Achieving Optimum Scientific Standards for Designing and Producing Fabrics Suitable for Ultraviolet Protective Clothing

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Abstract: This research is mainly concerned with producing woven cotton fabrics used in Ultraviolet Protective Clothing. The produced fabrics were treated with UV-Fast AO. Different parameters were studied including, fabric structure (plain weave 1/1, twill 3/3 and satin 6), Three weft sets were also used (24,30 and 36 pick/cm) and using two yarn counts (30/1 and 40/1 English).Their influence on the performance of the end-use fabric and the achieved properties were studied. On the other hand physic-chemical properties including, U.V resistance, air permeability, water permeability, handle, thickness and weight were evaluated according to the final product needs. Some more results were reached concerning structures and materials. Most samples have achieved the expected results.
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1. Introduction:

Safety and protective textiles have become an integral part of technical textiles. [1] Protective textiles refer to garments and other fabric- related items designed to protect the wearer from harsh environmental effects that may result in injury or death. [1] & [2] Safety and protective materials must often withstand the effect of multiple harsh environments, [2] such as extreme heat and fire, extreme cold, toxic chemicals and gases , bacterial/ viral protection , mechanical hazards, electrical hazards, radiation, etc. [1] & [3] In some cases these textiles could be used to protect the environment from contamination, as in case of clean rooms. [1]

Ultraviolet radiation (U.V. radiation)

Solar radiation striking the earths surface is composed of light waves with wavelengths ranging from the infrared of (800 – 3000 nm wavelength) to the ultraviolet of (280 – 320 nm wavelength). [4]Therefore to be useful in protecting the wearer from harmful solar UV radiation, textiles must demonstrate effectiveness in the 300 – 320 nm ranges. Ultraviolet radiation is a energetically high, short wavelength light and large doses of this radiation have detrimental effects on human skin. When the ozone layer is thinned, these effects may cause serious health problems. [5]

Effects of ultraviolet radiation

Effects of solar ultraviolet (UV) radiation on human skin were recognized in the early1990 s. [4] Elevated exposure to UV radiation can result in skin damage such as sunburn, premature skin ageing, allergies and even skin cancer . [6]& [7] . Sun protection must therefore involve a combination of sun avoidance and the use of suitable textiles, hats, sunglasses, sun-block creams (cosmetic materials), etc. [8]

Fabrics used in UV protection

Designing and modifying fabrics to offer high protection against ultraviolet (UV) radiation is a relatively new application, [6] and is considered one of the most important element in preventing skin cancer. Owing to their low weight, cotton fabrics especially viscose fabrics made from filament yarns, are ideal for summer clothing and enjoy a high degree of acceptance among consumers. [6]

The construction of woven and knitted fabrics and the fiber type have a great influence on protection from ultraviolet transmittance. [5] The ultraviolet protection factor (UPF) of a fabric depends also on spaces between fibers and yarns , fabric color , finishing processes , the presence of additives , and laundering.[6]

Mechanism of UV protection

When radiation strikes a fiber surface, it can be reflected, absorbed, transmitted through the fiber or passed between fibers. The relative amount of radiation reflected, absorbed, or transmitted depend on many factors, including the fiber type, the fiber surface smoothness, the fabric cover factor and the presence or absence of fiber debutants , dyes and UV absorbers.

The effect of fiber type on solar protection factor (SPF) is different. Cotton and silk, for example, offer little protection to UV radiation since the radiation can pass through without being markedly absorbed. Wool and polyester, on the other hand, have higher SPF since these fibers will absorb UV radiation. Nylon falls in between these extremes.

If the fibers absorb all of the incident radiation then the only source of transmitted rays is from the spacing between yarns and then the SPF maximum can be calculated according to the following equation:

SPF (max) = 1/ 1- cover factor

And so , tight micro-fibers provide a better UV protection than fabrics made from normal sized fibers with the same weight and type of construction which means that the more cover factor the more (SPF) the fabric become. [4]

Requirements of UV resistant fabrics

The general requirements of UV resistant fabrics are UV resistance, agronomical design, comfort, light weight, durability, easy maintenance, dimensional stability, color fastness and retaining appearance after repeated washings.

A proper choice of fibers, fabric design, weight and finishes is very important so that the fabric fulfills these requirements. [1]

2. Experimental Work

This research concerns with producing fabrics suitable for ultraviolet protective clothing. All samples in the research were produced with cotton yarns using three woven structures (plain weave 1/1,twill 3/3 and satin 6) .Three weft sets were also used (24,30 and 36 pick /cm) , using two different yarn counts (30/1 and 40/1 English)

Table (1) Specifications of all produced samples.

No	Property	Specification
1	Warp type	Cotton
2	Weft type	Cotton
3	Count of warp yarns	80/2 English
4	Count of weft yarns	24/1-36/1 English
5	Warp set (ends / cm)	40
6	Weft set (picks / cm)	24,30,36
7	Fabric structures	Plain weave 1/1,twill 3/3 and satin 6
8	Reed used	20 dents /cm
9	Denting	2 end /dent
10	Finishing	Samples were treated with UV- Fast AO

Table (2) Specifications of all produced samples.

Fabric specifications							
Sample No.	Yarn type	Fabric structure	Yarn count (English)		Warp set	Weft set	Finishing
			Warp	Weft			
1	Cotton	Plain weave 1/1	80/2	30/1	40	24	Treatment with UV-Fast AO
2	Cotton	Plain weave 1/1	80/2	30/1	40	30	Treatment with UV-Fast AO
3	Cotton	Plain weave 1/1	80/2	30/1	40	36	Treatment with UV-Fast AO
4	Cotton	Plain weave 1/1	80/2	40/1	40	24	Treatment with UV-Fast AO
5	Cotton	Plain weave 1/1	80/2	40/1	40	30	Treatment with UV-Fast AO
6	Cotton	Plain weave 1/1	80/2	40/1	40	36	Treatment with UV-Fast AO
7	Cotton	Twill 3/3	80/2	30/1	40	24	Treatment with UV-Fast AO
8	Cotton	Twill 3/3	80/2	30/1	40	30	Treatment with UV-Fast AO
9	Cotton	Twill 3/3	80/2	30/1	40	36	Treatment with UV-Fast AO
10	Cotton	Twill 3/3	80/2	40/1	40	24	Treatment with UV-Fast AO
11	Cotton	Twill 3/3	80/2	40/1	40	30	Treatment with UV-Fast AO
12	Cotton	Twill 3/3	80/2	40/1	40	36	Treatment with UV-Fast AO
13	Cotton	Satin 6	80/2	30/1	40	24	Treatment with UV-Fast AO
14	Cotton	Satin 6	80/2	30/1	40	30	Treatment with UV-Fast AO
15	Cotton	Satin 6	80/2	30/1	40	36	Treatment with UV-Fast AO
16	Cotton	Satin 6	80/2	40/1	40	24	Treatment with UV-Fast AO
17	Cotton	Satin 6	80/2	40/1	40	30	Treatment with UV-Fast AO
18	Cotton	Satin 6	80/2	40/1	40	36	Treatment with UV-Fast AO

Tests applied to samples under study

Several tests were carried out in order to evaluate the produced fabrics, these were:-

1-**UV resistance test**, this test was carried out according to the AATCC standard test method 90-1982 [9]

2- Air **permeability test** , this test was carried out according to the (ASTM-D 4491/92) ASTM-D737-1996[10]

3- **Water permeability test**, this test was carried out according to the ISO 811: 1981[11]

4-**Fabric handle ,** this test was carried out according to the B.S.3424: (1987) [12]

5-**Fabric thickness**, this test was carried out according to the (ASTM-D1777/1996) [13]

6-Fabric weight, this test was carried out according to the ASTM-D 3776- 79 [14]

Finishing treatment

Samples under study were coated with UV-Fast AO with 15 % concentration as follows:

The fabric samples were padded in an aqueous solution containing UV-Fast AO which is nonionic wetability substance (ejetol) and then squeezed to a wet pick up 100 %.after that samples were dried at 40 0 C for 20 min ,then thermo-fixed at 110 0 C for 20 seconds.

3. Results and Discussion

Results of experimental tests carried out on the produced samples were statistically analyzed and presented in the following tables and graphs

U.V resistance

It can be seen from tables and figures that there is an inverse relationship between number of picks and U.V resistance. Results show that the more picks /cm the more compacted the fabric become which cause decreasing in U.V permeability and so higher resistance to U.V effect.

It is also notice from the diagrams that samples of 30/1 English have scored the highest rates of U.V resistance followed by 40/1 English. This is due to the 30/1 English yarns are thicker in diameter than 40/1 English. So they obstruct the passage of U.V rays more than 40/1 English yarns leading to the increase in its U.V resistance

It is also clear from the diagrams that plain weave 1/1 structure has achieved the highest rates of U.V resistance, whereas satin structure has achieved the lowest rates. I can report that the plain weave structure has the ability of being more compacted because of the distribution of the intersection.

It can be also seen from tables and figures that treatment of fabrics led to improvement in properties of the U.V resistance. It was found that treatment of the fabrics provided good U.V resistance and it decreases with the increase of the exposure periods. So samples after three hours exposure have recorded the lowest rates of resistance rate against U.V. compared to samples of one hour exposure.

Table (3) Results of the UPF test applied of samples before exposure.

The test	UPF of samples before exposure					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Yarn count / **Weft set**	**30**	**40**	**30**	**40**	**30**	**40**
24	2.8	2.1	1.9	1.7	1.7	1.6
30	4.6	2.6	2.1	2.0	2.5	1.8
36	4.9	4.3	3.2	2.5	2.8	2.2

Table (4) Results of the UPF test applied of samples after one hour exposure.

The test	UPF of samples after one hours exposure					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Yarn count / **Weft set**	**30**	**40**	**30**	**40**	**30**	**40**
24	9.0	6.3	7.6	6.5	6.5	5.4
30	13.8	9.5	10.7	9.0	8.1	7.7
36	17.9	17.3	13.3	9.4	10.6	9.7

Table (5) Results of the UPF test applied of samples after three hour exposure.

The test	UPF of samples after three hours exposure					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Yarn Count / **Weft set**	**30**	**40**	**30**	**40**	**30**	**40**
24	5.9	5.1	4.1	3.7	3.5	2.3
30	7.4	7.0	6.9	4.4	6.4	4.3
36	10.0	7.5	9.4	5.2	8.9	6.6

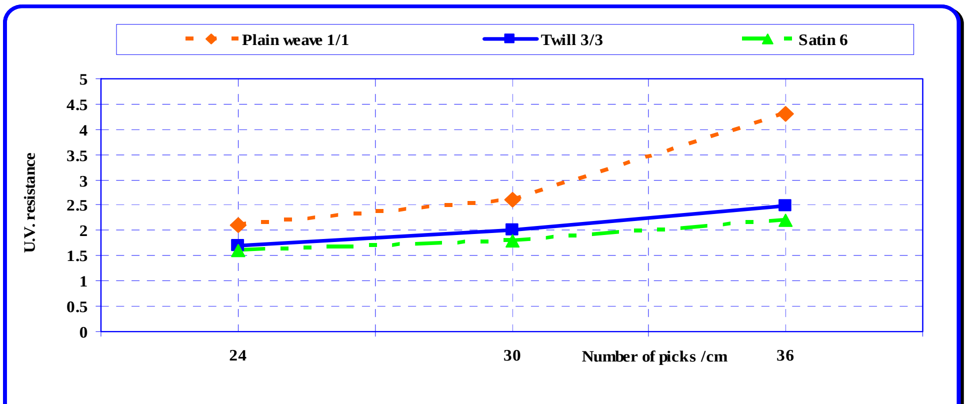

Fig. (1) The relationship between the handleand number of picks ,at yarn count 40 , before exposusre

Table (6) Regression equation and correlation coefficient for the effect of number of picks /cm on U.V. resistance, at yarn count 40 before exposure.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.18333X + 25	0.953821
Twill 3/3	Y = 0.06667X + 0.66667	0.989743
Satin 6	Y =0.05X + 0.036667	0.981981

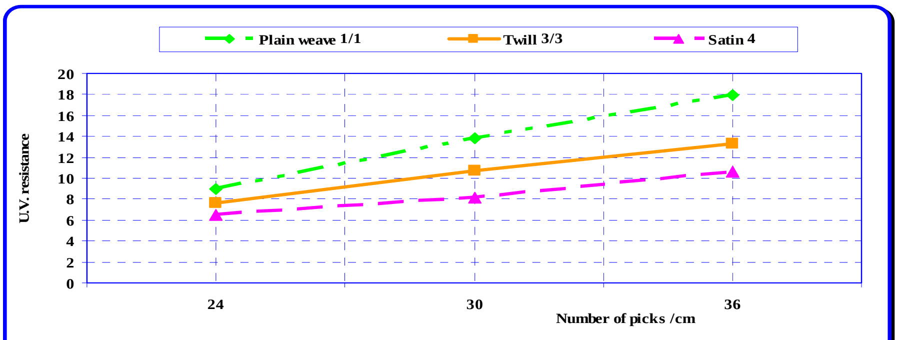

Fig. (2) The relationship between the handleand number of picks ,at yarn count 30 , after one hour exposusre

Table (7) Regression equation and correlation coefficient for the effect of number of picks /cm on U.V. resistance, at yarn count 30 before exposure.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.741667X + 8.6833	0.9988971
Twill 3/3	Y = 0.475X + 3.71667	0.99872
Satin 6	Y =0.0341667X + 1.85	0.9920965

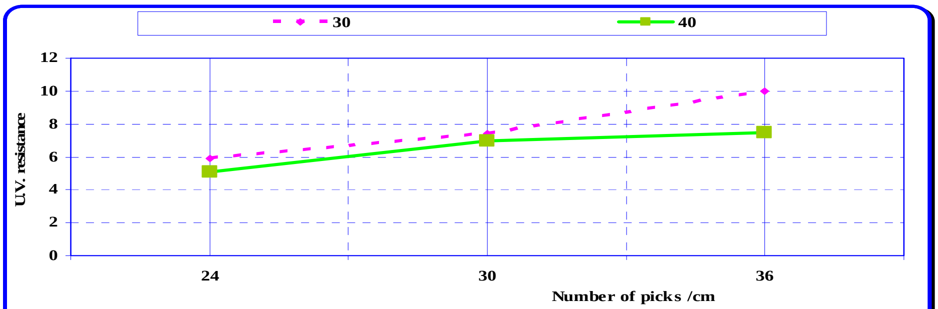

Fig. (3) The relationship between the handleand number of picks ,at plain weave 1/1 , after three hours exposure

Table (8) Regression equation and correlation coefficient for the effect of number of picks /cm on U.V. resistance, at plain weave 1/1, after three hours exposure.

Yarn count	Regression equation	Correlation coefficient
30	Y =0.2X + 0.53333	0.997697
40	Y = 0.341667X + 2.4833	0.988215

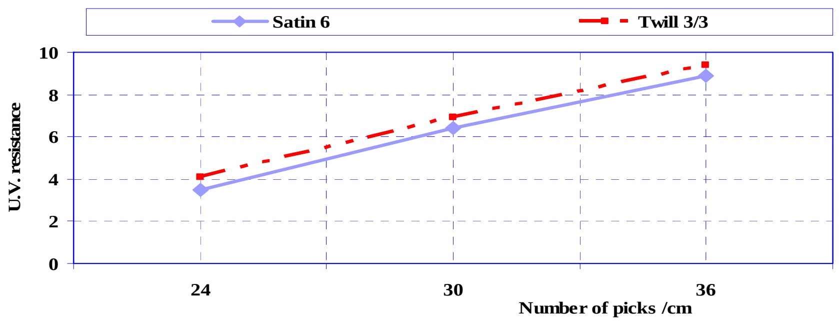

Fig. (4) The relationship between the handleand number of picks ,at yarn count 30 , after three hours expousre

Table (9) Regression equation and correlation coefficient for the effect of number of picks /cm on U.V. resistance, at yarn count 30, after three hours exposure.

Fabric structure	Regression equation	Correlation coefficient
Twill 3/3	Y = 0.441667X + 6.45	0.999466
Satin 6	Y =0.45X + 7.23333	0.999087

Fabric handle

In fabric handle test , the less angle value ,the more smoother the fabric become .According to this ,it is clear from the diagrams that samples of satin 4 is considered the most smooth fabrics among all woven fabrics followed by twill 3/3 , and then plain weave 1/1.This is probably because satin weaves have the advantage of containing long floats and less intersections besides that it has less ridges and hollows and so reduce the friction between the body and fabrics, besides that the warp and weft threads float freely on both sides, so that frication points between the tested fabrics and the standard woolen fabric ,used in the test are minimized allowing easily sliding of fabric down the slope. After treatment the fabrics smoothness is less because the treatment made in alkali and high temperature, these factors cause decrease in fabric smoothness. Softness material should be added in treatment bath to increase the fabric smoothness.

It was also found that the more picks per unit area the more handle for all the samples become, which means that samples with 36 have recorded the highest rates of smoothness.

It can be seen from the table and figures that the more yarn count number, the fabric become the samples become. I can report that the increase in this factor increase number of yarns leading the fabric to be more compacted which cause the increase the smoothness

Table (10) Results of the handle test applied to the samples produced with yarn count 30.

The test	Handle (angle)					
Fabric structure	Plain weave 1/1		Twill 3/3		Satin 6	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
24	41	42	40	43	39	41
30	42	43	41	44	40	42
36	43	44	42	45	41	43

Table (11) Results of the handle test applied to the samples produced with yarn count 40.

The test	**Handle (^{0})**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	39	42	38	40	37	41
30	40	43	39	41	39	43
36	41	45	41	43	40	44

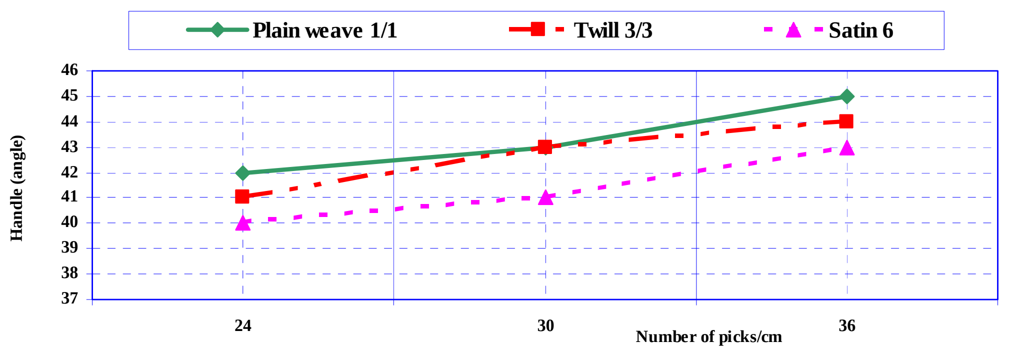

Fig. (5) The relationship between the the handle and number of picks ,at yarn count 40, after treatment.

Table (12) Regression equation and correlation coefficient for the effect of number of picks/cm on handle, at yarn count 40 after treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =0.25X + 35.83333	0.981981
Twill 3/3	Y =0.25X + 35.16667	0.981981
Satin 6	Y = 0.25X + 33.83333	0.981981

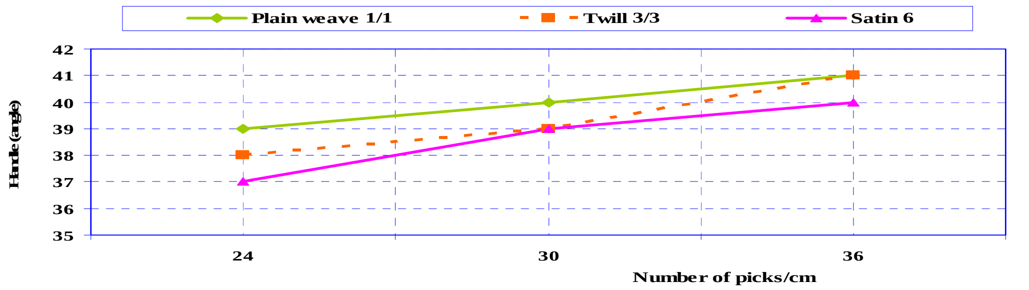

Fig. (6) The relationship between the the handle and number of picks, at yarn count 40, before treatment.

Table (13) Regression equation and correlation coefficient for the effect of number of picks/cm on handle, at yarn count 40 before treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =35 X + 1.66667	1
Twill 3/3	Y = 318333X + 0.25	0.981981
Satin 6	Y =0.25X + 31.16667	0.981981

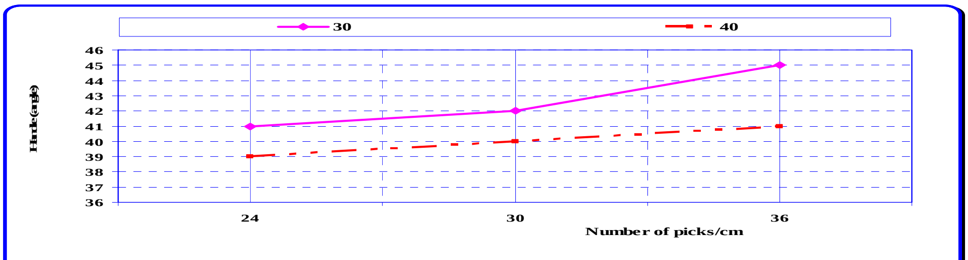

Fig. (7) The relationship between the handle and number of picks, at satin 4, before treatment.

Table (14) Regression equation and correlation coefficient for the effect of number of picks/cm on handle, at satin 6 before treatment.

Yarn count	Regression equation	Correlation coefficient
30	Y =0.3333X + 32.66667	0.960769
40	Y =0.16667 X + 35	1

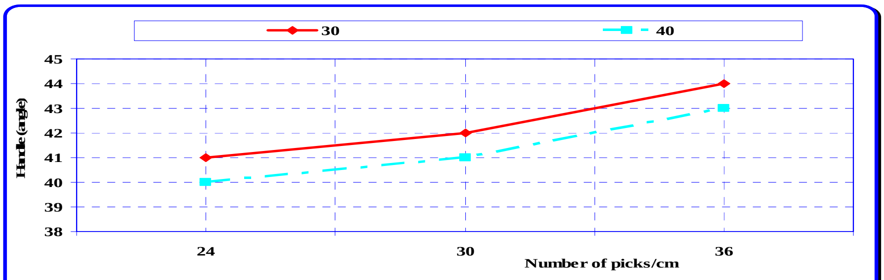

Fig. (8) The relationship between the the handle and number of picks ,at twill 3/3, after treatmeular .

Table (15) Regression equation and correlation coefficient for the effect of number of picks/cm on handle, at satin 6 before treatment.

Yarn count	Regression equation	Correlation coefficient
30	Y =34.8333X + 0.25	0.960769
40	Y =0.25 X + 33.83333	0.981981

Air permeability

It is clear from the diagrams that plain weave 1/1 has obtained the highest rates of air permeability, whereas satin 6 has obtained the lowest rates, and this is for sake of the increase of the pores in plain weave structure compared to satin structure which lead the produced fabric to be more permeable causing the increase in the air permeability.

It is also obvious from the statistical analysis of the air permeability results that there is an inverse relationship between number of picks per cm and air permeability. I can report that the increasing in ends and picks cause an obstruction in air passage, causing the decrease in air permeability.

It can be also noticed from the diagrams that samples made of 30/1 English have recorded the lowest rates of air permeability, whereas samples made of 40 /1 English have recorded the highest rates. I can report that yarns of 30/1 English are thicker in diameter than 40 /1 English which decrease the air passage.

Table (16) Results of the air permeability test applied to the samples produced with yarn count 30.

The test	**Air permeability (L/m/sec)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	1995	1567	1630	1088	1270	605
30	1590	1175	1250	870	699	280
36	1210	798	940	555	520	215

Table (17) Results of the air permeability test applied to the samples produced with yarn count 40.

The test	**Air permeability (L/m/sec)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	2030	1686	1647	1138	1320	710
30	1615	1345	1293	939	870	360
36	1267	920	1043	691	667	260

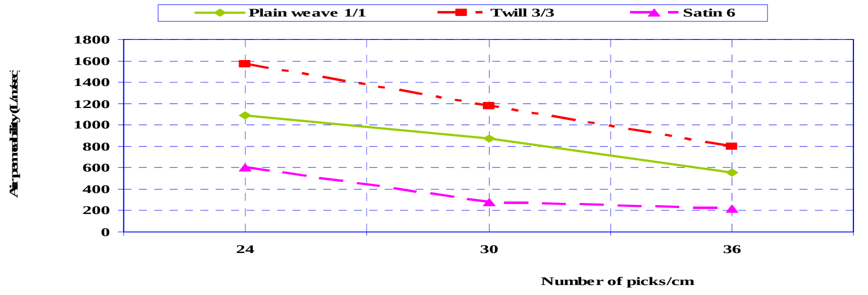

Fig.(9) The relationship between the air permeability and number of picks /cm ,at yarn count 30,after treatment

Table (18) Regression equation and correlation coefficient for the effect of number of picks/cm and fabric structure on air permeability, at yarn count 30 after treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =-2171.167 X + 44.4167	-0.994525
Twill 3/3	Y = -64.083333X + 3102	-0.999937
Satin 6	Y =-32.5 X + 1341.667	-0.933257

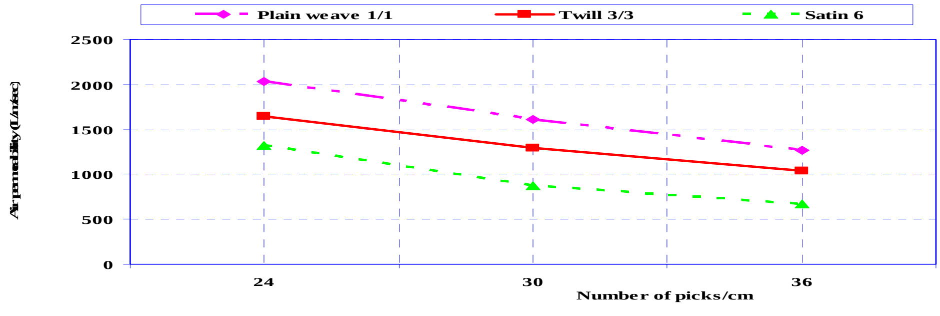

Fig. (10) The relationship between the air permeability and number of picks /cm ,at yarn count 40,before treatment

Table (19) Regression equation and correlation coefficient for the effect of number of picks/cm and fabric structure on air permeability, at yarn count 40 before treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =-63.5833 X + 3544.833	-0.998717
Twill 3/3	Y = -50. 333X + 2837.667	-0.995095
Satin 6	Y =-54.4167 X + 2584.833	-0.976974

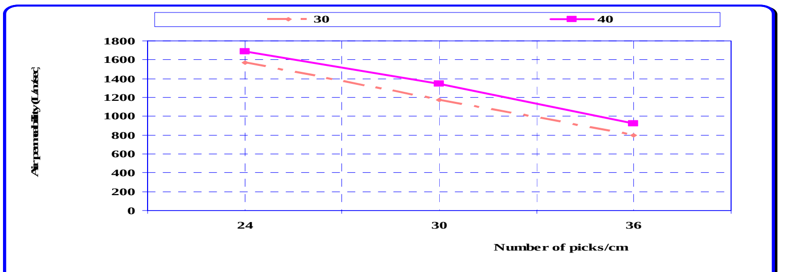

Fig. (11) The relationship between the air permeability and number of picks /cm ,at twill 3/3,after treatment

Table (20) Regression equation and correlation coefficient for the effect of number of picks/cm on air permeability, at twill 3/3 before treatment.

Yarn count	Regression equation	Correlation coefficient
30	Y =-64.8333X + 31025	-0.999947
40	Y =-63.83333X + 3232	-0.960769

Water permeability

It is obvious from the diagrams, that plain weave 1/1 has recorded the highest rates of water permeability, whereas satin 6 has recorded the lowest rates. I can report that this is because plain weave 1/1 has more intersections than satin 6, leading the fabric to be more compacted, and spaces in the fabric to be decreased causing the decrease in water permeability.

It is also clear from the diagrams that there is an inverse relationship between number of picks per cm and water permeability. This is for sake of that the increase in number of picks, cause fabrics to be compacted and so prevent the passage of water.

We can also notice that samples made of 30/1 English have obtained the lowest rates of water permeability, whereas samples made of 40/1 English have obtained the highest rates .This is probably due to that the more diameters the yarns get the less porosity the fabric become and this is because of the increasing of the cover factor

Table (20) Results of the water permeability test applied to the samples produced with yarn count 30.

The test	Water permeability (ml par)					
Fabric structure	Plain weave 1/1		Twill 3/3		Satin 6	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
24	4.5	2.35	3.25	2.25	3.1	1.25
30	5.5	2.5	3.5	2.3	3.3	1.75
36	5.85	2.72	4.0	2.6	3.6	2.0

Table (21) Results of the water permeability test applied to the samples produced with yarn count 40.

The test	Water permeability (ml par)					
Fabric structure	Plain weave 1/1		Twill 3/3		Satin 6	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
24	3.2	2.25	3.0	2.20	2.25	1.1
30	3.35	2.5	3.15	2.25	3.0	1.25
36	3.65	2.6	3.5	2.28	3.25	1.5

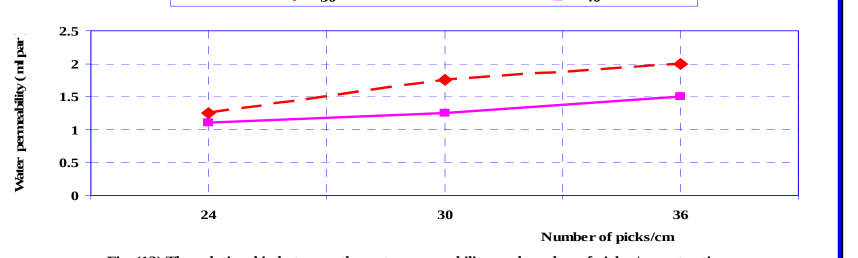

Fig. (12) The relationship between the water permeability and number of picks /cm ,at satin 4,after treatment

Table (22) Regression equation and correlation coefficient for the effect of number of picks/cm on water permeability, at satin 6 after treatment

Yarn count	Regression equation	Correlation coefficient
30	Y =0.625X + 0.208333	0.981981
40	Y =0. 3333X + 0.28333	0.989743

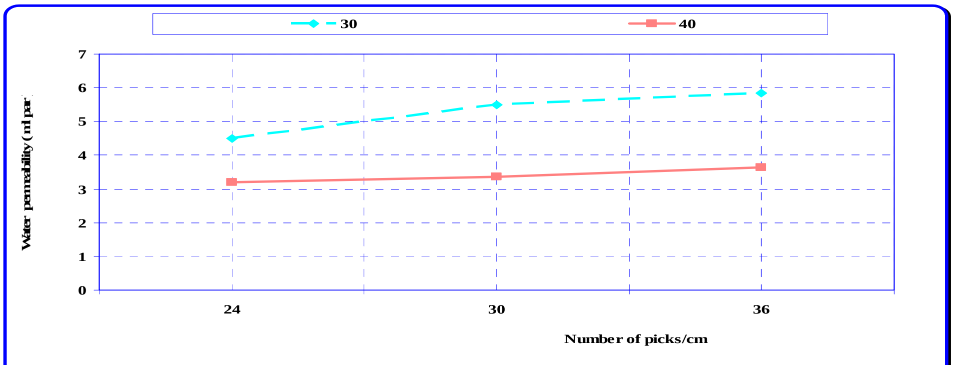

Fig. (13) The relationship between the water permeability and number of picks /cm ,at plain weave1/1 ,before treatment

Table (23) Regression equation and correlation coefficient for the effect of number of picks/cm on water permeability, at plain weave 6 before treatment

Yarn count	Regression equation	Correlation coefficient
30	Y =0.1125X + 1.90833	0.963467
40	Y =0.03703X + 2.275	0.981981

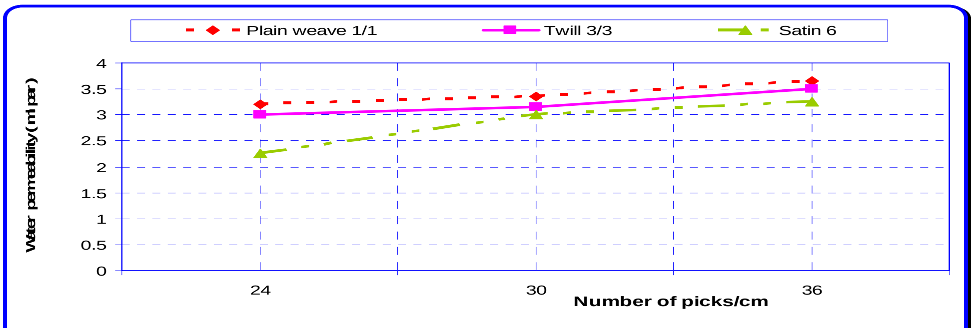

Fig. (14) The relationship between the water permeability and number of picks /cm ,at yarn count 40, before treatment

Table (24) Regression equation and correlation coefficient for the effect of number of picks/cm and fabric structure on water permeability, at yarn count 40 before treatment

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.375 X + 2.275	0.981981
Twill 3/3	Y = 1. 96667X + 0.41667	0.974355
Satin 6	Y =0.083333 X + 0.33333	0.970769

Thickness

It is clear from the diagrams, that regular hopsack 2/2 has recorded the highest rates of thickness, followed by twill and then satin weave , which achieved the lowest rates , and it was found that the difference between both of them was insignificant.

It is clear from the diagrams, that plain weave 1/1 has recorded the highest rates of thickness, followed by twill 3/3 and then satin 6 , which achieved the lowest rates , This is mainly for sake of that plain weave 1/1 have more intersections than twill and satin weave , which gives it the advantage of having ridges on fabric surface giving plain weave the ability of being thicker than the other structures .Another reason for these differences in thickness is yarn count, as samples with count 30/1 English have recorded the highest thickness followed by samples with 40/1 English, This is due to that diameter of 30/1 English are thicker than yarns of 40/1 English, causing the produced samples to be thicker .It was also found that the more yarns per unit area the more thicker the samples become, so samples with 36 picks per cm have recorded the highest rates of thickness, whereas samples with 24 picks per cm have recorded the lowest rates.

Table (25) Results of the thickness test applied to the samples produced with yarn count 30

The test	**Thickness (mm)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	0.30	0.32	0.45	0.49	0.40	0.42
30	0.31	0.32	0.45	0.51	0.41	0.43
36	0.32	0.34	0.46	0.53	0.43	0.45

Table (26) Results of the thickness test applied to the samples produced with yarn count 40

The test	**Thickness (mm)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	0.29	0.30	0.40	0.46	0.37	0.39
30	0.31	0.32	0.41	0.47	0.39	0.40
36	0.33	0.33	0.43	0.48	0.40	0.42

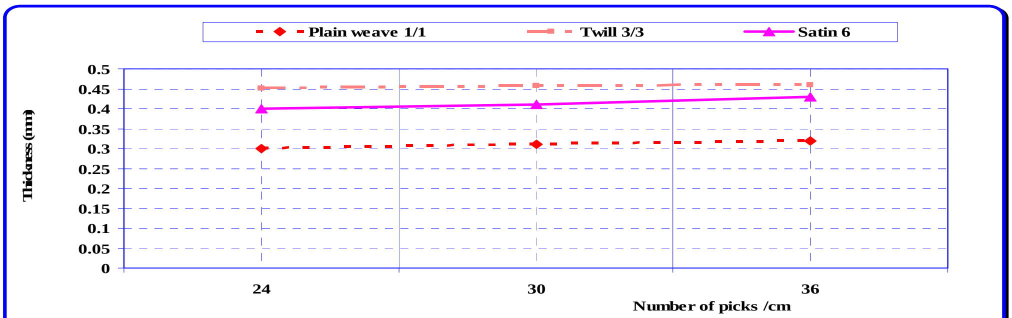

Fig. (15) The relationship between the thickness and number of picks/cms ,at yarn count 30,befre treatment

Table (27) Regression equation and correlation coefficient for the effect of number of picks/cm and fabric structure on thickness, at yarn count 30 before treatment

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =0.001667 X + 0.436667	1
Twill 3/3	Y = 0. 43667 X + 0.000067	0.960769
Satin 6	Y =0.33833 X + 0.0025	0.923077

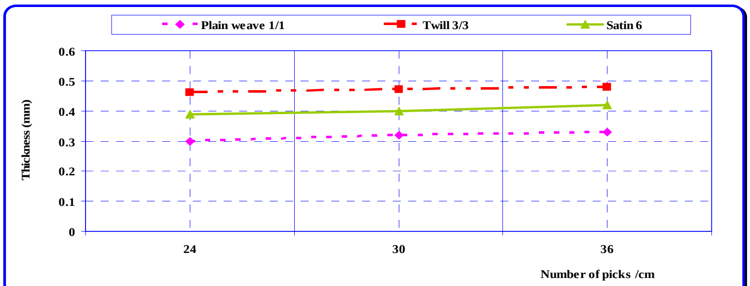

Fig. (16) The relationship between the thickness and number of picks/cm ,at yarn count 40, after treatment

Table (28) Regression equation and correlation coefficient for the effect of number of picks/cm and fabric structure on thickness, at yarn count 40 before treatment

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.0025 X + 0.241667	0.981981
Twill 3/3	Y = 0.001607 X + 0.42	1
Satin 6	Y =0.328333X + 0.0025	0.981981

Fabric weight

It is clear from the diagrams that there were insignificant differences in weight between the three structures.

It is also clear that samples produced of 30/1 English have recorded the highest weight followed by samples with 40/1 English, this is for sake of that yarns of 30/1 English are thicker than yarns of 40/1 English, causing the produced samples to be increased in weight.

It was also found that the more yarns per unit area the thicker the samples become, so samples with 36 picks per cm have recorded the highest weight, whereas samples of 24 picks per cm have recorded the lowest weight.

It is also clear from the diagrams and tables that there was insignificance difference in weight between the three structures.

Table (29) Results of the weight test applied to the samples produced with yarn count 30

The test	**Weight (g/m2)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	108	113	102	108	106	114
30	115	129	106	113	109	119.
36	119	132	113	122	118	128

Table (30) Results of the weight test applied to the samples produced with yarn count 40

The test	**Weight (g/m2)**					
Fabric structure	**Plain weave 1/1**		**Twill 3/3**		**Satin 6**	
Weft set	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**	**Before treatment**	**After treatment**
24	91	100	90	93	92	99
30	102	109	93	98	96	105
36	105	114	98	107	103	114

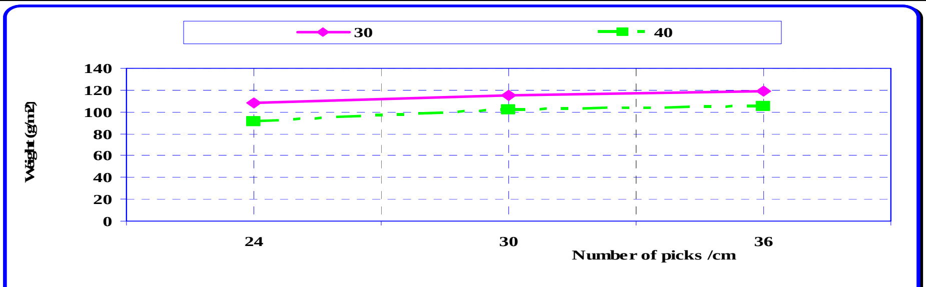

Fig. (17) The relationship between the weight and number of picks/cm ,at plain weave 1/1 ,before treatment .

Table (31) Regression equation and correlation coefficient for the effect of number of picks/cm on weight, at plain weave 1/1 , before treatment .

Yarn count	Regression equation	Correlation coefficient
30	Y =0.916667X + 86.5	0.987829
40	Y =1.66667 X + 64.333	0.999653

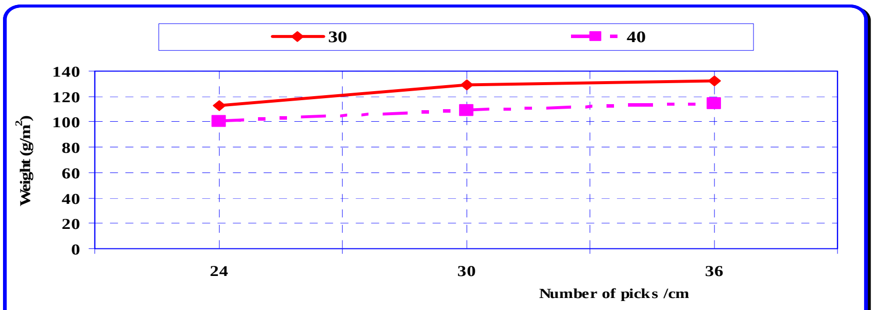

Fig. (18) The relationship between the weight and number of picks /cm ,at twill 3/3, after treatment .

Table (32) Regression equation and correlation coefficient for the effect of number of picks/cm on weight, at twill 3/3 , before treatment .

Yarn count	Regression equation	Correlation coefficient
30	Y =1.583333X + 77.16667	0.930062
40	Y =1.66667 X + 72.66667	0.986666

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