Designing and Producing Fabrics Suitable for Being Used as Waterproof Raincoats

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Abstract: This research is mainly concerned with producing fabrics suitable for raincoats, which is considered the main protection garment beside hoods, ponchos ….etc. which used to provide protection to the body from rain showers .All samples under study were produced of polyester yarns 50, 70 and 100 denier .Three weft sets were used 60, 80 and 100 picks /cm and three fabric structure (plain weave 1/1, twill 1/4 and satin 5). Samples were coated using P.V.C in order to produce a waterproof, moisture vapor permeable laminated fabrics and having perforation to provide ventilation to the user. Their influence on the performance of the end-use fabric and the achieved properties were studied. On the other hand physic-chemical properties including, tensile strength and elongation, abrasion resistance, water permeability, water repellency, tear resistance, 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

All types of clothing need to have a balance of properties: Aesthetic, cultural and protective, allied to good economics (1) . Protective textiles is the most growing segment of the industrial textiles market and it involves a number of new development in fibers, fabrics, coating and fabrication technology (2) . Protection from heat, flame, molten metal splashes, severe cold and frost, electrical hazards, radiation sources, etc. is a prime requirement for both civil and defense applications (3,4) . According to this safety and protective textiles are defined as any garments and other fabric- related items designed to protect the wearer from harsh environmental effects that may result in injury or death (5) .

Raincoats

Protection from cold is one of the oldest needs for clothing. Protection from extreme cold and rain is similar but greater effectiveness is needed.

In the last few years, the diversity of waterproof, water vapor permeable fabrics has grown with the refinement of coating and laminating techniques. All major rainwear fabric manufacturers now are seeking for producing breathable products that are meant to increase comfort (6) . Raincoat is a waterproof water-vapor permeable laminated structure that is used in rainy weather as a means of keeping the wearer dry (7). Raincoats are designed to prevent water from penetrating through to undergarments while at the same time permitting moisture vapor such as perspiration to pass out through it (8).

Types of rain protection garments

Various types of protective head and body coverings are available. Some of these coverings are disposable and the others are re-usable (9) .Rain protection garments, such as raincoats, rain hoods, ponchos, leggings and the like, (10)which are used to keep the individuals dry during rain showers , are typically designed for repeated use, and therefore made of durable rain impermeable material such as canvas, oilcloth, nylon and the like. Rain protection garments can also be disposable specially rain hoods and ponchos and they are typically made of plastic sheets. Disposable rain hoods find particular uses at outdoor events, such as festivals and sporting events, where a sudden unexpected rain shower may catch individuals (11) .

Properties of raincoats

In the past and through a long history of rain wear development, truly waterproof materials have not allow the evaporation of perspiration, so that a wearer of these raincoats and who is physical active becomes sweat soaked, which is considered the main disadvantage of most present raincoats. So protective garments for wear in rain and other wet conditions should keep the wearer dry by preventing the leakage of water into the garment and at the same time allow perspiration to evaporate from the wearer to the atmosphere. Rain garments should also withstand the impingement pressure of falling and wind blown rain and pressure that are generated in folds and crease in the garment (8.)

Theory of waterproof breathable raincoats

It is widely recognized that garments must be breathable to be comfortable. However, it is not necessary that air pass through the garment for it to be comfortable, only that water vapor from perspiration be transmitted from inside to outside so that undergarments do not become wet and so that the natural evaporative cooling effect can be achieved. The transport of water through a layer can be achieved in a number of ways. Wicking, which is used in this research, is the most common when large quantities of moisture are to be transferred. Wicking materials are hydrophilic in that a drop of water placed on the surface of these materials from an advancing water contact angle of less than 90 degrees so that they wet spontaneously. They are also porous with pores that interconnect to make complete pathways through the wicking material. Liquid water moves by capillary action from interior surface to exterior surface where it evaporates [8].

2. Experimental work

This research concerns with producing fabrics suitable as a protective clothing from rain showers. All samples in the research were produced with woven technique. all samples in the research were produced with polyester yarns using three woven structure (Plain weave 1/1, twill 1/4 and satin 5) three weft sets were also used (60,80 and 100 picks),sing three different yarns count (50,70 and 100 yarns).

Finishing treatment

The produced fabrics were undergoing special treatments before being used , Samples were treated using solution containing 250 ml P.V.C + 250 ml oxide titanium + 500 ml Dioxins-polychlorinated dibenzo dioxins Solvent and then mixed together to harmony in a mixer . The fabric samples were dried at 100 ^{0}C for 3 min, then thermo-fixed at 170 ^{0}C for 1 min. All samples were treated with P.V.C to make the fabric repellent and a barrier to rain and water proof

Table (1): Specifications of all produced samples.

No	Property	Specification
1	Warp type	Polyester
2	Weft type	Polyester
3	Count of warp yarns	70 denier
4	Count of weft yarns	50,70 and 100 denier
5	Warp set (ends / cm)	100 ends/cm
6	Weft set (picks / cm)	60,80 and 100 picks / cm
7	Fabric structure	Plain weave 1/1, twill 1/4 and satin 5
8	Reed used	10 dents /cm
9	Denting	10 ends /dent
10	Finishing	All samples were treated with P.V.C.

Tests applied to samples under study

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

1-**The tensile strength and elongation at break**, this test was carried out according to the (ASTM-D1682) [12]

2-**The abrasion resistance**, this test was carried out according to the (ASTM-D1175) [13]

3-**Water permeability**, this test was carried out according to the (ASTM-D 4491-82) [14]

4-**Water repellency**, this test was carried out according to the (AATCC392-63) [15]

5-**Tear resistance**, this test was carried out according to the (ASTM-D 1424) [16]

6-**Fabric thickness**, this test was carried out according to the (ASTM-D1777-96) [17]

7-**Fabric weight**, this test was carried out according to the (ASTM-D 3776- 79) [18]

3. Results and Discussion

Tensile strength and elongation

Tensile strength

It is clear from figures that there is a direct relationship between number of picks /cm and fabrics tensile strength, This is mainly because of that the increase of picks means an increase in the number of fibers per unit area and so the contact areas between fibers will be increased and its resistance to slippage will also be increased leading to the increase in fabric strength . It is obvious from the tables that plain weave has recorded the highest rates of tensile strength ,whereas satin has recorded the lowest rates, but difference is insignificant It is obvious from the tensile strength and elongation results that samples with 100 denier have recorded the highest rates of tensile strength and the lowest rates of elongation followed by samples with 70 denier and then 50 denier .this is due to the yarns of 100 denier are thicker than yarns of 50 and 70 denier and so spaces between yarns will be decreased leading to the increase in friction areas between them causing the produced samples to be higher in their tensile strength. It was also found that the more picks /cm the more tensile strength the samples become, so samples with100 picks /cm have recorded the highest rates of tensile strength, whereas samples with 60 picks/cm have recorded the lowest rates of tensile strength.

It is also obvious from the results that treated samples have achieved higher tensile strength compared to non-treated samples. It can be reported that the treatment caused a decrease in spaces between yarns and so the fabrics become more compacted, and thus increase fabric tensile strength.

Table (2): Results of the tensile strength test applied to the samples produced with 50 denier yarns.

Test	Tensile strength (Kg)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	123	211	117	202	108	187
80	149	264	141	249	132	230
100	174	312	164	294	151	264

Table (3): Results of the tensile strength test applied to the samples produced with 70 denier yarns.

Test	Tensile strength (Kg)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	150	265	145	254	139	242
80	165	298	161	284	154	271
100	199	363	187	332	180	321

Table (4): Results of the tensile strength test applied to the samples produced with 100 denier yarns.

Test	Tensile strength (Kg)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	220	381	203	361	185	329
80	249	452	234	411	227	397
100	305	496	291	472	278	454

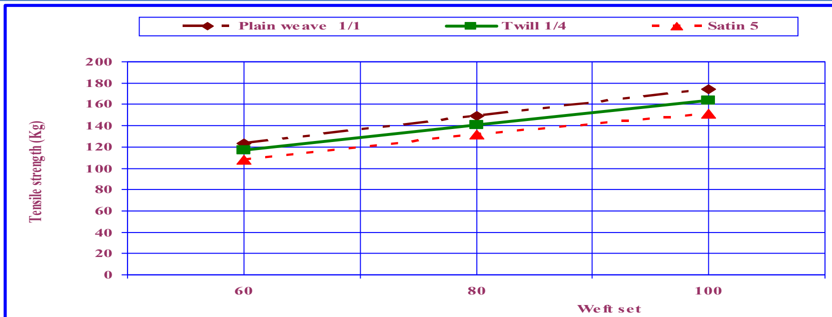

Fig.(1) effect of fabric structure and weft set on tensile strength before treatment ,using polyester 50 denier

Table (5): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on tensile strength, 50 denier yarns before treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =1.275X + 46.66667	0.999936
Twill 1/4	Y = 1.175X + 46.66667	0.999925
Satin 5	Y =1.075X + 44.3333	0.997754

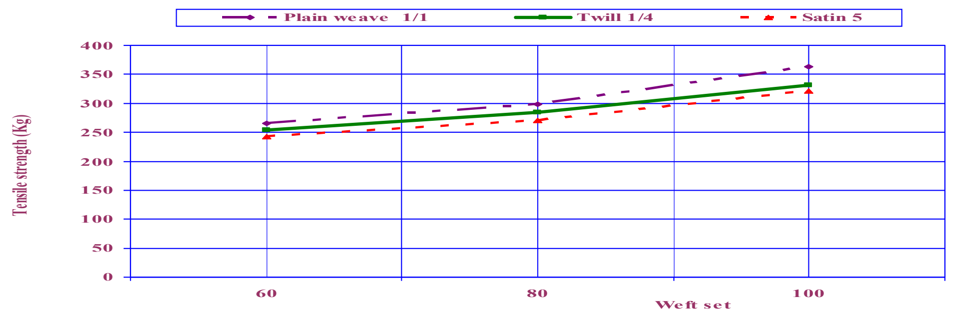

Fig.(2) effect of fabric structure and weft set on tensile strength after treatment ,using polyester 70 denier

Table (6): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on tensile strength, at 70 denier yarns after treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =1.975X + 120	0.988927
Twill 1/4	Y = 1.95X + 134	0.991241
Satin 5	Y =1.075X + 112.6667	0.98269

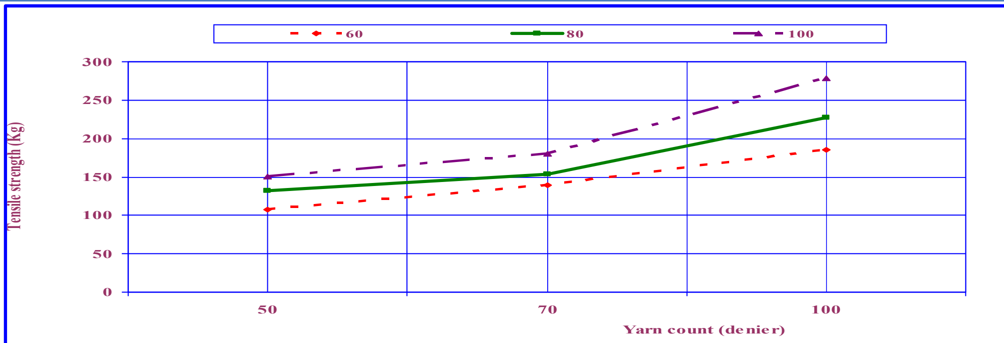

Fig.(3) effect of fabric structure and weft set on tensile strength before treatment ,using satin 5

Table (7): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on tensile strength, satin **5 before treatment**

Yarn count	Regression equation	Correlation coefficient
50	Y =1.075X + 44.3333	0.9997754
70	Y = 1.025X + 75.66667	0.988215
100	Y =2.325X + 44	0.998443

Elongation

It is clear from figures that there is an inverse relationship between number of picks /cm and elongation properties. This is mainly because of that the increase of picks means an increase in the number of fibers per unit area and so the contact areas between yarns will be increased and its resistance to slippage will also be decreased and so the elongation will be decreased.

It is also obvious from the tables that plain weave has recorded the highest rates of tensile strength, whereas satin has recorded the lowest rates, but difference is insignificant.

It is obvious from the tensile strength and elongation results that samples with 50 denier have recorded the highest rates of elongation followed by samples with 70 denier and then 100 denier .This is due to the yarns of 50 denier are thinner than yarns of 100 and 70 denier and so spaces between yarns will be decreased leading to the increase in friction areas between them causing the produced samples to be lower in their elongation.

It was also found that the less picks /cm the less elongation the samples become, so samples within 60picks /cm have recorded the highest rates of elongation, whereas samples with 100 picks/cm have recorded the lowest rates of elongation.

It is also obvious from the results that treated samples have scored lower elongation compared to non-treated samples, it could be reported that treatment caused a decrease in spaces between yarns and so the contact areas between yarns will be increased and its resistance to slippage will also be decreased and so the elongation will be decreased.

Table (8): Results of the elongation test applied to the samples produced with 50 denier yarns .

Test	**Elongation (%)**					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	61	46	62	49	64	50
80	59	45	60	46	61	48
100	58	43	59	45	60	47

Table (9): Results of the elongation test applied to the samples produced with 70 denier yarns.

Test	**Elongation (%)**					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	55	40	57	43	59	49
80	52	38	54	40	57	46
100	49	35	51	47	53	44

Table (10): Results of the elongation test applied to the samples produced with100 denier yarns.

Test	**Elongation (%)**					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	47	31	49	35	52	36
80	45	29	46	31	50	34
100	42	26	44	26	47	32

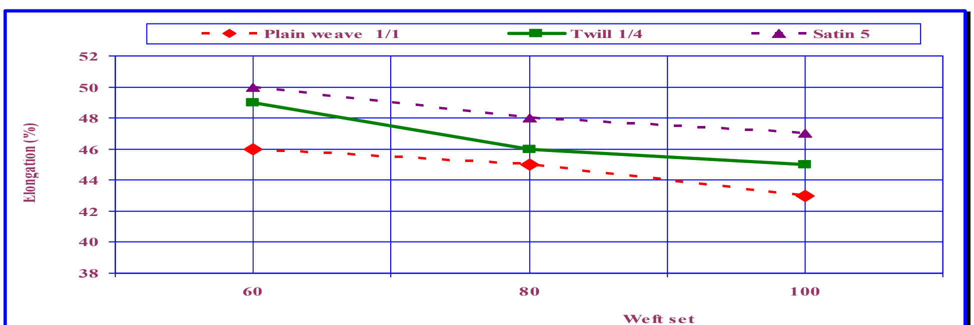

Fig.(4) effect of fabric structure and weft set on elongation after treatment ,using polyester 50 denier

Table (11): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on elongation, at 50 denier yarns after treatment.

Fabric structure	**Regression equation**	**Correlation coefficient**
Plain weave 1/1	Y =-.0075X + 50.66667	-0.981981
Twill 1/4	Y =- 0.1X + 54.66667	-0.960769
Satin 5	Y =0.075X + 54.3333	0.981981

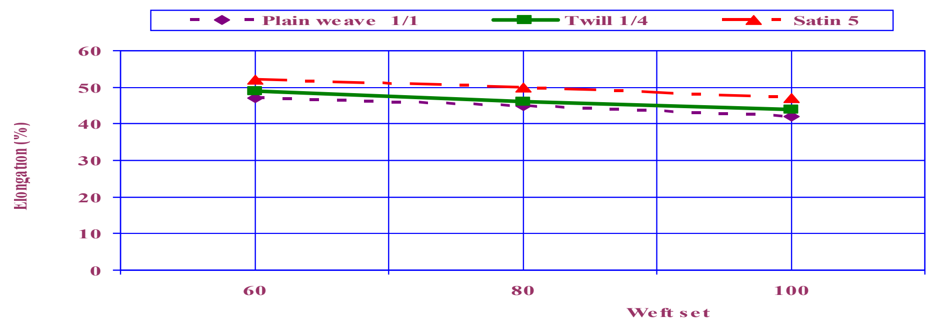

Fig.(4) effect of fabric structure and weft set on elongation before treatment ,using polyester 100 denier

Table (12): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on elongation, at yarn count 100 denier before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =-0.125X + 54.66667	-0.993399
Twill 1/4	Y =- 0.125X + 56.3333	-0.993399
Satin 5	Y =0.125X + 59.6667	-0.993399

Abrasion resistance

It is obvious from the tables plain weave has recorded the highest rates of abrasion resistance (lost weight and thickness ratio), followed by twill structure whereas satin has recorded the lowest rates, but differences were insignificant. It is also clear from the results, that there is a direct relationship between number of picks per cm and abrasion resistance (lost weight and thickness ratio). This is for sake of that the increased number of picks, which cause fabrics to be more compacted leading to a increase in fabric abrasion resistance (lost weight and thickness ratio).

I can also notice that samples made of 50 denier yarns have obtained the lowest rates of abrasion resistance whereas samples made of 100 denier have obtained the highest rates. This is probably due to that the more diameter the yarns get the more compacted the fabric become and this is for sake of the increasing of the cover factor

It is also obvious from the results that treated samples did not give any readings on the test apparatus which means that their abrasion resistance was larger than instrument capacity ,as samples were exposed to 30000 round .

Table (13): Results of the abrasion resistance test applied to the samples produced with 50 denier yarns.

	Abrasion resistance (Lost of thickness (%))								
Fabric structure	**Plain weave 1/1**			**Twill 1/4**			**Satin 5**		
Yarn count weft set	50	70	100	50	70	100	50	70	100
60	0.55	0.49	0.38	0.57	0.53	0.42	0.59	0.56	0.46
80	0.50	0.44	0.33	0.54	0.49	0.37	0.56	0.52	0.41
100	0.46	0.39	0.29	0.51	0.43	0.32	0.53	0.48	0.39

Table (14): Results of the abrasion resistance test applied to the samples produced with yarn count 100 denier

	Abrasion resistance (Lost of weight (%))								
Fabric structure	Plain weave 1/1			Twill 1/4			Satin 5		
Yarn count / weft set	50	70	100	50	70	100	50	70	100
60	3.15	2.72	2.29	3.61	3.11	2.53	3.99	3.52	2.71
80	2.87	2.41	2.03	3.21	2.67	2.27	3.64	3.02	2.48
100	2.43	2.07	1.73	2.92	2.41	1.94	3.32	2.72	2.19

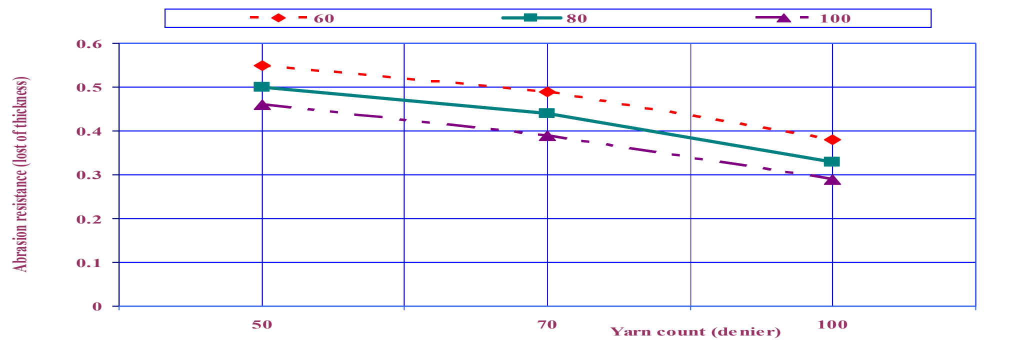

Fig.(6) effect of yarn count and weft set on abrasion resistance before treatment ,using plain weave 1/1.

Table (15): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on abrasion resistance, at plain weave 1/1 before treatment.

Yarn count	Regression equation	Correlation coefficient
50	Y =0.00225X + 0.683333	-0.997949
70	Y =- 0.0025X + 0.64	-1
100	Y =0.00225X + 0.51333	-0.997949

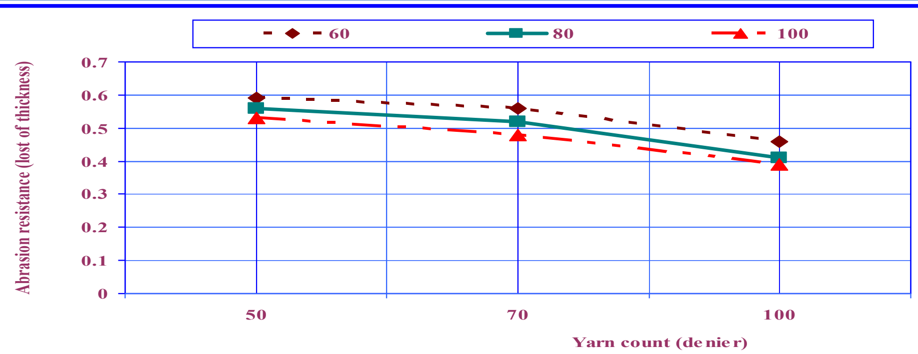

Fig.(7) effect of yarn count and weft set on abrasion resistance before treatment ,using satin 5.

Table (16): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on abrasion resistance, at satin 5 before treatment.

Yarn count	Regression equation	Correlation coefficient
50	Y =0.0015X + 0.68	-1
70	Y =- 0.002X + 0.68	-1
100	Y =0.00175X + 0.56	-0.970725

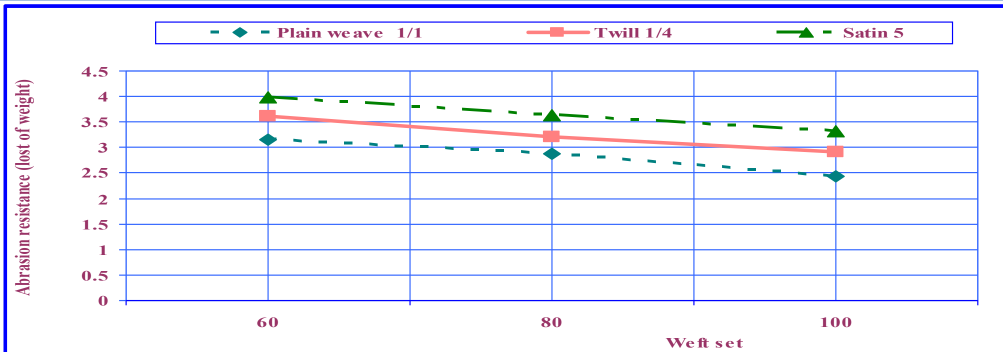

Fig.(8) effect of fabric structure and weft set on abrasion resistance before treatment ,using 50 denier

Table (17): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on abrasion resistance, at denier 50 before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.001675X + 4.99	-0.999666
Twill 1/4	Y =- 0.01725X + 4.626667	-0.995791
Satin 5	Y =0.018X + 4.256667	-0.99187

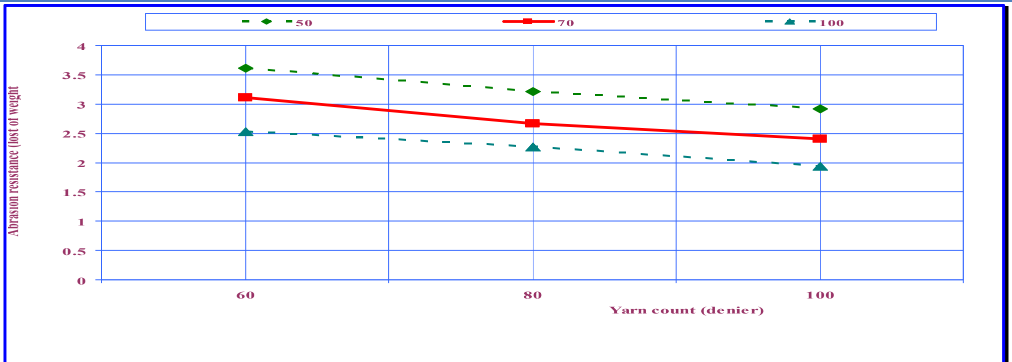

Fig.(9) effect of yarn count and weft set on abrasion resistance before treatment ,using twill 1/4.

Table (18): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on abrasion resistance, at twill 1/4 before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.01725X + 4.62667	-0.995791
Twill 1/4	Y =- 0.175X + 4.13	-0.989158
Satin 5	Y =0.01475X + 3.426667	-0.997662

Water permeability

It is obvious from the diagrams plain weave 1/1 has recorded the highest rates of water permeability, whereas satin 4 has recorded the lowest rates. I can report that because plain weave have more intersections than satin and twill weave which cause the produced fabric to be less compacted, so spaces in the fabric will be decreased causing decreasing in water permeability.

It is also clear from the diagrams that there is an inverse relationship between number of ends and picks per cm and water permeability. This is for sake of that the increased in number of ends and picks per unit area cause fabrics to be more compacted and decrease spaces between yarns, which decrease the passage of water.

I can also notice that samples made of 100 denier have obtained the lowest rates of water permeability, whereas samples made of 50 denier have obtained the highest rates.

This is probably due to that the more diameter the yarns get the less porosity the fabric become and this is for sake of the increasing of the cover factor

From results obtained after treatment, all samples did not give any results (0 % water permeability), this is due to that treatment caused a decrease in fabrics pores (blocking of the surface) and so the fabrics become more compacted, and thus prevents fabric water permeability.

Table (19): Results of the water permeability test applied to the samples produced under study

	Water permeability (Sec.)								
Fabric structure	**Plain weave 1/1**			**Twill 1/4**			**Satin 5**		
Yarn count weft set	50	70	100	50	70	100	50	70	100
60	41	43	54	48	55	71	58	73	95
80	45	49	58	54	68	83	71	82	101
100	48	57	75	63	81	89	80	98	114

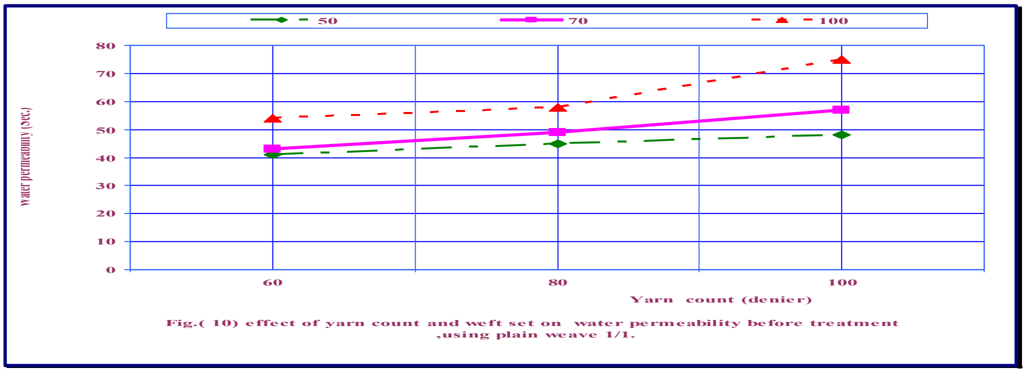

Fig.(10) effect of yarn count and weft set on water permeability before treatment ,using plain weave 1/1.

Table (20): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on water permeability, at plain weave 1/1 before treatment.

Yarn count	Regression equation	Correlation coefficient
50	Y =0.0175X + 30.66667	0.996616
70	Y =- 0.35X + 21.66667	0.996616
100	Y =0.525X + 20.3333	0.941663

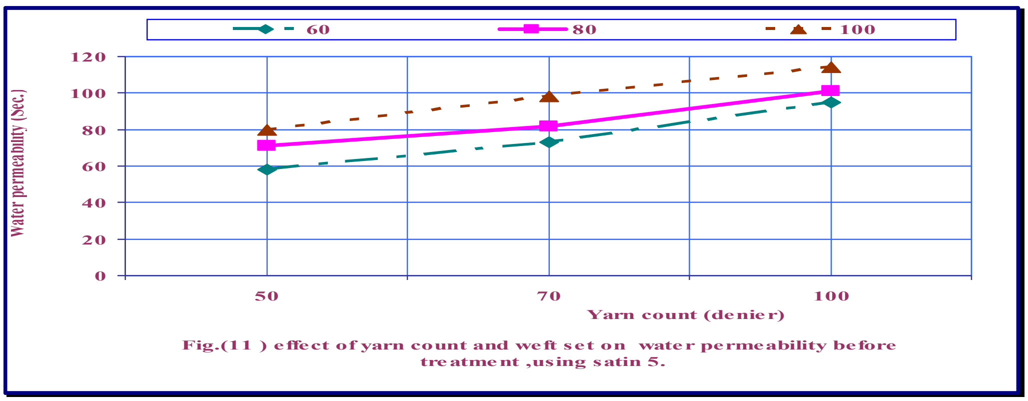

Fig.(11) effect of yarn count and weft set on water permeability before treatment ,using satin 5.

Table (21): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on water permeability, at satin 5 before treatment.

Yarn count	Regression equation	Correlation coefficient
50	Y =0.55X + 25.66667	0.994535
70	Y =- 0.625X + 34.3333	0.987184
100	Y =0.475X + 65.3333	0.978117

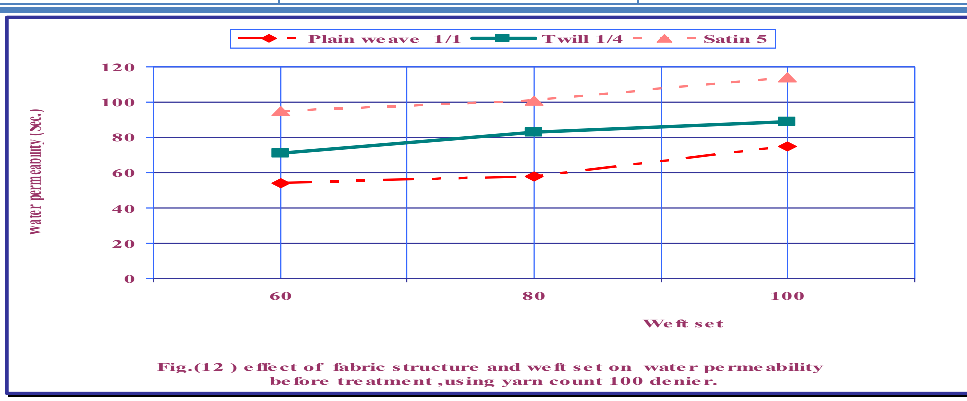

Fig.(12) effect of fabric structure and weft set on water permeability before treatment ,using yarn count 100 denier.

Table (22): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on water permeability, at 100 denier before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0.525X + 20.3333	0.9416533
Twill 1/4	Y = 0.45X + 45	0.98981
Satin 5	Y =0.475X + 65.3333	0.978117

Water repellency

From tables and figures that fabric structure was insignificant on water repellency.

From results It is also clear that samples produced of 100 denier have recorded the highest rates of water repellency followed by samples with 70 denier, and then samples with 50 denier, Where it could be reported that the treatment caused in fabrics pores (blocking of the surface) and so the fabrics become more compacted, and thus fabric increase water repellency.

It was also found that, there is a direct relationship between weft set and water repellency. Where it could be reported that the increase in weft set caused a decrease in fabrics pores (blocking of the surface) and so increase fabrics compactness, and thus increasing its fabric water repellency

From results obtained after treatment, all treated samples have achieved 100 % water repellency, this is due to that treatment caused a decrease in fabrics pores (blocking of the surface) and so the fabrics become more compacted, and thus increase in water repellency.

Table (23): Results of the water repellency test applied to the samples produced under study.

	Water repellency (%)								
Fabric structure	**Plain weave 1/1**			**Twill 1/4**			**Satin 5**		
Yarn count / weft set	50	70	100	50	70	100	50	70	100
60	55	60	70	65	75	80	70	75	80
80	60	65	75	70	80	85	80	85	90
100	65	70	85	75	85	90	85	90	95

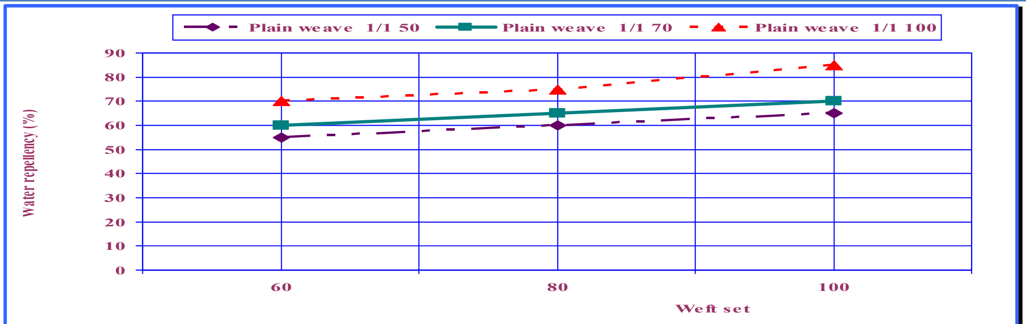

Fig.(13) effect of yarn count and weft set on water repellency before treatment ,using plain weave 1/1.

Table (24): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on water repellency, at plain weave 1/1 before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 25X + 40	1
Twill 1/4	Y = 0.25X + 45	1
Satin 5	Y =0.375X + 64.6667	0.98981

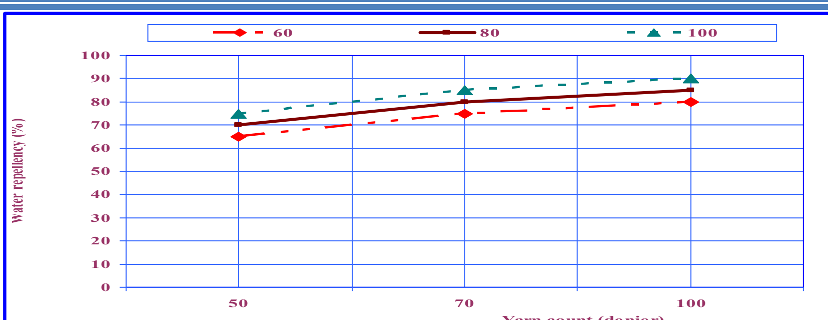

Fig.(14) effect of yarn count and weft set on water repellency before treatment ,using twill 1/4.

Table (25): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on water repellency, at twill 1/4 before treatment.

Yarn count	Regression equation	Correlation coefficient
50	Y =0. 25X + 50	1
70	Y = 0.25X + 60	1
100	Y =0.25X + 65	1

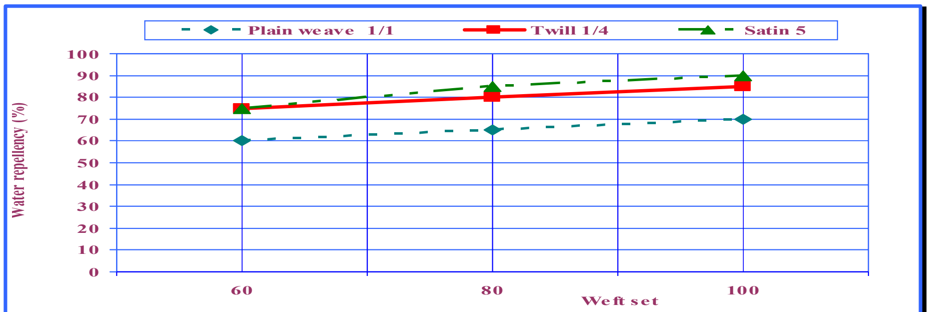

Fig.(15) effect of fabric structure and weft set on water repellency before treatment ,using 70 denier.

Table (26): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on water repellency, at 70 denier before treatment

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 25X + 45	1
Twill 1/4	Y = 0.25X + 60	1
Satin 5	Y =0.375X + 35.3333	0.98981

Tearing resistance

From the results in tables it can be seen that, with the increase of weft set, the tear resistance increases. This is mainly because of that the increase of weft set means an increase in the weight and thickness and so the contact areas between yarns will be increased and its resistance to slippage will also be increased leading to the increase in fabric tear resistance

It is also clear from figures that treatment samples had a highest tear resistance compared to samples before treatment .this is mainly due to that treatment caused a decrease in fabrics pores and so the fabrics become more compacted, and thus increase fabric tear resistance.

It is clear from figures that there is a direct relationship between fabric number of picks /cm and tensile strength, This is mainly because of that the increase of picks means an increase in the number of fibers per unit area and so the contact areas between fibers will be increased and its resistance to slippage will also be increased leading to the increase in fabric tear resistance.

It is also obvious from the tables that plain weave has recorded the highest rates of tear resistance followed by twill 1/4 and then satin has recorded the lowest rates.

It is obvious from the tearing resistance results that samples with 50 denier have recorded the lowest rates of tear resistance followed by samples with 70 denier and then 100 denier .this is due to the yarns of 100 denier are thicker than yarns of 50 and 70 denier and so spaces between yarns will be decreased leading to the increase in friction areas between them causing the produced samples to be higher in their tear resistance.

It is also obvious from the results that treated samples have scored higher tear resistance compared to non-treated samples. Where it could be reported that the treatment caused a decrease in fabrics pores and so the fabrics become more compacted, and thus increase fabric tensile strength.

Table (27): Results of the tearing test applied to the samples produced with 50 denier yarns.

Test	Tear resistance					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	1780	5800	1650	4240	1400	2890
80	2300	7300	1960	5650	1730	3900
100	2780	8300	2450	7200	2130	5400

Table (28): Results of the tearing test applied to the samples produced with yarn count 70 denier.

Test	Tear resistance					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	2890	8650	2400	6900	2200	5800
80	3200	9800	2700	8730	2300	6760
100	3500	10500	3100	9700	2600	7500

Table (29): Results of the tearing test applied to the samples produced with yarn count 100 denier.

Test	Tear resistance					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	3200	9250	2800	8460	2300	7620
80	3800	10750	2650	9800	2480	9100
100	4000	12800	3300	11600	2890	10400

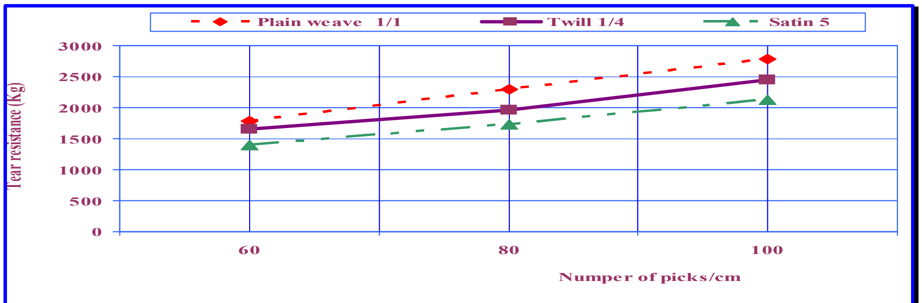

Fig.(16) effect of fabric structure and weft set on tensile strength before treatment using 50 denier

Table (30): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on tear resistance before treatment, at 50 denier yarns.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 25X + 266.6667	0.999733
Twill 1/4	Y = 20X + 420	0.991688
Satin 5	Y =18.25 X + 293.333	0.998471

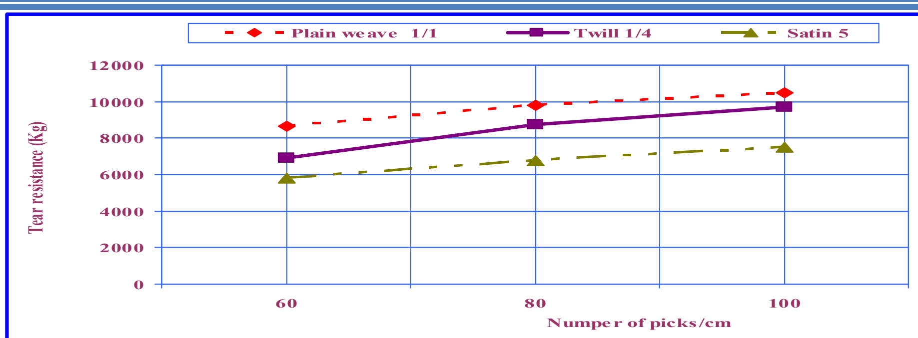

Fig.(17) effect of fabric structure and weft set on tensile strength after treatment using 70 denier

Table (31): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on tear resistance, at 70 denier yarns.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =70X + 2893.333	0.990282
Twill 1/4	Y = 70X + 2893.333	0.984639
Satin 5	Y =42.5X + 3288.667	0.99722

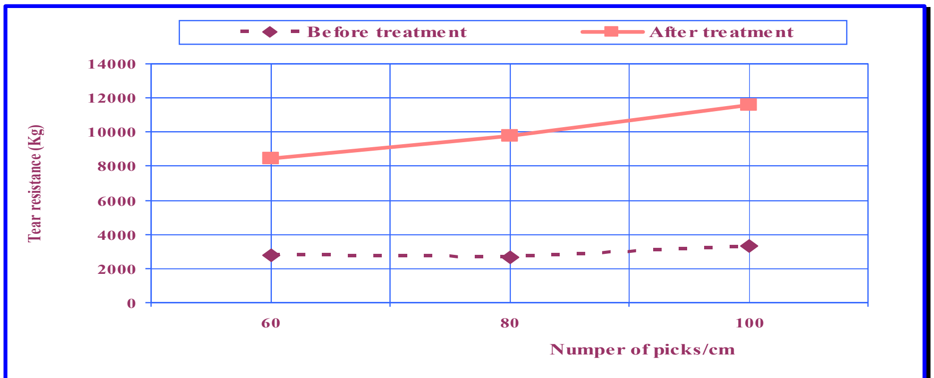

Fig.(18) effect of fabric structure and weft set on tensile strength before and after treatment using 100 denier and twill 1/4.

Table (32): Regression equation and correlation coefficient for the effect of number of picks /cm after and before treatment ,on tear resistance, at 100 denier and twill weave 1/4.

Variables	Regression equation	Correlation coefficient
Before treatment	Y =12.5X + 1916.667	0.834553
After treatment	Y = 78.5X + 3673.333	0.996442

Thickness

It is clear from the diagrams, that plain weave has recorded the highest rates of thickness, followed by twill weave, and then satin which achieved the lowest rates, and it was found that the differences between both of them were insignificant. This is mainly for sake of that plain weave have ridges on fabric surface giving the ability of being thicker than the other structure.

Another reason for these difference in thickness is yarn count, as samples with 100 denier have recorded the highest thickness followed by samples with 70 denier and then 50 denier , This is due to that yarns of 100 denier are thicker than yarns of 70 and 50 denier , 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 100 picks per cm have recorded the highest rates of thickness, whereas samples with 60 picks per cm have recorded the lowest rates . This is due to that increase of number of picks/cm cause the produced fabric to be more compacted and then the thickness will be increased.

Table (33): Results of the thickness test applied to the samples produced with yarn count 50 denier.

Test	**Thickness (mm)**					
Fabric structure	**Plain weave 1/1**		**Twill 1/4**		**Satin 5**	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	0.49	0.59	0.47	0.57	0.46	0.58
80	0.50	0.63	0.49	0.61	0.48	0.61
100	0.52	0.67	0.52	0.66	0.50	0.64

Table (34): Results of the thickness test applied to the samples produced with yarn count 70 denier.

Test	**Thickness (mm)**					
Fabric structure	**Plain weave 1/1**		**Twill 1/4**		**Satin 5**	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	0.55	0.64	0.54	0.68	0.53	0.70
80	0.58	0.67	0.58	0.70	0.55	0.73
100	0.59	0.70	0.61	0.72	0.57	0.75

Table (35): Results of the thickness test applied to the samples produced with yarn count 100 denier.

Test	**Thickness (mm)**					
Fabric structure	**Plain weave 1/1**		**Twill 1/4**		**Satin 5**	
Weft set	Before treatment	After	Before	After	Before	After

		treatment	treatment	treatment	treatment	treatment
60	0.59	0.74	0.58	0.74	0.57	0.72
80	0.62	0.75	0.63	0.76	0.60	0.74
100	0.64	0.79	0.65	0.80	0.63	0.78

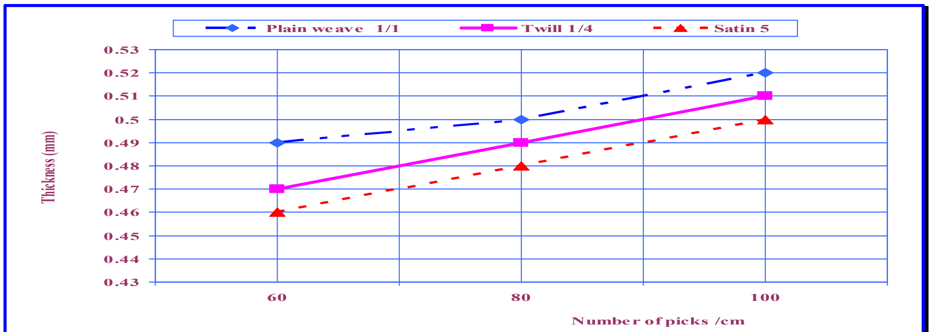

Fig.(19) effect of fabric structure and weft set on thickness before treatment ,using polyester 50 denier .

Table (36): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on thickness, at 50 denier before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 00075X + 0.443333	0.98981
Twill 1/4	Y = 0.001X + 0.41	1
Satin 5	Y =0.001X + 0.4	1

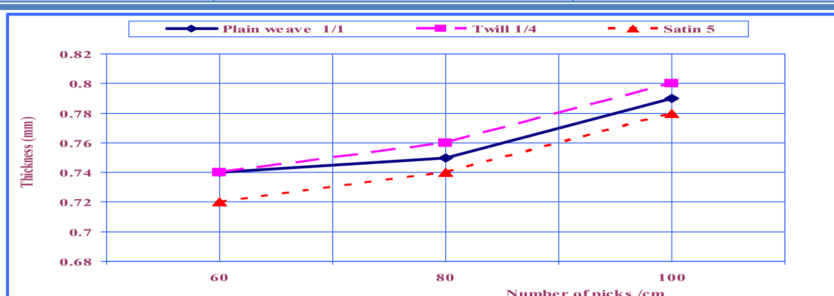

Fig.(20) effect of fabric structure and weft set on thickness after treatment ,using polyester 100 denier .

Table (37): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on thickness, at 100 denier after treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 00125X + 0.60	0.999911
Twill 1/4	Y = 0.0015X + 0.746667	0.98981
Satin 5	Y =0.0015X + 0.626667	1

Weight

It is clear from the results, that satin weave has recorded the highest rates of weight, whereas samples with satin which achieved the lowest rates, and it was found that the difference was insignificant.

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

It is also clear that samples produced of 100 denier have recorded the highest weight followed by samples with 70 denier, and then samples with 50 denier, This is for sake of that yarns of 100 denier are thicker than yarns of 70 and 50 denier, causing the produced samples to be increased in weight.

It was also found that the more yarns per unit area the more thicker the samples become, so samples with 100 picks per cm have recorded the highest weight, whereas samples with 60 picks per cm have recorded the lowest weight.

Table (38): Results of the weight test applied to the samples produced with yarn count 50 denier.

Test	Weight (g/m²)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	167	247	168	249	165	239
80	197	275	194	282	181	261
100	207	299	205	296	192	279

Table (39): Results of the weight test applied to the samples produced with yarn count 70 denier.

Test	Weight (g/m²)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	202	292	200	289	205	296
80	227	317	210	296	237	338
100	243	345	222	319	257	364

Table (40): Results of the weight test applied to the samples produced with yarn count 100 denier.

Test	Weight (g/m²)					
Fabric structure	Plain weave 1/1		Twill 1/4		Satin 5	
Weft set	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
60	278	391	279	392	281	391
80	223	449	313	436	312	438
100	339	471	331	474	327	454

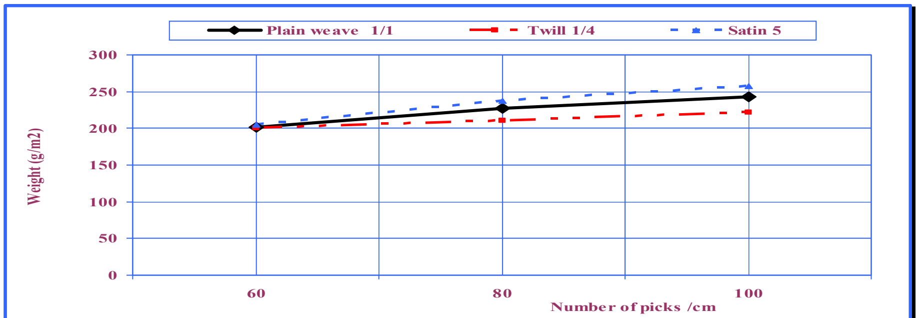

Fig.(21) effect of fabric structure and weft set onweight before treatment ,using polyester 70 denier .

Table (41): Regression equation and correlation coefficient for the effect of number of picks /cm and fabric structure on weight, at 70 denier before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 025X + 142	0.992065
Twill 1/4	Y = 0.55X + 166. 6667	0.998625
Satin 5	Y =1.3X + 129	0.991241

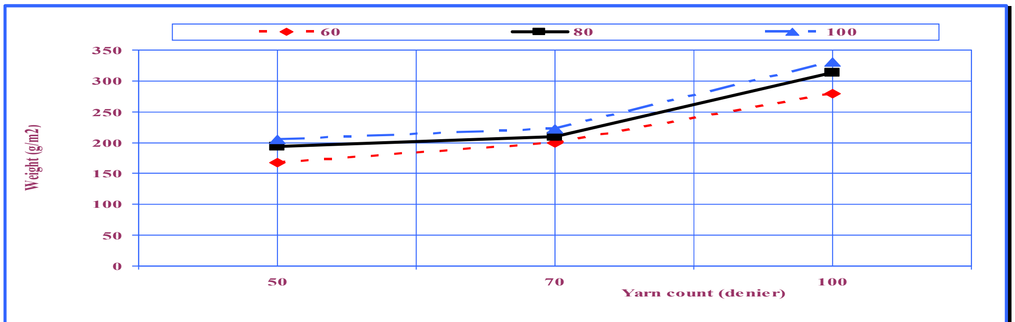

Fig.(22) effect of yarn count and weft set onweight before treatment ,using twill 1/4 .

Table (42): Regression equation and correlation coefficient for the effect of number of picks /cm and yarn count on weight, at twill 1/4 before treatment.

Fabric structure	Regression equation	Correlation coefficient
Plain weave 1/1	Y =0. 425X + 115	0.973689
Twill 1/4	Y = 0.56X + 166. 6667	0.998625
Satin 5	Y =1.3X + 203.6667	0.984585

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