STRUCTURE OF NEW TYPES OF FILTER BAGS OUT OF TEXTILE WASTE

تركيب الاقمشة الغير منسوجة المصنعه من العوادم النسيجية والمستخدمة كمرشحات للهواء بمصنع سماد طلخا .

By

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الخلاصة : تستخدم شركة النصر للاسمدة بطلخا أنواع مختلفة من الاقمشة المنسوجة كفلاتر، ويقدم هذا البحث نوع جديد من الاقمشة الغير منسوجة أستخدم لمنع تلوث الهواء بمصنع طلخا (١) . درس التركيب الفراغي للقماش السابق في ثلاثة أبعاد للتعرف على قدرة هذا النوع من الفلاتر على ترشيح الهواء .

قورنت خواص القماش الغير منسوج من العوادم والمستخدم كفلتر بأقمشة أخرى يتم استخدامها فعلا بعضها يتم استيراده وآخر يتم تصنيعه محليا ، ثبت تعوق القماش المختبر على بقية الاقمشة الاخرى من حيث سعر المتر المربع، النسبة المئوية للمسام ، خاصة التشعير ، نفاذية الهواء، مقاومته لحرارة التشغيل، اقتراب العمر الاستهلاكي للاقمشة الغير منسوجة من العمر الاستهلاكي للاقمشة المنسوجة المصنعة محليا .

ثبت أيضا أنه بزيادة زاوية ميل قنوات الترشيح داخل القماش تزيد كفاءة القماش كفلتر لترشيح الهواء، زيادة كثافة التغريز تناسب عكسيا مع كل من كفاءة الترشيح وزاوية ميل قنوات الترشيح (θv).

أعطى لأول مرة طريقة معملية لتقدير متجه ترتيب الشعيرات في الفراغ (0_f) وثبت أن :

- تقل كفاءة القماش ولاينصح باستخدامه كفلتر $0_f \equiv (0_x = 0_y = 0_z) = 0$
- تكون كفاءة القماش متوسطة $0_f \equiv (0_x = 0_z) = 1$
- تكون كفاءة القماش متوسطة $0_f \equiv (0_y = 0_z) = 1$
- تكون كفاءة القماش متوسطة $0_f \equiv (0_y = 0_x) = 1$
- تزيد كفاءة القماش وينصح باستخدامه كفلتر $0_f \equiv (0_x = 0_y = 0_z) = 1$

ثبت أيضا أن استخدام الاقمشة الغير منسوجة كفلتر يوفر حوالى ٨٢ ــ ٨٥٪ من سعر القماش المنسوج .

ثبت أيضا أن استخدام الاقمشة الغير منسوجة من العوادم كفلاتر يوفر حوالى ٩١ ــ ٩٤٪ من سعر القماش المنسوج ويعطى عمرا أستهلاكيا يقارب العمر الاستهلاكي لاقمشة الفلاتر المنسوجة محليا .

ABSTRACT: The structure of needle punched nonwoven fabrics out of textile waste has been studied in terms of packing density coefficient (Ø), proportion of pore (%), energy absorbed index (b), fibre orientation, i.e local vector $0_f \equiv (0_x, 0_y, 0_z)$, and inclination angle of filteration channels resulted from needles punching (θ_v).

The results indicated that the increase of punching density was accompanied by a drop in inclination angle (θ_v) and/or filter efficiency. It was found also that the nonwoven filter bags are better than woven felter bags from the following points of view, cost of 1.0 m^2, air permebility, working temp., energy absorbed index, proportion of pore, packing density coefficient, and filtration efficiency. On the other hand the woven filter bages are the best of all tested filter bags from serivce life point of view.

1. INTRODUCTION

1-1. General:

Attension is presently directed to open the waste obtained from the cotton and or wool garment manufacturing and utilized as suitable material for furniture pading, mattresses and quiltes. Lung/3/ and Painner /4/ show the economic of utilization of textile waste.

Pederson /5/ suggest that the garment waste can be used for pressed felts, padding, packing wall papers and also for upholostry.

The recycling of fibre and waate textiles provides an important contribution to world textile output. The last decade has been a move in the fibrere-cycling industry from the U.K. to Italy, India, and South Korea, while the quality of many Italian products (woollens) produced from recycled fibre has made them very competitive problems of sorting and dyeing mixtures of recovered fibres have increased with the increasing use of synthetic fibres /6/.

A number of publications /7 and 8/ relating to nonwoven fabrics and their uses are available, but informstion on the use of rag wastes, and related fibres for nonwoven is scanty.

The present work is a furtherance of the above studies in different aspects and given some details (Know how) of the process.

1-2. Typical Sources of Waets:

- soft and hard waste from spinning, weaving and knitting mills.
- manufacturers waste coming from man-made fibre plants.
- regenerated waste out of edge-cutting of nonwoven industry.
- reclaimed waste out of used apparel fabrics, (so-called shoddy).
- miscellaneous waste.

The properties of any material depends on it's constituents and distribution of basic molecules, this is what we call structure. According to the size of these constituents the structures are divided to: (a) micro-structure, and (b) macro-structure. The properties of non-woven depend primarily on the properties of the raw material from which it has been formed, the properties of the adhesive used, the type and form of the binding points or bonds, also the shape of these points.

Many investigations have been carried out by different authors to examine the effect of these parameters on the properties of the non-woven fabric /1,2,9,10,11,12,13 and 15/.

This means that till now no objective method is available that could be used to define the non-woven structure, without intermediate relationship that describes the physical and mechanical properties of non-woven fabrics.

The industrial fabrics represents about 25-30% of the world fabric production /15/, and it serves the following fields:- agriculture, building industry, civil engineering, sports, medical purposes....etc.

Filter fabrics are considered one of the best examples for the use of nonwoven fabrics in the industrial applications, especially it serves the following scopes:-

a) chemical and medecine industries.
b) food industries (sugar, milk, canned food, fats...etc).
c) ceramic and porcelain industries.
d) paper industry.
e) cement industry.
f) filteration of mineral oils.
g) workshop machines industry and others.

The textile fibres used in the manufacture of industrial fabrics (filter fabrics) may be natural fibres such as cotton and flax., also synthetic fibres such as polyester and polyamide, and this is according to end use.

In filter fabrics beside it should be strong it should be also of high resistance to abrasion, high filteration efficiency (high air and water permeability in the case of gas and liquid filteration), high retention of soil particles, low deformability, of smooth surface and of high chemical and thermal resistance.

1-3. Our Main Objectives Are:

1- enhance the capabilities of Mansoura University, Textile Dept. members involved in applied research.
2- assist the textile industry in solving the technical and economical problems facing this industry, and
3- strengthen the tie between academic researches and industrial specialists.

2- Recycling of Cotton Fibres in Soft/and Hard Waste Form:

The recycling of fibres from soft/and hard waste presents several possibilities. This requires the breakdown of finishing wastes into constituent fibrous materials by the cutting, garnetting, scouring and bleaching, drying, aerodynamic web formation, and then chemically reinforced. Having done this, and knowning the chemical nature of the mixture, several processes for nonwoven formation are available. Considering the quantity of waste cotton and viscose available this could make a major contribution of the reuse of cellulosic materials in sheet form. The scheme of cellulosic fibre recovery from both soft and hard wastes can be summarized as shown in Figure 1.

The work described in this paper aims towards the presentation, prediction, and understanding of the physical properties of nonwoven fabrics out of textile waste which must precede attempts to modify and control the properties to meet the demands of the user. As a first step in gaining this knowledge, the properties of several commercially available fabrics have been examined. In this way, we shall help to place nonwoven fabrics out of textile waste on a firm basis of physical engineering design.

Various textile wastes

Sorting and Cleaning

Cutting

Garnetting

CGC Processing

Wet Processing (1.5 - 3.5 mm) — Carding

Aerodynamic web formation — Lapping (20 - 150 mm)

NW Preparation

Reinforcing

Chemically bonded NW	Mechanically binded NW	- Regenerated Fibres
- using binders	- using needle felting m/cs	- Paper making
	- stitch bonded m/cs	- Others

Finishing

Nonwoven Fabrics For Various End Uses.

Fig. 1 Shows Fibres Recovery From Soft/and Hard Waste Out of Natural Fibres.

Table 1

Physical and Mechanical Properties of Cotton Rags

- Mass/area 200 (g/m^2)
- Fabric Structure Plain weave 1/1
- Density/inch. $\frac{42 \times 82}{30/2 \times 30/2}$

Physical and Mechanical Properties of Recycled Cotton Fibres:

	Length (mm)	Strength (P.I)	% Damage (%)	Quality Number (%)
Virging Fibres	37.5	9.9	4.6	93
Recycled Fibres	15.0	4.3	43	55

3- Experimental Arrangement and Technique:

In advanced industrial countries much felt production is done by needle punching. This technique eliminates some of the defficiencies of conventional woven felts, such as low dimensional stability, low water permeability, watermarks in the paper sheet and last, but not least, rather short service life.

The support of the needle felt is usually a loosely sett woven fabric, made preferably of plied yarns, into which a fibrous web is needled. The fabric weave is a 1:2 warp rib which provides firm interlacing of yarns. The support fabric is fed, well tensioned, to a needle-felting machine where a fibrous web is laid on it by a horizontal laying system. The fibres in the web are arranged crosswise to the direction of the run of the felt. The support fabric carrying the fibrous web passes through the needling machine to be reinforced by needling. The fibres in the web are oriented horizontally and the needles penetrate the composite vertically. Thus the fibres caught be the needle barbs are needled vertically in the web structure and anchored in the support fabric. The usual needling density is 60 to 90 needle puncher per 1 sq. cm, and possibly more, depending on the desired stiffness and strength of the felt.

The finishing of needle felts, confined earlier to dimensional setting and singeing of the back and exceptionally also of the top of the parameters felt, has been improved recently. The felts are now bonded with polymer dispersions, most often with acrylics. Such bonding agents must be applied very uniformly and this is a very difficult task, considering the dimensions of the felts whose width reaches up to 10 m. The impregnated felts are dryed, while stretched, at about 120°C and set at temperature between 150 and 160°C.

Structure of Industrial Nonwoven Fabrics out of Textile Waste in Three Dimensions:

Till now there is no theory that could be used to describe the structure of nonwoven fabrics in three dimensions. It is known that many of the physical and mechanical properties of nonwoven fabrics depend to a large extent on the method of arranging the fibres within the fabric.

The first trial made to study mechanically the structure of nonwoven fabrics in three dimensions is that made in 1984 /19/. Since the properties of industrial fabrics in general, and especially that made from waste have various applications and serves many industries, therefore it is essential to study the structure of this new raw material, but it has not been studied till now.

Raw materials and technique used to measure the structure of nonwoven fabrics in three dimensions:

Three types of industrial fabrics manufactured locally from cotton waste have been selected for the study. Given in Table 1 the physical and mechanical properties of these samples, also given the properties of the fibres. The technique described in Ref./19/ has been used for the study of the previously mentioned specimens.

Five cubes of nonwoven fabrics has been prepared after immersion in PVC and heat setted at 115^{0}C, and the apparatus in Ref. /19/ was used to cut it in three directions.

Using the light microscope (X 100), the number of fibres in each face of the cube has been counted to obtain n(θ) and from that it was possible to obtained the function of the distribution:-

$$\emptyset = \frac{n(\theta)}{N} \qquad \text{....... (1)}$$

where N is the total number of fibres in each face of the cube. This has been repeated in the various directions from 0^{0} to 180^{0}, and by a step of 15^{0}.

4- RESULTS

Sodomka's /18/ equations were used to measure the anisotropy(s) of the specimens tested in this work:-

$$S_3 = \frac{n_{max} - n_{min}}{n_{max} + n_{min}}, \qquad \text{....... (2)}$$

$$S_4 = \frac{n_{max} - n_{min}}{n_{max}} \qquad \text{....... (3)}$$

It is known that the structure is compact and close to the structure of metals when S = o, at which we reach to isotropic or arthotropic properties. Plotted the block diagram for specimen No. 1 this is for the function distribution Ø and n(θ) for six class-intervals for each of the five specimens.
The importance of studying the structure of NW fabric in three dimensions appears when testing it's performance when used for the purposes of filteration or artificial leather or shoe linings. For this purpose three types of fabrics of NW fabrics made from waste (recycled fibres) have been designed and the best of it is tested in the time being as air filter in the production line in Talkha Mill (No. 1) for fertilizers. The results of this experiment including a comparison between woven fabrics (local and imported) and NW fabrics (virgin and recycled fibres) are given in Table 1 and Table 2.

Fibres distribution in three dimensions may be descriped using the local victor 0_f where:-

$$0_f \equiv (0_x, 0_y, 0_z) \qquad \text{....... (4)}$$

0_x is partial fibre orientation in x axis as shown in Fig. 2_{11} - 2_{56}

0_y is partial fibre orientation in y axis as shown in Fig. 2_{12} - 2_{54}

0_z is partial fibre orientation in z axis as shown in Fig. 2_{13} - 2_{55}

In case of surface fibre orientation the range of values 0_x, 0_y, 0_z are:

$$0 \leq 0_x \leq 1 \qquad \text{....... (5)}$$

Table 2

Comparison of Some Properties of Woven and Needled Punched Filter Bags.

	Woven Filter		Nonwoven Filter Bags				
	50/50 wool/nylon		Virgin		Waste		
	exported	local	PES_s	POP_s	No. 1	No. 2	No. 3
Filter thickness (mm)	2.360	2.680	5.720	5.460	5.600	8.260	4.970
Packing Density	0.119	0.145	0.029	0.047	0.053	0.051	0.106
Proportion of Pore (%)	88.0	86.0	97.2	95.4	95.0	95.0	78.0
Energy Absorbed Index ($g.cm^{-2}.mm$)	9.61	6.65	9.70	9.58	11.51	18.62	7.98
Maximum Temp. ^oC	90	90	250-260	163-175	80	80	80
Air Parmebility Per 1 sq. m of filter/min.	19.5 cu.m	21 cu.m	39 cu.m	27.5 cu.m	28 cu.m	25 cu.m	30 cu.m
Filter Efficiency (%)	22.1	2.2	37.3	34.8	-	-	-
Total Cost of Filter Bag 1.0 m^2 (L.E)*	70	25	12	10	4	6	11
Reduction of Cost (%)	0	64.3	82.9	85.7	94.3	91.4	84.3
Service Life (month)	12	2	1	1	-	-	-

* The prices given here are those of 1980.

$$0 \leqslant 0_y \leqslant 1 \qquad \text{....... (6)}$$

$$0 \leqslant 0_z \leqslant 1 \qquad \text{....... (7)}$$

"0" value means there are no orientation of fibres in this direction, while value (1) represents the total orientation in measured direction.

In ideal case we can find that:-

$0_x = 0_y = 0_z = 0$, means randome fibre orientation .... (8)

$0_x = 0_z = 1$, means cross wise fibre orientation .... (9)

$0_y = 0_z = 1$, means horizontal fibre orientation ....(10)

$0_y = 0_x = 1$, means vertical fibre orientation ....(11)

$0_x = 0_y = 0_x = 1$, means both cross and horizontal fibre orientation. ....(12)

It was found that:
the local victor (0_f) according to Sodomka is

$$0_f = S_3 = (0.75,\ 0.82,\ 0.79) \qquad \text{.......(13)}$$

and also

$$0_f = S_4 = (0.85,\ 0.90,\ 0.89) \qquad \text{.......(14)}$$

It means that the orientation of fibres in the tested industrial non-woven fabric out of textile waste is a combination of cross and horizontal fibre orientation and is exisiting in large value.

Figure 3 shows the inclination angle (θ_v) of filteration channels resulted from needles punching and density of punching /19/.

Both inclination sngles and diameter of channels are used in the calculation of the rate of flow of the liquid through the fabric.

From the figure it is evident that as the density of punching increases the angle of inclination (θ_v) decreases and the efficiency of filtration decreases also. The increase in punching denaity increases fibre entaglment, hence the channels decreases and consequently filtration efficiency decreases. This concides with the statement of Iawa and Smith /20/.

5- CONCLUSIONS AND RECOMMENDATIONS

The use of industrial nonwoven fabrics out of textile waste is highly recommended as:

- Filter felts for oil-air-fuel-dust collector, and
- Filter bags for cement works, lime works, metallurgical works, chemical works, flour mills, silos and in foodstuff industry, and contributes greatly to the reduction of air pollution by these works.

Air pollution, which has become a world problem, may by sappressed to a minimum when these new types of modern filters cloth are used. More over, no capital expenditure is needed and the efficiency of filters is increased.

The economical analysis which assumed that the weaving surface layer is constant before and after filteration proved that a reduction of filter bag cost, when using nonwoven out of waste, is in the range of 91.4 - 94.3% of the total initial woven felter bag cost.

ACKNOWLEDGEMENT

Gratitude and thanks are due to Eng. Mahmoud Tallawi, President Egyptex, Engineered Nonwovens, Badrashen, Giza and all those who cooperated with the research team.

Also thanks to General Manager of El-Nasr company for fertilizers Company in Talkha, and the general manager of the mills for their co-operation with the research team in the experiments of using nonwoven fabrics out of waste as filters in Talkha mill No.1 (Urea Salt) and also in air filters in acid mill-Talkha/2.

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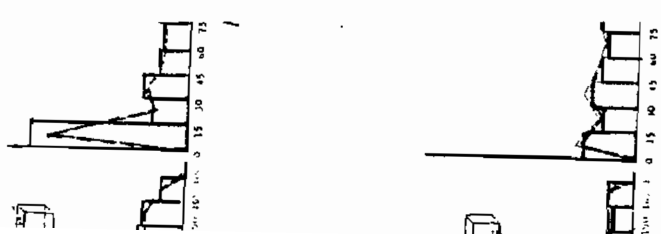

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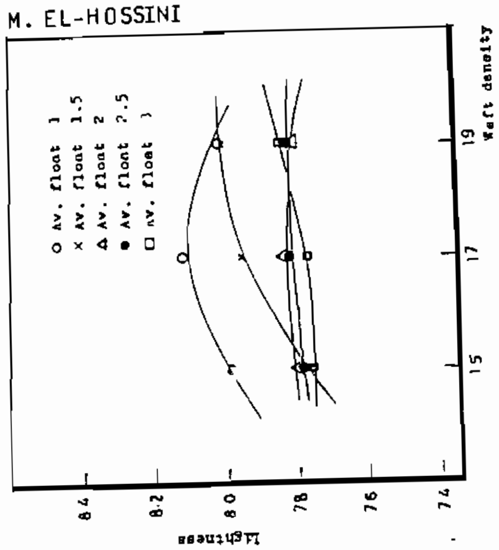


Fig.(10)
(Effect of weft density on lightness)

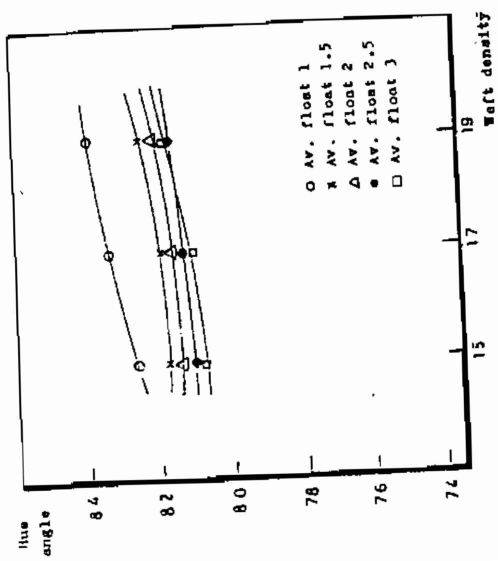


Fig. (9)
(Effect of weft density on hue angle)

— $n(\Theta)$
... $n(\phi)/N$

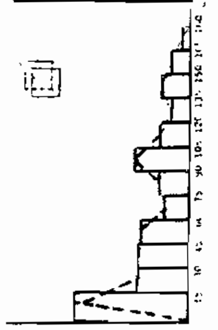


Fig. 2_{11}

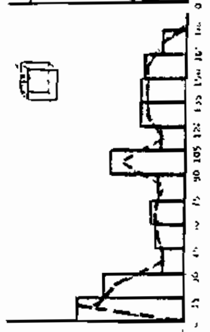


Fig. 2_{21}

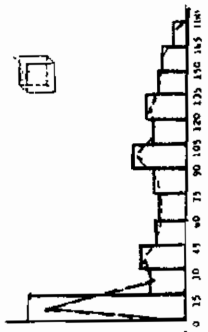


Fig. 2_{31}

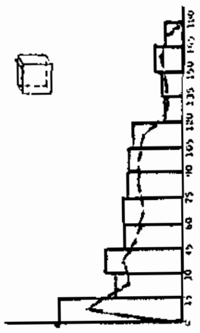


Fig. 2_{41}

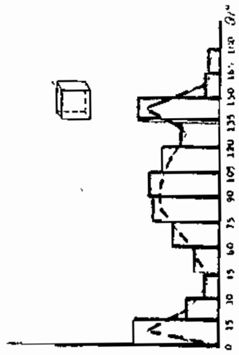


Fig. 2_{51}

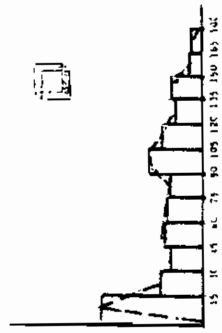


Fig. 2_{16}

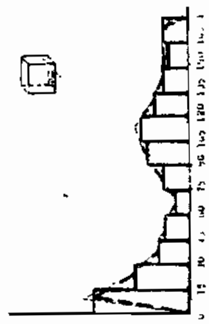


Fig. 2_{26}

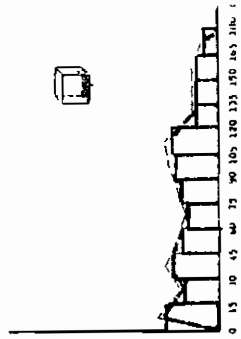
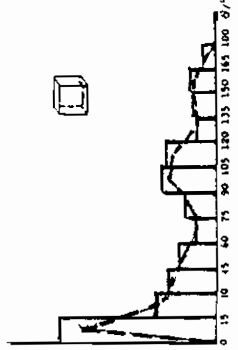


Fig. 2_{36}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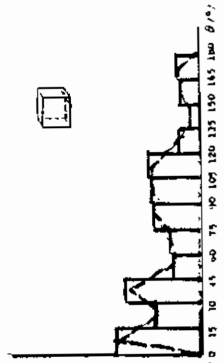
Fig. 2_{56}

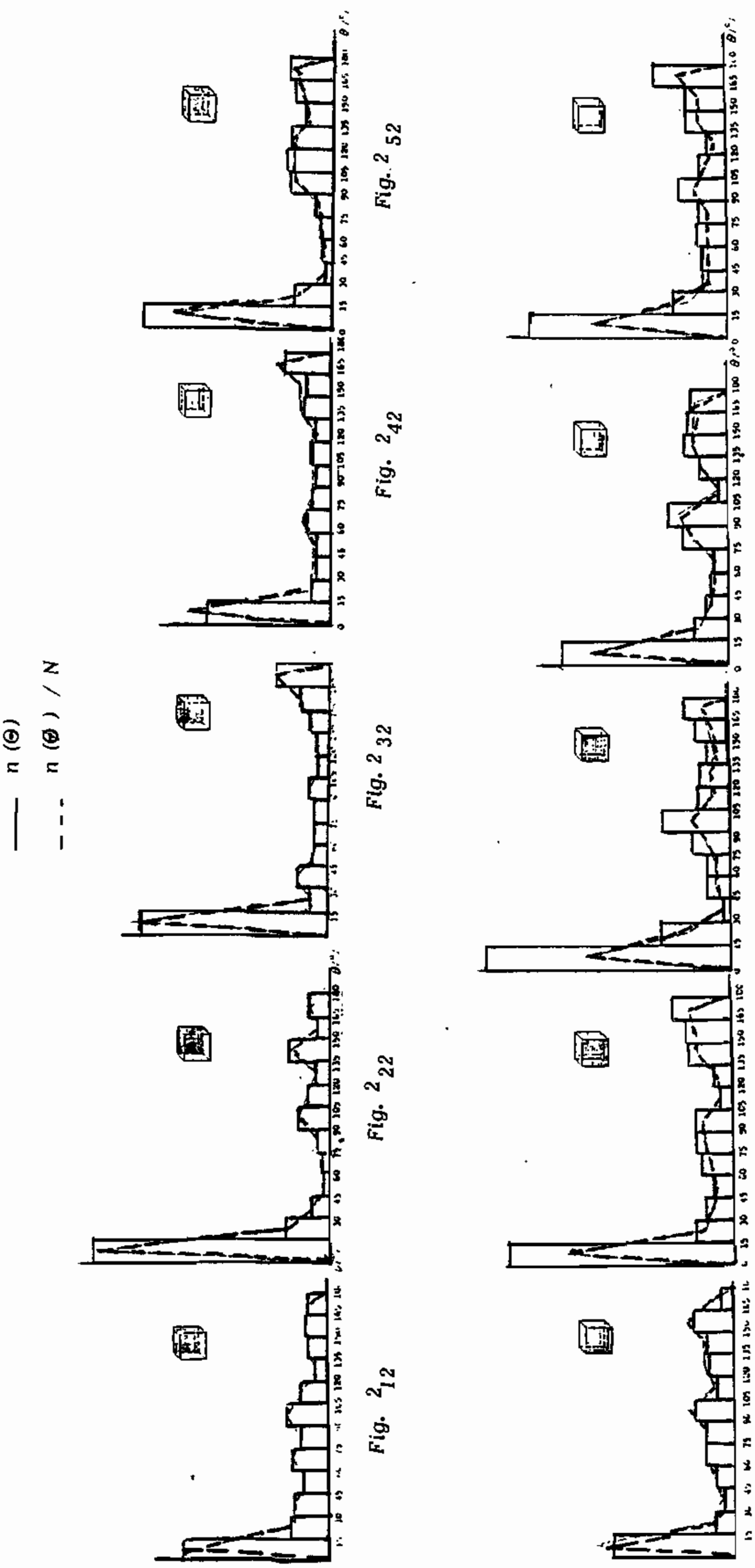

Fig. 2_{12} Fig. 2_{22} Fig. 2_{32} Fig. 2_{42} Fig. 2_{52}

Fig. 2_{14} Fig. 2_{24} Fig. 2_{34} Fig. 2_{44} Fig. 2_{54}

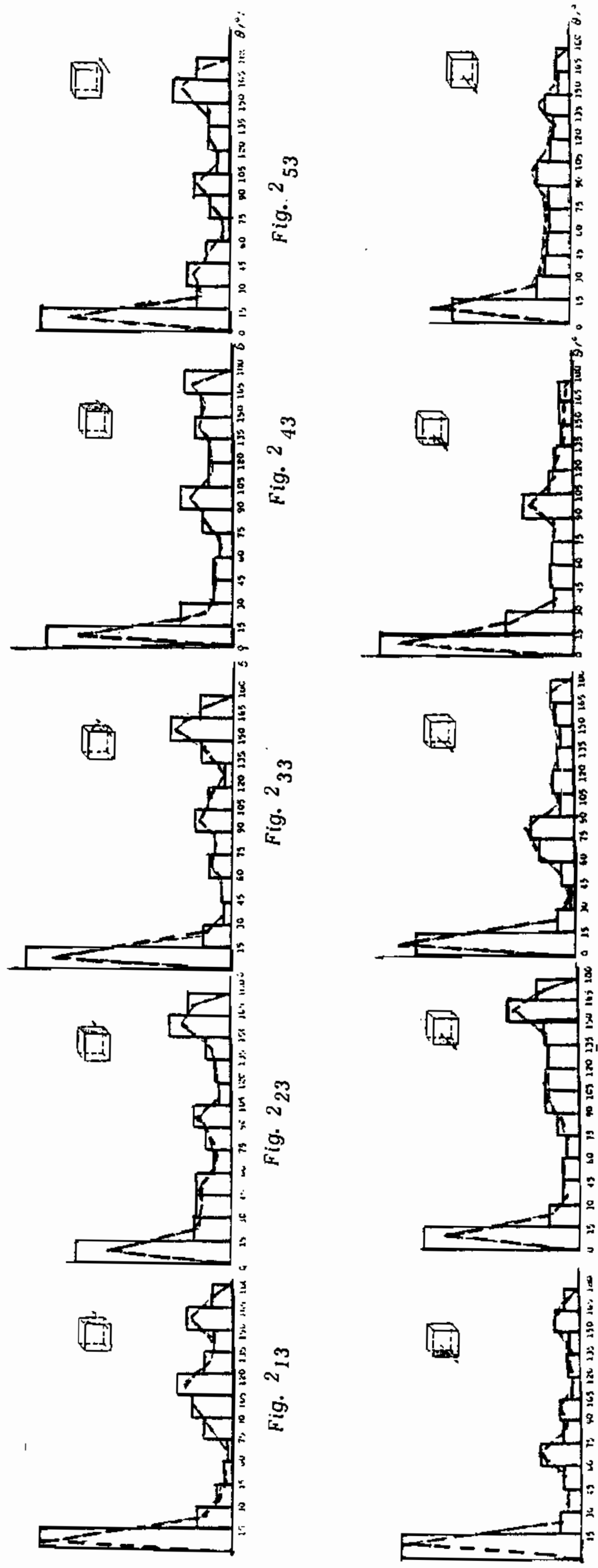

Fig. 2_{53} Fig. 2_{43} Fig. 2_{33} Fig. 2_{23} Fig. 2_{13}

Fig. 2_{55} Fig. 2_{45} Fig. 2_{35} Fig. 2_{25} Fig. 2_{15}

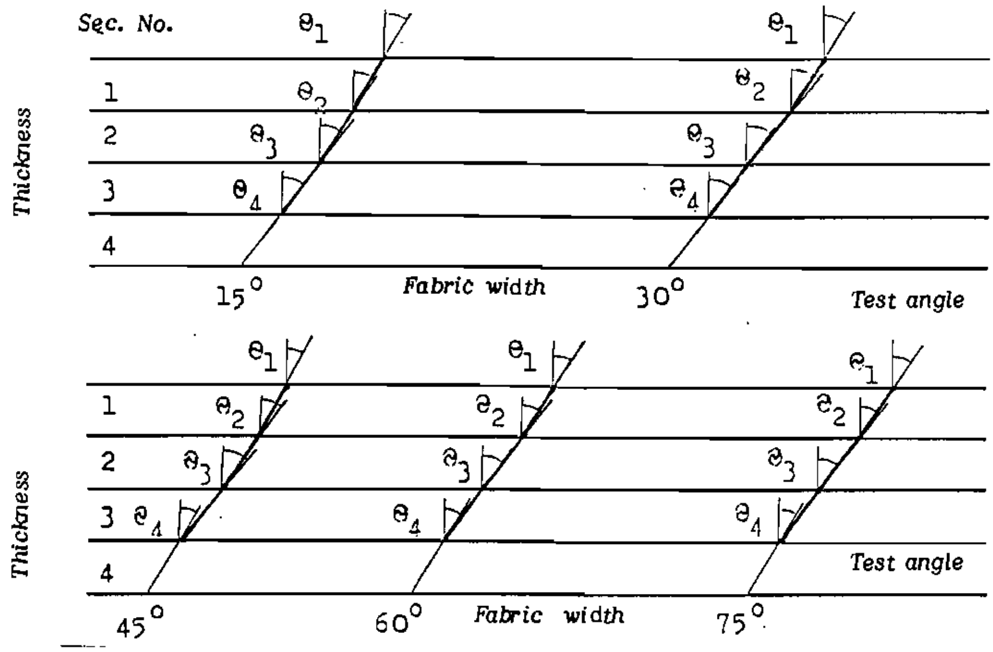

Fig. 3_1 Shows values of (Θ_v) versus angle of test (150 stitch/cm^2)

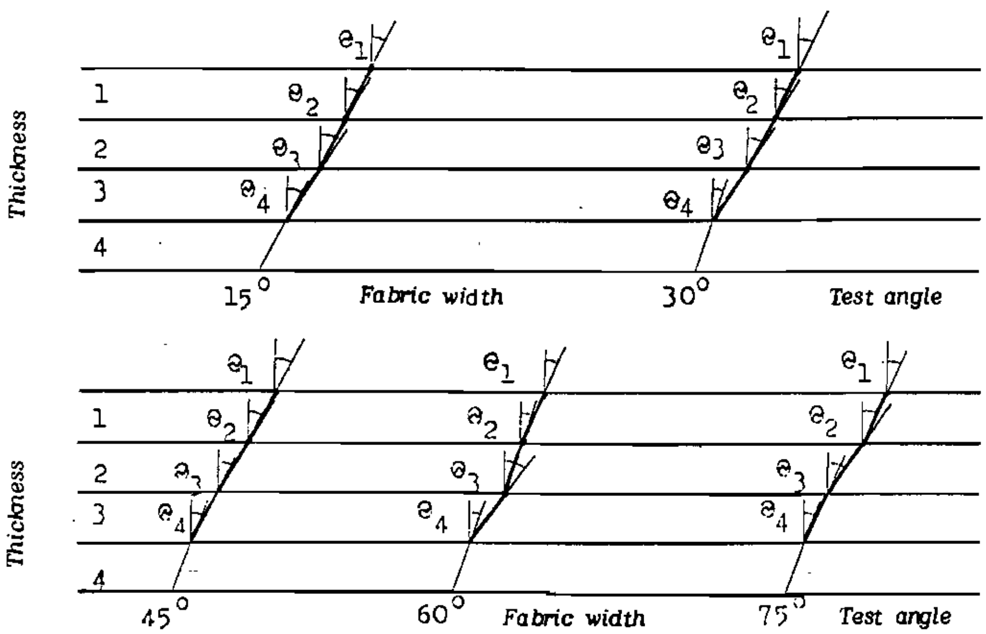

Fig. 3_2 Shows values of (Θ_v) versus angle of test (600 stitch/cm^2).