Improving the Functional Properties of Endless Felt Blanket Used in Transfer-Printing Machines

Dr. Nahla Fawzy Ahmed
Assistant professor spinning and weaving dept., Faculty of Applied Arts / Helwan University, Egypt

Abstract:

Technical textiles are the textile materials and products manufactured primarily for their technical and performance properties. Endless felt blanket is one of the technical textile which named Nomex endless felt, also called Nomex blanket or sublimation felt. This blanket is a very important part of printing process and has direct effect on printed image quality. The purpose of the sublimation felt is to press the fabric against the printed-paper and both against the heated calendar. The contact between the fabric and the printed paper needs to be long enough, to ensure the transfer of the dyestuffs to the fabric, using high temperatures (up to 230º C / 450º F), or less than 250º C. At the end of usage. The problem of this research is the repetitive exchange for the endless felt blanket on Transfer printing machines due to the long working hours that reaches to 18 Hrs. per day. The continuous rotational motion expose the endless felt blanket to tensile strength , elongation, compression force, abrasion and high temperatures (230)° c . This leads to exchange it every 3 or 4 months which considered tremendous financial cost especially with rapid cost increasing of both Nomix fibers and it's importation cost .

The objective of the paper has been: to produce the nonwoven endless felt blanket suitable for using in the transfer printing machine with high tensile strength, low elongation at break, high abrasion resistance, high compression force resistance, high dimensional stability and high heat resistance, and to produce endless felt blanket with longer consumption period that exceeds 12 months by improving Its properties by supporting the material with 3 or 4 layers of woven instead of 1 or 2 layers.

The obtained test results are presented and discussed. The sample made of 100% Nomix with (3400 g/m² , puncture depth 13 mm) achieved the best results.

Keywords:

Dyestuff
endless felt
Inner scrim
Nomex blanket
sublimation felt
transfer printing

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1. Introduction:

Technical textiles are considered all materials designed for specific applications requiring concrete and demanding properties.(1) Endless felt blanket is one of the technical textile which named: Nomex . Endless felt or Nomex blanket . This blanket is very important part of printing process and has direct affect of printed image quality.

Statement of the Problem:

The problem of this research is the repetitive exchange for the endless felt blanket on Transfer printing machines due to the long working hours that reaches to 18 Hrs. per day. The continuous rotational motion expose the endless felt blanket to tensile strength , elongation, compression force, abrasion and high temperatures (230)° c . This leads to exchange it every 3 or 4 months which considered tremendous financial cost especially with rapid cost increasing of both Nomix fibers and it's importation cost **.**

Aim of Study:

1- to produce the nonwoven endless felt blanket suitable for using in the transfer printing machine with high tensile strength, low elongation at break, high abrasion resistance, high compression force resistance, high dimensional stability and high heat resistance.
1. to produce endless felt blanket with longer consumption period that exceeds 12 months by improving Its properties by supporting the material with 3 or 4 layers of woven instead of 1 or 2 layers.

1.1. Transfer printing:

Transfer printing is the common term used to describe the printing of fabrics with a pattern or that is released from a paper by a combination of heat, pressure and dwell time. There are several types of papers used to release a pattern but this article will focus on transfer printing or thermo-printing using sublimely dispersed dyes.

Transfer printing is the term used to describe textile and related printing processes in which the design is the first printed on to a flexible non textile substrate and later transferred by a separate process to a textile. This devious route should be chosen instead of directly printing the fabric. The reasons are largely commercial but, on occasion, technical as well. They are based on the following considerations.

1- Designs may be printed and stored on a relatively cheap and non-bulky substrate such as paper, and printed on to the more expensive textile with rapid response to sales demand.

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2- The production of short-run repeat orders is much easier by transfer processes than it is by direct printing.
3- The design may be applied to the textile with relatively low skill input and low reject rates.
4- Stock volume and storage costs are lower when designs are held on paper rather than on printed textiles.
5- Many complex designs can be produced more easily and accurately in paper than on textiles.(2)

1.2. Sublimation transfer:

This method depends on the use of a volatile dye in the printed design. When the paper is heated the dye is preferentially absorbed from the vapor phase by the textile material with which the heated paper is held in contact. And also it is the process of converting solid dyes into a gas without going through the liquid stage. Heat and pressure are used to infuse colorant into a polymer material (usually polyester).

There are two basic methods for printing with dye sublimation inks, direct and transfer.

This is commercially the most important of the transfer-printing methods in the production of sublimation transfer papers and prints, four factors must be considered:-

- Selection of the paper.
- Printing methods.
- Dyes and inks.
- The mechanism of sublimation transfer.
- Producing transfer prints on both man-made fibers and natural fibers.(3)

1.3. The purpose of a transfer printing machine:

The purpose is to transfer and fix colors from a transfer paper to textile with a heated drum. This sublimation process requires however a regular temperature of the heated drum. Once the requested temperature is reached, sublimation takes place as the transfer paper and the fabric are brought together during their run around the heated roll by the Nomex endless felt.

It can be used for the printing of all kinds of textile fabrics such as:- curtain, cloth, decoration cloth, bedcovers and non woven fabrics made of polyester, nylon, acrylic and blends.

This type of machine has several advantages:

- It does not need much place.
- There is no need of finishing for the printed fabrics.
- The time of process is quite short.
- The machine is easy to maintain.
- It does not need water.
- It does not need solvents.(4)

1.4. Blanket for Transfer printing machines:

The blanket for offset printing is very important part of process of printing and has direct affect of quality of printed image. It has to be constructed to meet very high demands not only to transfer a quality image from the plate to the blanket, but can function at high speeds with different papers.

These blankets have an inner scrim and a surface batt, made of polyamide “Nomex” fibers, to endure the high temperatures of the transfer printing machine cylinders. Such endless blankets, which have a good tracking, show a very smooth surface to avoid any possible marks on the fabrics to be processed and, thanks to a special heat-setting treatment, they run even under tension and do not shrink while in use. Their weight varies according to how they are used.(5)

At the same time, it also has to convey dampening solution evenly, and correct irregularities in thickness in the printing stock.

The most important features that blanket for offset printing must have are:

1.4.1. Tensile Strengths:

Blankets should be tightened around the cylinder with as much force as they need to not move on the run. The reason is the tensile strength, or the ability of the woven fabric to withstand the pull around the cylinder, is extremely strong. The basic idea is to have the blanket stretch as little as possible for two reasons:-

a) The blanket can tip.
b) Blanket height is lost as more torque is applied to the mounted blanket.

1.4.2. Solvent Resistance:

Blanket must resist the tendency to swell, crack or distort when coming in contact with chemicals (inks, dampening solutions …) because this will result with distortion in the image.

1.4.3. Caliper measure: Compressibility:

is the single most important factor influencing dynamic performance on press and print quality. With reference to offset blankets, Compressibility is defined as the volume reduction capacity of a substrate under load. Offset blanket compressibility is a very important factor in the printing process. Having the proper range of compressibility will prevent excessive printing pressures and should help to lengthen the lifetime of the press, blankets and plates. Furthermore, the compressibility factor also allows the blanket to recover sufficiently and quickly after smashes without resulting in distorted print quality.

1.4.4. Surface release:

Typically the smoother a blanket is, the better the image it will reproduce on the paper. The problem is that the smoothness will not release the ink as easily as if it had a rough surface. There must be a balance.

1.4.5. Stretch:

There is usually at least one layer inside the blanket that consists of a sewn fabric. This is the strength of the blanket that holds it together. It is sewn in such a way that the most strength is given to the circumferential property. When tightening the blanket, a certain amount of stretch will occur as these threads pull on one another. However, overdoing it will cause your blanket height to go down and possibly rip the blanket.

1.4.6. Squareness:

Blanket manufacturers will sometimes send blankets that are not completely square, or possibly they were not square to how the fabric was sewn. This will cause major tension and slur problems so always must be a quality check before mounting blankets on sheet feed press.

1.4.7. Blanket surface:

The offset blanket surface structure, profile, and hardness are extremely important and contribute significantly to the printing performance of an offset blanket. Additionally, surface imperfections will certainly cause printing problems; therefore, production standards are set to guarantee the highest quality of printing surface. It is not an easy task to develop a suitable rubber compound for the printing surface of an offset blanket utilized for high quality offset printing. The difficulty is due to the conflicting chemical and mechanical requirements, which can be found during the printing operation.

The blanket surface must exhibit a “dual” personality. The surface rubber compound must have the capacity to take the maximum amount of ink possible from the printing plate without distorting the image and transfer it almost half way around the cylinder to the printing stock. This precise operation must be done at very high circumferential speeds. The tack of the printing surface must remain low in order to ensure a minimum build-up of paper dust, dirt and ink.(6)

1.5. Nomex Felt:

Nomex felt is used on a heat transfer-printing calendar. Synthetic fabrics are usually printed on this calendar using high temperatures (up to 230ºC / 450ºF) or less than 250ºC at the end of usage, the convergence shrinkage is 2% and the extending rate is 3%.

The blanket belt adopts the imported high-temperature-resistant aramid fabric, and the medium substrate can be divided into two kinds, namely polyester dry net and Kevlar substrate.

The pre-printed paper carries the dyestuffs, which are then sublimated on the fabric using high temperature. The purpose of the sublimation felt is to press the fabric against the printed-paper, both against the heated drum. The contact between the fabric and the printed-paper needs to be long enough to ensure the transfer of the dyestuffs to the fabric. Heat transfer printing is an economical way to print synthetic fabrics.(5)

1.6. Nomex:

Aramids are a family of nylon including Nomex and Kevlar. Chemical structure of Nomex and Kevlar fibers can be described by the common formula in fig (1 and 2).

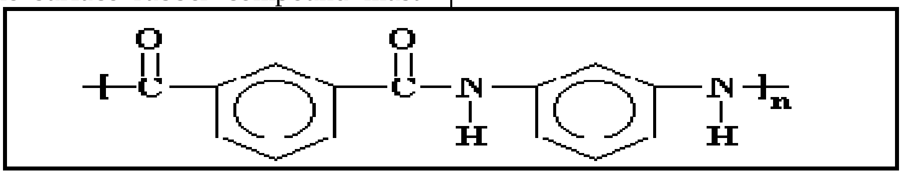

Figure 1: Structure of Nomex fiber

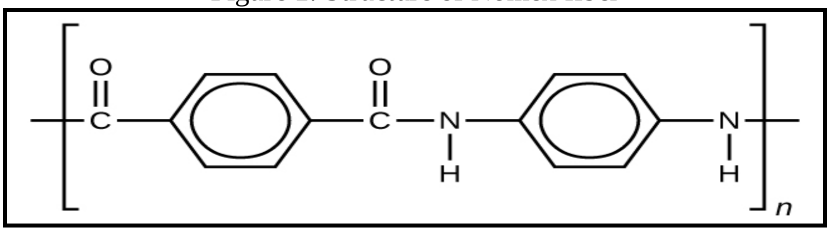

Figure 2: Structure of Kevlar fiber

Nomex is inherently flame resistance and present a high resistance to chemicals and does not dissolve easily. Their applications are focused on the technical sphere. They are usually used in tyre reinforcement, ballistics applications, ropes and cables and in protective apparel where high strength and thermal puncture and cut resistance. Common deniers are (200, 1200, 1600, 2400).(7,8)

Materials and methods:

- Woven and nonwoven technique was used to produce 12 samples. The nonwoven fabrics made of 100% Nomex fibers having (4, 8 den.): of weight (3400 gm/m^2) contains 4 layers of woven Nomex fabric and of weight (3150 gm/m^2) contains 3 layers of woven Nomex fabric. The nonwoven fabrics made of blending between (75% nomex+25% polyester)

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fibers having (3, 6 den. For polyester and 4,8 den. for Nomex), of weight (3400 gm/m^2) contains 4 layers of woven polyester fabrics and of weight (3150gm/m²) contains 3 layers of woven polyester fabrics; needle-punching technique is using 1200 beats/min, penetration depth (9,11, and 13mm).

- The woven layer (inner) was produced from 100% Nomex yarns, warp and weft count was (1200 den.) and (12 ends/cm, 8 picks/cm) with weaving structure (plain weave 1/1). The woven layer (inner) was produced from 100% polyester yarns, warp and weft count was (900 den.) and (14 ends/cm, 10 picks/cm) with weaving structure (plain weave 1/1). Tests are carried out to evaluate the produced samples. The obtained test results are presented and discussed. The sample made of 100% Nomix with (3400 g/m² , puncture depth 13 mm) achieved the best results.

2. Experimental work:

2.1. Materials and methods:

2.1.1. Specifications of samples under study:

The present research is concerned with the non-woven fabrics, which are suitable for using the endless felt for transfer printing machines.

Twelve samples were produced with cross-laid non-woven technique and bonded using needle punching method, using two types of textile materials: Nomex and Polyester. The produced samples pass through the needle punching machine twenty times at 1200 beats/min to decrease the thickness and increase the density with weight remains constant.

Table (1) shows the specifications of non-woven fabrics. The woven layer (inner) was produced from polyester continuous filament yarn of weft and warp and Nomex continuous filament yarn of weft and warp by using weave structure (plain weave 1/1). Table (2) shows the specification of woven fabrics. Whereas the non-woven fabrics that weight 3400 gm/m^2 contain four inner layers of woven fabrics, the non-woven fabrics that weight 3150 gm/m^2 contain three inner layers of woven fabrics.

Furthermore, the non-woven Nomex fabrics contain inner layers of woven Nomex fabrics, and the non-woven (75% Nomex + 25% polyester) fabrics contain inner layers of woven polyester fabrics.

Table (1): Nonwoven fabrics specification (under test)

No.	properties	Specification			
		Nonwoven Nomex fabric		**Nonwoven (75% Nomex + 25% polyester) fabric**	
1	Fiber type	Nomex		75% Nomex + 25% polyester	
2	Fiber length	80 mm		80 mm Nomex + 64, 80mm polyester	
3	Fiber count	4, 8 den.		4,8 den. Nomex + 3,6 den. Polyester	
4	Fabric weight	3400 gm/m² With 4 layers of woven Nomex	3150 gm/m² With 3 layers of woven Nomex	3400 gm/m² With 4 layers of woven polyester	3150 gm/m² With 3 layers of woven polyester
5	Web bonding	Needle punching		Needle punching	
6	Number of beats/min	1200		1200	
7	Puncture depth	9, 11 and 13 mm		9, 11 and 13 mm	
8	Web formation	C.L. (cross- laid)		C.L. (cross- laid)	

Table (2): Woven fabrics specification (inner layer)

No.	**Property**	**Specification**	
		Woven Nomex fabrics	**Woven polyester fabrics**
1	Warp type	Nomex filament yarn	Polyester filament yarn
2	Weft type	Nomex filament yarn	Polyester filament yarn
3	Warp set	12 ends/cm	14 ends/cm
4	Weft set	8 picks/cm	10 picks/cm
5	Warp count	1200 den.	900 den.
6	Weft count	1200 den.	900 den.
7	Weave structure	Plain weave 1/1	Plain weave 1/1

2.1.2. Tests applied to samples under study:

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

1) Tensile strength and elongation at break in both directions.
2) Fabric abrasion resistance was determined in accordance with their lost of weight at 2000 cycle.

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3) Fabric compression force measurements in accordance with their lost of thickness.
4) Fabric thickness test.
5) Dimensional stability: shrinkage of fabric ratio in both directions after a 15 hour exposure at up to 240°C.

3. Results and discussions:

Results of experimental test carried out on the produced samples in the following tables and charts. Results were also statistically analyzed for the date listed and relationships between variables were obtained.

3.1. Tensile strength at break:

Table (3): Tensile strength measurements results in both directions

Tensile strength kg/cm^2									
Fabric type		100% Nomex				75% Nomex + 25% Polyester			
Weight		3400 gm/m^2		3150 gm/m^2		3400 gm/m^2		3150 gm/m^2	
Direction		Length	Width	Length	Width	Length	Width	Length	Width
Puncture depth (mm)	9	656.61	548.4	605.73	499.8	623.81	518.8	565.6	468.5
	11	669.63	557.6	617.15	511.7	634.43	525.3	580.53	477.4
	13	685.74	570.3	632.43	525.6	648.12	536.9	591.31	489.7

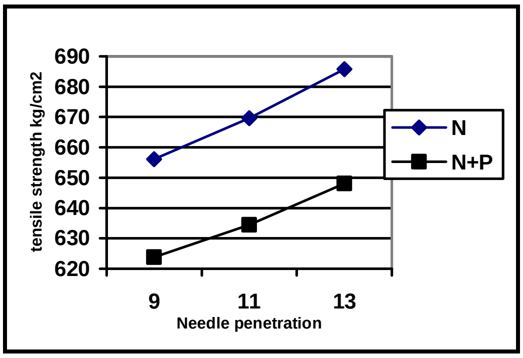

Fig. (1) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the length direction at weight 3400 gm/m^2

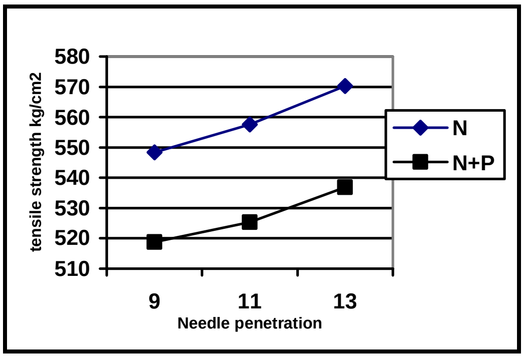

Fig. (2) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the width direction at weight 3400 gm/m^2

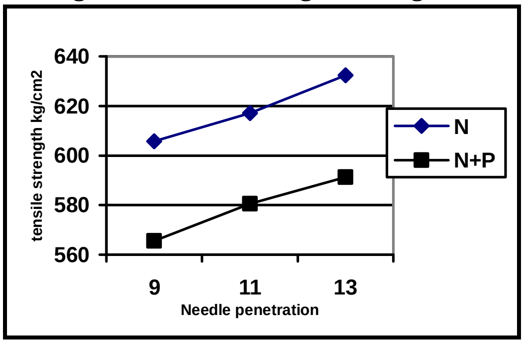

Fig. (3) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the length direction at weight 3150 gm/m^2

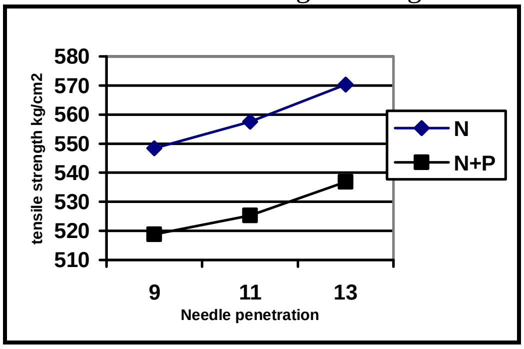

Fig. (4) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the width direction at weight 3150 gm/m^2

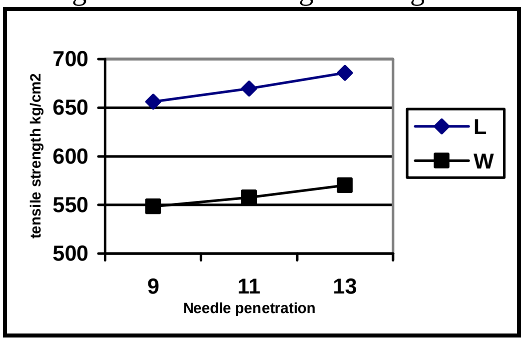

Fig. (5) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the two directions of the fabric type 100% Nomex at weight 3400 gm/m^2

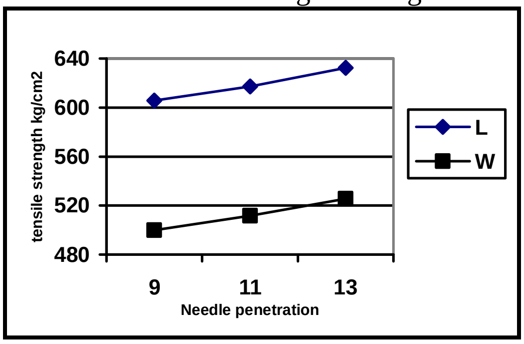

Fig. (6) Effect of fabric type and needle penetration depth mm on the tensile strength at break in the two directions of the fabric type 100% Nomex at weight 3150 gm/m^2

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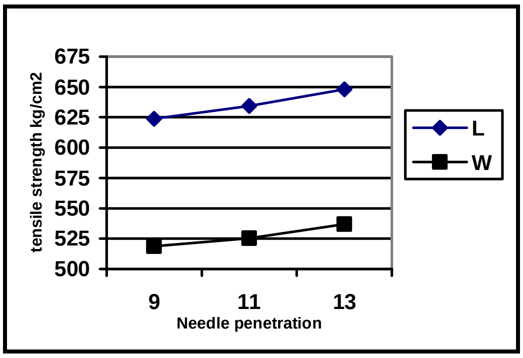

Fig. (7)
Effect of fabric type and needle penetration depth mm on the tensile strength at break in the two directions of the fabric type 75% Nomex + 25% polyester at weight 3400 gm/m^2

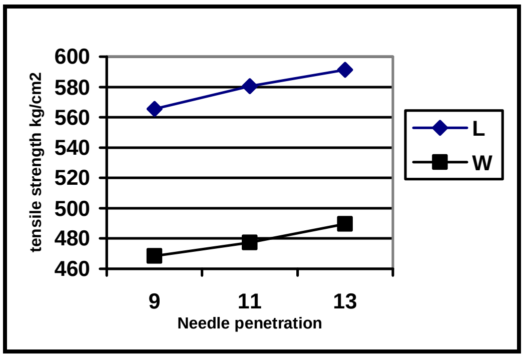

Fig. (8)
Effect of fabric type and needle penetration depth mm on the tensile strength at break in the two directions of the fabric type 75% Nomex + 25% polyester at weight 3150 gm/m^2

Table (4) Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of fabric on the tensile strength (kg/cm^2) in the two directions at different weights

Weight	Direction	Fabric type	Regression equation	Correlation coefficient
3400 gm/m^2	Length	Nomex	Y = 7.41 X + 588.98	0.9987
		Nomex + Polyester	Y = 6.0775 X + 568.601	0.9974
	Width	Nomex	Y = 5.47499 X + 498.542	0.9958
		Nomex + Polyester	Y = 4.52501 X + 477.225	0.9870
3150 gm/m^2	Length	Nomex	Y = 6.675 X + 545.012	0.9965
		Nomex + Polyester	Y = 6.42751 X + 508.444	0.9957
	Width	Nomex	Y = 6.45 X + 441.417	0.9990
		Nomex + Polyester	Y = 5.3 X + 420.233	0.9957

3.1.1. Effect of the fabric type on the tensile strength at break in the both direction:

It is clear from table (3) and figs. (1,2,3,4,5,6,7,8), which is concerned with testing the fabric, produced for the present study that the non-woven Nomex fabrics have higher tensile strength than the non-woven (75% Nomex + 25% polyester) fabrics for all the weights and all the needles penetration depth.

This can be interpreted, as the reason is the difference between properties of materials. (Nomex has higher tensile strength than polyester).

3.1.2. Effect of fabric weight on the tensile strength at break in both directions:

It is clear from table (3) and figs. (1,2,3,4,5,6,7,8) that there is a direct relationship between the fabric weight and samples tensile strength this is due to the increase in fabric weight means an increase in the number of fibers per unit area leading to the increase in contact area between fibers and woven layers, whereupon both fibers and layers contribute to the resistance against tensile for all the fabric types and all the needle penetration depth.

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

It is clear from table (3) and figs. (1,2,3,4,5,6,7,8) that there is direct proportionality between the needles penetration depth and tensile strength of fabrics, this can be explained that the increase in needles penetration depth leads to increase the merging between the fibers and yarns hence, fabric to be more compacted to the resistance against tensile.

3.2. Elongation at break:

Table (5): Fabric elongation at break measurements results in both directions

Elongation at break %									
Fabric type		100% Nomex				75% Nomex + 25% Polyester			
Weight		3400 gm/m^2		3150 gm/m^2		3400 gm/m^2		3150 gm/m^2	
Direction		Length	Width	Length	Width	Length	Width	Length	Width
Puncture depth (mm)	9	7.5	6.6	9.8	7.5	9.6	8.2	11.8	9.4
	11	6.8	5.8	9.3	7.1	8.8	7.4	11.3	8.5
	13	6.4	5.2	8.6	6.3	8.3	6.9	10.6	7.9

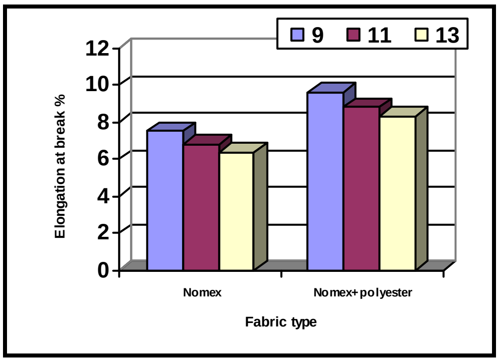

Fig. (9) Effect of fabric type and needle penetration depth mm on the elongation at break % in the length direction at weight 3400 gm/m^2

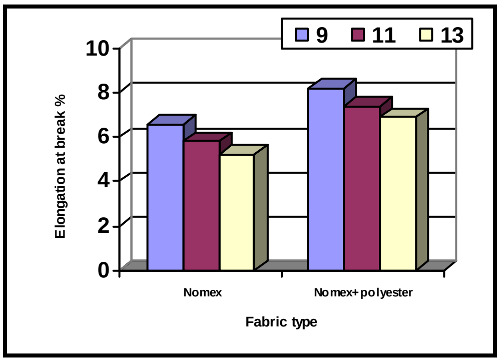

Fig. (10) Effect of fabric type and needle penetration depth mm on the elongation at break % in the width direction at weight 3400 gm/m^2

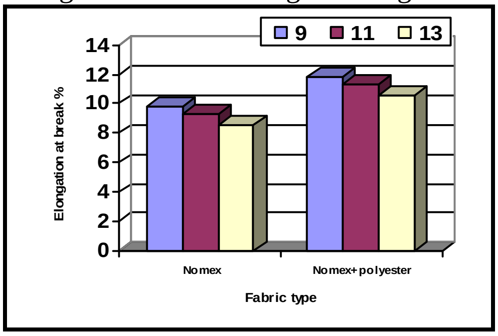

Fig. (11) Effect of fabric type and needle penetration depth mm on the elongation at break % in the length direction at weight 3150 gm/m^2

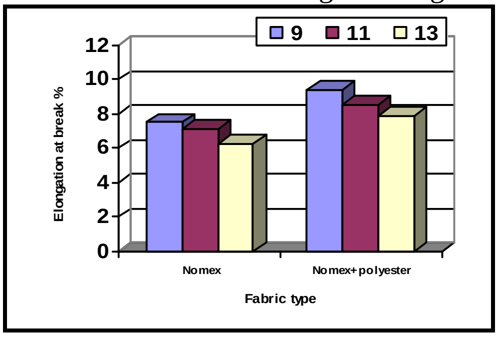

Fig. (12) Effect of fabric type and needle penetration depth mm on the elongation at break % in the width direction at weight 3150 gm/m^2

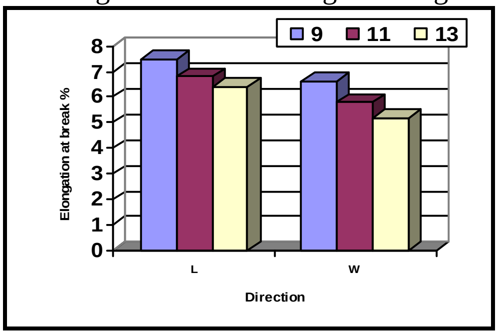

Fig. (13) Effect of fabric type and needle penetration depth mm on the elongation at break % in the two directions of the fabric type 100% Nomex at weight 3400 gm/m^2

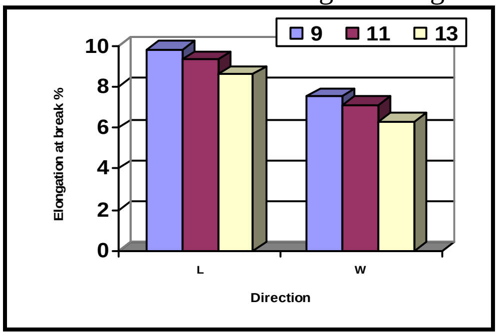

Fig. (14) Effect of fabric type and needle penetration depth mm on the elongation at break % in the width direction of the fabric type 100% Nomex at weight 3150 gm/m^2

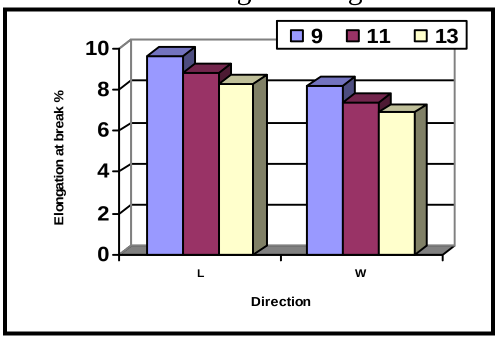

Fig. (15) Effect of fabric type and needle penetration depth mm on the elongation at break % in the two directions of the fabric type 75% Nomex + 25% polyester at weight 3400 gm/m^2

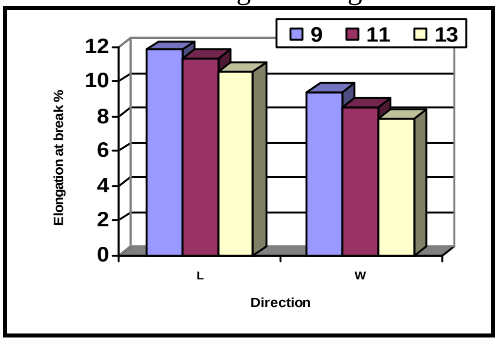

Fig. (16) Effect of fabric type and needle penetration depth mm on the elongation at break % in the two directions of the fabric type 75% Nomex + 25% polyester at weight 3150 gm/m^2

3.2.1. Effect of the fabric type on the elongation at break in both directions:

It is clear from table (5) and figs.(9,10.11,12,13,14,15,16) that the nonwoven(75% Nomex + 25% polyester) fabrics have higher elongation at break than the

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nonwoven Nomex fabrics for all the weights and all the needles penetration depth this can be interpreted as the reason is difference between properties of materials. (Polyester fibers have higher elongation than the Nomex fibers). Whenever the elongation at break of endless felt decreased the more is suitable for usage.

3.2.2. Effect of fabric weight on the elongation at break in both directions:

It is obvious from table (5) and figs. (9,10,11,12,13,14,15,16) that there is an inversely proportional relation between the fabric weight and elongation at break. This happens mainly due to the increase in weight that leads to the increase in number of fibers and woven layers. Therefore, it results in increasing contact areas between fibers and yarns, so their resistance to slippage will increase leading to the decrease in elongation at break.

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

It is obvious from table (5) and figs. (9,10,11,12,13,14,15,16) that there is an inversely proportional relation between the needles penetration depth and the elongation at break. This can be attributed to increase in needles penetration depth causes increasing the merging between the fibers and yarns and increasing in number of fibers per unit area leading to decrease the space between the fibers and yarns so their resistance to slipping will increase causing decreasing in elongation at break.

3.3. Abrasion resistance:

Table (6) Abrasion resistance measurements results

Abrasion resistance (lost of weight ratio % at 2000 cycle)					
Fabric type		100% Nomex		75% Nomex + 25% Polyester	
Weight		3400 gm/m^2	3150 gm/m^2	3400 gm/m^2	3150 gm/m^2
Puncture depth (mm)	9	4.49	4.65	5.48	5.75
	11	4.35	4.51	5.27	5.60
	13	4.13	4.28	5.10	5.39

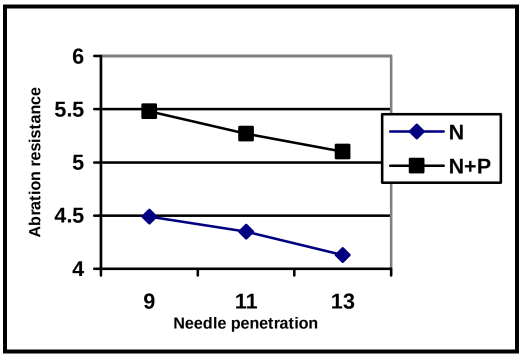

Fig. (17) Effect of fabric type and needle penetration depth mm on the abrasion resistance (lost weight ratio% at 2000 cycle) at weight 3400 gm/m^2

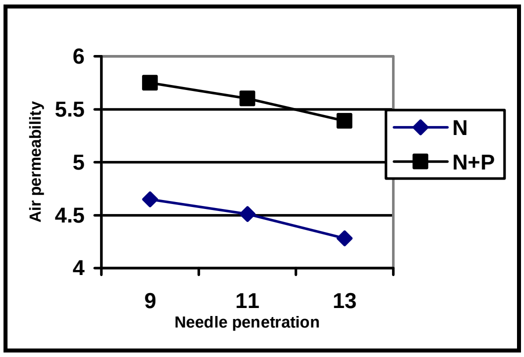

Fig. (18) Effect of fabric type and needle penetration depth mm on the abrasion resistance (lost weight ratio% at 2000 cycle) at weight 3150 gm/m^2

Table (7) Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and type of fabric on the abrasion resistance at different weights

Weight	Fabric type	Regression equation	Correlation coefficient
3400 gm/m^2	Nomex	Y = - 0.0899999 X + 5.31333	- 0.9919
	Nomex + Polyester	Y = - 0.095 X + 6.32833	- 0.9982
3150 gm/m^2	Nomex	Y = - 0.0925 X + 5.4975	- 0.9903
	Nomex + Polyester	Y = - 0.09 X + 6.57	- 0.9954

3.3.1. Effect of the fabric type on the abrasion resistance:

It is clear from table(6) and figs. (17,18) that the nonwoven Nomex fabrics have higher abrasion resistance than the nonwoven (75% Nomex + 25% polyester) fabrics for all the weights and all the puncture depth. This can be explained, as the reason is difference between the properties of materials. (Nomex is higher abrasion resistance than the polyester).

3.3.2. Effect of fabric weight on the abrasion resistance:

It is clear from table (6) and figs (17,18) that there is direct proportionality between the

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fabric weight and the abrasion resistance, which means the fabrics have the highest weight are more abrasion resistance than the fabrics have the lowest weight but the difference were insignificant.

3.3.3. Effect of the needles penetration depth on the fabric abrasion resistance:

It is clear from table (6) and figs (17,18) that there is direct proportionality between the needles penetration depth and the abrasion resistance this can be explained that the increase in needles penetration depth causes greatest fibers entanglement because needles penetration cause fibers to be reoriented so, increasing the contact areas between the fibers and yarns leading to the increase in fabric abrasion resistance.

3.4. Fabric compression force(lost of thickness ratio %):

Table(8): Fabric compression force measurements results

Compression force kg/cm^2 (lost of thickness ratio %)																	
Fabric type		100% Nomex								75% Nomex + 25% Polyester							
Weight		3400 gm/m^2				3150 gm/m^2				3400 gm/m^2				3150 gm/m^2			
Lost of thickness		10%	20%	30%	40%	10%	20%	30%	40%	10%	20%	30%	40%	10%	20%	30%	40%
Puncture depth (mm)	9	1.03	2.78	5.21	9.66	0.89	2.41	4.86	9.39	0.90	2.51	4.96	9.45	0.75	2.16	4.57	9.16
	11	1.26	2.99	5.52	9.95	1.12	2.57	5.18	9.57	1.07	2.72	5.18	9.70	0.96	2.30	4.75	9.38
	13	1.49	3.46	5.72	10.21	1.32	2.79	5.37	9.89	1.28	3.25	5.42	9.94	1.14	2.53	4.99	9.68

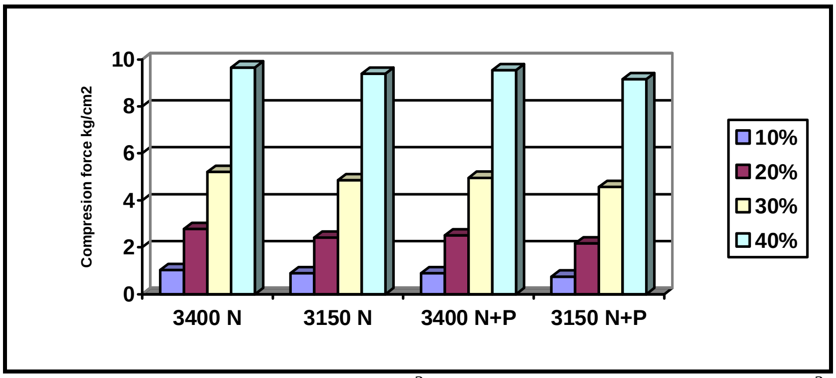

Fig. (19) Effect of fabric type and the weight gm/m^2 on the compression force kg/cm^2(lost of thickness ratio %) at puncture depth 9 mm

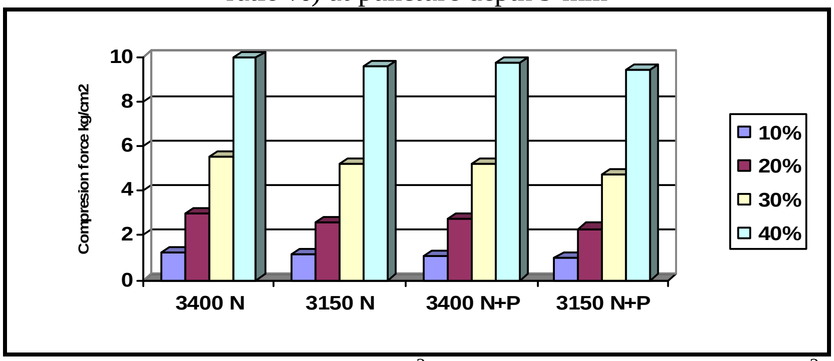

Fig. (20) Effect of fabric type and the weight gm/m^2 on the compression force kg/cm^2(lost of thickness ratio %) at puncture depth 11 mm

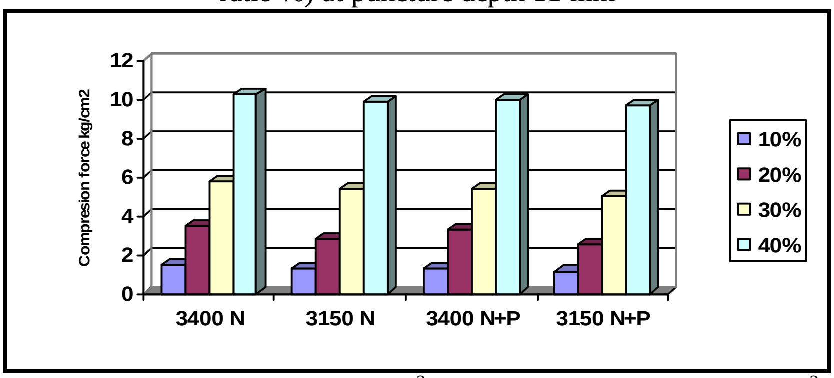

Fig. (21) Effect of fabric type and the weight gm/m^2 on the compression force kg/cm^2(lost of thickness ratio %) at puncture depth 13 mm

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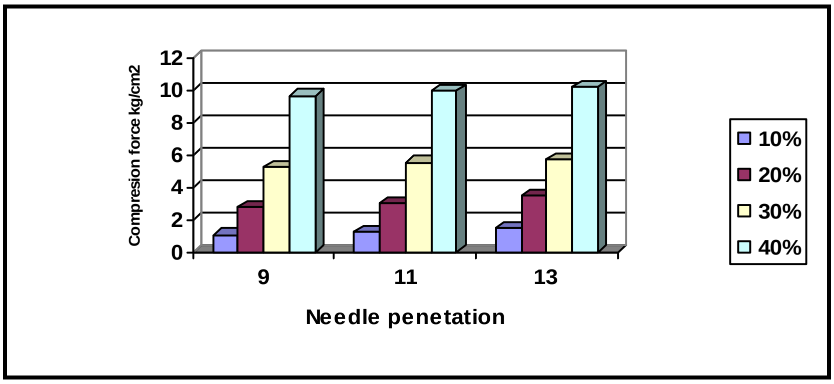

Fig. (22) Effect of needle penetration depth mm on the compression force kg/cm^2 (lost of thickness ratio %) at weight 3400 gm/m^2 of 100% Nomex fabric type

3.4.1. Effect of the fabric type on the fabric compression force:

It is clear from table (8) and figs. (19,20,21,22) that the nonwoven Nomex fabrics have higher compression force resistance than the nonwoven (75% Nomex + 25% polyester) fabrics.

For all the weights and all the needles penetration depth this can be interpreted as the reason in the difference between properties of materials (Nomex has higher compression for resistance than the polyester).

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

It is clear from table (8) and figs. (19,20,21,22) that the increasing in the fabric weight leads to increasing in more compression force resistance 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 large number of fibers contribute to the resistance against compression force hence, decrease in the lost of thickness.

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

It is clear from table (8) and figs . (19,20,21,22) that the increasing in needles penetration depth leads to increase in more compression force resistance which used to decrease the fabric thickness this can be explained that increase in needles penetration depth cause fibers to be reoriented 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.

3.5. Dimensional stability:

Table (9) Dimensional stability measurements results

Dimensional stability (shrinkage of fabric ratio % in both direction)					
Fabric type		100% Nomex		75% Nomex + 25% Polyester	
Weight		3400 gm/m^2	3150 gm/m^2	3400 gm/m^2	3150 gm/m^2
Puncture depth (mm)	9	0.0745	0.0907	0.0958	0.1097
	11	0.0699	0.0861	0.0906	0.1038
	13	0.0641	0.07808	0.0828	0.0971

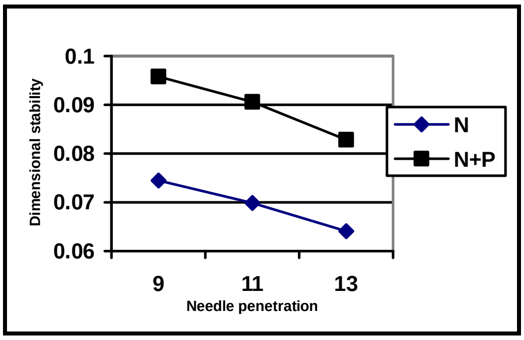

Fig. (23) Effect of fabric type and needle penetration depth mm on the dimensional stability(shrinkage of fabric ratio % in both direction) at weight 3400 gm/m^2

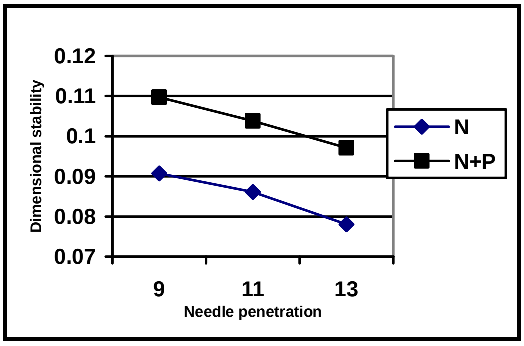

Fig. (24) Effect of fabric type and needle penetration depth mm on the dimensional stability(shrinkage of fabric ratio % in both direction) at weight 3150 gm/m^2

Table (10) Regression equation and correlation coefficient for the effect of the needle penetration depth (mm) and fabric type on the dimensional stability (shrinkage of fabric ratio % in both direction) at different weights

Weight	Fabric type	Regression equation	Correlation coefficient
3400 gm/m^2	Nomex	Y = - 0.0026 X + 0.0981	- 0.9978
	Nomex + Polyester	Y = - 0.00325 X + 0.125483	- 0.9934
3150 gm/m^2	Nomex	Y = - 0.003155 X + 0.119665	- 0.9880
	Nomex + Polyester	Y = - 0.00315 X + 0.138183	- 0.9993

3.5.1 Effect of the fabric type on the fabric dimensional stability in both direction:

It is clear from table (9) and figs.(23,24) the nonwoven Nomex fabrics have higher dimensional stability in both direction than the nonwoven (75%Nomex+25%polyester)fabrics this can be explained as the reason is difference between the properties of materials (Nomex fibers have higher heat resistance than polyester fibers).

3.5.2 Effect of fabric weight on the dimensional stability:

It is clear from table (9) and figs.(23,24) that there is directly proportional relation between the fabric weight and the dimensional stability this can be explained that the increase in weight leads to the increase in number of fibers and layers and as a result increase the contact areas between fibers and yarns and decreasing in prose size between the fibers so their resistance to shrinkage will increase leading to the increase in dimensional stability.

3.5.3 Effect of the needles penetration depth on the fabric dimensional stability:

It is clear from table (9) and figs.(23,24) that there is a direct proportionality between the puncture depth and the dimensional stability in both direction. This can be explained that the increase in needles penetration depth causes greatest fibers entanglement because needles penetration depth causes fibers to be reoriented and so increase the contact areas between the fibers and yarns leading to the increase in shrinkage resistance and as a result increase in dimensional stability of fabrics .

3.6. Thickness:

Table (11): Thickness measurements results

Thickness (mm)					
Fabric type		100% Nomex		75% Nomex + 25% Polyester	
Weight		3400 gm/m^2	3150 gm/m^2	3400 gm/m^2	3150 gm/m^2
Puncture depth (mm)	9	10.82	9.51	12.05	10.88
	11	10.47	9.16	11.78	10.57
	13	10.22	8.88	11.36	10.18

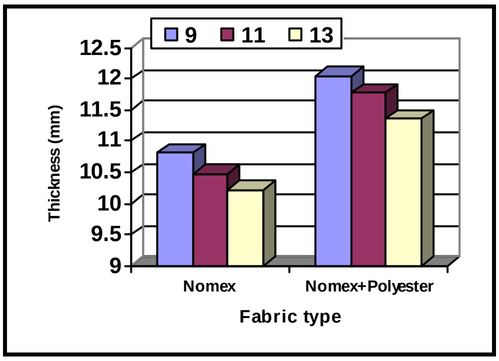

Fig. (25) Effect of fabric type and needle penetration depth mm on the thickness (mm) at weight 3400 gm/m^2

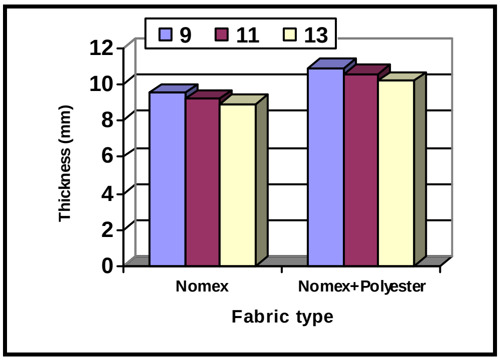

Fig. (26) Effect of fabric type and needle penetration depth mm on the thickness (mm) at weight 3150 gm/m^2

3.6.1. Effect of the fabric type on the fabric thickness:

It is clear from table (11) and figs. (25,26) that the nonwoven (75% Nomex + 25% polyester) fabrics have higher thickness than the nonwoven Nomex fabric for all the weights and all the needles puncture. This can be explained, as the reason is difference between properties of materials.

3.6.2. Effect of fabric weight on the thickness of fabrics:

It is clear from table (11) and figs. (25,26) that there is a directly proportional relation between the fabric weight and the thickness this can be attributed to the increase in fabric weight leads to

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increase in number of fibers per unit area and increase the layers number of fibers and layers number of woven fabric which leads to the increase in fabric thickness.

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

It is clear from table (11) and figs. (25,26) 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 depth causes increase in merging between fibers and layers of fabric which increases fabric compactness and decreases pores size between fibers and layers, hence the fabric thickness will be decreased.

4. Conclusion:

The weight of fabrics and the type of materials have great impacts on the tensile strength, elongation, abrasion resistance, dimensional stability, compression force resistance and thickness. Nevertheless the needles penetration depth has little impacts on the same properties.

- Increasing the fabric weight leads to increase the tensile strength, abrasion resistance, dimensional stability compression force resistance and thickness.
- Increasing the fabric weight leads to decrease the elongation at break.
- Increasing the needles penetration depth leads to increase the tensile strength, abrasion resistance dimensional stability and compression force resistance.
- Increasing the needles penetration depth leads to decreasing the elongation at break and thickness.
- The fabrics made of 100% Nomex have higher tensile strength abrasion resistance, dimensional stability and compression force resistance than the fabrics made of (75% Nomex + 25% polyester).
- The fabrics made of (75% Nomex + 25% polyester) have higher elongation at break and thickness than the fabrics made of 100% Nomex. Whenever the elongation at break of endless felt blanket decreased the more is suitable for usage.
- The fabrics in the length direction recorded higher tensile strength and elongation than the fabrics in the width direction.
- The sample made of 100% Nomix with (3400 g/m² , puncture depth 13 mm) achieved the best results.
- Through the applied tests , this research achieved the goals.

5. References:

1. Properties, applications and uses of technical textile: http://www.leiTaT.org.
2. Textile printing www.zimmeraustria.com second edition October 2015.
3. S.,clyn.woods, “ Developments in transfer printing March 1992.
4. Transfer printing felts http://www.dollfus-Muller.com/en/transfer printing calendar.
5. Rene’ L.W MuTsaerTs Executive Member MuTiMEX “http://www.muTimex.coza 2005.
6. Michael syverson, “ The heat on Dye sublimation” July 2012.
7. M. Stephan Kova, J., Gregr and J., Wiene “Using of DSCBD plasma for treatment of Kevlar and Nomex fibers” chemlisty 102,s1515-s1518, 2008.
8. Suf, Zhangz, GuoF, SongH, liu W. Wear 261, 293, 2006.
9. ASTM-D4595-83, “Standard test method for measuring tensile strength and elongation at break in both directions.
10. ASTU-D4158-79, “Standard test method for measuring fabric abrasion resistance was determined in accordance with their lost of weight at 2000 cycle (%).
11. ASIM-D35+4-03 “standard test method for measuring fabric compression force was determined in accordance with their lost of thickness (%).
12. ASTM-DI111 “Standard test method for measuring fabric

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