"Application of Lycra in Heart Prostheses"

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Abstract

This research is mainly concerned with designing fabrics used in heart prostheses (patches , valves frames and vasculars). The woven technique was applied to produce these fabrics, using different constructions (regular hopsack 2/2,twill 1/3 , satin 4 and double weave). One textile materials was employed in this research (Lycra covered with polyester) The produced fabrics were treated with Chitosan. Different parameters were studied including, the fabric structure, warp and weft set. Their influence on the performance of the end-use fabric and the achieved properties were studied. On the other physical properties including; air permeability, water permeability, thickness and weight, were evaluated according to the final product needs.

Introduction 3

Textile has swept over new fields in the last three decades, such as agriculture, transportation, filtration, military, and medicine, with the aim of improving the performance efficiency and reducing costs. (1)

Egypt suffer from great shortage in designing and manufacturing medical textiles, hence most medical products in Egypt are imported which represent a great burden on the national budget because of the hard currencies paid in importing these medical products and subsequently there will be a noticeable increase in the product price. (2) A prosthesis is a device that is used to overcome surgical deficiency in the body, perhaps caused by the necessary surgical removal of diseased tissues. This implies that the prosthetic device must perform its function for the rest of the life of the patient . the most common prostheses are vascular prostheses , prosthetic heart valves ,patches , heart valve …. Etc (3)

Requirements of fabrics used in heart prostheses

Requirements specified for implants with regard to duration of contact with human body where the contact medium and the intended biostability of the material are stricter compatibility than those for operating. (4) Theatre textiles and products which are used in direct contact with the central nervous system or in the immediate vicinity of the heart or those which are deliberately dissolved in the body .The most important general requirement of heart prosthesis is the compatibility of the material to the human body and the ease with it can be sterilized .(5)

Biocompatibility requirements

1-Blood compatibility where blood compatibility is necessary in fabrics used in heart prostheses, blood compatibility implies that fabrics should not cause thrombosis, which is the clotting of blood formed within a blood vessel .In addition to must not elements of the blood such as the red blood cells, white blood cells and platelets .(6)

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change in blood composition and blood properties (blood clothing haemolysis)
2-Should not cause alteration of the plasma proteins, destruction of the enzymes, depletion of electrolytes, damage to adjacent tissue or destruction of the cellular
3-No triggering of immunological reactions and allergies
4- No causing of unusual foreign body reaction
5- No cytotoxic reaction.
6- No mutagenic, teratogenic or earunogenic reaction
7- No undesirable biodegradation
8-Wide –lumen textile vascular replacement a cement thrombogenic for intraco - operative sealing
9-Be sterility
10-Freedom from pyrogens
11-Adequate stability of the structure (including under long term loading - tensile-pressure- bending)
12-Load- elongation characteristics compatible with the tissue being replaced
13-Inter operative length matching of the prosthesis
14-Availability in suitable dimensions (7)

II. The experimental Work

This study aimed to produce fabrics used in heart prostheses (patches , valves frames and vasculars) by using Lycra covered with polyester for different woven structures were used in this research to produce samples as follow:
Regular hopsack 2/2, twill weave 1/3 , satin weave 4 and double weave

Finishing treatment

The produced fabrics were undergoing special treatments before being used. These treatments include crimping ,coating with Chitosan, and then sterilization as following.

Crimping

Crimping is affected by the application of internal steam pressure in a mould designed according to the required configuration .The formation of an accordion pleat which were made permanent by heat-setting at 30ºc for 30 min. The process normally produces a circular crimp, the technique is especially suited to velour grafts since the velour feature is well preserved .Crimping improves the grafts bending ability without kinking , besides reducing the likelihood of kinking crimping has added advantage of improving the longitudinal compliance , and vascular handle (8).

Coating

The fabric samples were padded in an aqueous solution containing 12% Chitosan, solution then squeezed to a wet pick up 100 %. The fabric samples were dried at 85 ^{o}C for 5 min, then thermo- fixed at 140 ^{o} C 90 sec . (9)

Sterilization

The fabric samples were sterilized by ethylene oxide gas, where ethylene oxide gas is a colorless gas. It applied in special autoclaves under carefully controlled condition of temperature and humidity .The gas alters proteins, killing bacteria, fungi spores and viruses. A through cleaning cycle is required before sterilization and a gas removal cycle is needed before use. (10)

Table (1) the specification of the machine used for producing samples

No	Property	Specification
1	Model	K.Y
2	Company	Muller
3	Type	Tapes machine
4	Year of manufacturing	1998
5	The manufacturer country	Switzerland
6	Shedding system	Dobby
7	Number of healds	4 healds
9	Speed	1200 RPM
10	Width of the tape	13 cm
11	Number of tapes	2 tapes

Table (2) the specifications of the samples, produced in this research

No	Property	Specification	
1	Warp type	Lycra covered with polyester	Lycra covered with polyester
2	Weft type	Textured polyester	Textured polyester
3	Count of warp yarns	60 dtex	60 dtex
4	Count of weft yarns	denier 70	denier 70
5	Warp set(ends /cm)	80 ,100 ،and 120	100 ,120 ،and 150
6	Weft set (picks / cm)	75,100 and 125	72,108 and 144
7	Fabric structures	Regular hopsack 2/2, twill 1/3 and satin 4	Double weave
8	Reed used (dents / cm)	10 dents /cm	10 dents /cm
9	Denting	8,10 and 12 ends	10,12 and 15 ends
11	Finishing	Samples were treated with Chitosan and sterilized	Samples were crimping with heat setting , treated with Chitosan and sterilized

Tests and analysis

In this part several tests were carried out in order to evaluate the produced fabrics, these tests were

The air permeability of fabrics were determined according to the British standard (BS 2925) (11)

The Fabric water permeability were determined according to the (ASTM.-D 449) (12)

The Fabric thickness were determined according to the (ASTM-.D 3776) (13)

The fabric weight determined according to the (ASTM.-D 3787) (14)

III .Results &discussion

Results of experimental examination on the produced samples are presented in the following table and graphs. Results were statically analyzed for data listed.

Table (3) the results of the air permeability test applied to patches and valves frames samples produced in this research

The test	Air permeability (L^3/min.m^2)								
Fabric structure	Regular hopsack 2/2			Twill 1/3			Satin 4		
Weft set / Warp set	75	100	125	75	100	125	75	100	125
80	5.5	5	3.5	5	4.5	3	3.5	4	2.5
100	4	4.5	2.5	4	3.5	2	2.5	3	1.5
120	3	2.5	1.5	2.5	2	1	1.5	1.5	0.5

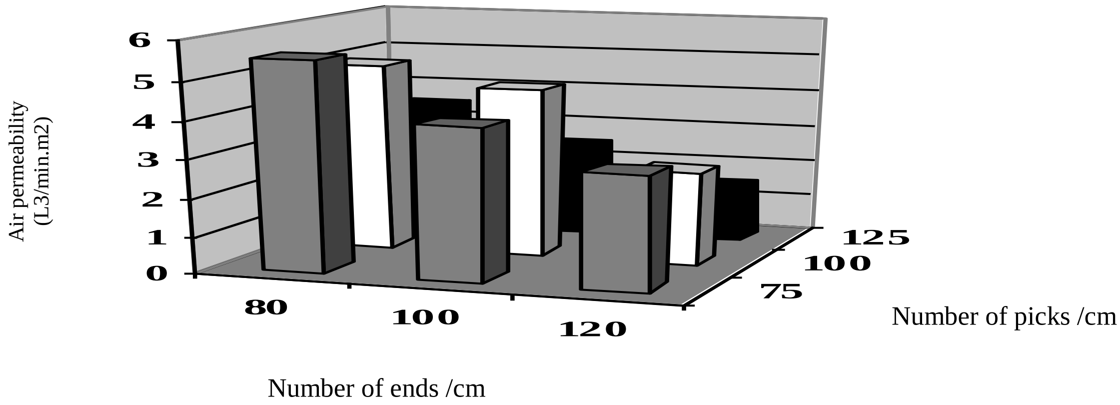

Fig (1)
The effect of number of picks and ends /cm on air permeability for produced patches and valves frames samples ,at twill structure .

Table (4) regression equation and correlation coefficient for the effect of number of picks / cm and ends/cm on air permeability, at regular hopsack

Fabric structure	**Regression equation**	**Correlation coefficient**
80	Y = -0.04X + 8.666667	-0.96069
100	Y = -0.03 X + 6.333333	-0.981981
120	Y = -0.03 X + 5.33333	-0.981981

Table (5) the results of the water permeability test applied to patches and valves frames samples produced in this research

The test	**Water permeability (sec)**								
Fabric structure	**Regular hopsack 2/2**			**Twill 1/3**			**Satin 4**		
Weft set / **Warp set**	**75**	**100**	**125**	**75**	**100**	**125**	**75**	**100**	**125**
80	40	52	61	45	54	66	50	70	74
100	44	56	63	56	67	68	61	82	100
120	54	60	70	66	75	76	85	90	110

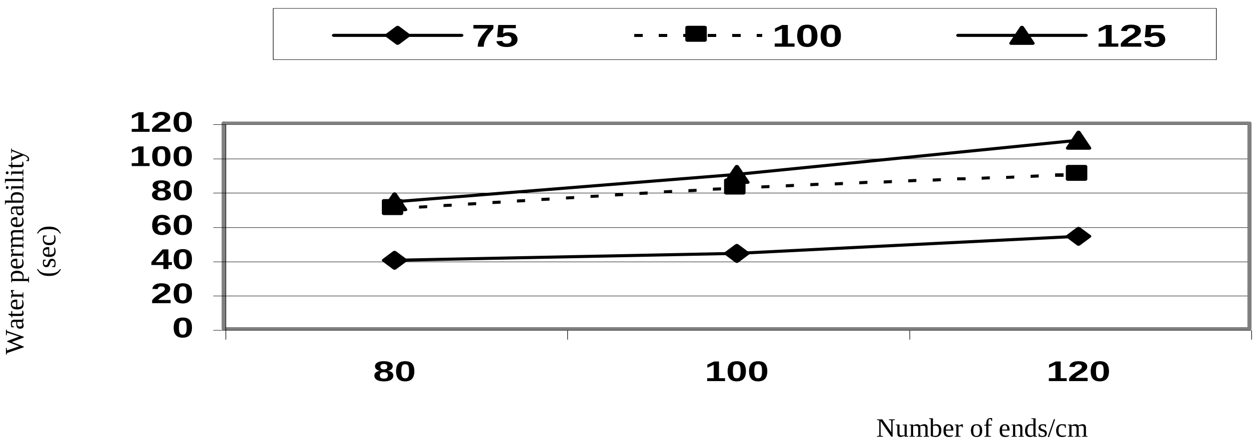

Fig (2)
The effect of number of picks and ends /cm on water permeability for produced patches and valves frames samples, at satin structure .

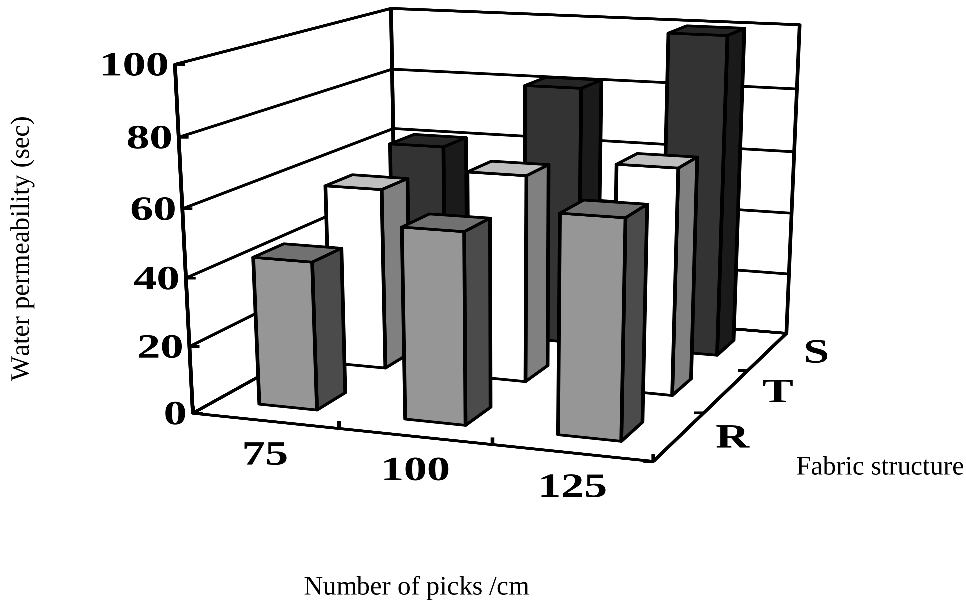

Fig (3)
The effect of number of picks / cm and fabric structure on water permeability for produced patches and valves frames samples, at 100 ends /cm

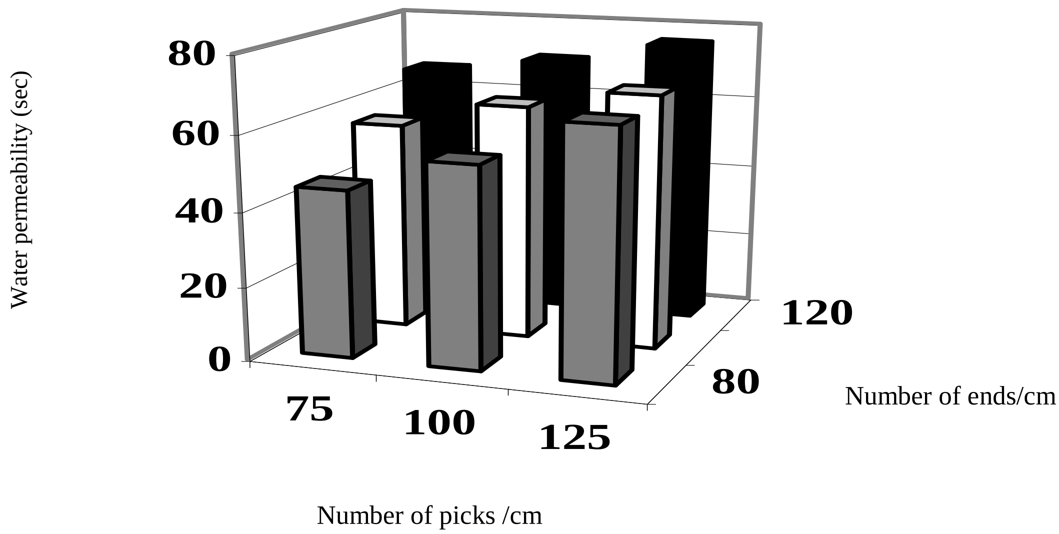

Fig (4)
The effect of number of ends and picks /cm on water permeability for produced patches and valves frames samples at regular hopsack 2/2

Table (6) regression equation and correlation coefficient for the effect of number of picks and ends /cm on water permeability ,at satin 4

Number of picks /cm	**Regression equation**	**Correlation coefficient**
75	Y = 0.525 X +3.166667	0.999622
100	Y = 0.4 X + 22.3333	0.997406
125	Y = 0.25X +45	0.944911

Table (7) regression equation and correlation coefficient for the effect of number of picks per cm and fabric structure on water permeability, at 100 ends per cm.

Fabric structure	**Regression equation**	**Correlation coefficient**
Regular hopsack 2/2	Y = 0.38 X + 16.3	0.98435566
Twill 1/3	Y = 0.24 X + 38.3	0.9987423
Satin 4	Y = 0.78X +3	0.992321

Table (8) regression equation and correlation coefficient for the effect of number of picks per cm and fabric structure on water permeability, at regular hopsack 2/2.

Number of ends /cm	**Regression equation**	**Correlation coefficient**
80	Y = 0.04X + 8.666667	0.96069
100	Y = 0.03 X + 6.333333	0.981981
120	Y =0.03 X + 5.33333	0.981981

Table (9) the results of the thickness test applied to patches and valves frames samples produced in this research

The test	**Thickness (mm)**								
Fabric structure	**Regular hopsack 2/2**			**Twill 1/3**			**Satin 4**		
Weft set / **Warp set**	**75**	**100**	**125**	**75**	**100**	**125**	**75**	**100**	**125**
80	0.79	0.76	0.84	0.75	0.78	0.81	0.74	0.77	0.82
100	0.81	0.78	0.89	0.77	0.81	0.86	0.75	0.80	0.85
120	0.83	0.80	0.93	0.80	0.84	0.88	0.76	0.83	0.89

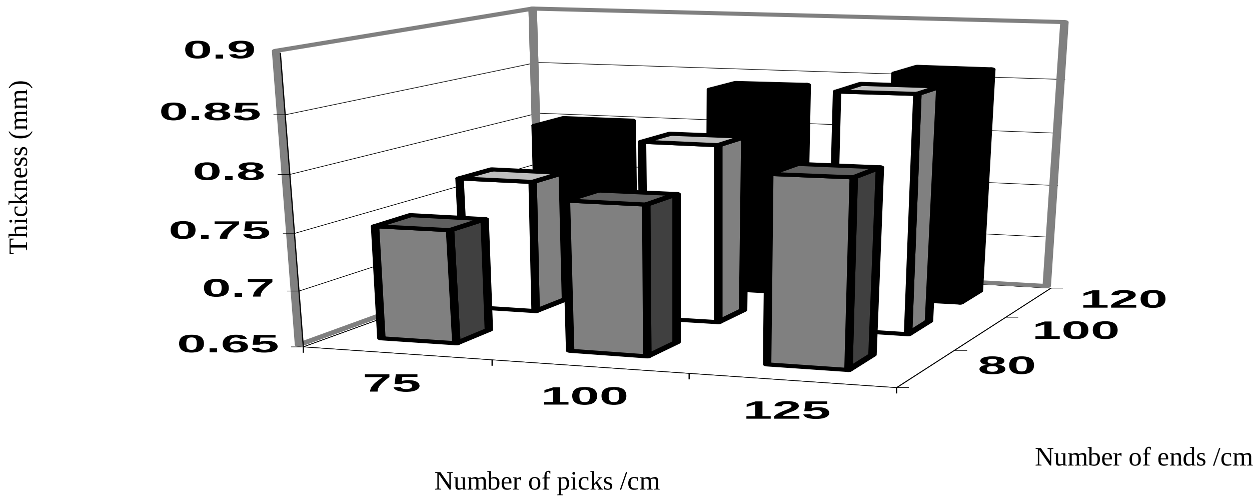

Fig (5)

The effect of number of ends /cm and ends/cm on thickness for produced patches and valves frames samples at regular hopsack 2/2

Table (10) regression equation and correlation coefficient for the effect of number of picks per cm and ends/cm on thickness at satin 4

Number of ends /cm	Regression equation	Correlation coefficient
80	Y = 0.04X + 8.666667	0.96069
100	Y = 0.03 X + 6.333333	0.981981
120	Y =0.03 X + 5.33333	0.981981

Table (11) the results of the weight test applied to samples produced in this research

The test	Weight (g/m^2)								
Fabric structure	Regular hopsack 2/2			Twill 1/3			Satin 4		
Weft set / Warp set	75	100	125	75	100	125	75	100	125
80	411.9	421.0	467	305.1	451	491.1	300.1	452.6	494.0
100	433.1	441.2	478	.337	461	512	410.0	497.1	521.1
120	461.1	473.5	511	457.3	488	539.8	422.3	500.1	542.8

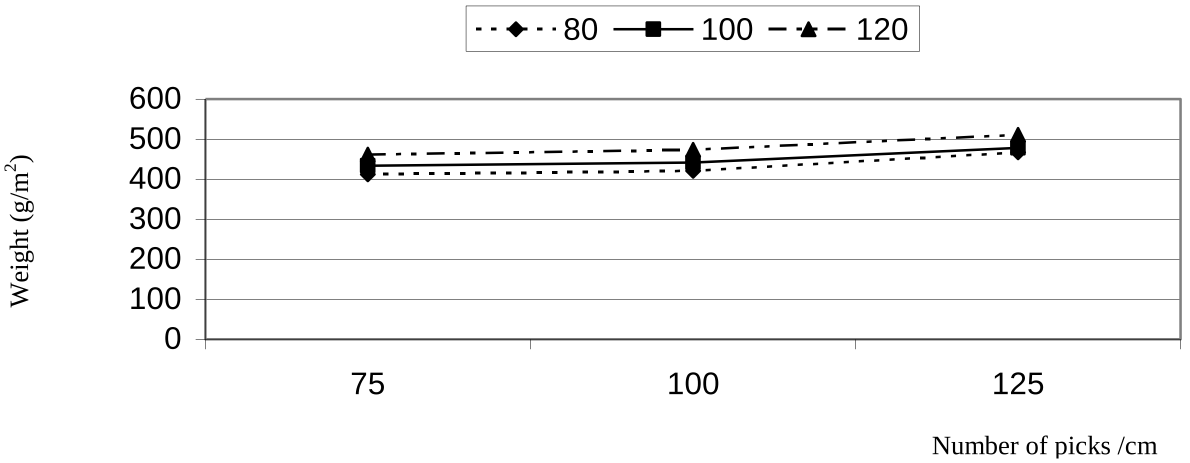

Fig (6)
The effect of number of ends /cm and fabric structure on weight for produced samples at regular hopsack 2/2

Table (12) regression equation and correlation coefficient for the effect of number of picks per cm and ends/cm on weight, at regular hopsack 2/2.

Number of ends /cm	Regression equation	Correlation coefficient
80	Y = 1.1 X + 375.33	0.96976
100	Y = 1.3125 X + 313.98	0.991263
120	Y = 1.23X + 312.3667	0.996831

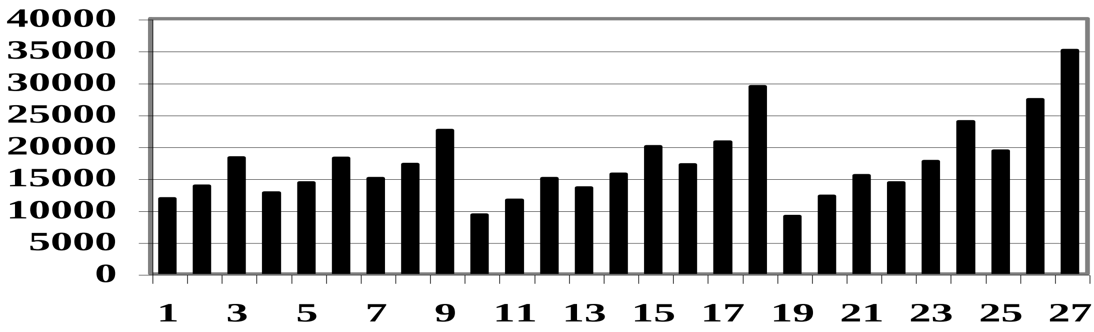

Fig (7)
Determination of the ideal patches and valves frames samples by radar analysis

Table (13) the results of the air and water permeability tests applied to vasculars

The test	Air permeability			Water permeability		
Weft set / Warp set	٧٢	١٠٨	144	٧٢	١٠٨	144
100	٠.٠٧٤	٠.٠٦٩	٠.٠٠٧	٥١	٥٦	٦١
120	٠.٠٧٠	٠.٠٦٣	٠.٠٠٥	٥٥	٦٢	٦٤
150	٠.٠٦١	٠.٠٥٦	٠.٠٠٣	٦٠	٦٥	٦٨

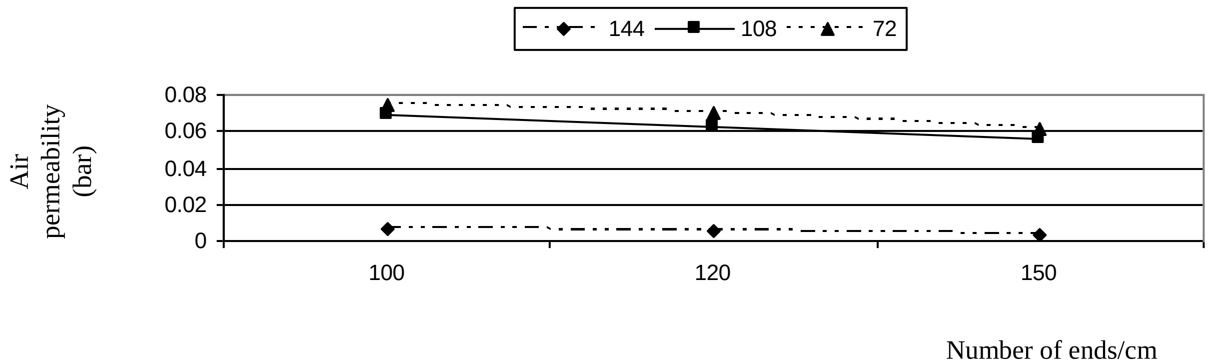

Fig (8)
The effect of number of ends and picks /cm on air permeability for produced vascular samples

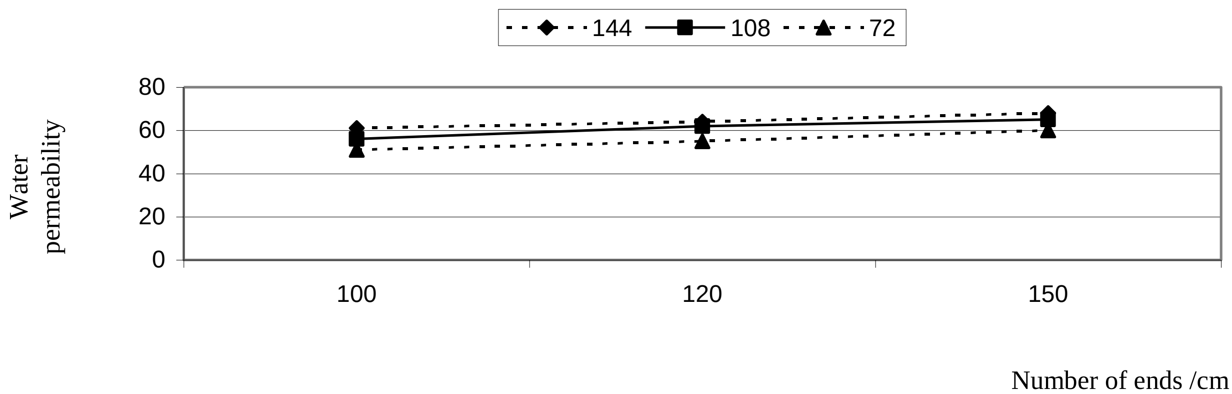

Fig (9)
Effect of number of picks /cm and /cm ends on water permeability for vasculars, at 100 ends /cm

Table (14) regression equation and correlation coefficient for the effect of number of picks per cm and fabric structure on air permeability, at Lycra 60 dtex ,at regular hopsack 2/2.

Number of picks /cm	Regression equation	Correlation coefficient
72	Y = -1.00026 X + 0.100789	0.99643
108	Y = -0.00025 X + 0.99474	0.99975
144	Y = 0.993399X + 0.00005	0.993399

Table (15) regression equation and correlation coefficient for the effect of number of picks per cm and fabric structure on water permeability, at Lycra 60 dtex ,at regular hopsack 2/2.

Number of picks /cm	Regression equation	Correlation coefficient
72	Y = 0.178947 X + 33.26316	0.999466
108	Y = 0.173684 X + 39.578	0.998705
144	Y = 0.139947X + 47.131	0.999466

Table (16) the results of thickness and weight tests applied to woven vasculars, using Lycra 60 dtex.

Property	Thickness (mm)			Weight (g/m^2)		
Weft set / Warp set	٧٢	١٠٨	**144**	٧٢	١٠٨	**144**
100	٠.٤١	٠.٤٦	٠.٥٥	١٩٨.٥	٢٤٥.٧	٢٩٣.٤
120	٠.٥٣	٠.٥٨	٠.٥٧	٢٢٥.٦	٢٦٧.٥	٣١٣.٨
150	٠.٥٥	٠.٦٠	٠.٧٠	٢٥٠.٤	٢٩٨.٨	٣٤٥.٦

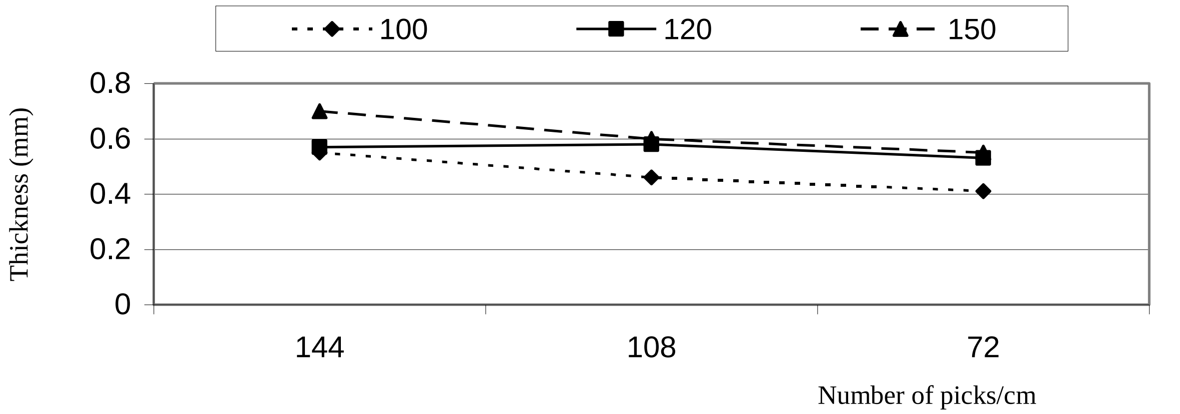

Fig (10)

Effect of number of picks /cm and ends on thickness for vasculars samples

Table (17) regression equation and correlation coefficient for the effect of number of picks per cm and ends on thickness

Number of picks /cm	Regression equation	Correlation coefficient
72	Y = 0.002632 X + 0.172105	0.874639
108	Y = 0.002632X + 0.222105	0.874639
144	Y = 0.0031057X + 0.22368	0.959508

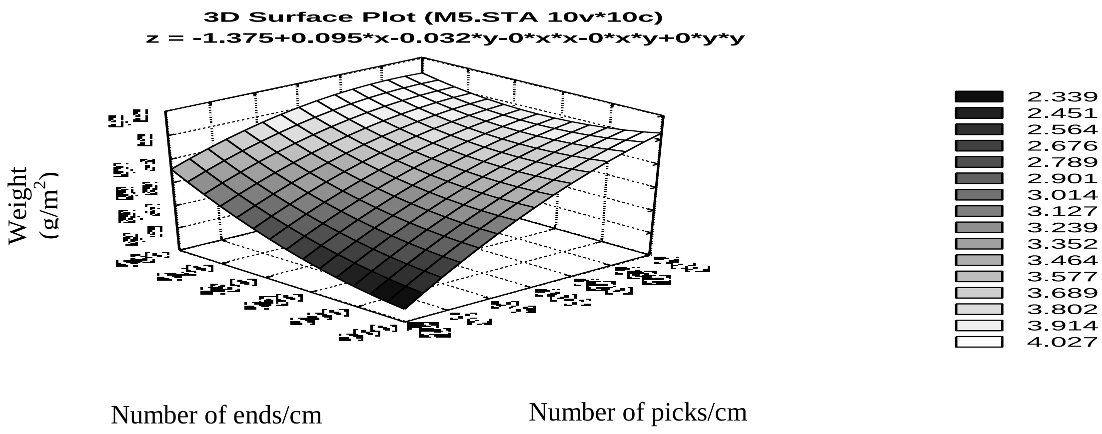

Fig (11)
Effect of number of picks /cm and /cm ends on weight for vasculars samples

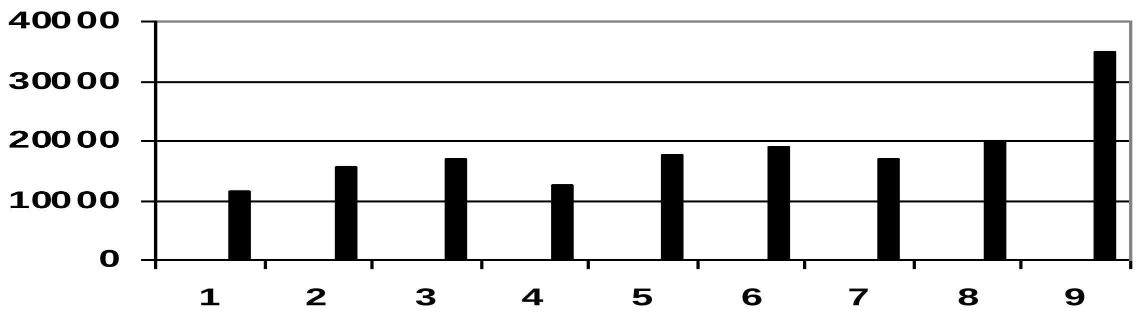

Fig (12)
Determination of ideal vasculars samples by radar analysis

Through this research, it was reached to the following results

Air permeability

. It is clear from the diagrams (1) to (6) that irregular hopsack 2/1 has obtained the highest rates of thermal isolation, whereas twill 1/2 has obtained the lowest rates but the difference is insignificant.

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

Water permeability

It seen from the tables (3-4) that the regular hopsack 2/2 have obtained the highest rates of water permeability , followed by twill 1/3 and then satin weave

.This is for sack of the increase of the number of intersections per cm for the hopsack 2/2 weave which cause increasing of the air spaces in the fabric .so air spaces in the fabric will be increasing causing increasing in the water permeability .

It seen from the table (4) that the more densities the warp &the weft get , the lower water permeability the samples become. This is for sake of that because of the increasing number of ends & picks, which prevent the passage of water.

Thickness

It seen from the tables (5-6) that the more densities the warp &the weft get , the higher thickness the samples become.

It seen from the table (7) that the regular hopsack 2/2 have achieved the highest rates of thickness , followed by twill 1/3 and then satin weave. I can report that the regular hopsack 2/2 have more intersections than twill and satin, which given it the advantage of having ridges on fabric surface giving regular hopsack 2/2 weave the ability of being thicker than the other structures.

Weight

It seen from the table (7) that the regular hopsack 2/2 have achieved the highest rates of weight , followed by twill 1/3 and then satin weave. I can report that the regular hopsack 2/2 have more intersections than twill and satin, which given it the advantage of having ridges on fabric surface giving regular hopsack 2/2 weave the ability of being thicker than the other structures.

It also seen from previous results proved that

All samples have achieved the excepted results for end uses , and the sample produced with lycra (60 dtex) covered with polyester for warp and textured polyester denier 70 for weft, 120 ends/cm and 125 picks /cm has achieved the best results.

After treatment

It obvious from the results that All treated samples have prevented air and water from passing through them, and so blood was prevented from passing. An insignificant changes have occurred to the samples after being coated. Where the coating fill the spaces in fabrics

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