The relation between fabric construction, treatments and sewability

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Abstract: In this study, the effects of fabric construction and treatments on the sew ability of cotton/polyester woven fabric are investigated. Fabric mechanical tests are measured using FAST (Fabric Assurance by Simple Testing) system, for assessing aspects of the performance in garment manufacture and garment appearance after wear. The optimization construction are used to carry out treatments impart to improve pilling and antimicrobial activity. The effect of fabric construction and treatments on sewing needle penetration of untreated and treated fabric is measured for determine any damage which appears in garment. It was found that formability, bending rigidity and shear rigidity decrease with decrease the weft count, but extensibility increase consistently. Also, the construction of plain has count No.40/1 gave low force penetration.

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1. Introduction

The idea of using the objective measurement of properties to predict fabric performance is not new. Measurements have been used to predict some aspects of fabric performance for many years. Recently, techniques have been developed to measure the mechanical properties of fabrics and use these measurements to quantify handle[1] and predict performance in both garment manufacture and its appearance[2].

The first experimental work on the objective measurement of fabric mechanical properties dates back to the 1930s [3]. The prediction of fabric performance in garment manufacturing from mechanical properties was first extensively examined by Lindberg[4] research teams in the 1960s. These teams identified many properties of fabric associated with performance in garment manufacture. These were included extensibility, bending and shear properties as well as fabric weight. Several measurements are required to fully describe tensile, shear or bending behavior of fabric. Those used to describe resistance to deformation[5]. The Fabric Objective Measurement can be used for various purposes; the main ones are:- fabric quality and hand;- evaluation of the formability of fabrics and the appearance of finished garments; creation of specific techniques to enable the making-up industry to select fabrics, as well as for quality and process control[1].

Pilling is defined as entangling of fibers on a fabrics surface during wearing, washing, dry- cleaning or testing to form fibers balls or pills that stand on the fabric surface and are of such density that light will not pass through them and they cast a shadow[6]. Pilling phenomenon has always been a major drown back in using acrylic fibers for making woven goods, it affects not only the fabric appearance, but also its texture and quality. Pilling in general is a self limiting process which emerges at three consumptive different stages, formation of surface fuzz, entanglement, and transformation into pills[7].

The problem of pilling became even more serious with the emergence if synthetic fiber such as polyester, especially these fibers such are present in the form of a blend with some fiber of lower tensile strength[8]. Sivakelmar etal found that twill weaves tend to pill more compared with plain weaves[9]. Polyester / viscose blend woven fabric was subjected to different softening and sanforising treatment[10].

The sewing needle penetration force is the quantitative measure of the damage which appears in agreement as the result of the sewing process[11,12]. A high penetration force means a high resistance of fabric and thus a high risk of damage[13].

Sewing needle penetration force is one of the most significant technical parameters in the sewing process which affected by various factors such as type and amount of layers of the sewing material, needle size, needle point shape, speed of the sewing machine, and treatment of the sewing material, among others[13].

It is also used as a binder and thickener in the pigment printing of both polyester and polyester/cotton fabrics[14]. Pretreatment of acrylic and polyester fabrics with chitosan in presence of binder enhances ability to acid dyes. A new technique is used for improving the adhesion of chitosan molecules to the surface of these fabrics which is manifested by the higher color strength[15]. Waterborne polyurethane is prepared and reacted with chitosan as chain extender. The prepared polyurethane chitosan was studied as antimicrobial agent of acrylic fabrics[16]. The chitosan- modified acrylic fibers showed excellent antimicrobial activity against Staphylococcus aureus, compared with the original acrylic fibers. The modified acrylic fibers treated with chitosan showed high durability to laundering probably due to strong ionic interaction between chitosan and modified acrylic[17].

The aim of this study carried out to found the relation between the construction and the sew ability of garment as well as the effect of some treatments on performance properties of garment. In these study fabric mechanical properties tests were measured using FAST.

2. Material and Methods

2.1 Fabric

Twelve cotton/blend woven fabric samples (75% cotton 25% polyester) with two fabric structures (plain & Twill weaves) and different construction properties were used. The constructions properties of woven fabrics are given in Table 1.

Table 1: Constructions properties of woven fabrics

S. CO	F. ST	E	W.C	Pick/ cm
1	plain 1/1	24	20/1	18
2	twill 1/7	24	20/1	25
3	twill 1/7	24	20/1	18
4	twill 1/7	24	20/1	23
5	plain 1/1	24	30/1	20
6	plain 1/1	24	30/1	25
7	twill 1/7	24	30/1	19
8	twill 1/7	24	30/1	27
9	plain 1/1	24	40/1	23
10	plain 1/1	24	40/1	34
11	twill 1/7	24	40/1	24
12	twill 1/7	24	40/1	33

S.Co: Sample code F. ST: Fabric structure W.C: weft count Warp cotton yarn 100%
Warp Count: 4o/1 Weft blended yarn ratio cotton /polyester 75/25% E: Ends/cm Twist factor: 4

2.2 Chemicals

Chemicals of technical grades vis chitosan of molecular weight (N 150000), Citric acid**,** β-Cyclodextrin hydrate (CD), monochlortriazinyl β-cyclodextrin Na-salt (CD-T) were products of Wacker –Chemie GmbH, Munich, Germany. Acetic, citric acid and copper sulphate were of used.

2.3 Dyestuffs

Reactive dyestuff Remazol Red violet R (C.I. Reactive violet 4) and disperse dyestuff Samaron B. Pink HFG (C.I. Disperse Red 185) were used.

3. Treatments

Chitosan solution (0.4 % owf) was prepared by stirring the material in water containing acetic acid (2% v/v) overnight at room temperature. The fabrics were immersed at room temperature for 1 h., liquor ratio 1:10, then padded to pick up of 100% using a laboratory padder and cured at 150^{o}C, for 5 min in a laboratory drying chamber (Type 450 MM model HT–V- from RBE – India). Some treated fabric was immersed in copper sulphate solution (2% w/v), at room temperature for 30 min., liquor ratio 1:10, then padded to pick up of 100%, and cured at 120^{o}C, for 10 min.

The treatment carried out by fabric was immersed in 10% citric acid at room temperature for 1 h., liquor ratio 1:10, then padded to pick up of 100% using a laboratory padder and cured at 150^{o}C, for 10 min. Also, the fabric was treated with was immersed in 10% citric acid at room temperature for 1 h, then solution of 15 g/l (o. w .f) of CD, or CD-T adjusted to pH 4 using citric acid. It was immersed in immersed at room temperature for 1h, liquor ratio 1:10 and padded to pickup 100 % using a laboratory padder, cured at 150^{o}C, for 10 min.

4. Dyeing

The blend fabric was dyed with tow dyes in tow steps. The first step carried out to dye the cotton fibres with reactive dye in the blend fabric, the second step carried out to dye the polyester fibres with disperse dye in the blend fabric.

4.1 Dyeing with Reactive dye

The dye bath was prepared by accurately weighing the dyestuff to give the prescribed shade. The paste was then dissolved by adding hot boiling water. The dye solution was adjusted to pH 5 using acetic acid. The dye bath of C.I. Reactive violet 5 was heated to 60^{o}C and added the sample to the dye bath, the temperature was then raised gradually up to 90^{o}C through 30 minutes then added 40g/l sodium sulphate after 30 min., and the dyeing continued for 60 min., at liquor ratio 1:50. The dyed sample was thoroughly washed in warm and cold water and air-dried.

4.2 Dyeing with disperse dye

The dye bath of C.I. Disperse Red 185 was prepared by pasted the dye with 1% acetic acid in hot water, then added 2g/l of carrier. The dye bath was gradually heated to 100^{o}C. The sample fabric was added to the bath and the dyeing continued for 60 min., at liquor ratio 1:50. The dyed sample was thoroughly washed in warm and cold water and air-dried.

5. Methods

In this work, fabric mechanical properties tests were measured using FAST (Fabric Assurance by Simple Testing) system, for assessing aspects of the performance in garment manufacture and garment appearance after wear. The samples were dyed only before carried out the FAST system. Fabrics mechanical properties have been calculated, three different weft counts cotton blended have been used (20/1, 30/1, 40/1) with two fabric structures (plain1/1&twill1/7).FAST tested properties are given in Table 2.

5.1 FAST - Fabric Assurance by Simple Testing

FAST is a set of instruments and test methods for measuring mechanical, physical, and dimensional properties of fabrics. These measurements allow the prediction of fabric performance in garment manufacture and the appearance of the garment during wear[20]. The instruments were developed by the Australian CSIRO.The FAST system was designed for measuring properties of fabrics important to the intended performance and the appearance of tailored.

FAST consists of three parts and a test method:

FAST-1 is a compression meter that measures fabric thickness[18, 19].

FAST-2 is a bending meter that measures the fabric bending length.[20]

FAST-3 is an extension meter that measures fabric extensibility.[21, 22, and 23]

FAST-4 is a test procedure for measuring dimensional properties of fabric.[24, 25]

Table 2: FAST test (Fabric Assurance by Simple Testing) of cotton/polyester blend fabrics

S. CO	P	T	F-1 (mm²)	F-2 (mm²)	E100-1 %	E100-2 %	B-1 μ-Nm	B-2 μ-Nm	G N-m	T2 mm	ST mm	W (g/m²)
1	18	4	1.27	0.24	7.7	2.7	13.1	6.7	29.4	0.643	0.206	122
2	25	4	0.76	0.32	6.4	2.2	8.2	9.3	32	0.626	0.226	133
3	18	4	1.15	1.3	6.3	11.2	9	5.1	7.1	0.82	0.275	115
4	23	4	1.53	1.43	6.9	10.8	10.9	6.9	24.5	0.93	0.34	138
5	20	4	0.43	0.34	6.2	4.2	6.1	5.2	45	0.624	0.258	91
6	25	4	0.44	0.17	4.3	3.5	8.1	4.3	35.8	0.535	0.211	108
7	19	4	0.74	0.74	5.3	10.4	7.4	3.2	7.7	0.813	0.356	94
8	27	4	0.98	1.84	5.3	9.7	9.4	8.9	11.5	0.848	0.337	116
9	23	4	0.52	0.62	6.7	7.6	7.3	5.5	23.4	0.488	0.181	87
10	34	4	0.35	0.37	2.8	4.2	17.3	5.6	47.6	0.494	0.185	98
11	24	4	0.94	0.93	7.1	11.5	9.3	4.2	9.8	0.868	0.368	112
12	33	4	0.81	0.59	8.4	12	5.1	2.3	7.5	0.769	0.338	88

S.Co: Sample code Formability Warp = F-1 Formability Weft = F-2 Extensibility Warp = E100-1 Extensibility Weft = E100-2 Bending Rigidity Warp = B-1 Bending Rigidity Weft = B-2 Shear Rigidity = G Thickness = T2 Surface Thickness = ST Weight = W

5.2 Roughness

Surface roughness was measured according to JIS 94 Standard by Surface roughness measuring instrument.

5.3. Colour Intensity

Spectral reflection measurements of the dyed fabrics were carried out using a recording filter spectrophotometer. The colour intensity expressed as K/S values of the dyed samples were determined by applying the Kubleka -Munk equation. (28)

$$K/S = \frac{(1-R)^2}{2R} - \frac{(1-R_0)^2}{2R_0}$$

Where R: is the decimal fraction of the reflectance of the dyed substrate.

R_o: is the decimal fraction of the reflectance of the undyed substrate

S: is the scattering coefficient K: is the absorption coefficient.

5.4 The L&M sew ability tester:

Fig 1 The L+M sewability Tester [27]

Testing fabric sewing properties, US patent 3979951, 1976), a device used in many studies on needle penetration force. This equipment simulates a sewing machine by penetrating the tested fabric with an unthreaded needle, at a rate of 100 penetrations per min., with needle count 100/16 DB Singer. Sewability tested properties are given in Table 3.

Table 3: Sew ability tested properties

S. CO	Sew ability at weft /N	Sew ability at warp/N
1	7	8
2	28	29
3	8	8
4	8	7
5	6	8
6	17	23
7	9	9
8	8	9
9	7	7
10	21	18
11	9	9
12	8	8

S.Co: Sample code

5.5 Pilling test

Pilling tester is used to determine the pilling resistance of all kinds of textile structures. Sample was rubbed against the same material of sample at low pressures and the amount of pilling is compared against standards parameters. Pilling taste was carried out according to standards ASTM standard D4970 (pilling), all samples and standard fabrics should be conditioned in the standard atmosphere for testing (20c - , + 2 and 65% RH - , + 2%). The specimens assed are using the following 5 point scale.

5.6 Antimicrobial activity

The antibacterial activity of the NMA-HTCC was evaluated against the Gram positive - Staphylococcus aureus and the Gram negative bacteria Escherichia. coli (AATCC 6538). (29)

3. Results and Discussions

Fast Results

Table2 illustrated FAST tested properties. Six samples were selected from the total samples. The chosen samples have almost the same picks/cm in the different fabric structure. Selection was on the basis that there are two samples of each weft count include the two fabric structure. (a) To assess the effect of different fabric structure at the same weft counts on fabric properties. (b) To evaluate the effect of the difference of the weft count of the same fabric structure on fabric properties. (c) To evaluate the best fabric structure on fabric properties. The selection samples code are (1,3,5,7,9,11). In figures (2-6) fabrics mechanical properties have been calculated, three different weft counts cotton blended have been used (20/1, 30/1, 40/1) with two fabric structures (plain1/1&twill1/7).

Fig.2 compared formability values in both fabric structures for weft direction. FAST meter tends to provide lower values of plain weave compared with twill weave in the three weft counts. In the same fabric structure, the weft formability decreases as the weft count decrease. A possible explanation for this trend may be the higher values of extensibility of twill weaves.

Fig. 3 compared fabric extensibility values in case of plain weave and twill weave. For plain weave FAST meter tends to provide lower values compared to that obtained from twill weave. Extensibility increases as a decrease of weft count diameter.

Fig. 4 compared fabric shear rigidity values in both fabric structures for weft direction. FAST meter tends to provide higher values of plain weave than twill weave in the three weft counts.

Fig. 6 illustrated fabric bending rigidity values in both fabric structures. FAST results recorded almost the same values in the both fabric structures, exception in the case of weft count 20/1 in the two fabric structures. This result attribute to, the bending rigidity values increases as fabric weight increase regardless of fabric structure.

Fig. 6compared fabric thickness values of two fabric structures. FAST meter tends to provide higher values of twill weave than plain weave. These differences in thickness values may be attributed to the nature of fabric structure.

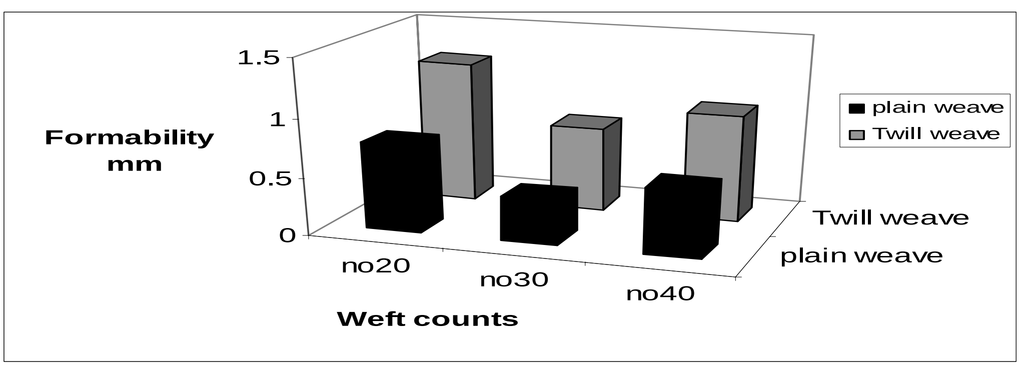

Figure 2: Effect of fabric structure on fabric formability with different weft counts

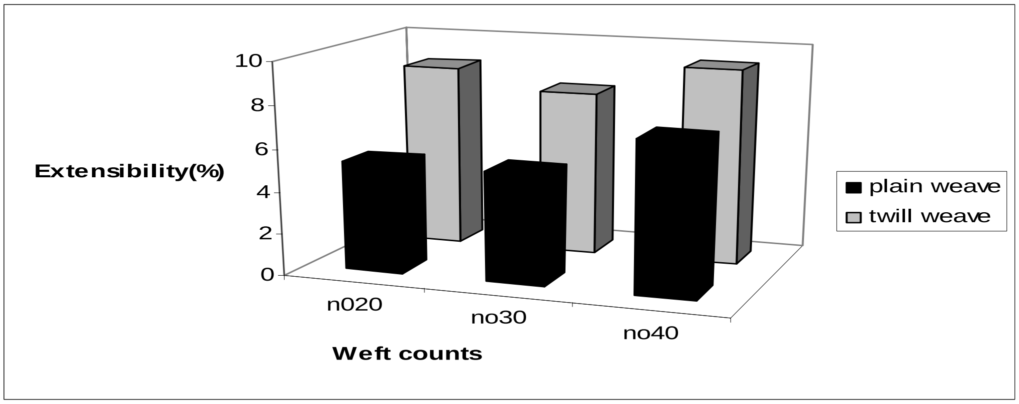

Figure 3: Effect of fabric structure on extensibility with different weft counts

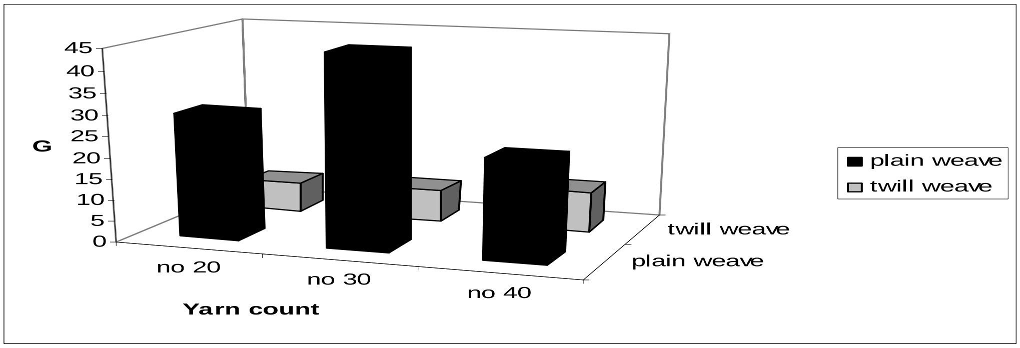

Figure 4: Fabric shear Rigidity with 2 fabric structure

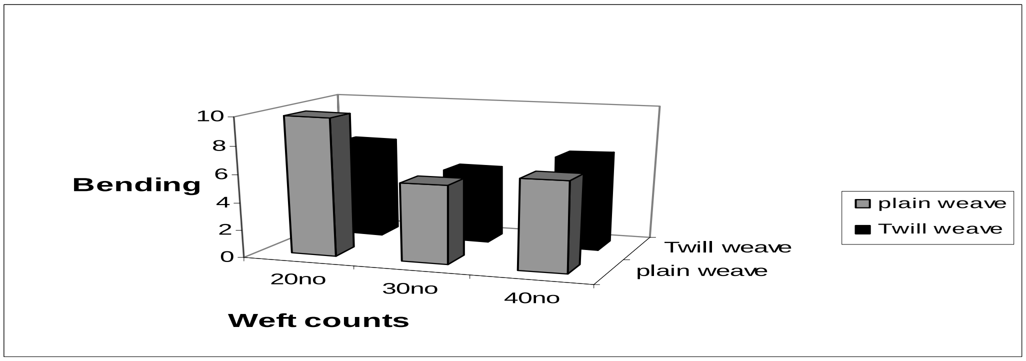

Figure 5: Effect of fabric structure on fabric bending with different weft counts

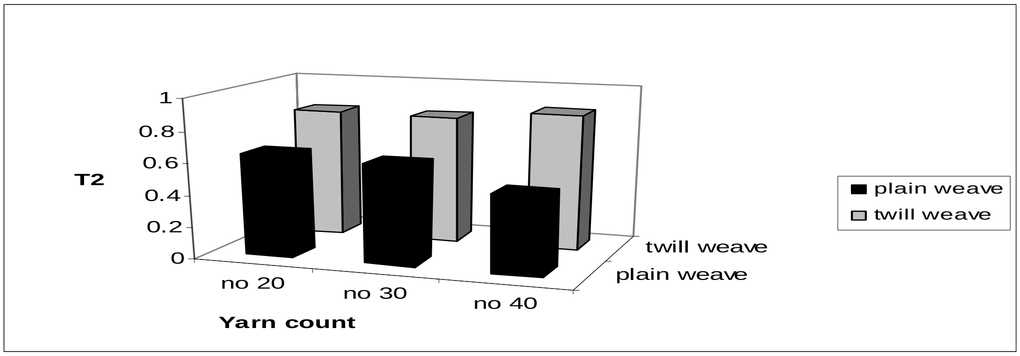

Figure 6: fabric thickness with 2 fabric structure

In figures (2-6) it can see that the increasing of weft count caused the fabric mechanical properties such as (formability, bending rigidity, thickness and shear rigidity) decrease, while fabric extensibility increases consistently. This can explained as a result of increasing consolidation of fibers within the fabrics.

Also, in the same figures, it can be seen that the formability, bending rigidity, extensibility and thickness of twill fabrics have increased than plain fabrics, while shear rigidity of plain fabrics have increased than twill weave.

Regard to the specific fabric structure used or the fabric weight per unit areas. An explanation for the observed results may be that the nature of fabric structure permitted easy fibers movement such as twill weave 1/7 than plain weave 1/1. And as a result, the mechanical properties produced using this combination, are different of their results.

Sewability (Sewing needle penetrations force) results

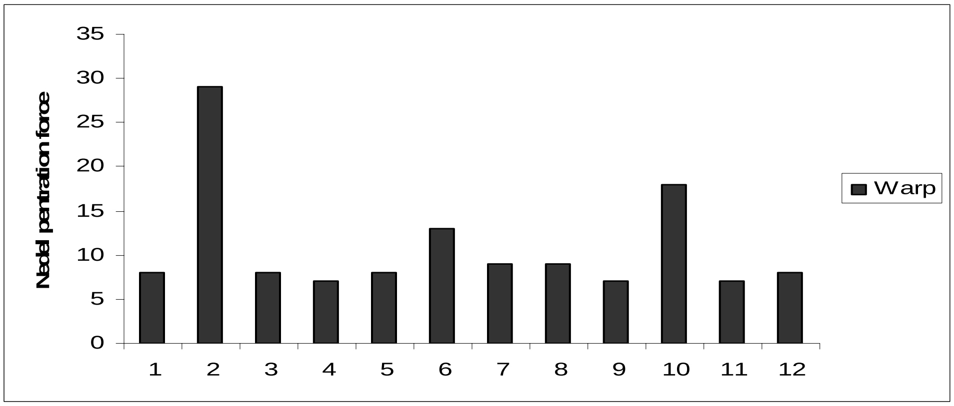

Figure 7: Sewing needle penetrations force/N at warp direction

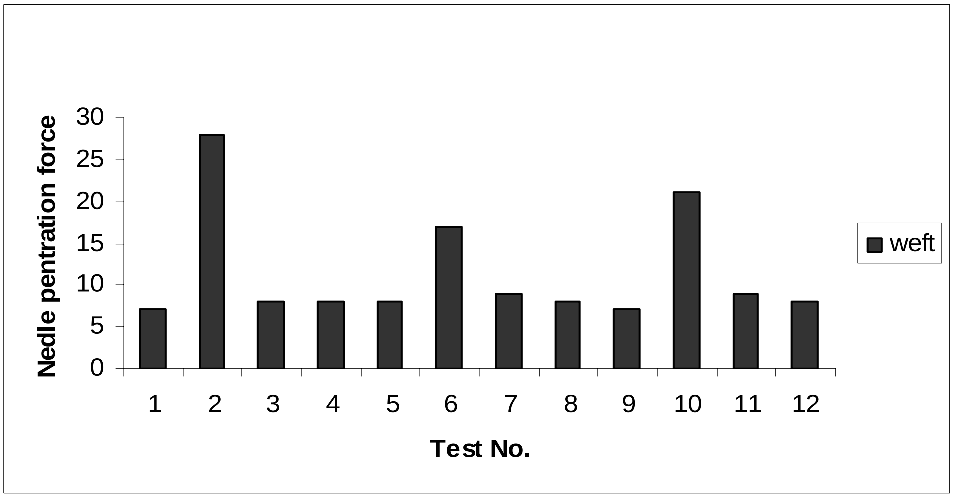

Figure 8: Sewing needle penetrations force/N at weft direction

The figures (7, 8) illustrated the sewing needle penetration force, which have been calculated, three different weft counts cotton blended have been used (20/1, 30/1, 40/1) with two fabric structures (plain1/1&twill1/7). It can see that needle penetrations force increase for sample no 2 (fabric weft count 20/1, 25 pick/cnm) than others, that due to structure plain, density of weft at (weft &warp) direction. And sample no 6 (fabric weft count 30/1 – 25 pick/cnm) that is due to the structure plain, density of weft at (weft &warp) direction - sample no 10 (fabric weft count 40/1 -34 pick/cnm) that is due to the structure plain, density at (weft &warp) direction as shown in figures (7, 8).

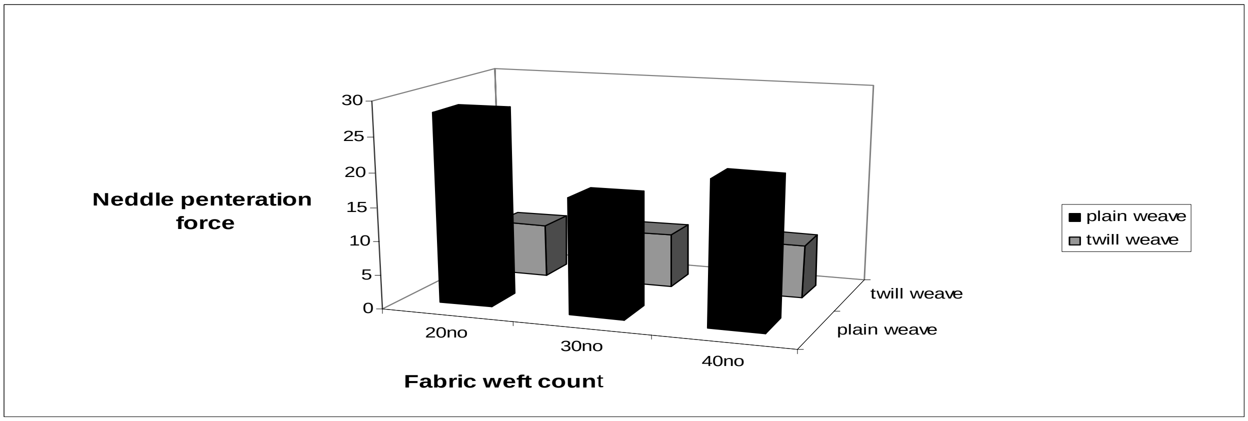

Figure 9: The relation between sewing needle penetrations force/n and fabric structure

In figure (9) it can see that needle penetrations force decrease for twill weave than plain that is due to density**,** structure.

Pilling, color intensity and roughness of untreated and treated fabrics

Table 4 shows pilling, color intensity and roughness of untreated and treated fabrics with chitosan on fabrics have different construction. It was found that the treatment enhanced anti pilling and gives little change in roughness. The color intensity don't give different The results show that various constructions don't affect on treatment results, this means that the treatment results are affected only by chemical structures of fibers.

Table 4: Pilling, colour intensity and roughness of untreated and treated fabrics with chitosan

Samples constriction		Pilling		colour intensity K/S		Roughness µm	
W.C	P./cm	Untreated	Treated	Untreated	Treated	Untreated	Treated
20/1	18	1-2	3	1.8	1.9	18.8	19.2
30/1	25	1	2	3.2	3. 2	18.9	19.6
20/1	34	1	3	3.03	3.01	18.6	19.2
20/1	15	1	3	2.48	2. 48	18.7	19.8

W.C P./cm Treatment: immersed in 0.4% o.w.f chitosan, at room temperature for 1 h., liquor ratio 1:10, padded to pick up of 100%, curing at 150^{o}C, for 10 min.

Table 5: Roughness, pilling and colour intensity of untreated and treated fabrics

Constriction of treatment	Pilling	Colour intensity K/S	Roughness µm
Untreated	1-2	2.9	18.8
0.4% (o.w.f.) chit+1% o.w.f. cit. acid	4-5	3.1	23.83
0.4% (o.w.f.) chit	4	3	17.12
1% (o.w.f.) cit. acid	4	3	16.59
1% (o.w.f.) sodium iso-phthalic acid	2-3	2.9	20.55
0.4% o.w.f. chit+1% o.w.f. cit. acid, 2% CuSO4	4-5	3	24.25
15 g/l (o. w .f) CD+1% o.w.f. cit. acid	2-3	3.1	17.59
15 g/l (o. w .f) CD	2	3	17.03
15 g/l (o. w .f) CD-T+1% o.w.f. cit. acid	2-3	3	16.12
15 g/l (o. w .f) CD-T	2	3.1	16.91

Dyeing: C.I. Disperse Red 55 (1% o.w.f), 100^{o}C, pH 5, liquor ratio 1: 50
C.I. Reactive violet 5 (1% o.w.f), 90^{o}C, pH 5, liquor ratio 1: 50

Pilling, color intensity and roughness of untreated and treated fabrics have the same construction (No. 1) with different chemicals materials illustrated in table 5. It can found that the treatments with chitosan, chitosan/copper sulphate, citric acid and 1**% (**o.w.f.) sodium iso-phthalic acid gave higher roughness and higher ant pilling than the untreated one. But the treatment with 15 g/l (o. w .f) CD+1% o.w.f. cit. acid and 15 g/l (o. w .f) CD-T+1% o.w.f. cit. acid gave little enhancement in roughness ant pilling. The treatments don't give effect in color intensity between untreated and treated polyester/ cotton blend fabric. This change color intensity may be attributed to different construction structure, and different thickness of fabrics only.

Table 6: Antimicrobials activity for the untreated and treated fabric.

Samples	Inhibition zone diameter (mm/1 cm sample)	
	Escherichia Coli (G^-)	Staphylococcus aureus (G^+)
Untreated	0	0
0.4% o.w.f. chit+1% o.w.f. cit. acid	6	7
2% CD+1% o.w.f. cit. acid	8	7
2% CD-T+1% o.w.f. cit. acid	8	8
0.4% o.w.f. chit+1% o.w.f. cit. acid, 2% CuSO4	9	9

Table 7 shows inhibition zone diameter (mm/1 cm sample) for Esherichia coli (G^-) and staphylococcus aureus (G^+) for the untreated and the treated fabrics. The treatments give antimicrobials activity than untreated one. The highest antimicrobials activity was observed with treatment with (0.4 % w/v) chitosan in presence of citric acid and (2 % w/v) copper sulphate. This may attributed to copper sulphate**.**

5. Conclusion

- FAST results recorded almost the same values in the both fabric structures, exception in the case of weft count 20/1 in the two fabric structures. FAST meter tends to provide higher values of twill weave than plain weave.
- It can see that needle penetrations force increase for sample no 2 (fabric weft count 20/1, 25 pick/cm) than others, that due to structure plain, density of weft at (weft &warp) direction.
- It can found that the treatment with citric acid, CD and citric acid CD-T was reduced roughness and give enhance than the untreated one. But the treatment with chitosan and chitosan/copper sulphate gave higher roughness and higher ant pilling than the untreated one.
- The highest antibacterial activity was observed with treatment with (0.4 % w/v) chitosan in presence of citric acid and (2 % w/v) copper sulphate than the untreated one.

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