Design Fabrics Suitable for Saddle Pad of Horse

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Abstract: Horses are sensitive animal and a poorly fitted saddle will causes the horse pain and eventually back problems leading to poor behavior and performance or resistance to work in competition horses. So the primary purpose of a saddle pad is to facilitate riding comfort for the horse, it eases the connection between the horse's back and the hard surface of the saddle. This research aims to produce fabrics suitable for using as a horse saddle pad. Woven and non woven technique was used to produce 12 samples with triple layers. The non woven (outer layers) was produced by using polyester % (the upper surface) and semi blending between cotton and polyester (the lower surface). Whereas the lowers surface is facing the horse's back and the upper surface is facing the hard surface of the saddle. The non woven layers made of polyester fibers (weight 1000, 650 gm/m2) for each layer having 6 den. and blending between cotton and polyester (weight 1000, 650 gm/m2) for each layer having 2 den. for cotton. Needle punching technique is using 500 beats/ min, depth of needle penetration (10, 12 and 14 mm). The woven layer (inner) was produced form 100% polyester yarns, warp and weft count was (900 den.) and 10 ends/ cm,14 picks/cm) with two weaving structure (regular hopsack 2/2 and twill 1/3). Tests are carried out to evaluate the products samples. The obtained test results are presented and discussed.

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Key words: Hard saddle tree - horse's back-pressure distribution- poor saddle fit- saddle- saddle pad.

1. Introduction:

Horses are sensitive animal and a poorly fitted saddle will cause the horse pain and eventually back problems. A saddle with good fit on the other hand enhance the performance of both the rider and horse.[1]

1.1. The saddle:

The saddle is a supportive structure for a rider or other load, fastened to an animal's back by a girth [2].

Poor saddle fit or improper positioning has been found to cause back pain in many horses, where as the back pain is one of the most common and least under stood clinical problem in horses' sports [3].

As an important cause or aggregator of back pain, badly designed or poorly fitting sad leading to behavior and performance problems, such as decreasing speed on the racetrack or resistance to work in competitions. This poor performance syndrome is the consequence of soft tissue pain and is noticeable along before serious tissue damage occurs [4].

Saddle fit is a difficult term to define and many issues should be taken into consideration to achieve a suitable definition. The saddle tree and its panels have to fit the horse's body shape and back line precisely. The horse's back shape and symmetry were also contributing factors. A saddle that fits well, has even contact with the horse's back and is flocked uniformly is actually more likely to slip than a poorly- fitting saddle [5].

It is thought that the less well fitted areas offer resistance to slipping and help to hold the saddle in place. On the other hand, when the saddle is perfectly fitted, there is no obstruction to prevent it from sliding over the horse's back [6].

However the development of the back muscles change with the age and training level of the horse and so the saddle fit varies with the time.

1.2. Types of horse saddles:

- Dressage saddles: are riding saddles which are specifically designed to be suitable for riding dressage [7].
- Jumping saddles: Riding saddles which are designed for jumping are kind of the other extreme than the dressage riding saddles.
- Hunting saddles: are designed for riders who regularly go fox hunting. The saddle is shaped to push the rider's weight back in the saddle and their feet for wards in the stirrups.
- Racing saddles: are very small, and light weight, rather like horse racing jockeys actually [8].

Saddle pad:

The primary purpose of a saddle pad is to facilitate comfort riding for the horse. It eases the connection between the horse's back and the hard surface of the saddle. A pad can ease minor fit problems by acting as space filler evenly distributing pressure and eliminating high pressure points underneath the saddle. It can also pull moisture away from the horses back, anchor the saddle, and protect it from sweat and dirt [9].

Saddle pads are used widely in riding sport saddle pads come in many varieties and styles, and are made from different materials. Now days they are sold mainly to reduce the pressure underneath the saddle for endurance and jumping sports. Pads are used to create a cushion between saddle and back muscles. A few general points have to be considered when using a saddle pad. The pad should be large enough to fit under the saddle and should not slip to one side during movement. It should be placed evenly with out creating a bulge that can cause aching pressure peaks, it is also very important to choose a pad that is shaped to the withers. If the pad touches too tightly the skin above the dorsal processes of the vertebrae at the withers. It may cause open sores a pain [10].

Besides a saddle pad always has to be fitted together with the saddle, to minimize the risk that the saddle becomes too narrow with the pad. The saddle pad allows the horse to be more comfortable from the hard saddle tree and weight of the rider. Even great riders give some impact on the horses back, especially if that horse is ridden many hours and ridden at fast speeds [11].

1.3. Materials used:

Saddle pads are made from many materials and combination of materials. The most common are made of felt, cotton, wool. This type of saddle pad provides good comfort levels if the saddle fits the horse well. Cotton batting is still a staple of the pad industry in comfort pad. New develop in both foam and gels and treatment for natural fibers have meant that sheepskin and lambskin has had a resurrection in popularity, and foam, gels developed in the medical world have made therapeutic pads available to alter fit [12].

1.4. Shaped saddle pad:

Shaped saddle pads are curved to mimic the shape of the saddle; they are available for jumping all-purpose and dressage saddles.

- **Square saddle pads:** Square pads may have at thin layer of batting or foam on the interior to provide bit of cushioning for the horse. "Square" dressage saddle pad are essentially rectangular in appearance with straight sides to accommodate the longer saddle flaps of dressage saddles.
- **Pillow or comfort pads**: they are filled with polyester batting and quitted for cushiony comfort.
- **Baby pads**: are ultra- thin sheets typically used under heavier saddle pads to keep then clean, the purpose of baby saddle pads is to cut down on having to launder the larger more cumber some pads.
- **Specialty pads**: are designed to solve many problems ranging from saddle fitting issues to reducing equine back pain, heat, trauma and friction. [12].

2. The experimental work:

2.1. Specifications of samples under study:

The present research is concerned with on of such multilayer fabrics which are suitable for saddle pad. Woven and non-woven technique was applied to produce 12 samples with triple layers. The needle felting is a bonding technique was used to bond the layers together. The non woven layers (outer) were produced from polyester (the upper surface) and semi blending between polyester and cotton (the lower surface), the lower surface is facing the horse's back and the upper surface is facing the hard surface of the saddle.

Tables (1) and (2) show the specification of non woven fabrics. The woven layer (inner) was produced from polyester continuous filament yarn of weft and warp by using two differences weave structure (regular hop sack 2/2 and twill weave 1/3). Table (3) shows the specification of woven fabric.

Table (1): Non woven polyester fabric specification (outer layer)

No.	Property	Specification
1	Fiber type	Polyester
2	Fiber count	6 den.
3	Fiber length	64 mm
4	Web formation	C. L. (cross – laid)
5	Fabric weight	1600, 2300 gm/m2
6	Beats/min	500
7	Needle penetration depth (two sides)	10, 12 and 14 mm

Table (2): Non woven semi blending between polyester and cotton fabric specification (outer layer)

No.	Property	Specification	
1	Fiber type	Cotton	Polyester
2	Fiber count	2 den.	6 den.
3	Fiber length	30 mm	64 mm
4	Web formation	C. L. (cross – laid)	
5	Fabric weight	1600, 2300 gm/m^2	
6	Beats/min	500	
7	Needle penetration depth (two sides)	10, 12 and 14 mm	

Table (3): woven fabric specification (inner layer)

No.	Property	Specification
1	Warp type	Polyester filament yarn
2	Weft type	Polyester filament yarn
3	Warp set	10 ends/cm
4	Weft set	14 picks/cm
5	Warp and weft count	900 den
6	Weave structure	Regular hopsack 2/2 and twill weave 1/3

2.2. Tests applied to samples under study:

The experimental tests have been achieved in the weave laboratory the national institute for standards in Haram, Giza in a standard environment (relative moisture: 65±2, temperature 20C ±2).

In order to evaluate the performance properties of the produced samples, the following tests were carried out.

1- Tensile strength and elongation at break in both directions was determined in accordance with (ASTM-D 4595-83) by using tensile testing machine – tinius olsen –SDLATLATLAS, model h5 kt.
2- Tear resistance was determined in accordance with (ASTM-D 4533-82) by using tensile machine –tinius olsen- SDLATLATLAS, model H5K T.
3- Fabric abrasion resistance was determined in accordance with their lost of weight (%) after 500 cycle accordance with (ASTM-D 4158-79) by using RUB tester –computext- Budapest.
4- Fabric compression force measurements in accordance with their lost of thickness (%) accordance with (ASTM–D 3574-03).
5- Fabric air permeability measurements in accordance (ASTM-D 737) using TEXTEST FX 3300 air permeability tester at a pressure of 120 pa.
6- Fabric absorptive capacity and absorbency time was determined in accordance with (ASTM –D 1117-80).
7- Fabric thickness this test was carried out according to the (ASTM-D -1777-1996).

3. Results and discussion

3.1. Tensile strength at break:

Table (4): Tensile strength measurements results in both directions

Tensile strength kg/cm^2								
Layer type	Triple layers (NWN) with regular hopsack 2/2				Triple layers (NWN) with twill weave 1/3			
Weight	1600 gm/m^2		2300 gm/m^2		1600 gm/m^2		2300 gm/m^2	
Direction / Needles penetration	Length	Width	Length	Width	Length	Width	Length	Width
10 mm	258.6	240.4	336.5	316.3	245.7	228.9	324.4	304.6
12 mm	264.5	246.7	343.4	322.5	251.8	233.7	333.8	311.4
14 mm	270.3	252	348.3	328.6	258.4	239.8	343.2	318.8

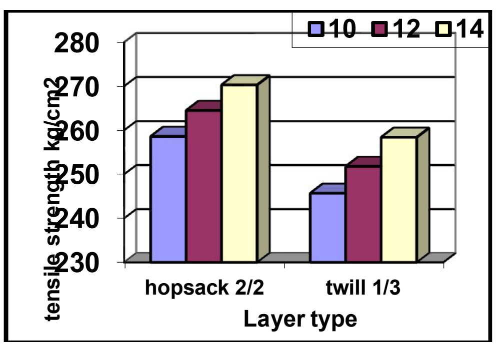

Fig. (1): Effect of layer type and needle penetration depth mm on the tensile strength at break in the length direction at weight 1600 gm/m^2

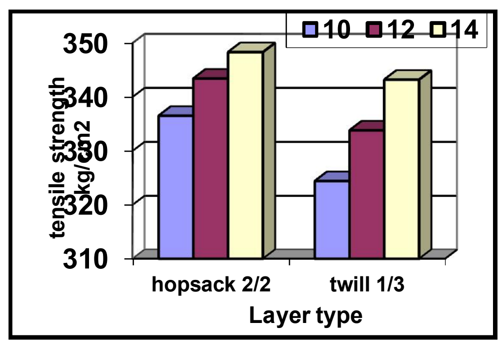

Fig. (2): Effect of layer type and needle penetration depth mm on the tensile strength at break in the length direction at weight 2300 gm/m^2

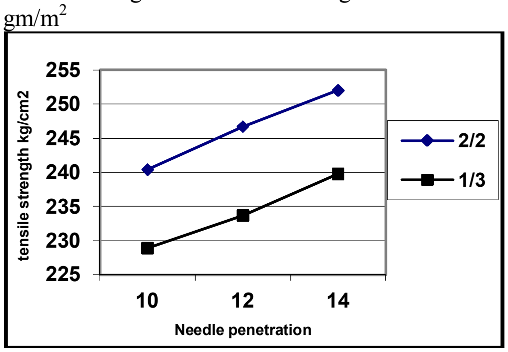

Fig. (3) Effect of layer type and needle penetration depth mm on the tensile strength at break in the width direction at weight 1600 gm/m^2

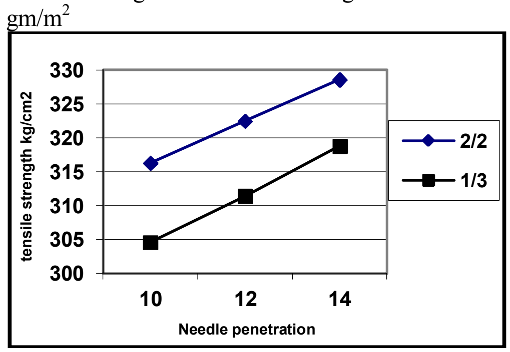

Fig. (4) Effect of layer type and needle penetration depth mm on the tensile strength at break in the width direction at weight 2300 gm/m^2

Table (5): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the tensile strength (kg/cm^2) in the width direction at weight 1600 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 2.9 X + 211.567	0.9988
twill weave 1/3	Y = 2.725 X + 201.433	0.9976

Table (6): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the tensile strength (kg/cm^2) in the width direction at weight 2300 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 3.075 X + 285.567	0.9999
twill weave 1/3	Y = 3.55 X + 269	0.9997

3.1.1. Effect of the fabric weight outer layers on the tensile strength at break in both directions:

It is clear from table (4) and figs. (1), (2), (3) and (4) which is concerned with testing the fabric produced for the present study that there is a directly proportional relation between the fabric weight and the tensile strength at break in both direction for all the samples under study. This is due to that the increase in weight means an increase in number of fibers per unit area in all contained layers leading to the increase in contact area between fibers and the layer number of fibers contribute to the resistance against tensile.

3.1.2. Effect of the weave structure (inner layer) on the tensile strength at break in both directions:

It is clear from table (4) and figs. (1), (2), (3) and (4) that the samples of regular hopsack 2/2 is the higher tensile strength than the samples of twill weave 1/3 this can be explained as that an increasing the number of intersections per unit lead to increase the merging of yarns and weft in the fabrics. And hence, increasing in resistance against tearing.

3.1.3. Effect of the needles penetration depth on the tensile strength at break in both directions:

It is clear from table (4) and figs. (1), (2), (3) and (4) that there is direct proportionality between the needles penetration depth and tensile strength this can be explained that the increasing in needles penetration depth lead to increase the merging between the fibers and yarns, and hence fabric to be more compacted to the resistance against tensile.

3.2. Elongation at break:

Table (7): Fabric elongation at break measurements results in both directions

Elongation at break %								
Layer type	Triple layers (NWN) with regular hopsack 2/2				Triple layers (NWN) with twill weave 1/3			
Weight	1600 gm/m^2		2300 gm/m^2		1600 gm/m^2		2300 gm/m^2	
Direction / Needles penetration	Length	Width	Length	Width	Length	Width	Length	Width
10 mm	27.4	24.8	34.8	31.5	24.8	22.1	32.4	29.1
12 mm	29.6	26.7	36.7	33.8	26.7	23.9	34.6	31.3
14 mm	32.2	29.2	39.4	36.4	28.9	26.5	37.2	33.4

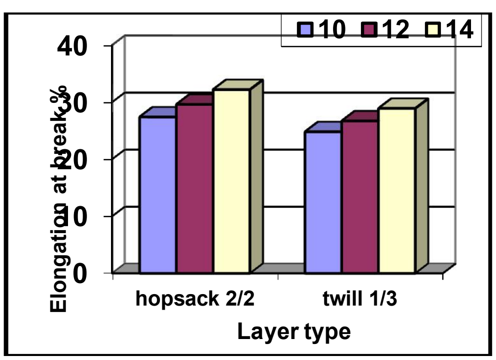

Fig. (5): Effect of layer type and needle penetration depth mm on the elongation at break % in the length direction at weight 1600 gm/m^2

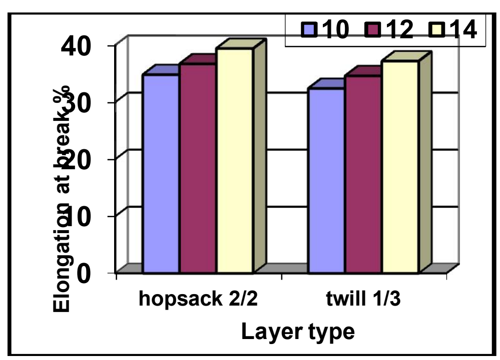

Fig. (6): Effect of layer type and needle penetration depth mm on the elongation at break % in the length direction at weight 2300 gm/m^2

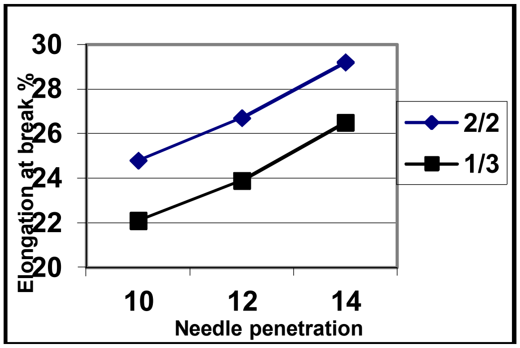

Fig. (7): Effect of layer type and needle penetration depth mm on the elongation at break % in the width direction at weight 1600 gm/m^2

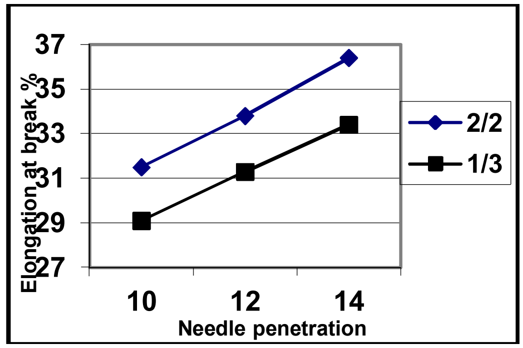

Fig. (8): Effect of layer type and needle penetration depth mm on the elongation at break % in the width direction at weight 2300 gm/m^2

Table (8): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the elongation at break % in the width direction at weight 1600 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 1.1 X + 13.7	0.9969
twill weave 1/3	Y = 1.1 X + 10.9667	0.9945

Table (9): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the elongation at break % in the width direction at weight 2300 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 1.225 X + 19.2	0.9994
twill weave 1/3	Y = 1.075 X + 18.3667	0.9999

3.2.1. Effect of the fabric weight (outer layers) on the elongation at break in both directions:

It is clear from table (7) and figs. (5), (6), (7) and (8) that there is a directly proportional relation between the fabric weight and the elongation at break in both directions far all the samples. This is due to that the increase in weight mean an increase in number of fibers per unit area in all contained layers leading to the increase in contact area between the fibers and hence increase the number of fibers exposed to elongation and there by more elongation for all the fabrics.

3.2.2. Effect of the weave structure (inner layer) on the elongation at break in both directions:

It is clear from table (7) and figs. (5), (6), (7) and (8) that the samples with regular hopsack 2/2 is the higher elongation than the samples of twill weave 1/3 this can be explained as that an increasing the number of intersection per unit lead to increase the merging of yarns and weft which exposed to elongation and there by more elongation in both direction.

3.2.3. Effect of the needles penetration depth on the elongation at break in both directions:

It is clear from table (7) and figs. (5), (6), (7) and (8) that there is direct proportionality between the needles penetration depth and elongation at break this can be explained that the increasing in needles penetration depth lead to increase the merging between the fibers and yarns and hence fabrics to be more compacted and more elongation.

3.3. Fabric tear resistance:

Table (10): Fabric tear resistance measurements results in both directions

Tear resistance (kg)								
Layer type	Triple layers (NWN) with regular hopsack 2/2				Triple layers (NWN) with twill weave 1/3			
Weight gm/m^2	1600 gm/m^2		2300 gm/m^2		1600 gm/m^2		2300 gm/m^2	
Direction / Needles penetration	Length	Width	Length	Width	Length	Width	Length	Width
10 mm	26.8	22.4	44.5	40.2	24.2	20.3	42.8	38.3
12 mm	28.9	24.8	46.6	42.3	26.4	22.5	45.1	40.4
14 mm	31.2	27.2	48.8	44.5	28.6	24.7	47.2	42.6

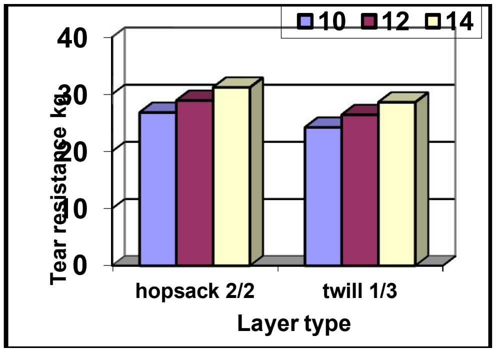

Fig. (9): Effect of layer type and needle penetration depth mm on the tear resistance kg in the length direction at weight 1600 gm/m^2

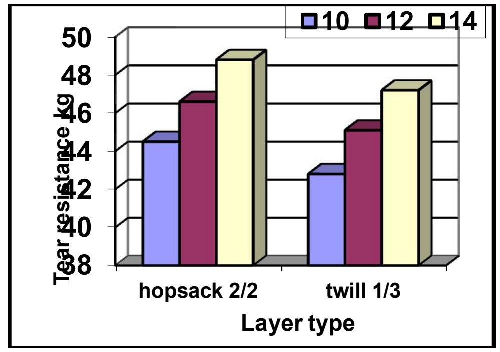

Fig. (10): Effect of layer type and needle penetration depth mm on the tear resistance kg in the length direction at weight 2300 gm/m^2

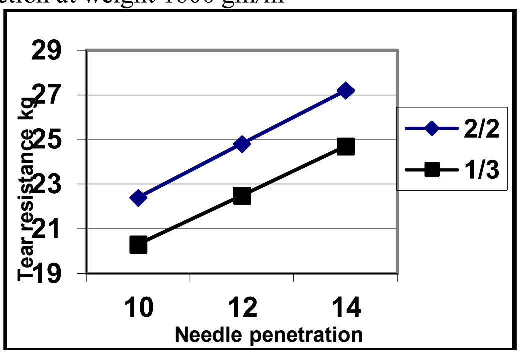

Fig. (11): Effect of layer type and needle penetration depth mm on the tear resistance kg in the width direction at weight 1600 gm/m^2

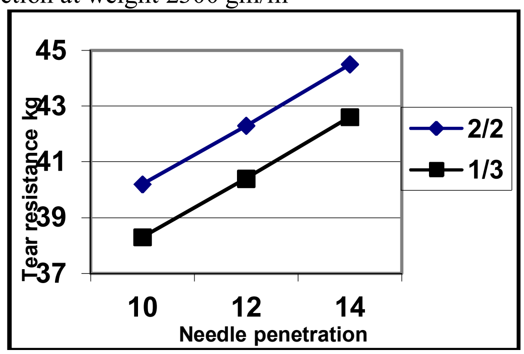

Fig. (12): Effect of layer type and needle penetration depth mm on the tear resistance kg in the width direction at weight 2300 gm/m^2

Table (11): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the tear resistance kg in the width direction at weight 1600 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 1.2 X + 10.4	1
twill weave 1/3	Y = 1.1 X + 9.3	1

Table (12): Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the tear resistance kg in the width direction at weight 2300 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = 1.075 X + 29.4333	0.9999
twill weave 1/3	Y = 1.075 X + 27.5333	0.9999

3.3.1. Effect of the fabric weight (outer layers) on the tear resistance in both directions:

It is clear from table (10) and figs. (9), (10), (11) and (12) that there is a directly proportional relation between the fabric weight and the tear resistance in both directions. This is due to that the increase in weight means an increase in number of fibers per unit area in all contained layers leading to the increase in contact area between fibers and the larger number of fibers contributes to the resistance against tearing.

3.3.2. Effect of the weave structure (inner layer) on the tear resistance in both directions:

It is clear from table (10) and figs. (9), (10), (11) and (12) that the samples of regular hopsack is higher tear resistance that the samples of twill weave can be explained as that an increasing the number of intersection per unit lead to increase the merging of yarns and weft in the fabrics and hence increasing in resistance against tearing.

3.3.3. Effect of the needles penetration depth on the tear resistance in both directions:

It is clear from table (10) and figs. (9), (10), (11) and (12) that there is a direct proportionality between the needles penetration depth and the tear resistance this can be explained that the increasing in needles penetration depth leads to the fibers become more near one there and increase the merging between the fibers and yarns, which result in increasing the tear resistance.

3.4. Fabric abrasion:

Table (13): Fabric abrasion resistance measurements results

abrasion resistance (lost of weight ratio %) at 2000 cycle								
Layer type	Triple layers (NWN) with regular hopsack 2/2				Triple layers (NWN) with twill weave 1/3			
Weight gm/m^2	1600 gm/m^2		2300 gm/m^2		1600 gm/m^2		2300 gm/m^2	
Surface type / Needles penetration	The upper surface polyester	The lower surface polyester + cotton	The upper surface polyester	The lower surface polyester + cotton	The upper surface polyester	The lower surface polyester + cotton	The upper surface polyester	The lower surface polyester + cotton
10 mm	14.42	14.92	14.28	14.73	14.51	15.04	14.37	14.86
12 mm	14.19	14.65	13.93	14.48	14.32	14.78	14.16	14.64
14 mm	13.96	14.34	13.81	14.32	14.18	14.49	14.03	14.43

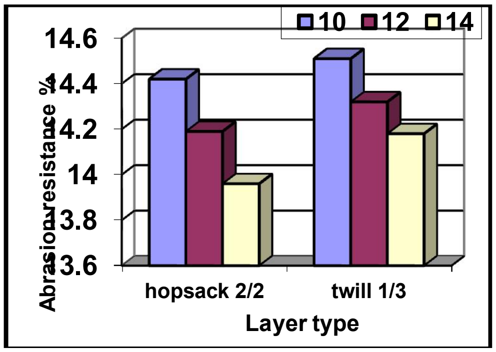

Fig. (13) **:**Effect of layer type and needle penetration depth mm on the abrasion resistance % for the upper surface polyester at weight 1600 gm/m^2

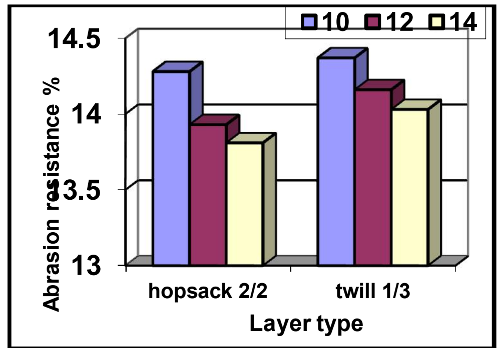

Fig. (14) **:**Effect of layer type and needle penetration depth mm on the abrasion resistance % for the upper surface polyester at weight 2300 gm/m^2

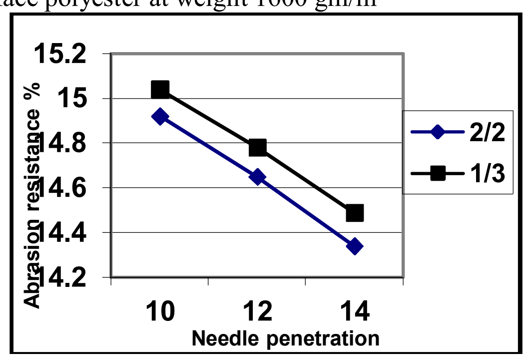

Fig. (15)**:** Effect of layer type and needle penetration depth mm on the abrasion resistance % for the lower surface polyester + cotton at weight 1600 gm/m^2

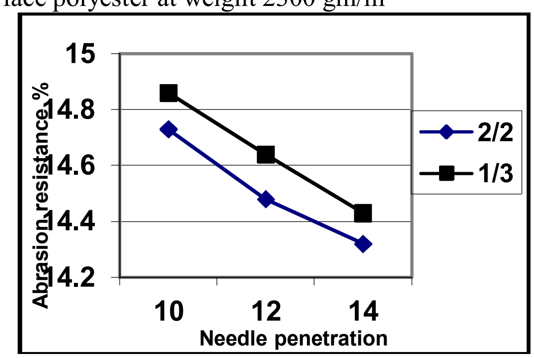

Fig. (16)**:** Effect of layer type and needle penetration depth mm on the abrasion resistance % for the lower surface polyester + cotton at weight 2300 gm/m^2

Table (14) :Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the abrasion resistance % at weight 1600 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = - 0.145 X + 16.3767	- 0.9992
twill weave 1/3	Y = - 0.1375 X + 16.42	- 0.9995

Table (15) :Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of weave structure on the abrasion resistance % at weight 2300 gm/m^2

Layer type	Regression equation	Correlation coefficient
regular hopsack 2/2	Y = - 0.1025 X + 15.74	- 0.9921
twill weave 1/3	Y = - 0.1075 X + 15.9333	- 0.9999

3.4.1. Effect of surface types (outer layers) on the abrasion resistance:

It is clear from table (13) and figs. (13), (14), (15) and (16) that the upper surface (polyester %) is the higher abrasion resistance than the lower surface (polyester + cotton) this can be explained that the polyester is abrasion resistance than the cotton. It can be seen from table (7) and figs. (13), (14), (15) and (16) the fabrics have the highest weight are abrasion resistance than the fabrics have the lowest weight but the difference were insignificant.

3.4.2. Effect of the needle penetration depth on the fabric abrasion resistance:

It is clear from table (13) and figs. (13), (14), (15) and (16) that there is a direct proportionality between the needles penetration depth and the abrasion resistance this can be explained that the increasing in needles penetration depth causes greatest fibers entanglement because needles penetration cause fibers to be reoriented and so increasing the contact areas between the horizontal and vertical level structure increasing fabric abrasion resistance.

3.5. Fabric compression force (lost of thickness rat 10%):

Table (16): Fabric compression force measurements results

Compression force kg/cm² (lost of thickness ratio %)																					
Layer type		Triple layers (NWN) with regular hopsack 2/2										Triple layers (NWN) with twill weave 1/3									
Weight		1600 gm/m²					2300 gm/m²					1600 gm/m²					2300 gm/m²				
Lost of thickness		10%	20%	30%	40%	50%	10%	20%	30%	40%	50%	10%	20%	30%	40%	50%	10%	20%	30%	40%	50%
Needles penetration depth mm	10	0.29	0.79	1.61	3.13	6.54	0.33	0.90	1.73	3.24	6.71	0.25	0.71	1.53	3.03	6.39	0.30	0.85	1.66	3.16	6.61
	12	0.36	0.84	1.70	3.22	6.63	0.40	0.97	1.82	3.31	6.82	0.31	0.78	1.59	3.12	6.48	0.36	0.90	1.72	3.23	6.69
	14	0.42	0.89	1.78	3.32	6.75	0.48	1.05	1.89	3.38	6.92	0.37	0.84	1.65	3.21	6.56	0.43	1.095	1.80	3.30	6.76

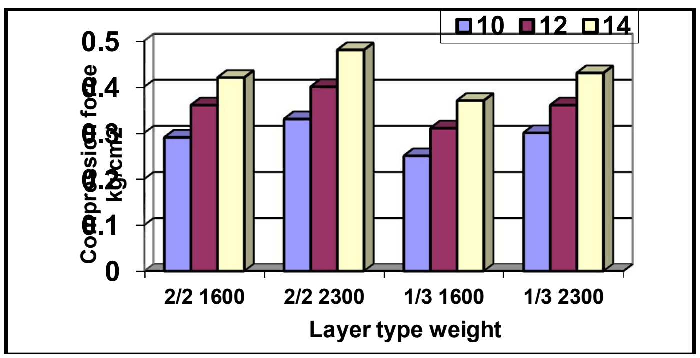

Fig. (17) Effect of layer type's weight and needle penetration depth mm on the compression force kg/cm² at 10% lost of thickness

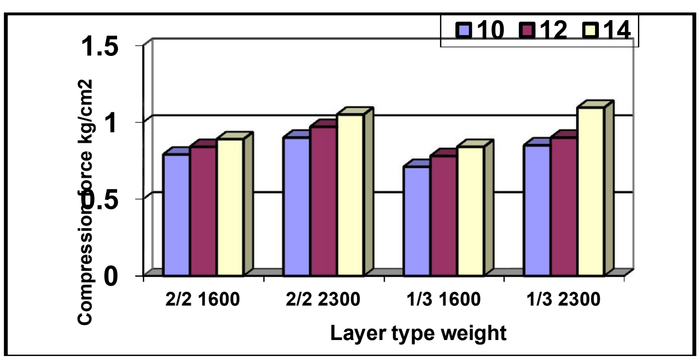

Fig. (18) Effect of layer type's weight and needle penetration depth mm on the compression force kg/cm² at 20% lost of thickness

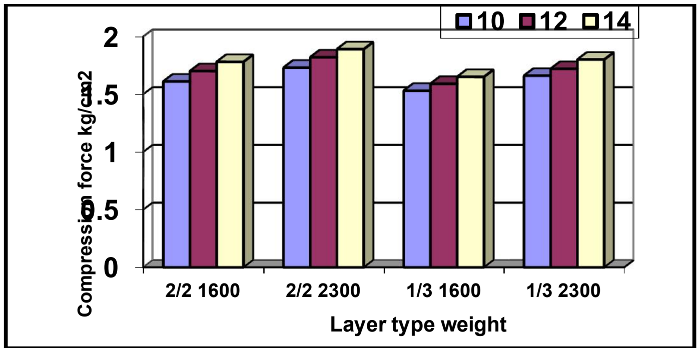

Fig. (19) :Effect of layer type's weight and needle penetration depth mm on the compression force kg/cm^2 at 30% lost of thickness

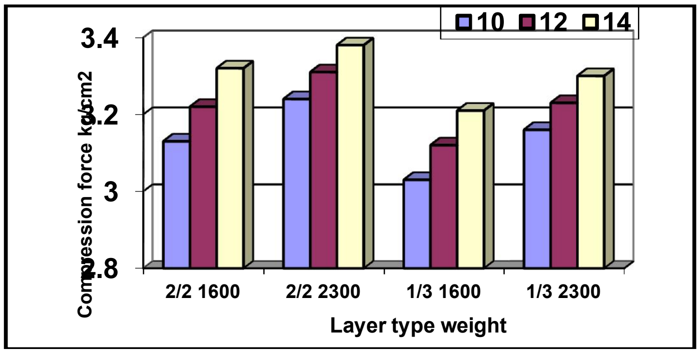

Fig. (20) :Effect of layer type's weight and needle penetration depth mm on the compression force kg/cm^2 at 40% lost of thickness

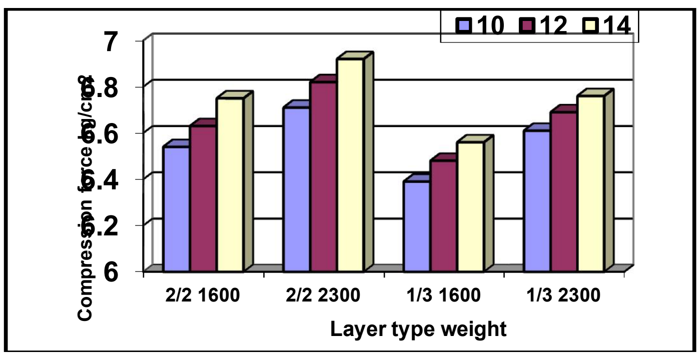

Fig. (21) Effect of layer type's weight and needle penetration depth mm on the compression force kg/cm^2 at 50% lost of thickness

3.5.1. Effect of the fabric weight on the fabric compression force:

It is clear from table (16) and fig. (17), (18), (19), (20) and (21) that the increasing in fabric weight leads to increasing in more compression force which used to decrease the fabric thickness this can be explained that the increase in weight means an increase in number of fibers per unit area in all contained layers leading to the increase in contact area between fibers and the larger number of fibers contribute to the resistance against compression force and hence decrease in the lost of thickness. It can be seen from table (8) and fig. (17), (18), (19), (20) and (21) that the samples of regular hopsack in inner layer have higher compression force resistance than the twill weave this can be explained as that an increasing the number of intersections per unit area lead to increase the merging of yarns and weft and decrease the spaces between the yarns in the fabric and hence increase in resistance against compression force.

3.5.2. Effect of the needles penetration depth on the fabric compression force:

It is clear from table (16) and fig. (17), (18), (19), (20) and (21) that the increasing in needles penetration leads to increasing in more compression force which used to decrease the fabric thickness this can be explained that increase in needles penetration depth cause fibers to be reoriented and so increasing the contact between the horizontal and vertical level structure increasing fabric compactness and decreases the spaces between fibers leading to increase in resistance against compression force and hence decreasing in the lost of thickness.

3.6. Fabric air permeability:

Table (17): Fabric air permeability measurements results

Fabric air permeability $cm^3/cm^2/sec$.					
Layer type		Triple layers (NWN) with regular hopsack 2/2		Triple layers (NWN) with twill weave 1/3	
Weight		1600 gm/m^2	2300 gm/m^2	1600 gm/m^2	2300 gm/m^2
Needles penetration depth mm	10	22.1	19.4	23.2	20.8
	12	20.8	17.5	21.8	18.4
	14	19.4	16.8	20.3	17.3

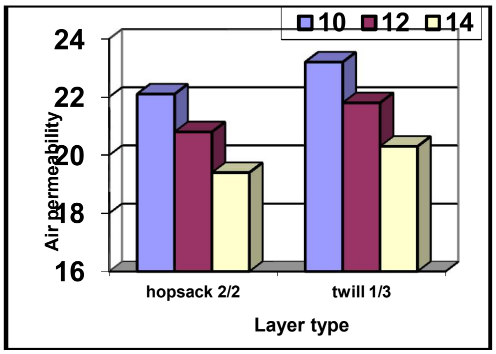

Fig. (22) :Effect of layer type and needle penetration depth mm on the air permeability $cm^3/cm^2/sec$ for the upper surface polyester at weight 1600 gm/m^2

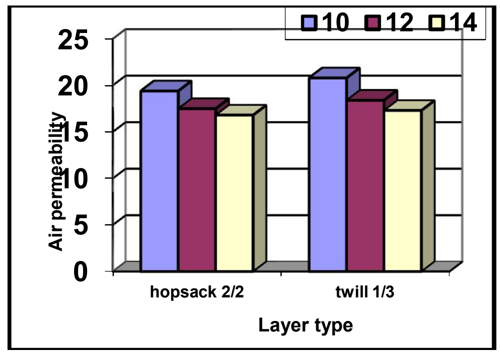

Fig. (23) :Effect of layer type and needle penetration depth mm on the air permeability $cm^3/cm^2/sec$ for the upper surface polyester at weight 2300 gm/m^2

3.6.1. Effect of the fabric weight on the air permeability:

It is clear from table (17) and fig (22) and (23) that there is an inversely proportional relation between the fabric weight and the air permeability this can be explained that the increase in weight means increasing in fibers per unit area and the more compression of the fibers leading to decreasing in pore size between the fibers and hence decrease the air permeability. It can be seen from table (17) and fig (22) and (23) that the samples of twill weave in the inner layer have scored the higher air permeability than the samples of regular hop sack this can be explained that the twill weave has less intersection than the regular hop sack and the less the number of intersection per unit area the less the compression of the yarns and hence the more the air permeability, but the difference was insignificant.

3.6.2. Effect of the needles penetration depth on the fabric air permeability:

It is clear from table (17) and fig (22) and (23) that there is an inversely proportional relation between the needles penetration depth and the fabric air permeability this can be attributed to the increase in needles penetration depth cause fibers to be reoriented and so increasing the contact between the horizontal and vertical level structure increasing fabric compactness and decreases the spaces between fibers leading to the decrease of fabric air permeability.

3.7. Fabric absorptive capacity and absorbency time:

Table (18): Fabric absorptive capacity and absorbency time measurements results

Absorbency % (at 10 sec.)					
Layer type		Triple layers (NWN) with regular hopsack 2/2		Triple layers (NWN) with twill weave 1/3	
Weight		1600 gm/m^2	2300 gm/m^2	1600 gm/m^2	2300 gm/m^2
Needles penetration depth mm	10	155.8	203.4	161.6	207.7
	12	147.1	197.2	152.9	200.5
	14	137.1	186.1	142.8	191.8

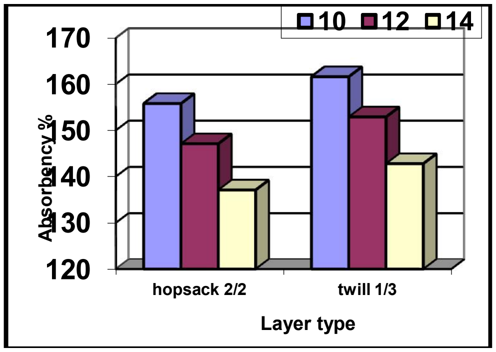

Fig. (24) :Effect of layer type and needle penetration depth mm on the absorbency % for the upper surface polyester at weight 1600 gm/m^2

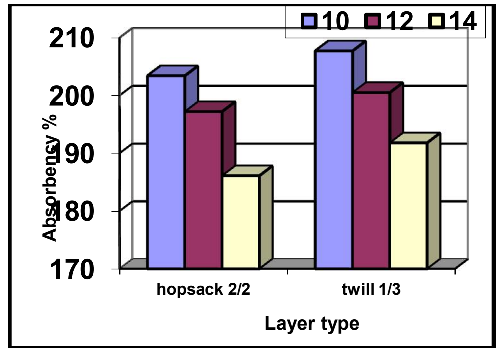

Fig. (25) :Effect of layer type and needle penetration depth mm on the absorbency % for the upper surface polyester at weight 2300 gm/m^2

3.7.1. Effect of the fabric weight on the fabric absorptive capacity:

It is clear from table (18) and fig (24) and (25) that there is a directly proportional relation between the fabric weight and the absorbency time this can be explained that the increase in weight means increasing in fibers per unit area the more fibers contribute to the absorption and hence the more the fabric absorbency. It can be seen from table (18) and fig (24) and (25) that the samples of twill weave in the inner layer have scored the higher absorption than the samples of regular hopsack this can be explained that the twill weave has less intersection and hence increasing the space between they are leading to increasing in absorption

3.7.2. Effect of the needles penetration depth on the fabric absorptive capacity:

It is clear from table (18) and fig (24) and (25) that there is an inversely proportional relation between the needles penetration depth and the fabric absorptive capacity this can be attributed to the increase in needles penetration depth cause increasing the merging between the fibers and yarns leads to increasing fabric compactness and decrease the spaces between the fibers and hence decrease of fabric absorptive capacity.

3.8. Fabric thickness measurements results:

Table (19): Fabric thickness measurements results

Fabric thickness					
Layer type		Triple layers (NWN) with regular hopsack 2/2		Triple layers (NWN) with twill weave 1/3	
Weight		1600 gm/m^2	2300 gm/m^2	1600 gm/m^2	2300 gm/m^2
Needles penetration depth mm	10	10.8	14.1	11.2	14.4
	12	10.2	13.7	10.6	13.9
	14	9.5	12.9	9.9	13.3

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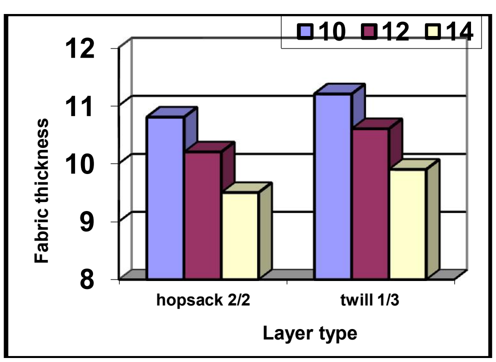

Fig. (26) :Effect of layer type and needle penetration depth mm on the fabric thickness for the upper surface polyester at weight 1600 gm/m^2

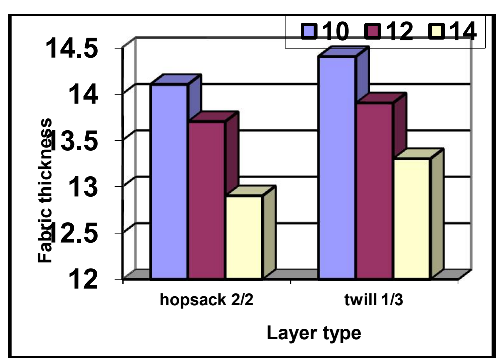

Fig. (27) :Effect of layer type and needle penetration depth mm on the fabric thickness for the upper surface polyester at weight 2300 gm/m^2

3.8.1. Effect of the fabric weight on the thickness of fabric:

It is clear from table (19) and fig (26) and (27) that there is a directly proportional relation between the fabric weight and the thickness this can be attributed to the increase in weight means increase in number of fibers per unit area and so increases samples thickness. It can be seen from table (19) and fig (26) and (27) that the samples of twill weave 1/3 in the inner layer have scored the higher thickness than the samples of regular hopsack 2/2 this can be explained that the regular hop sack has more intersection than the twill weave and the more the number of intersections per unit area the more the compression of the yarns and hence, the less the thickness. But the differences were insignificant.

3.8.2. Effect of the needles penetration depth on the fabric thickness:

It is clear from table (19) and fig (26) and (27) that there is an inversely proportional relation between the needles penetration depth and the fabric thickness this can be attributed to the increase in needles penetration cause fibers to be reoriented and so increasing the contact between the horizontal and vertical level structure increasing fabric compactness and decreases the spaces between fibers leading to the decrease of fabric thickness.

4. Conclusion:

The weight of fabrics and the needle penetration depth have great impacts on the tensile strength, elongation, tear resistance, abrasion resistance, air permeability, absorptive capacity, compression force and thickness.

- Increasing the fabric weight leads to increase the tensile strength, elongation, tear resistance, compression force resistance and thickness and absorptive capacity.
- Increasing the weight of fabric leads to decrease the air permeability.
- Increasing the needles penetration depth lead to increase the tensile strength, elongation, tear resistance compression force resistance and abrasion resistance.
- Increasing the needles penetration depth lead to decrease the air permeability, absorptive capacity and thickness.
- Increasing the fabric weight leads to increase the abrasion resistance but the difference is insignificant.
- The fabric has regular hopsack2/2 (inner layer) has higher tensile strength, elongation, tear resistance, compression force resistance than the twill weave1/3.
- The fabric has twill weave 1/3 (inner layer) has higher air permeability, absorptive capacity and thickness than the regular hopsack 2/2.
- The layers made of polyester have higher abrasion resistance than the layers made of polyester and cotton.
- The fabrics in the length direction recorded the higher results in tensile strength, elongation, and tear resistance than the fabrics in the width direction.

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