Analysis of Weft Yarn Tension in Air – Jet Loom and its Influence on Fabric Physical Properties

Hooshang Nosraty[1] and Ali Asghar Asgharian Jeddi[2]

ABSTRACT

The tension of warp and weft yarns plays an important role in weaving process, such as yarn breakage rate and weaving efficiency. They also influence the physical properties of fabric. To investigate the effect of weft yarn tension in an air – jet loom, five fabric samples were woven from 32/2 Ne polyester – viscose warp and weft yarn with five different weft yarn tension levels (with average of 30, 35, 40, 45 and 50 cN). Then, they were measured and analyzed for weft and warp density and crimp, the strength and elongation at warp and weft direction, weight, thickness, drape, and abrasion resistance. Statistical analysis revealed that there is a linear relationship between weft yarn tension and investigated fabric physical properties with high correlation.

KEYWORDS

Weaving, Weft yarn tension, Fabric, Physical Properties.

1. INTRODUCTION

The imposed tension to warp and weft yarns in a loom has two important effects. At first, it has an effect on warp and weft yarn breakage and, secondly fabric quality and its physical and mechanical properties are affected by weft and warp yarn tension. Therefore, many researchers have tried to weft and warp yarn tension measuring and studying of its effect on fabric properties and loom performance. Chahal [1] has measured the dynamic weft yarn tension for two weft yarn type, polyester- wool 50/2 Ne and 2/50/30 textured filament yarn in a projectile loom. The fabric samples have woven with different weft yarn tension levels and their weight, width, warp crimp, weft crimp, shrinkage and abrasion resistance are measured and relationship between weft yarn tension and fabric properties has been studied. Results indicate that in samples woven by staple weft yarn the effect of weft yarn tension variation on fabric physical properties is more pronounced.

In Adanur's work [2], the weft yarn tension during weft insertion has been investigated in air-jet weft insertion. Due to difference in weft insertion time, the maximum pick of the weft yarn tension occurs at different times.

Thus, the measuring of weft yarn tension average in large number of weft insertion cycles is necessary in order to predict the maximum pick of tension occurring with better estimation, however due to average taking of yarn tension in different weft insertion cycles, the tension peaks are evened out and so their magnitude decreases and for real maximum of tension attachment the measuring of weft tension in individual weft insertion cycles would be necessary.

Yoshida et al. [3] have studied the weft yarn velocity variation experimentally in an air-jet loom during weft insertion. The weft yarn velocity was measured by Laser-Doppler velocity-meter that applied for fluids velocity measuring. Also, the weft yarn tension variation was measured. Results indicated that there is significant relation between weft yarn tension variation and weft yarn velocity variation.

The effect of weft yarn strength and loom speed on weft yarn tension in projectile and rapier looms have been investigated by Nosraty and Behzadan [4]. In their work, three samples of 28.5 Tex cotton yarn with different strength are woven on looms with three different speeds. The weft yarn tension was measured during weft insertion.

For both of looms weft yarn tension in relating to loom speed and weft yarn strength has been analyzed by ANOVA technique and the effects of these factors have been determined. Weft yarn tension increased by loom speed increasing and decreasing of weft yarn strength increases the weft yarn tension, especially in high loom

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speeds. The results for projectile and rapier looms were the same. Blanchonette [5], for investigation of weft and warp yarn tension variation in weaving machines, has measured the yarn tension on looms in on-line form. The single 25 Tex worsted wool yarn has woven on projectile, rapier and air-jet looms, the maximum warp yarn tension variation was 35-45 Newton per second (N/S) during beat up and for weft yarn was 600-1000 Newton per second (N/S) in regard to weft insertion system. He concluded that by weft yarn tension measuring and attention to its physical properties, the weft yarn breakage rate would be predictable.

In work that has been done by Wulfhorst [6] a test trial suggested for prediction of weft insertion behavior in an air-jet loom.

For this purpose he measured the weft yarn tension imposed by the main nuzzle during weft insertion. Results show that the weft insertion behavior in an air-jet loom would be predictable by weft yarn tension measuring on the loom and statistical analysis in a PC computer simultaneously considering weft yarn properties and air flow characteristics.

Nosraty et al [7] have measured weft yarn tension in a Single-Nozzle air-jet loom during weft insertion. Also, they have studied the effect of the nozzle input air pressure, loom speed and mechanical brake force on weft yarn tension.

The weft yarn motion simulation in a single-nozzle air-jet loom has been done by Nosray et al [8] by derivation of equation for weft yarn dynamic motion. From the numerical solution of the differential equation of the weft yarn motion, the position-time, velocity- time and tension-time graphs for weft yarn have been obtained that identify the system and supply the useful information for weft yarn tension control .

In regard to the effectiveness of weft yarn tension variation on fabric physical properties, Nosraty et al [9] have designed and installed a weft yarn tension controller in a single-nozzle air-jet loom. The tests on woven fabric samples show that the weft yarn tension control affects the fabric physical properties variation and reduces it considerably. In the present work, the effect of the weft yarn tension on the fabric physical properties in a single-nozzle air-jet loom has been investigated.

2. MEASURING METHOD

To measure the weft yarn tension during weft insertion, the Rothschild electronic tension meter was used. Tension meter has a measuring head which works based on the variation of capacity in a variable capacitor. Its capacity varies in accordance with yarn pressure on sensor rod. Tension meter output in cN is printed on the paper film of a recorder unit. In the present work, the recorder unit has omitted and measured tension transferred to a PC computer in digital values form by an A/D circuit. Computer input data are stored in data files by designed software. The required values such as total tension, average of tension, time, loom degree and etc are obtained by a data processing on input tension and then the tension variation graphs are plotted. A micro switch was installed against sley which when sley reaches to front center (0 degree of the loom) pushes the micro switch and send a signal pulse to computer for separating each weaving cycle data. Therefore, the system can consider the successive weaving cycle information separately.

Schematic diagram of tension measuring unit and PC processor is shown in Figure 1. The loom for weaving of fabic samples with different weft tension level was an Investa single-nozzle air-jet loom with speed of 300 rpm and 150 Cm reed width.

3. EXPERIMENTAL WORK

Five fabric samples in plain structure were woven on the Investa single – nozzle air jet loom at different weft yarn tension level (with average of 30, 35, 40, 45, and 50 cN). The fabrics were produced using a 37 tex polyester – viscose ring-spun yarn (67% - 33%) for both weft and warp with 22 ends/cm and 16 picks/cm. The reed width of the loom used in this work was 150 cm. For the purpose of determining the influence of weft yarn tension on the physical properties of the fabrics, the following characteristics of fabrics were measured; the fabric density in weft and warp directions, the weft and warp yarn crimp, the breaking strength and elongation of the samples in weft and warp directions,weight, thickness, abrasion resistance and drape.

All fabrics tests were done based on ASTM standards at laboratory condition (20°C ± 3°C and 50 ± 5% R.H.). The test for breaking strength and breaking elongation carried out on Instron tenacity tester with CRE method and fabric drape was measured by a modified Shirley drape meter which works by photocells and computer processing. For other tests, the conventional equipments were used. The average results are shown in Table 1.

4. RESULTS AND DISCUSSIONS

The ANOVA test was performed on the experimental data in order to show the statistical significant differences on the physical properties due to weft yarn tension variation. The results are presented in Table 2 in summary.

The statistical data analyses of test results show that there is a linear relationship between weft yarn tension and fabric physical properties with a high correlation coefficient (Table 3).

The experimental fabric densities against weft yarn tension are shown in Figure 2 for weft direction and in Figure 3 for warp direction. These graphs show that the increase of weft yarn tension causes an increase in fabric density in both directions. The increase of warp density is expected, since the increase of weft yarn tension causes reduction of distances between the warp yarns. However, the warp yarn movement in fabric width is not very much because of the reed width effect and also the high tension of warp yarns. Consequently, the warp yarn crimp is increased (Figure 4) and then it causes an increase in weft density. Figure 5 also shows the relation between weft yarn crimp and weft yarn tension.

It is clear that with an increase in weft yarn tension, the weft yarn tends to shrink more after fabric take up, hence the weft yarn crimp would be increased. This result is in disagreement with the crimp interchange theory in woven fabric because in this research the yarn tension increases during weaving process not in produced fabric.

Figure 6 shows that the fabric breaking strength in weft direction decreases with an increase in weft yarn tension. We have not expected this result, because with the increase of weft yarn tension the fabric density and weft yarn crimp increased, thus its strength should be increased, as we can see in Figure 7 for fabric breaking strength in warp direction. Therefore, this result probably arises from the reduction of weft yarn strength because of its more elongation during weaving process on the loom due to increase of weft yarn tension.

Indeed the fabric breaking elongation is affected by two factors. First factor is fabric initial elongation that increases by an increase in the weft yarn crimp. Second factor is yarn elongation after the fabric initial elongation. Because the weft yarn with higher tension during weaving subjected to more elongation which a part of it compensated by yarn crimp but other part of elongation remains in the yarn. Therefore, during load-elongation test the second factor reduces the breaking elongation of fabric. Considering the test results, it seems that the effect of second factor is more than first one and totally the increasing of weft yarn tension reduces the weft wise breaking elongation of fabric.

The relationship between weft yarn tension and fabric breaking elongation are shown in Figures 8 and 9. As we mentioned before, the increase of weft yarn tension causes an increase in weft yarn elongation during weaving. Thus, the fabric breaking elongation in weft direction decreased (Figure 7). Also, with the increase of fabric density due to weft yarn tension, the tightness of fabric is increased, and the fabric breaking elongation is decreased in both directions.

Since increase of fabric density causes an increase of fabric weight then, with the increases of weft yarn tension the fabric weight increases (Figure 10). Also, the increase of weft yarn tension causes a compression on fabric therefore the reduction of fabric thickness is expected (Figure 11). As it can be seen from Figure 12, with the increase of weft yarn tension the fabric abrasion is increased, in other words the fabric abrasion resistance is decreased. This is probably due to reduction of weft and warp yarns movement inside the fabric followed by increase of fabric density and its more tightness. Therefore, the fabric is exposed to more abrasion.

Figure 13 shows that with the increase of weft yarn tension the value of fabric drape percent decreases, because the fabrics become tighter due to increase of weft yarn tension that increases the weft and warp yarn densities and crimps and fabric weight.

5. CONCLUSION

A useful weft yarn tension measuring unit with automatic data acquisition and analysis was developed. The application of this system to study the influence of weft yarn tension on fabrics physical properties woven on an air – jet loom is the subject of this research.

Five fabric samples with different weft yarn tension values (with average of 30,35,40,45 and 50 cN) were produced. The physical properties of woven samples included weft and warp density, weft and warp crimp, weft wise and warp wise breaking strength and breaking elongation, fabric weight, fabric thickness, fabric abrasion resistance and fabric drape were measured. Data analysis of experimental tests results shows that there are linear regression equations with very high correlation coefficient between weft yarn tension and fabric measured properties. Increasing of weft yarn tension increases the average of weft density, warp density, weft crimp, warp crimp, warp wise breaking strength and fabric weight. With the increase of the weft yarn tension, the weft wise breaking strength, weft wise and warp wise breaking elongation, fabric thickness, abrasion resistance and fabric drape are decreased.

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TABLE 1

THE AVERAGE RESULTS OF FABRIC S CHARACTERISTICS

Fabric property	The average of weft yarn tension (cN)				
	30	35	40	45	50
Weft density (picks/cm)	15.79	15.94	16.34	16.81	17.17
Warp density (ends/cm)	23.27	23.39	23.46	23.68	23.74
Weft crimp (%)	6.7	7.45	8.3	9.35	9.7
Warp crimp (%)	30.2	30.5	30.9	31.8	32.25
Breaking strength (weft direction) (kg)	94.6	92.1	89.1	81.7	79.3
Breaking strength (warp direction) (kg)	131.5	132.4	134.7	135.9	136.3
Breaking elongation (weft direction) (mm)	49.4	46.7	45.4	41.4	39.7
Breaking elongation (warp direction) (mm)	68.45	68.3	67.2	66	65.9
Fabric weight (gr/10cm^2)	1.61	1.64	1.66	1.7	1.74
Fabric thickness (mm)	0.4388	0.4248	0.4228	0.399	0.3862
Abrasion (weight reduction) (gr)	0.01016	0.01166	0.01247	0.01518	0.01683
Fabric drape (%)	14.6	12.4	10.7	8.3	8

TABLE 2

THE SUMMARY RESULTS OF ANOVA TEST ON FABRIC PHYSICAL PROPERTIES DUE TO WEFT YARN TENSION VARIATION

Physical property	Statistical difference
Weft density (picks/cm)	+ **
Warp density (ends/cm)	+ *
Weft crimp (%)	+ **
Warp crimp (%)	+ *
Breaking strength (weft direction) (kg)	- **
Breaking strength (warp direction) (kg)	+ **
Breaking elongation (weft direction) (mm)	- **
Breaking elongation (warp direction) (mm)	- *
Fabric weight (gr/10cm^2)	+ *
Fabric thickness (mm)	- **
Abrasion (weight reduction) (gr)	+ **
Fabric drape (%)	- *

**	95 % Significant level	+	increase
*	90 % Significant level	_	decrease

TABLE 3

THE RELATION BETWEEN WEFT YARN TENSION AND FABRIC PHYSICAL PROPERTIES

No.	**Physical property**	**Relation between physical property and weft yarn tension (T)**	**Correlation Coefficient (R^2)**
1	Weft Density (picks/cm)	F.D= 0.0726T+13.506	97.77%
2	Warp Density (ends/cm)	W.D.= 0.0246T+22.524	96.81%
3	Weft crimp (%)	F.C= 0.0632T+0.792	98.36%
4	Warp crimp (%)	W.C= 0.0432T+10.724	96.62%
5	Weft wise breaking strength (kg)	F.S= -0.82T+120.16	96.11%
6	Warp wise breaking strength (kg)	W.S= 0.262T+123.68	94.96%
7	Weft wise breaking elongation (mm)	F.E= -0.45T+62.3	96.36%
8	Warp wise breaking elongation (mm)	W.E= -0.148T+73.09	92.85%
9	Fabric weight (gr/10cm^2)	W= 0.0064T+1.415	99.22%
10	Fabric thickness (mm)	TIC= -0.00262T+0.52	95%
11	Abrasion(weight reduction) (%)	A= 0.0172T+0.102	97.32%
12	Fabric drape (%)	D= -0.346T+24.64	96.23%

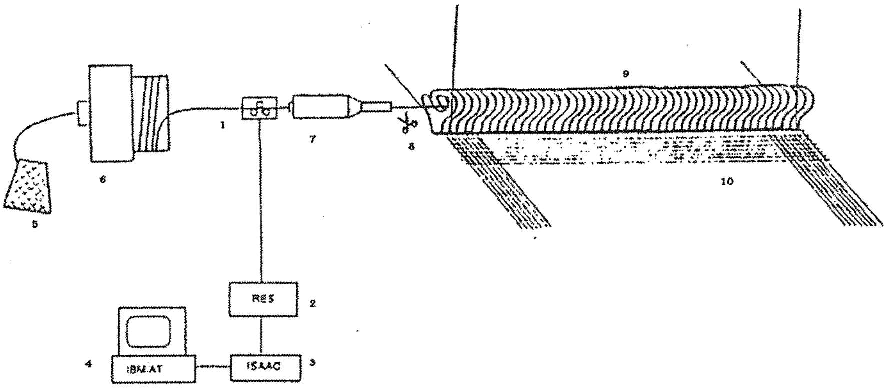

Figure 1: A schematic diagram of air-jet weft insertion mechanism and tension meter.

1- Tension measuring head	2- Tension meter	3- A/D Electronic card
4- PC Computer	5- Weft yarn package	6- Weft yarn drum storage
7- Air nozzle	8- Scissor for weft yarn	9- Confusor 10- Fabric

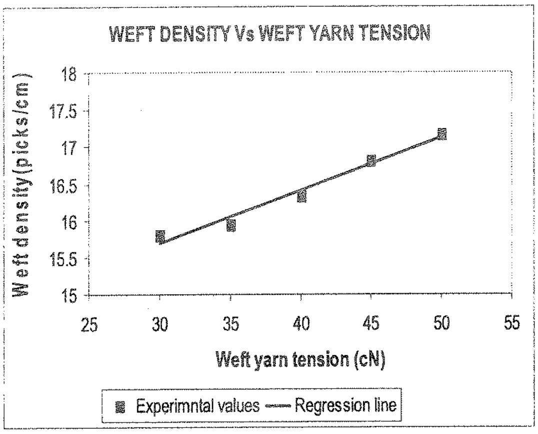

Figure 2: The effect of weft yarn tension on the weft density.

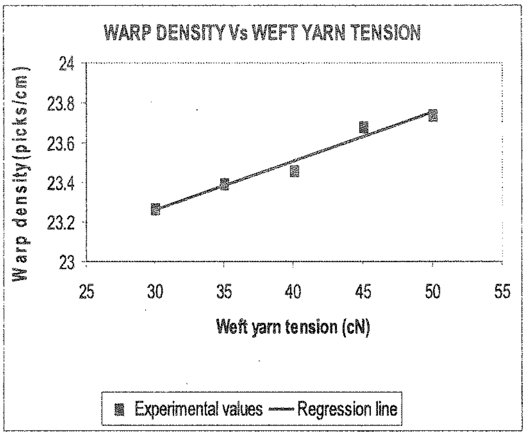

Figure 3: The effect of weft yarn tension on the warp density.

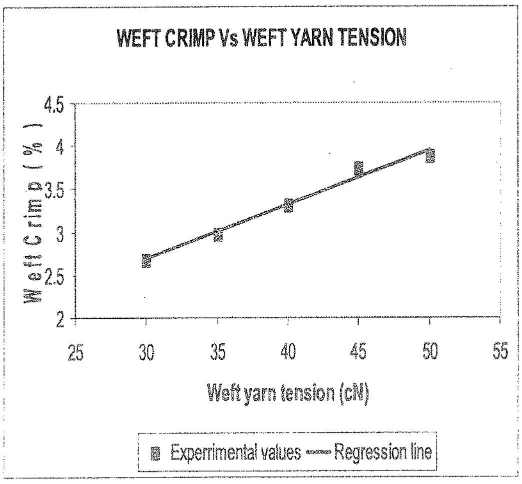

Figure 4: The effect of weft yarn tension on the weft crimp.

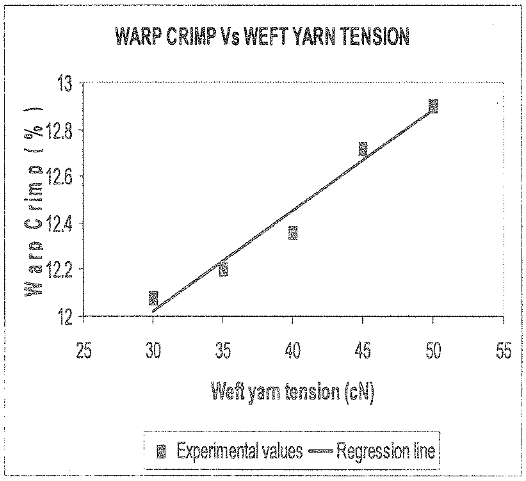

Figure 5: The effect of weft yarn tension on the warp crimp.

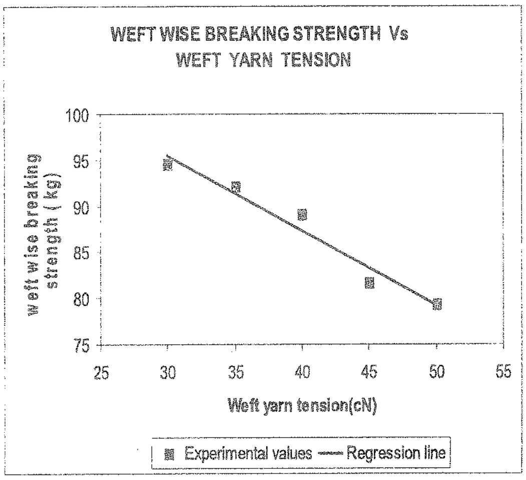

Figure 6: The effect of weft yarn tension on the weft wise breaking strength.

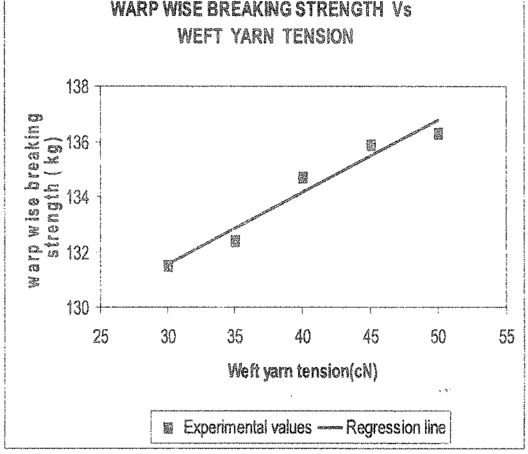

Figure 7: The effect of weft yarn tension on the warp wise breaking strength.

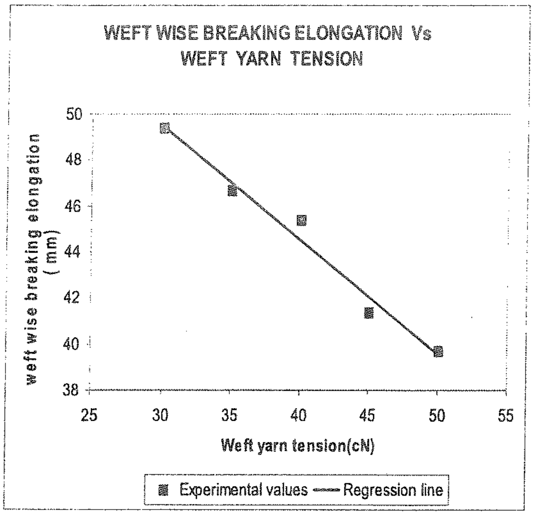

Figure 8: The effect of weft yarn tension on the weft wise breaking elongation.

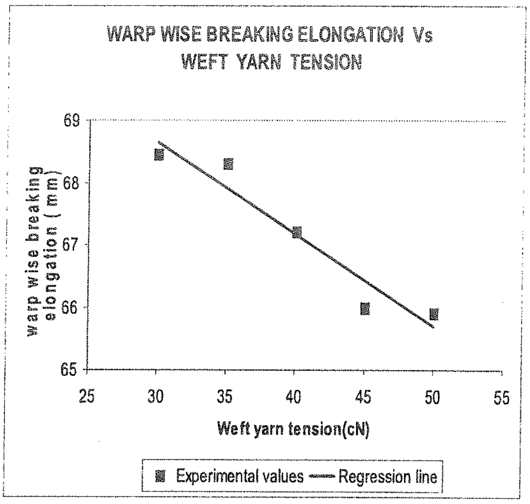

Figure 9: The effect of weft yarn tension on the warp wise breaking elongation.

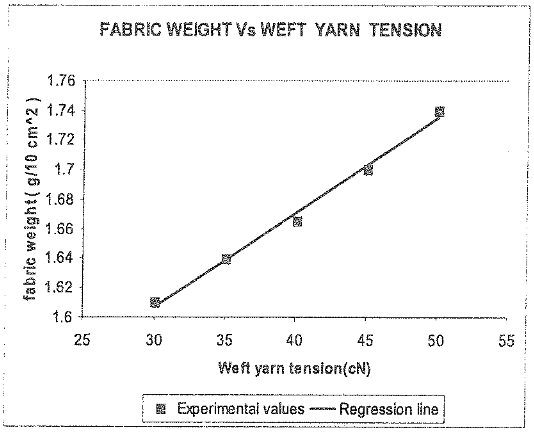

Figure 10: The effect of weft yarn tension on the fabric weight.

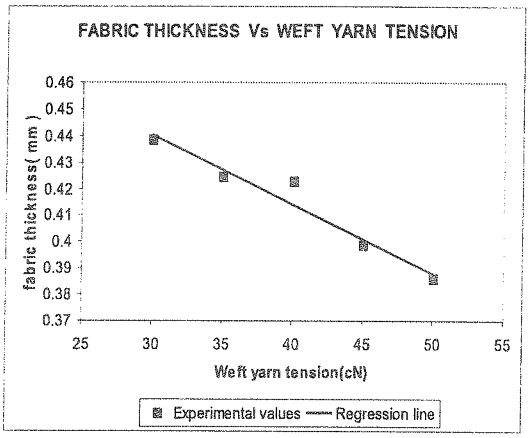

Figure 11: The effect of weft yarn tension on the fabric thickness

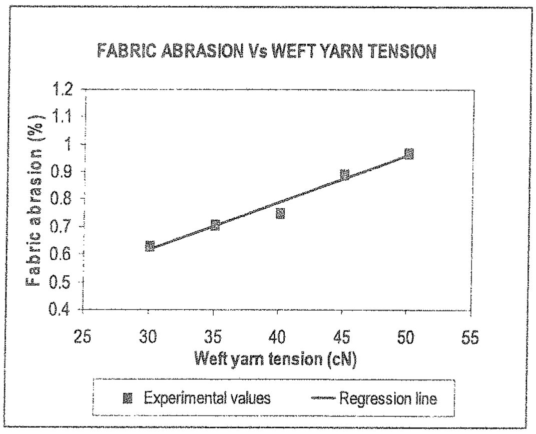

Figure 12: The effect of weft yarn tension on the fabric abrasion.

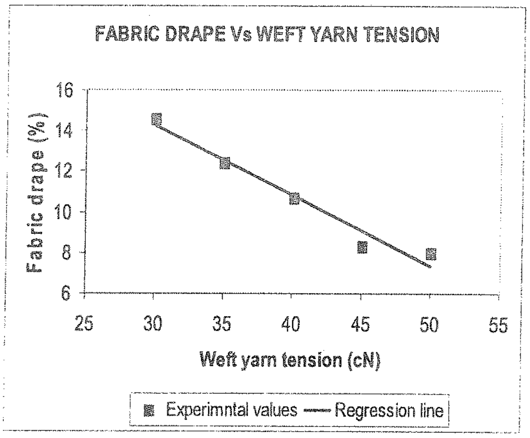

Figure 13: The effect of weft yarn tension on the fabric drape.