. The coefficient of variation of the fabric's breaking strength in warp direction over the fabric width [**weft density (weft /cm) and *weft yarn count (denier)]

4. CONCLUSION

The effect of warp tension distribution on fabric's breaking strength distribution over fabric width was investigated for different fabric constructions. Warp tension was lower in the edge zones and increased towards the middle of the loom. It took the highest values around the middle of the loom width. The reason for this warp tension variation over the warp width was the slip of the weft yarn inwards at the fabric edge zones.

The CV % was used to evaluate the effect of warp tension, weft yarn count and weft density on warp tension distribution over the warp width. It was found that as the level of warp tension increased, warp tension variation over the warp width also increased. Besides, both increasing weft density and increasing weft yarn thickness decreased warp tension variation over the warp width.

There was no uniform change of fabric's breaking strength in warp direction over the fabric width. The effect of the warp tension, weft density and weft yarn count on fabric's breaking strength variation over the fabric width was similar to the effect of warp tension, weft density and weft yarn count on warp tension variation over the warp width. The CV % of the fabric's breaking strength in warp direction decreased with decreasing warp tension, increasing weft density and weft yarn thickness. In other words, reducing warp tension and increasing weft density and weft yarn thickness increased the uniformity of fabric's breaking strength in warp direction over the fabric width.

These results showed that the greater CV % of warp tension distribution over the warp width, the greater was CV % of fabric's breaking strength distribution over the fabric width. Based on above discussion, it was thought that a denser fabric woven with a lower warp tension had less fabric's breaking strength variation in warp direction over the fabric width. To improve the uniformity of fabric's breaking strength in warp direction over the fabric width, warp tension variation over the warp width should be reduced. This was an important result that may improve the fabric's tensile qualities.

There was no uniform change of fabric's breaking strength in weft direction over the fabric width. The CV % of the fabric's breaking strength in weft direction in all fabrics was different and did not have a regular change with respect to warp tension, weft density and weft yarn thickness.

REFERENCES

1. Saville B. P., 2002, "Physical Testing of Textiles", Woodhead Publishing Limited, pp: 115-167.
2. Greenwood K., 1975, "Weaving: Control of Fabric Structure", Merrow Publishing, Durham, pp:12-14.
3. Adanur S., 2001, "Handbook of Weaving", Technomic Publishing Company Inc., p:564.
4. Mohamed M.H., Lord P.R., 1973, "Comparison of Physical Properties of Fabrics Woven from Open-End and Ring Spun Yarns", *Textile Research Journal,* Vol. 43(3), pp:154-166.
5. Lee W., Dhingra R.C., Lo T.Y., Abbas M.S., 1996, "Effects of Finishing on Low Stress Mechanical and Surface Properties of Silk and Denim Fabric", *Journal of Federation of Asian Professional Textile Associations,* Vol.3, pp:50-58.

6. Richard J.B., Ron P., 1999, "Experimental Methods for Measuring Fabric Mechanical Properties: A Reviev and Analysis", *Textile Research Journal,* Vol. 69 (11), pp: 866-875.

7. Cook J.G., 2001, "Handbook of Textile Fibers, Volume 1: Natural Fibers", Woodhead Publishing Limited, Cambridge, England, p:208.

8. Kumpikaité E., 2007, "Analysis of Dependencies of Woven Fabric's Breaking Force and Elongation at Break on its Structure Parameteres", *Fibers and Textiles in Eastern Europe,* Vol.15 (1), pp:35-38.

9. Ludwig H.W., Gries T. 2003, "Measurements Carried Out To Minimise Warp Tension Wariations in Weaving Machines", *Melliand Textilberichte,* Vol.2, pp:55-58.

10. Weinsdorfer H., Azarschab M., Murrweib H., Wolfrum J., 1988, "Effect of The Selvedge and The Temples on The Running Performance of Weaving Machines and on The Quality of The Fabric", *Melliand Textilberichte,* Vol.35, pp: 364-372.

11. Weinsdorfer H., Wolfrum J., Stark U., 1991, "The Distribution of The Warp End Tension Over The Warp Width and How It is Influenced by the Weaving Machine Setting", *Melliand Textilberichte,* Vol.72, pp: 903-905.

12. Ozkan G., 2005, "Investigation of Crimp-Warp Tension Relation in Woven Fabrics", Ph.D. Thesis, Uludag University, Turkey, p: 240.

13. Ozkan G., Eren R., 2010, "Warp Tension Distribution Over The Warp Width and Its Effect on Crimp Distribution in Woven Fabrics", *International Journal of Clothing Science and Technology*, 22(4), pp:272-284.

14. Blanchonette I., 1996, "Tension Measurements in Weaving of Singles Worsted Wool Yarns", *Textile Research. Journal,* Vol.66, (5), pp:323-328.

15. Nosraty H., Jeddi A.A.A., Kabganian M., Nejad F.B., 2006, "Influence of Controlled Weft Yarn Tension of a Single Nozzle Air-Jet Loom on The Physical Properties of The Fabric", *Textile Research Journal,* Vol.76 (8), pp:637-645.

16. ASTMD 1682-64, 1999, "Standard Test Methods for Breaking Load and Elongation of Textile Fabrics".

---

*Bu araştırma, Bilim Kurulumuz tarafından incelendikten sonra, oylama ile saptanan iki hakemin görüşüne sunulmuştur. Her iki hakem yaptıkları incelemeler sonucunda araştırmanın bilimselliği ve sunumu olarak **"Hakem Onaylı Araştırma"** vasfıyla yayımlanabileceğine karar vermişlerdir.*