Effect of Some Production Parameters on Net Wrap Used in Agricultural Products Packaging on the End Use Properties

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Abstract: This research is mainly concerned with designing net wrap used for packaging agricultural products. Twenty seven samples were produced using polyethylene yarns. Warp knitted technique was applied to produce all samples under study using different parameters. Different parameters were studied including, inlay tape thickness 20,25 and 30 micron, inlay tape width 1,1.25 and 1.5 mm ,pillar blades number 99, 101 and 213,treatment with ultra violet and anti static. Many tests were carried out in order to evaluate the net according to the final product needs such as tensile strength and elongation of net and inlay tape and linear meter tests. Some more results were reached concerning structures and materials. The results showed that there is a direct relationship between tensile strength and number of pillar, the more inlay tape width, the higher tensile strength of the sample become, the more inlay tape thickness per unit area the more tensile strength of the sample become, the more number of pillar yarns the lower elongation the samples become, and the higher pillar yarns per unit area the more linier meter weight the sample become.

[Ibrahim, G. E. and Dorgham, M. E. Effect of Some Production Parameters on Net Wrap Used in Agricultural Products Packaging on the End Use Properties. Life Science Journal,. 2011; 8(2):964-975] (ISSN: 1097-8135). http://www.lifesciencesite.com.

Key words: Production Parameters, Net Wrap, Agricultural, Products Packaging End Use Properties

1. Introduction:

Warp knitting is the most versatile fabric production technique in textiles industry, warp knitted fabrics can be produced continuously, elastic or stable, with an open or closed structure, they can be produced flat, tubular or three dimensional .The flexibility of warp knitting techniques makes them attractive both to the designer and the manufacturer of technical textiles[1]. Knitted fabrics are textile structures assembled from basic construction units called loops. There are two basic technologies for manufacturing. In warp knitted technology every loop in the fabric structure formed from a separate yarn called warp mainly introduced in the linier fabric direction. The most characteristic feature of the warp knitted fabric is that neighboring loops of one course are not created from the same yarn. [2] Warp knitting technology enables the individual products to be adapted to suit specific requirements[3]. Basic warp knitting constructions, can be given as follows[1].

1-Elastic structures.
2-Stable structures.
3-Directionally oriented structures.
4-Multi-axial structures.
5-Open structures.
6-Closed structures.
7-Three-dimensional structures.
8-Bi-axial structures.

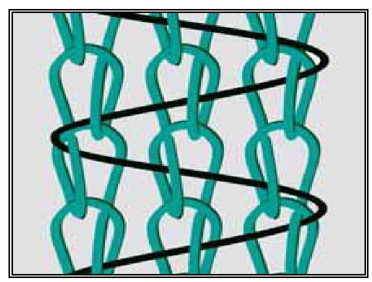

Fig (1) the open warp knitting structures

Mc Murray invented an integrally knitted tubular shaped net structure having first and second parallel knit fabric layers formed on separate parallel spaced front and back needle beds using the same yarn ingredients and knitted identical in fabric construction and yarn runner feed lengths producing a perfect continuously uniform cylindrical shaped tubular blank that can be joined together at one end of the tube by jacquard selected threads being deflected to knit on both front and back needle beds at predetermined joining points in the design. Another Fabrics were produced using circumferentially consecutive portions of one laid-in yarns which are bound in respective spaced chains to stitches aligned in a circumferential or course wise direction, but the consecutive portions of the laid-in yarn are offset in the same wale wise direction which is axial relative to the tube into which the fabric may be expanded in an approximate helix. The amount of laid –in yarn employed may be varied to suit requirements of mechanical strength or mesh size by varying the number of gaps between adjacent chains. [5]Warp knitting technology can be seen in diverse applications as it offers a wide range of possibilities for producing nets they may have open or dense constructions, and may have fine or coarse structures the net is used to protect persons and buildings during construction. Fishnets are other possible end-uses. Textile nets have a wide range of end uses. One of their main uses is to protect against adverse weather conditions this has led to the development of many new applications, both inside and outside. [3]

Packaging nets (Net Wrap)

Packaging products has always been a major sector of industries; these products are stacked and then secured by wrapping stretch wrap around them. The main issue with this packaging method is that millions of pounds of waste are produced. Some of the other effects include green house gas emissions during its production, limited recycling, and high packaging costs. Net wraps are porous materials designed to shed water and permit greater air flow at the bale surface at less cost than plastic wraps. Like plastic wraps, net wraps can be applied during baling and eliminate the need for twine. Studies comparing yield loss between various storage methods indicate that net wrap is somewhat intermediate between twine-tied outside bales and plastic wrap.

In recent years, new technologies have been developed that attempt to reduce outside storage losses by covering the circumference of product with solid plastic sheeting to shed water. Past research has demonstrated that wrapping the product bale surface with ultraviolet (UV) light-stabilized. [6]

In order to reduce the amounts of stretch wrap used by industries and distribution centers, various other types of packaging materials were developed. There are various reasons for packaging, such as: easing storage and transportation of products, maintaining products together, and preventing products from becoming damaged. This new packaging technology is made of light, but extremely durable polypropylene (PP) or polyethylene (PE) material. Both of these have a good damage resistance to ultra violate (UV) rays. It works like a large plastic cover strapped with strong plastic buckles. With this packaging method, the tension that is created aids to protect and stabilize the load. Due to its reusable nature, it reduces stretch wrap costs, damage claims, waste expenses, plastic stretch wrap by 80-90%, and other shipping wastes. The covers also have the benefit of being easy to handle for operators and it provides personnel with a consistent and uncomplicated method to secure loads.[7] A packaging wrap is also provided for agriculture products, a net can be placed to increase its strength ,the used material that is safe in accordance with packaging regulation and prevents the products from binding with the packaging wrap during the storage .[8] Large package sizes and rapid baling rates minimize labor requirements for baling and transport around the farm (local). However, storage losses of round bales are frequently much greater than those of similar product in smaller rectangular bales. Most of the increased storage loss for product appears to result from storage outside without protection from the weather. Losses during outside storage of twine-tied round bales result from weathering and from moisture movement from. Weathering is visually associated with a change in color and deterioration of the outer layers of product following exposure to rainfall, sunlight, and other factors during storage. Weathered hay suffers substantial losses of both yield and forage quality and is much less palatable to livestock than undamaged product.

Package type and size effects

Agriculture products storage research indicates that the increase in size and densities of round bales increase heat-damaged protein and fiber concentrations compared with rectangular bales, possibly due to restricted heat and moisture exchange. Due to the cylindrical shape of round bales, even a seemingly insignificant layer of weathered material on the bale surface can represent a substantial loss of yield.

Characteristics of the nets used in packaging

Characteristics of the nets used in packaging to suit the end-use are the level of shade provided, or sun-protection factor, the wind permeability, the opacity, the stability, or elasticity, in the lengthwise and crosswise directions .Most of the nets produced on single-bar raschel machines are produced by a pillar stitch-inlay lapping or by other simple basic constructions. The loops in the various lappings can be processed so that they are open or closed. Some of the most frequently used basic lapping. [3]

2. The experimental Work

This research concerns with producing fabrics suitable for net wrap used for packaging agricultural products. In this study 27 samples were produced using polyethylene yarns and warp knitting technique.

Raw Materials Used and Manufacturing Method

All samples under study were produced in fixed width (123 cm) according to the following variables:

Table (1) Variables used to produce samples under study

Property	Group 1			Group 2			Group 3		
No. of Pillar/piece	49			50			51		
Inlay Tape Thickness Mic	20	25	30	20	25	30	20	25	30
Inlay Tape Width (mm)	1	1.25	1.5	1	1.25	1.5	1	1.25	1.5
Pillar-pillar Gap Approx Cm	2.5			2.45			2.4		

Table (2) Specification of the machine used in producing samples under study

Property	Specification
Machine Type	Warp Knitting Machine
Company	Karl Mayer
Model	RS 2 NK-F-ISO ET1
Manufacturing Year	1996
External Apparatus	ISO
Machine Speed	1225 rpm
machine Width	590 cm
No. of Product Pieces	4
No. of Needle Bar	2
No. of guide bar	2
Long Shogging Distance Guide	1

Table (3) Specifications of raw materials used, and ISO Parameters

Property	Specification
Pillar width Film (mm)	645 Double
Inlay width Film (mm)	335 single
Film (Mic.) Pillar thickness	80
Film (Mic.) Inlay thickness	75
Inlay tape thickness (Mic.)	20,25 and 30
Inlay tape width (mm)	1,1.25 and 1.5
Pillar blades Number	201,209 and 213
inlay blades Number	99, 101, and 103
Number of pillar	49,50 and 51
Pillar-pillar Gap Approx (Cm)	2.5,2.45 and 2.4
No.of Pillar /unit area	196,200and 204
No.of Inlay /unit area	200,208and 212
Film Color	Natural
Chemical Treatment	Ultra violet stabilized and Anti static

Tests applied to samples under study

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

1- **Tensile strength & elongation at break** according to ASTM-D 1682 [9]

2- **Weight test**, this test was carried out according to the **ASTM-D 3776- 1979** [10]

Table (4) results of all tests applied to samples produced with pillar yarn 49, pillar Gap Approx 2.5 cm and varieties in the thickness and width of Inlay yarn.

Property	Sample No.								
	1	2	3	4	5	6	7	8	9
Net tensile strength (Kg)	245.4	249.5	256.1	246.1	254.8	255.7	256.9	258.3	259.2
Net Elongation (%)	14.6	14.9	15.4	15.3	15.6	15.9	15.5	16.3	17.1
Inlay Tensile strength (Kg)	5.9	6.4	6.5	6.2	6.4	6.6	6.3	6.6	6.7
Inlay Elongation (%)	53.2	55.1	56.9	54.3	57.6	61.1	58.8	59.6	62.8
Wt / LM (g)	11.3	11.5	11.7	11.6	11.9	12.1	12	12	12.2

Table (5) results of all tests applied to samples produced with pillar yarn 50, pillar Gap Approx Cm 2.45 and varieties in the thickness and width of Inlay yarn.

Property	Sample No.								
	10	11	12	13	14	15	16	17	18
Net tensile strength (Kg)	252.9	256.2	258.5	254.6	258.9	263.3	262.1	269.3	276.6
Net Elongation (%)	11.7	12.3	12.7	12	13.2	13.7	13.1	13.9	14.4
Inlay Tensile strength (Kg)	6.3	6.5	6.8	6.4	6.7	6.9	6.6	6.8	7.1
Inlay Elongation (%)	39.5	42.5	46.3	45.6	48.9	51.2	49.3	52.8	55.6
Wt / LM (g)	12.1	12.1	12.3	12.3	12.4	12.6	12.5	12.7	12.7

Table (6) results of all tests applied to samples produced with pillar yarn 51, pillar Gap Approx Cm 2.4 and varieties in the thickness and width of Inlay yarn.

Property	Sample No.								
	19	20	21	22	23	24	25	26	27
Net tensile strength (Kg)	261.9	263.0	267.8	265.7	269.1	271.4	268.3	278.9	287.1
Net Elongation (%)	9.5	10.2	11.3	10.8	11.5	11.8	11.3	11.9	12.3
Inlay Tensile strength (Kg)	6.8	7	7.2	7.4	7.6	7.7	7.3	7.6	7.8
Inlay Elongation (%)	33.4	35.7	36.1	35	37.6	39.8	39.2	40.5	41.7
Wt / LM (g)	12.2	12.2	12.4	12.5	12.7	12.8	12.6	12.8	13

Result and Discussion

Tensile strength:

It is obvious from figure (1) to (3) that there is a direct relationship between net tensile strength and number of pillar. We can report that, this is because of the increase in number of Pillar means an increase in number of yarns per unit area causing fabrics to be more compacted leading to the increase in fabric tensile strength.

It was also found that the more inlay tape thickness per unit area the more net tensile strength for all the samples become, which means that samples with 30 micron and 20 micron have recorded the highest rates of tensile strength,

It can be seen from the table and figures that the more inlay tape width, the higher tensile strength the samples become. We can report that the increase in this factor increase number of yarns leading the fabric to be more compacted which cause the increase the cutoff durability

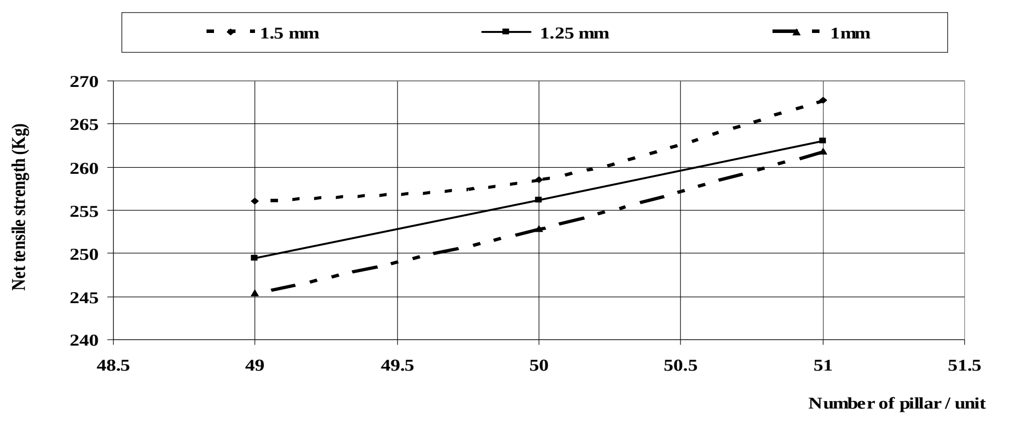

Fig (2) the relationship between net tensile strength and number of pillar / unit , at inlay tape (20) micron and varieties inlay tape width.

Table (7) regression equation and correlation coefficient for the effect of number of pillar on net tensile strength, at inlay tape 20 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =223.5833X + 21.4	0.901024
50	Y = 241.6667X + 11.2	0.989483
51	Y = 249.4833 X + 11.8	0.940266

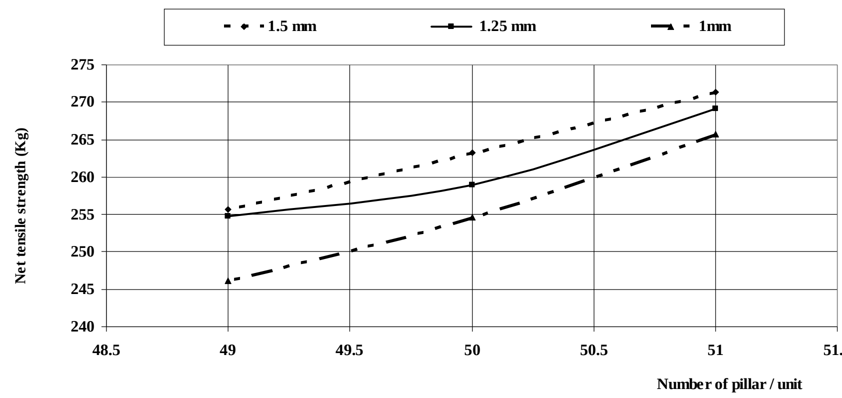

Fig (3) the relationship between net tensile strength and number of pillar / unit ,at inlay tape (25) micron and varieties inlay tape width.

Table (8) regression equation and correlation coefficient for the effect of number of pillar on net tensile strength, at inlay tape 25 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =254.4833X + 11.4	0.99385
50	Y = 237.1833X + 17.4	0.999974
51	Y = 228.2 X + 19.2	0.905338

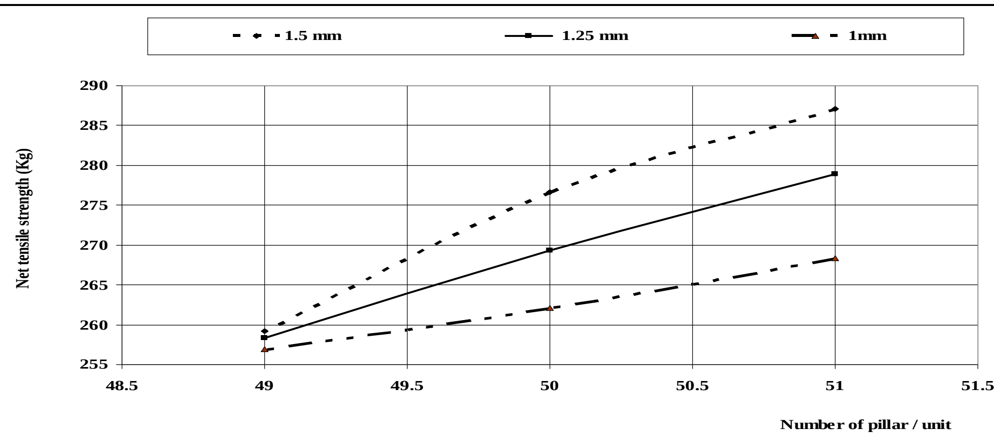

Fig (4) the relationship between net tensile strength and number of pillar / unit , at inlay tape (30) micron and varieties inlay tape width.

Table (9) regression equation and correlation coefficient for the effect of number of pillar on net tensile strength, at inlay tape 30 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =252.3833X + 4.6	0.992215
50	Y = 233.0833X + 29	0.99992
51	Y = 37.6 X + 231.1	0.997295

Elongation at break

It can be seen from tables and figures that the more number of pillar yarns the lower elongation the samples become, and so samples with 49 pillar of piece have recorded the highest rates of elongation whereas samples with 51 ends per piece have recorded the lowest rates. It is noticed that % elongation at break of the net samples decrease as the number of pillar yarns increases, this is due to more cohesive forces is resulted between yarns.

It is obvious from the statistical analysis that the increase in inlay tape thickness the lowest rates of thickness, whereas samples with 30 micron have recorded the lowest rates. We can report that increase the thickness of inlay tape stress to which cause net to be more compacted leading to the decrease in fabric elongation.

It is obvious from the statically analysis of the elongation results that there are an inverse relationship between inlay tape width and elongation

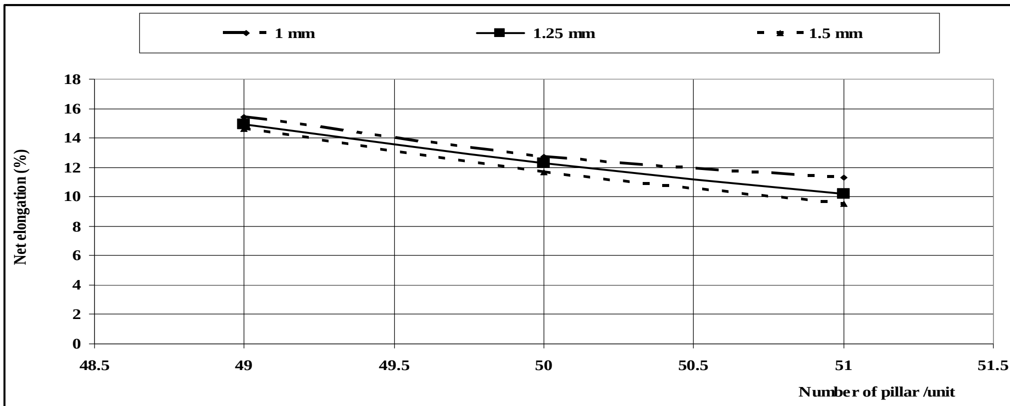

Fig (5) The relationship between net elongation and the number of pillar /unit, at constant of inlay tape thickness (20) micron and varieties inlay tape width.

Table (10) regression equation and correlation coefficient for the effect of number of pillar on net elongation, at inlay tape 20 micron and varieties inlay tape width .

Number of pillar	Regression equation	Correlation coefficient
49	Y =16.7X - 1.3	-0.9285714
50	Y = 14.1X – 1.4	-0.8029550
51	Y =14.2X - 2.9	-0.9226129

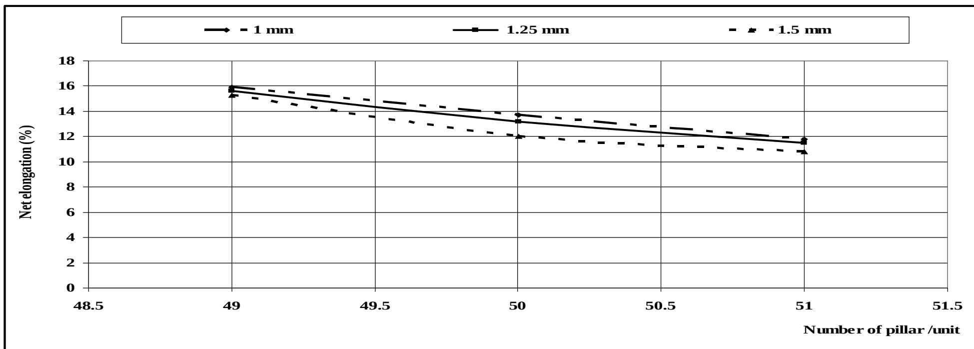

Figure (6) The relationship between net elongation and the number of pillar /unit, at constant of inlay tape thickness (25) mmicron and varieties inlay tape width.

Table (11) regression equation and correlation coefficient for the effect of number of pillar on net elongation, at inlay tape 25 micron and varieties inlay tape width .

Number of pillar	Regression equation	Correlation coefficient
49	Y =16.8X - 0.9	-0.8660254
50	Y = 15.9X – 2.2	-0.72690046
51	Y =13.1X - 1.3	-0.73131071

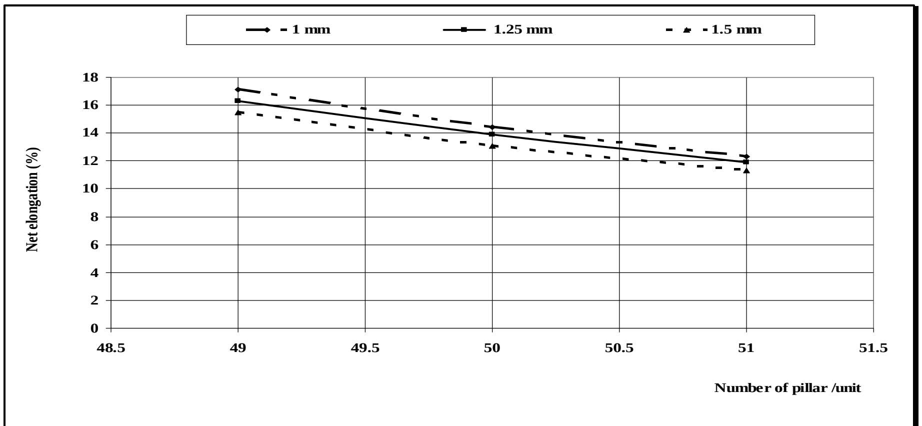

Fig (7) The relationship between net elongation and the number of pillar / unit, at constant of inlay tape thickness (30) micron and varieties inlay tape width.

Table (12) regression equation and correlation coefficient for the effect of number of pillar on net elongation, at inlay tape 30micron and varieties inlay tape width .

Number of pillar	Regression equation	Correlation coefficient
49	Y =19.5X - 2.4	-0.8660254
50	Y = 16.2X – 1.8	-0.7924058
51	Y =13.7 X - 1.4	-0.8029550

Inlay Tensile strength

It is clear from the diagrams from (8) to (10) that there is a direct relationship between Inlay Tape thickness and tensile strength this is due to that the increase in inlay thickness cause the fabric to be more compacted leading to the increase in tensile strength.

It can also be noticed from tables, that there is a direct relationship between inlay tape width and tensile strength, we can report that the increase in inlay tape width leads to higher compactness in the produced fabric, thus increase its tensile strength. So the inlay tape produced with 1.5 mm width has recorded the highest rates of tensile strength, followed by inlay tape produced with 1mm width and then inlay tape produced with 20 Mic. thickness, which achieved the lowest rates, and it was found that the difference between both of them was infixed. We can report that the decrease in stress on inlay tape during manufacture cause the increase in the consistence between yarns in inlay tape which increases the cutoff durability leading to the increase in inlay tape tensile strength

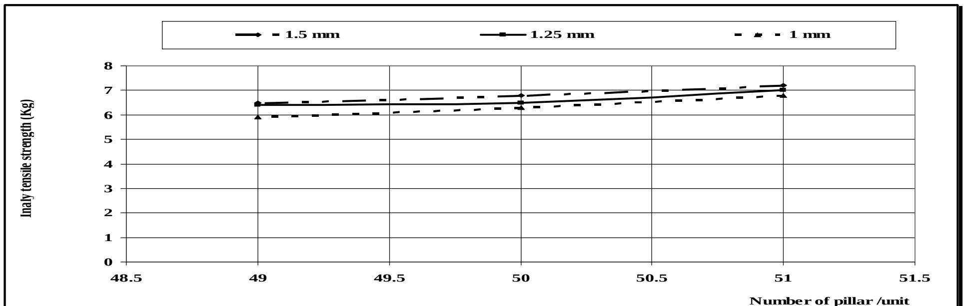

Fig (8) The relationship between inlay yarns tensile strength and the number of pillar /unit ,at constant of inlay tape thickness (20) micron and varieties inlay tape width.

Table (13) regression equation and correlation coefficient for the effect of number of pillar on inlay tape tensile strength, at inlay tape thickness 20 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =4.766667X + 1.2	0.9333254
50	Y = 5.283333X +1	0.99333399
51	Y =6 X +0.8	1

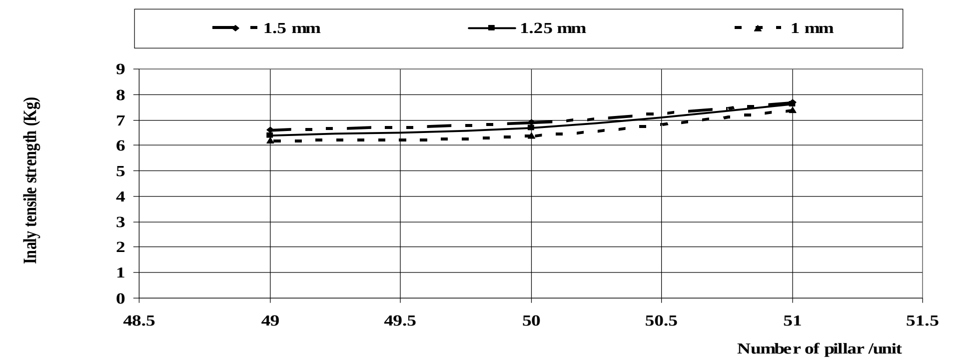

Fig (9) The relationship between inlay yarns tensile strength and the number of pillar /unit ,at constant of inlay tape thickness (25) micron and varieties inlay tape width.

Table (14) regression equation and correlation coefficient for the effect of number of pillar on inlay tape tensile strength, at inlay tape thickness 25 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =4.5X + 0.8	1
50	Y = 5.416667X +1	0.9933399
51	Y =6.816667 X +0.6	0.981981

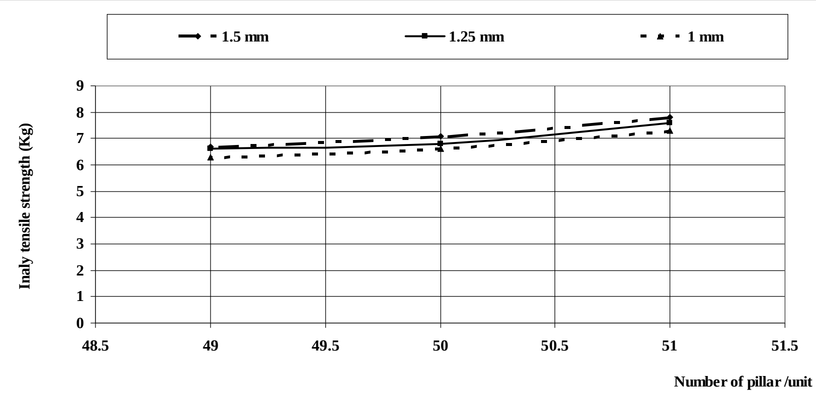

Fig (10) The relationship between inlay yarns tensile strength and the number of pillar /unit ,at constant of inlay tape thickness (30) micron and varieties inlay tape width.

Table (15) regression equation and correlation coefficient for the effect of number of pillar on inlay tape tensile strength, at inlay tape thickness 30 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =5.533333X + 0.8	1
50	Y = 5.5833333X +1	0.9933399
51	Y =6.316667 X +1	0.993399

Inlay Elongation %

It can be seen from tables and figures that the more inlay tape width, the lower elongation the samples become. We can report that the increase in this fabrics compact increase the consistence between the yarns which cause the decrease in elongation.

It is also clear from figures that, there is an inverse relationship between inlay tape thickness and elongation. Increase in inlay tape thickness increases its density, thus the contact areas between fibers will be increased leading to decrease in its elongation break.

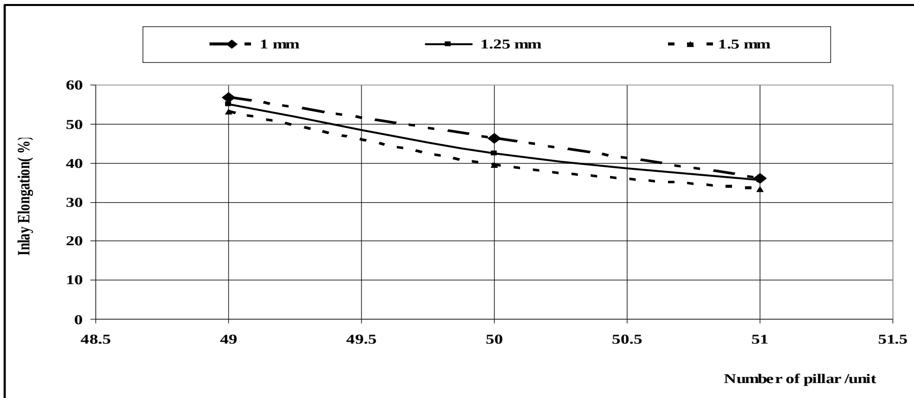

Fig.(11) The relationship between inlay yarns elongation and the number of pillar yarns ,at constant of inlay tape thickness (20) micron and varieties inlay tape width.

Table (16) regression equation and correlation coefficient for the effect of number of pillar on inlay tape elongation, at inlay tape thickness 20 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =64.31667X - 7.4	-0.999878
50	Y = 59.76667X -3.6	-0.997701
51	Y =41.81667 X -5.5	-0.926456

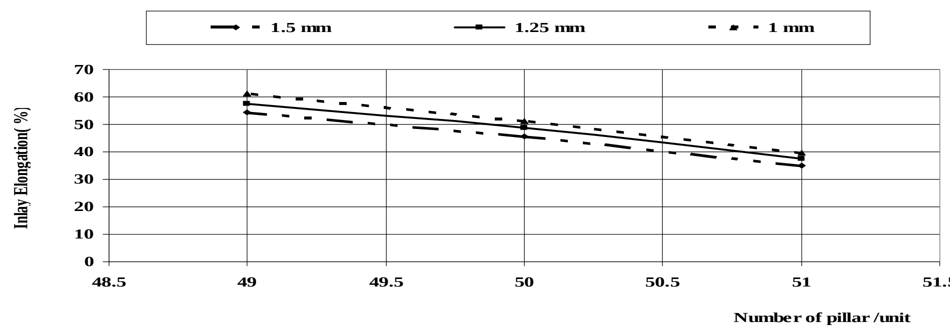

Fig. (12) The relationship between inlay yarns elongation and the number of pillar yarns at constant of inlay tape thickness (25) micron and varieties inlay tape width.

Table (17) regression equation and correlation coefficient for the effect of number of pillar on inlay tape elongation, at inlay tape thickness 25 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =71.4X - 10.3	-0.87439
50	Y = 59.1X -7.9	-0.910182
51	Y =46.8 X -7	-0.8409996

Table (18) regression equation and correlation coefficient for the effect of number of pillar on inlay tape elongation, at inlay tape thickness 30 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =49.46667X - 9.6	-0.998845
50	Y = 62.56667X -11.2	-0.994727
51	Y =74.66667 X -13.6	-0.999656

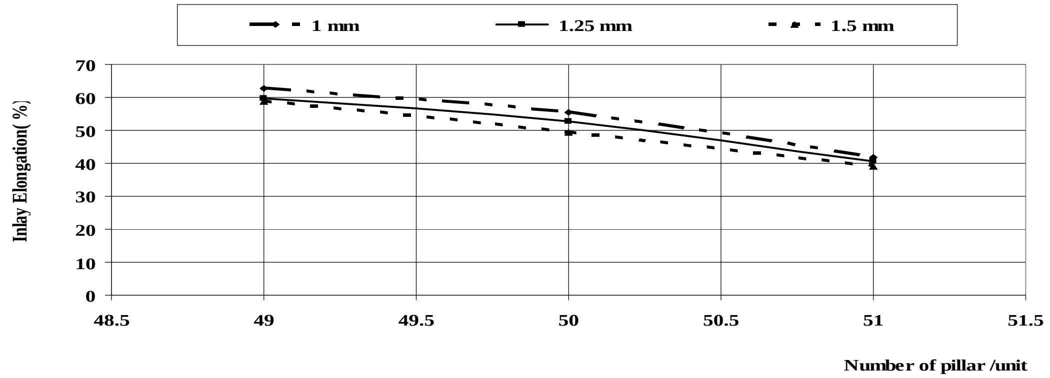

Fig. (13) The relationship between inlay yarns elongation and the number of pillar yarns at constant of inlay tape thickness (30) micron and varieties inlay tape width.

Linear meter weight:

It is clear from the diagrams that samples produced of inlay width tape 1.5 mm have recorded the highest linier meter weight, followed by samples produced of with of 1.25. and then produced of 1 mm .This is due to that tape of 1.5 mm have a lot of weight, causing the produced samples causes an increase in weight ,but the differences are insignificant.

It is obvious from tables that there is a direct relationship between inlay tape thickness and linier meter weight. So samples produced with 30 micron thickness have recorded the highest rates of linier meter weight .We can report that, this is because of the fact that the increase in inlay tape width, means an increase in tapes per unit area which leads to the increase in linier meter weight of inlay tape. But the differences are insignificant.

It was also found that the more pillar yarns per unit area the more linear meter weight the samples become, so samples with 51 pillar yarns per unit area have recorded the highest linier meter weight, whereas samples with 49 pillar yarns per unit area have recorded the lowest linier meter weight. This is due to that an increase in fabric weight means an increase in number of pillar yarns tapes per unit area, which cause increasing in final linier meter weight.

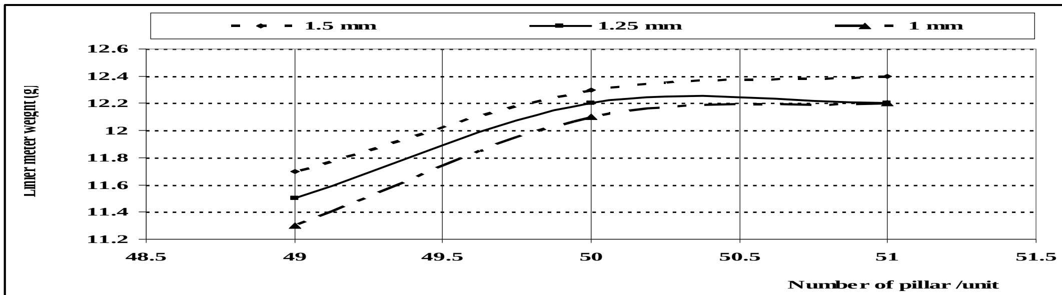

Fig. (14) The relationship between linier meter weight (g/m) and the number of pillar yarns, at inlay tape thickness (20) micron varieties inlay tape width.

Table (19) regression equation and correlation coefficient for the effect of number of pillar on linier meter weight, at inlay tape thickness 20 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =10.5X + 0.8	1
50	Y = 11.7X +0.4	1
51	Y =11.766 X +0.4	1

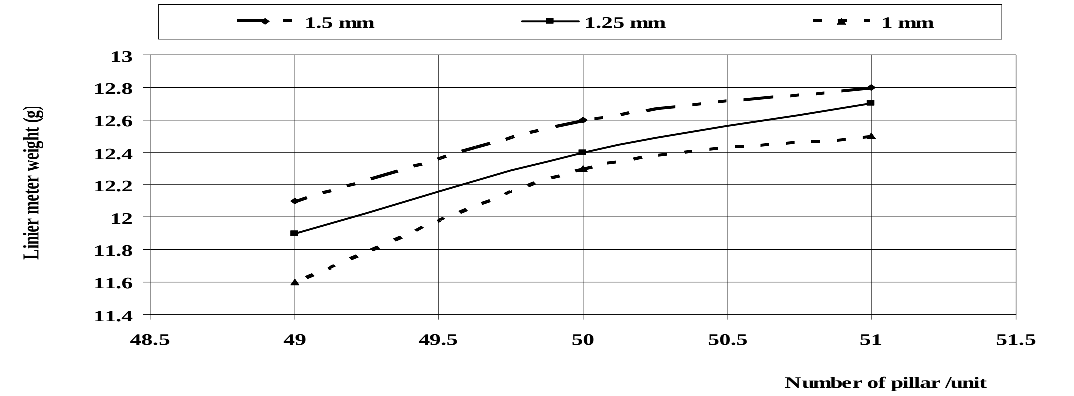

Fig. (15) The relationship between linier meter weight (g/m2) and the number of pillar yarns, at inlay tape thickness (25) micron varieties inlay tape width.

Table (20) regression equation and correlation coefficient for the effect of number of pillar on linier meter weight, at inlay tape thickness 25 micron and varieties inlay tape width .

Number of pillar	Regression equation	Correlation coefficient
49	Y =10.61667X + 1	0.9933999
50	Y = 11.683333X +0.6	0.981981
51	Y =11.91667 X +0.6	0.981981

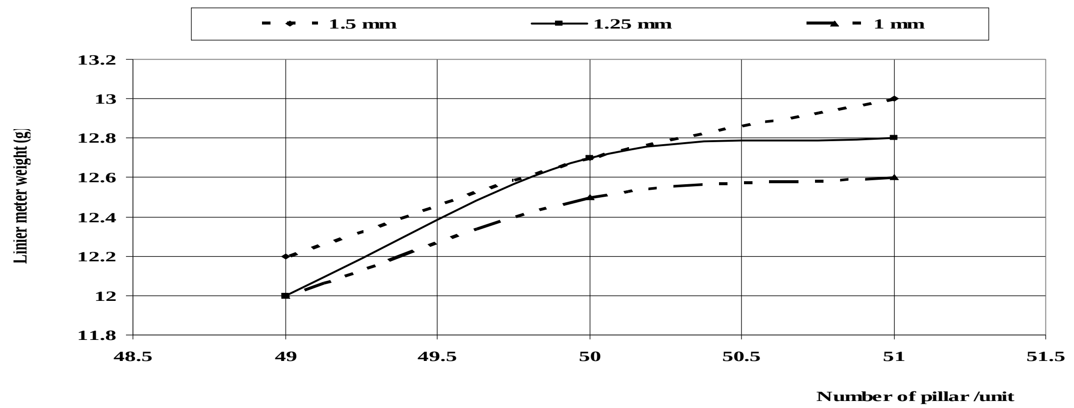

Fig. (16) The relationship between linier meter weight (g/m2) and the number of pillar yarns, at inlay tape thickness (30) micron varieties inlay tape width.

Table (21) regression equation and correlation coefficient for the effect of number of pillar on linier meter weight, at inlay tape thickness 30 micron and varieties inlay tape width

Number of pillar	Regression equation	Correlation coefficient
49	Y =11.56667X + 0.4	0.886025
50	Y = 12.13333X +0.4	0.866025
51	Y =11.8 X +0.8	1

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6/12/2011