SEWABILITY OF MATERIALS FOR UPHOLSTERING CAR SEATS

El – Hadidy, A., M[1]. and El-hawwary,S.[2]

[1]Mansoura University, Egypt.
[2]National Research Center, Textile Division, Dokki, Cairo.

ABSTRACT

The influence of material types (woven, knitted, Nonwovens, technical textiles and artificial leather) of car seat covering were investigated. The following parameters of the materials were examined: material sew ability specific sewing stress (cN/tex); material damage due to sewing process; and material comfort. It was found that the characteristics of tested materials on joined places differ in sew ability parameters.

Keywords: woven Fabric, knitted fabric, Nonwovens fabric, artificial leather, and composite sewn seems fabric resistance to needle penetration (cN), specific sewing stress (cN.tex-1); Fabric-Skin comfort Ratio.

1. Introduction

Technical textiles are used in many industry branches, such as motor, aircraft, furniture, catering industry...etc. One of the most important markets of technical textiles sector is automobile textile. So the automotive industry is the largest user of technical textiles, which about 20 kg in each car of the 45 million or so cars made every year world wide . In 2000 global car production was 38 million units and this means that 500000 tons of textile materials were consumed for this purpose. Interior accessories (e.g. upholstery, roof coating, door panels, and carpets) are equivalent to 2/3 of automotive textiles. Nowadays if we look at the material used in an automobile we can see 28 different usage places, such as : carpets(33%) ; upholstery (seat fabrics, 18%); previously assembled materials (14%) ; tires (12.8%) safety belt (8.8%), airbag(3.7%); others(9.4%) [1]

1.1 Technical Textiles (TT) – Mobile Textiles(MT):

Technical textiles are materials specified for their performance characteristics. These include aerospace, agriculture, construction, health care, personal protective equipment, transportation, firefighters protective garments, airbags, bullet-proof clothing, surgical stints, flam- retardancy, high visibility, filtration, tensile strength and automotive. While the term mobile textiles addresses the market of transportation means, such as cars, train, busses, airplanes, ships, spacecrafts…etc. This sector processes a lot of textile, sometimes very visibly (upholstery of seats, doors, Sealing, carpets,….etc); sometimes invisibly (airbags), but also very often in spare parts where one hardly suspects the presence of textiles (tires, transmission belts, filters, ….etc). Usually, the fabrics produced are finish is often required, such as sun blinds for cars, safety nets, for station wagons, nets for seat and door bags,….etc. Function of textiles in cars are: (1) isolation against heat, acoustics and machines;)2) safety like airbags and belts; (3) tire and tire cord;(4) indoor equipment like seats, canopy, and doors; and (5) structure elements like composite structures against crash, lightweight structure.

Nowadays different types of materials are used for upholstering automobiles, whereby the application of materials (technical textiles such as: woven, knitted, Nonwovens, artificial leather, and composite sewn seams) from synthetic polymers-polyester, polyamide, Nomex ,Glass and Polypropylene as well as from Cotton in blends with synthetic fibers prevail. For the sake of comfort more flexible and softer materials are used; at the same time they should be abrasion resistance and durable.

Special attention is given to the places of the sewn seam in woven or knitted fabrics, especially in the warp and weft directions, so that light refraction is not different as it disturbs the appearance of the whole product. When sewing up woven fabric attention should be paid to the warp and weft directions, and in the case of knitted fabric to the course or wale directions as well as to both ends being sewn up. Sewing direction should be in the direction of fibers . If it is not done this way the upper layer of the fabric will be shifted.

Corresponding Author : E-Mail : elhadidyy@ yahoo.com

1.2 Automobile Textiles-Substrates Products

Coated substrates are used as backing for automotive fabrics, furniture, shoes, luggage, and tablecloths. The fabrics used in these applications needle punched and composites of foam and/or plastic film. In the automotive area, the substrates are used mainly for seat backings. In the furniture market, substrates are used in upholstery, tablecloths, and luggage.

The increasing scale of automobile production, and consequently its world-wide stocks (Table I), is based on rapid industrializations in Asia, Africa and Latin America plus increasing demand in Eastern Europe, the proportion of textiles in the motor car rising in response to more stringent comfort and safety requirements in industrialized countries like the USA, Japan and Western Europe. Automobile textiles are therefore an interesting market for information too, as technical events for example indicate for Germany alone. David Rigby Associates, (GB) market study on industrial textiles as-signs to automobile textiles growth of 1408 kiloton's (1985) via 1918 kiloton's (1995) to 2483 kiloton's in 2005, that is to say a product group for quantity growth and innovation with technical justification for currently up to date information [2].

Automobile textiles, such as transport tarpaulins, windscreen protection, seat covers, children's seats, tow ropes are current examples. Further quantitative and qualitative development of textile usage in the automobile is determined by the following possibilities:

1-Textiles replace plastics or other materials at recognized application points with familiar functions. Examples : replacement of soft polyurethane foam in seat upholstery fabric components by Nonwovens.

2-Textiles are used in cars for new applications with new functions. Example :the use of an absorbent glass batt in car batteries. These Nonwovens surrounds and confines the acid preventing acid leakage in the event of damage to the casing, and making new location for the car battery possible.

3-Textiles are replaced in the car by the other materials. Example : leather door panel trim.

4-Textiles lose their applications in cars due to function elimination. Example: radio signals will replace electrical leads, with the consequent elimination of textile cable shrouding.

1.2.1 Car Seats

The main features of car seats are: i)clean ability; ii) durability (over 10 years), iii) slide ability; iv) color fastness; v)UV resistance; vi) Heat protection (-20co to 100co, and from o to 100% RH); vii) Abrasion resistance, viii) resistance and crease resistance, ix) tear strength) breath-ability; xi) comfort; and xii)mildew resistance.

Automotive seat fabric is almost invariably a tri- laminate:

1-polyester fabric(wool, ramie, leather),

2- Polyurethane foam; and

3- Nylon-polyester scrim backing.

Meet a specific minimum strength, the joined places must have similar or almost the same properties. The properties of the joined place depend on the selected sewing thread, tension, seam type, seam size, stitch type, and sewing conditions, i.e., fabric sew ability.

To make sitting in the car, sometimes for hours as comfortable as possible and to pose the body in the correct posture, some construction standards are to be met:

The framework of the seat should be designed firmly according to the correct posture of the body in sitting position.

Each segment of the seat should be designed correctly and made from material imparting safe feeling and comfortable sitting .

The external layer is a fabric, which should have specific properties such as strength, elasticity, resistance to a abrasion, pilling and inflammability, good hygroscopic properties…etc[3].

Technical textiles such as woven and knitted fabrics enable an unlimited combination of designs and colors. The have good properties: good air permeability humidity and warmth transfer, soft hand, good resilience, easy care, high abrasion resistance etc. Since materials for upholstering should meet not only some characteristics, but also requirements, they can be separated from other fabrics. It is possible to make textile materials resistance to soil, water, fire,….etc, but they are used only for special purposes.

Nonwovens-since they may be engineered to have a soft hand and high elasticity, as well as being air permeability, they are used for the sidewalls of the car seats or as lining material heat to the backside of the fabric.

Artificial leather has high abrasion resistance, but due to its discomfort (cold), low elasticity and stretch, its use is not widespread in the automobile industry.

2. Objectives

The word quality does not have the popular meaning of best in any absolute since, it means best for certain customer requirements. These requirements are the (a) actual use and (b) selling price of the product. This investigation provides an introductory text on the science and technology of car seats fabrics from the following points of view:

1- Fabric surface engineering,
2- Fabric quality and sew ability assessment, and
3- Interrelation between fabric hands, fabric sew ability, and seam quality.

The intention here is to calculate and measure the following characteristics values:

A–mean deviation of fabric surface engineering, i.e., frictional measurement and roughness measurements.

$$\beta = \frac{1}{x}\int_{o}^{x}(\sigma - \overline{\sigma}).dx \qquad (1)$$

Where:

β = mean deviation of surface roughness(mean deviation of fabric resistance to needle penetration (unit-cN),

x = 10cm is taken in this investigation as standard measurement, and

σ mean value of fabric resistance to needle penetration (FRNP).

b – Parameter to monitor car seat fabric damage due to sewing process,

c- General comments on fabric hand modulus, it focuses on mechanical properties related to hand evaluation, and,

d – non – destructive examination of fabric sews ability, with particular emphasis on fabric resistance to needle penetration (FRNP), [4].

This investigation will be essential reading for engineers and technical of automotive technical textiles.

2.1 Case Study

2.1.1 Objective

Hand Evaluation of Tactical fabrics used for automobile seat covering

2.1.2 Materials

Circular knitted fabrics are generally produced from colored yarns, Jersey, Pique, Rib, Melton, Plush fabrics are manufactured on a circular knitting machine and has high elasticity and smooth surface. Woven, none worsens, and Leather is used also for comparison point of view.

2.1.3 Methods

The sew ability taster have been used for objective hand measurements. Also, the subjective hand was evaluated from judgment of 30 persons. They rated the fabrics to 5-point scale. The subjective hand was computed as median of rating divided by 30, where:

$$M = Me + 0.5 - \frac{Fi - 0.5}{fi} \qquad (1)$$

Where:

$\sum_{i=1}^{n} n_i = N$, fi =ni /N, Me= Sample – rating median.

3. Experimental Work

Experimental were carried out on woven, knitted, Nonwovens, composites and on artificial leather, which were intended for upholstering car seats. Fabric resistance (material) to sewing needle penetrating and /or specific sewing stress were tested on the sew ability tester[3,4].

Two samples of woven, knitted, Nonwovens, technical fabrics, composite and artificial leather, which form the main part of the upholstered sitting seat part, were tested. The prepared samples were 250mm long and 100mm wide, which was reduced to 50mm by unraveling edge threads, standard ASTMD 1682. The sew ability tests were cared out without sewing thread and for each material separately.

3.1 Test Results and Discussion

Fig(1) shows the relation between Total Hand Value (THV) subjective – evaluation and specific sewing stress (SSS), Objective measurements).

The test results of the fabric resistance to sewing needle penetration (cN) for use in motorcars are as follows: woven fabric (1) has a little higher (FRNP) than fabric (2) referring to the samples with and without seam (Table II). On the basis of the results it is evident that the (FRNP) of seam samples is higher for both tested fabrics. The sample without seam differing fiber type (cotton, wool, polyester), blend ratio (100%, 50%, 40%); fabric set-fabric thickness – fabric structure, i.e. fabric tightness, so that in fabric (1) the FRNP in weft direction with 100g/m2, twill 1/3 is 412.5 (cN) and 887.5 (cN) respectively, while knitted fabric (1) with 50% cotton, 50% polyester, 210 g/m2, Melton, is 502, (cN) and 87(cN) respectively. It was found from Table II, that the (FRNP) without seam is from 87.5 (cN) to 502 (cN), respectively. The obtained results the (FRNP) is higher in composite structure in all tested samples.% increase reaches 98.8%, 17.5%, 53.7%, for composite sew seams (FRNP) of the tested technical fabric is from 335 (cN) to 850 (cN), i.e.% increase is 53.7% .According to the out of woven, technical respectively. It is well known that as the (FRNP) increases the %of fabric resistance of car seating covering increase also, and sewing is bad. So it is easy to say that the different in car seat materials will lead to different sewing troubles i.e. different stitch types, seam type, seam size, thread size,….etc.

Where:

SSS[5]= Specific sewing stress= $\frac{FRNP(cN)}{w(g/m^2)*\Phi N(mm)}, (cN.Tex)$ (2)

L= Artificial leather,
S= Sponge and (thermally bonded), and
NW=Nonwovens web (Thermally bonded)3.2

3.2 Correlation Coefficients

Correlation Coefficient between the dependent variable (HM) and the impendent variables of all mechanical and physical properties related to fabric hand has been done .

Table III shows that there are four parameters with significantly high correlation coefficient with hand modulus, these are the fabric weight, air permeability, fabric shrinkage, and fabric compress ional ratio, these results obtained show that air permeability has the highest correlation coefficient followed by fabric shrinkage ratio and fabric weight. Table III shows that air permeability and shrinkage ratio are correlated so that only one of these can be replaced each other, the same is true for fabric weight, and compression ratio.
Because of this interrelation of these mechanical properties, we used a multiple regression to fine the primary parameters that could best predict fabric hand.

3.3 Multiple Regression Models

In order to find a reliable equation to describe the relationship between hand modulus and fabric mechanical properties and to obtain an accurate hand modulus prediction we examined four mathematical models based on the earlier studies as follows:

$$HM = bo + \sum_{i=1}^{i=n} bi(xi) \quad (3)$$

$$HM = bo + \sum_{i=1}^{i=n} bi(xi)^{y3} \quad (4)$$

$$HM = bo + \sum_{i=1}^{i=n} bi(Lnxi) \quad (5)$$

$$LnHM = bo + \sum_{i=1}^{i=n} bi(Lnxi) \quad (6)$$

Where (xi) is the typical values of physical – mechanical properties and they are given in Table II.

3.3.1 Multiple Regression Analysis

Multiple regression analysis has been performed on the relationships between hand modulus and fabric mechanical properties. To investing the interaction of selected fabric properties, an equation relating the fabric hand modulus to the variables of fabric weight tightness, air permeability, fabric hardness, softness, shrinkage, compression ratio, bending length, absorption, crease ratio, and bursting index was fitted to the experimental results using multiple regression analysis in the following

$$Y = bo + \sum_{i=1}^{i=n} \text{bixi} \quad (7)$$

Where:
Y=fabric hand modulus
Xi= measurable fabric properties, and
bo, bi= the constant and fabric hand modulus terms.
Values of coefficients bo, bi and standard error regression equation for fabric handle in terns of fabric measurable mechanical properties is shown as:

FH = 0.09 Z +0.3 (8)

Where

$$Z= (\sigma_1.\sigma_2.....\sigma_n)^{\frac{1}{n}} \quad (9)$$

3.4 Complex Assessment of Hand Modulus

From such study, performance properties of car seats fabrics can be divided into two groups: positive properties such as fabric weight (W-g/m2) ; air permeability (cm3/Cm2, Sec); absorption capability(%) ; softness (mm); compression ratio(%); and bursting Index (Kap/cg/m2), and negative properties such as fabric hardnesss ((g/cm2)/mm); shrinkage (%); bending length (Cm); and crease ratio (warp/ weft-%). Relative characteristics of each property may be evaluated by the following:

+ive correlation= $\sigma_i / \sigma_{max} .10^2$ (10)

- ive correlation= $\sigma_{max} / \sigma_i .10^2$ (11)

Where σ_i, σ_{max}, and σ_{win} - typical value, max. value, and min. value of each tested property.
Table II: shows The typical and / or relative values of selected fabrics:
No.l representing the best fabric and No. 6 representing the worse one.

3.5 Hand-Sew ability of Automobile upholstery

One of the recent trends in textile and clothing manufacturing industries is to shifting towards producing high quality fabrics. The 21 century will put much value upon human life and clothing will play an important role in the improvement of human life in the future. In this investigation , the analysis of the objective hand measurement of the textiles in car is first introduced and then a trial amide at the objective elevation of both fabric hand – sew ability is introduced.

The handle – sew ability of the sheet materials for covering the dashboard and front panel of automobiles was examined using the objective measurements (fabric resistance to needle penetration – FRNP). This material used also as the covering sheet of the car seats, dashboard, and steering wheel is made from textiles (Woven, Knitted, Nonwovens, and Nonwovens Related Products).

There are two types of performance for technical car seats one of them is utility performance such as sun shine resistance; resistance of friction; resistance to burning; and resistance against mildew.

Table IV: shows the typical values of car seat performance characteristics .

3.6 Interrelation Between Fabric Hand and Fabric Sew ability

The problem is complicated by the fact that all properties are not necessary independent of each other, e.g. fabric stiffness, smoothness, fullness, crispness, anti-drape stiffness, and flexibility with soft feeling may be interrelated, and it is desirable to reduce the number of basic independent variables to as small a number as possible. The procedure of statistical analysis can be explained in terms of its application to some experimental results. The first stage in the analysis of the results is the calculation of the correlation coefficients between the sets of measurements or assessment, taken in pairs. Fabric hand may be a function of the following fabric physical and mechanical properties:

Stiffness ;b) smoothness; c) cloth weight; d) cloth thickness; e) fabric hardness; and f) fabric tightness,

Table V&VI : shows the results of fabric properties related to fabric hand .

On the other hand fabric sews ability may be calculated from the following parameters[5]:

a) Fabric anisotropy (s);

b) fabric range (Δ);and

c) parameter"

where:

S= $(\sigma_{max} - \sigma_{min}) / (\sigma_{max} + \sigma_{min})$, (12)

Δ = $\sigma_{max} - \sigma_{min}$ (12), and

C= $\dfrac{\sigma_{min}}{\sigma_{max}}$ (13)

Where:

σ_{max} , and σ_{min} are fabric resistance to needle penetration.

After caring out fabric hand and fabric sew ability (fabric resistance to needle penetration) tests on a series of fabrics it is necessary to correlate the two types of tests. This point will be dealt with more fully later [6]. The results of objective fabric hand tests were related to objective fabric sew ability (R=0.886); Also it was found that the correlation between fabric hand modulus and fabric sew ability reaches – 0.77while the correlation between fabric hand and fabric performance reaches 0.143.

3.7 Rank Agreement

The six fabric samples are to be ranked in order of general hand- sew ability using the two methods of fabric hand (physical–mechanical properties related to fabric hand) and hand evaluation using sew ability tester. These fabrics have been ranked from "1" to "6". "1" representing the best fabric and "6" representing the worse one. The ranking of two methods are set out in Table VI. If all the methods were in complete agreement, the rank totals would be in series 2,4,6,8,10and 12, the sum of the rank total is 42. If the methods of assessment had no ability in ranking the fabrics, the ranking numbers would be random and in our case the average rank total would be one-six of the total 42 and equals to 7, the actual rank totals are compared with the average 7 as listed in Table VII & VIII.

The measure of the degree of agreement among the different methods is given by the coefficient of concordance, W, as follows:

W= $\dfrac{12\,S}{m^2(n^3 - n)} = 0.941$ (14)

Where S-the sum of squares of the differences,

m- the no. of methods, and

n- the no. of fabrics.

Since in this example, W=0..941, hence the different methods of assessment exhibit a high degree of agreement on the ranking of fabrics for hand. The significance of the coefficient of concordance may be tested by reference to the F- Tables. The value of "F" is then calculated:

F= $\dfrac{(m-1)W}{1-W}$ = 15.949 (15)

It could be concluded that the different methods are really in close agreement because the calculated value of "F" 15.949, is above the 1 percent level of F= 15.52 for the degree of freedom of :

$$P_1 = (n-1)\frac{2}{m} = 5 \quad (16)$$

and

$$P_2 = (m-1)(n-1) - \frac{2}{m} = 4 \quad (17)$$

The results of final ranking are given in Table VIII. The fabrics are arranged in order of increasing final ranking. It could be noticed that the fabric no.3 and fabric no, 5 has the best and worse hand respectively.

4.Car Seat Covering Sew ability Assessment The information's given here are mainly abstracted from sewing Focus – Technical Sewing Information Seat covers are most commonly sewn from foam – backed woven or knitted fabrics. These fabrics are described as composites because seat upholstery materials usually consists of three layers: fabric forming the outer surface of the product – foam – knitted fabric on the inside of the product. Typical sewing problems affecting seat production are primarily:

* Thermal damage,
*Fabric damage, and
* skip stitches.

This broad spectrum of variations results in varied sew ability from one material to another, and necessitates individual and precise adaptation of all sewing parameters such as machine, sewing speed, sewing needle and sewing thread. An additional factor to consider when optimizing sew ability is the height of the foam backing. The higher the foam, the lower the sewing speed should be set.

The choice of needle size and point style is always guided by the material quality, the number of layers and martial combinations. Depending on the thickness and finish of the material as well as on sufficient inherent elasticity in the fabric threads, no damage is to be expected if a suitable needle size is used . An overview of the recommended sewing parameters can be found in the Table VIII.

Table IX . Checklist for sewing vehicle seating.

Due to the relative different principles used by objective measurement (fabric specific sewing stress (cN/tex), and subjective evaluation (fabric total hand value), for measuring the various deformation mechanical properties, variations in results could be expected. The previous discussion emphasized that car seat fabrics can be expected to have relatively low linear correlation, between the measurements from two test methods.

However, Figure 1a, 1b, and 1c illustrates a significantly good linear correlation of 0.946, o.792, o.626. between objective measurements and subjective evaluation results. The reasons behind that: First, this may be due to the insufficient similarity between car seat fabrics, i.e., woven, knitted , and technical fabrics. Second, objective measurements (SSS-cN.tex^{-1}) is a function of test direction, while subjective evaluation are not.

The regression equations used to describe that phenomenon are:

a. for woven:
   $y= 24.702 X^2-23.994 X +16.559$ (18)
b. for technical fabrics:
   $y= 0.4359 X^2 – 10.757X+67.432$ (19)
c. for knitted fabrics:
   $y= 0.5676X^2 - 2.3728X +11.82$ (20)

Good and acceptable correlations have been found in some of car seat fabrics properties determined by the two different test methods, while other car seat fabrics gave week correlation leading investigation on the best car seat fabric selection.

5. Car Seat Fabric-Skin Comfort

The most important property of any upholstering car seat is comfort. Comfort is an experience that is caused by integration of impulses passed up the nerves from a variety of peripheral receptors smell, smoothness, consistency and color etc in the brain. Comfort is a quantitative term and it is one of the most important aspects of clothing. The car seat fabric comfort can be divided into three groups, i.e. psychological, tactile, and the thermal comfort [7]. Psychological comfort is mainly related to the latest fashion trend and acceptability in the society and bears little relation to the properties of fabrics. The tactile comfort has relationship with fabric surface and mechanical properties. The thermal comfort is related to the ability of fabrics to maintain the temperature of skin through transfer of heat and perspiration generated within the human body.

Comfort, as felt by the user, is a complex factor depending on the above attributes. Some early study [8-12] reported various aspects of comfort related fabric properties.

For each car seat fabric sample we have measured five values of fabric resistance to sewing needle penetration (fabric sew ability), i.e. arithmetic mean, maximum value, minimum value, 25th, and 75th percentiles. Comfort of various fabric samples in this study was evaluated by the quotient of the 25th percentile and 75th percentile.

Percentiles are measures of central tendency that divide a group of data into 100 parts. There are 99 percentiles because it takes 99 dividers to separate a group of data into 100 parts. The nth percentile is the value such that at least n percent of the data are below that value and at most (100-n) percent are above that value. Specifically, the 87th percentile is a value such that at least 87% of the data are below the value and no more than 13% are above the value.

Percentile can be determined as the following steps:

1- Organize the values of fabric sew ability in ascending order array.
2- Calculate the percentile location (I) by:

$$i = \frac{p}{100}(n) \quad (21)$$

Where,
p = the percentile of interest
I= percentile location
n= number in the data set

3- Determine the location by either (a) or (b)
a- if I is a whole number, the p^{th} percentile is the average of the value at the i^{th} location and the value at the $(i+1)^{st}$ location.
b- if " i" is not a whole number, the pth percentile value is located at the whole number part of i+1.

Fig. 2 , shows the relationship between fabric – skin ratio, and type of technical fabrics. Out of the varieties examined ,technical fabric out of PES(1) shows the highest , fabric –skin ratio , whereas technical fabric , out of POP(5) shows the lowest ratio. It is well known that if the value of fabric – skin ratio is zero the comfort could be described as excellent [13].

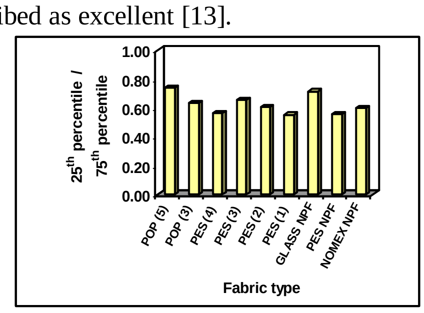

Fig. 2 Relationship of fabric-skin comfort ratio to type of tested car seat fabrics.

6. Conclusions

By testing materials for the automobile industry the following conclusions were reached:
Technical woven fabric represents the best material with the highest fabric resistance to sewing needle and/or specific sewing stress.

The advantage of knitted fabric is not its strength but elasticity and softness what makes it more comfortable then woven, but due to its considerably lower sewing damage and high "SSS" its durability compared with woven and leather is shorter.

Artificial leather has the highest "SSS" but due to its low elongation penetration resistance and damage did not produce good results.
Nearly in all tests and samples the test results were better for the samples having smaller "SSS". It leads to the confusion that "SSS" represents the most important parameter affecting the examined values. It was not tested which "SSS" may be applicable, but on the basis of the obtained results the upper limit can be calculated.

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The proposed technique is capable to estimate hand characteristics of technical textile used for automobile seat covering.

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Table I: World automobile production and stocks (10^6 units).

Type	2001	2008
Annual private vehicle production	38.5	43
Annual freight vehicle production	15.5	17
Stocks	700	885

Table II: Car Seat Coverings Resistance To Sewing Needle Penetration

Properties / CSC	Woven(W)		Knits(K)		Tech. Textiles		Composite Sewn Seams							
	(1)	(2)	(1)	(2)	(1)	(2)	2W	2K	2L	W+K	W+L	2K+S	2K+NW	K+L
Weight(g/m²)	100	230	210	235	200	280	560	440	900	500	730	530	550	670
FRNP(cN)-	412.5	887.5	502	87.5	335	850	335	500	740	420	535	524	548	620
FRNP(cN)≠	550	975	720	130	606	1275	610	660	1110	800	861	4951.6	4354	430
SSS----	5.5	4.8	3.4	0.57	1.19	2.17	0.43	0.81	0.59	0.6	0.52	0.72	0.72	0.66
SSS≠	3.4	2.4	1.9	0.31	1.08	1.63	0.39	0.54	0.44	0.57	0.421	3.3	2.83	0.49

Fig.1a.Total Hand Value versus Specific Sewing Stress.

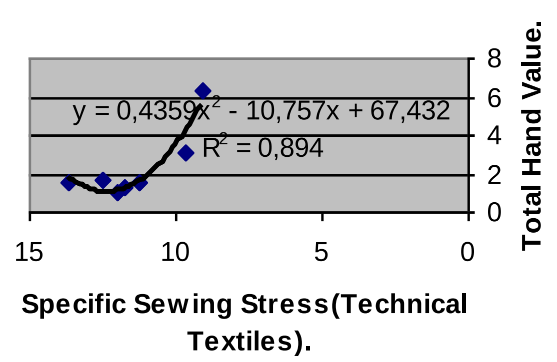
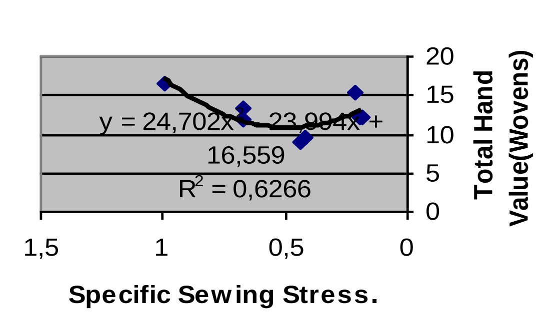


Fig.1b.Total Hand Value versus Specific Sewing Stress.



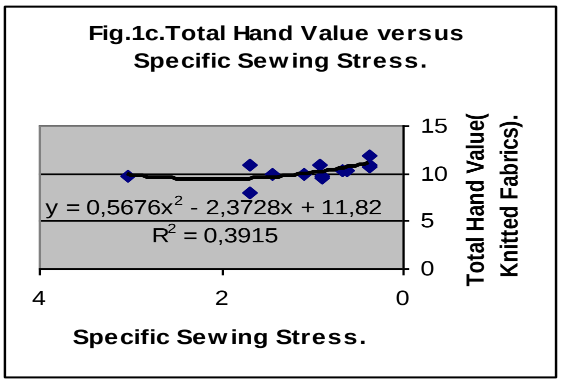


Table III: Correlation coefficient between hand modulus and mechanical physical properties.

	W	T.	A.P.	H	S	Sh.	CR	BL	AC	Cr.R	B.I
W	1										
T	0.143	1									
AP	0.429	-0.543	1								
H	-0.714	0.486	-0.657	1							
S	**0.829**	**0.029**	**0.257**	**-0.714**	**1**						
Sh	**-0.029**	**0.029**	**0.029**	**0.086**	**-0.143**	**1**					
CR	**0.314**	**0.371**	**0.029**	**-0.086**	**0.371**	**-0.6**	**1**				
BL	**0.343**	**0.114**	**0.4**	**0.343**	**-0.171**	**0.914**	**-0.171**	**1**			
AC	**0.429**	**-0.6**	**0.943**	**-0.714**	**0.314**	**-0.257**	**0.029**	**0.171**	**1**		
Cr.R	**0.486**	**0.143**	**0.143**	**-0.086**	**0.657**	**-0.657**	**0.829**	**-0.4**	**0.257**	**1**	
B.L	**-0.571**	**-0.086**	**-0.857**	**0.514**	**-0.4**	**0.286**	**0.114**	**0.029**	**-0.686**	**-0.171**	**1**

Table IV

Fabrics	Results of Fabric Resistance against				
	1-Sun Shine (%)	2-Burning (cm/sec)	3-Friction (µ)	4-Mildew (%)	Rank
Jersey	8.6	0.29	0.90	38.6	1
Pique	14.7	0.16	1.10	27.2	3
Tuck	15.2	0.31	0.93	26.0	6
Rib	11.9	0.17	0.95	25.4	2
Melton	18.6	0.20	0.78	29.2	4
Plush	20.3	0.21	0.92	20.0	5

Continue Table IV

	Absorb. Capability%	Crease ratio%	Busting Index[(cap/cg/m^2)]	Ran(cin/g)	
				H.Mo	F.H.s
1	61.4	2.048	13.6	5	2
2	72.8	0.489	10.4	3	3
3	74.	1.831	5.4	4	4
4	74.6	1.000	10.2	2	6
5	70.8	0.369	10.2	1	5
6	80	0.451	5.9	6	1

Table V: Shows the results of fabric sew ability.

Table V

Fabrics	**Fabric Resistance to needle penetration**		**S Smoothness**	**Δ Stiffness**	**C Fullness**	**Rank**
	σ_{max}	σ_{min}				
Jersey(1)	16.5	8.50	0.32	8	0.52	3
Pique(2)	7.7	0.70	0.83	7	0.09	5
Tuck(3)	8.2	1.20	0.75	7	0.15	1
Rib(4)	7.9	0.96	0.79	7	0.12	4
Melton(5)	6.6	0.60	0.83	6	0.09	6
Plush(6)	8.7	2.70	0.53	6	0.31	2

Table VI

Fabrics	Stiffness (BL)	Smoothness (cu)	Cloth weight	Cloth thickness	Cloth hardness	Cloth tightness	Rank
1	0.61	0.9	210	0.6	0.69	19.157	3
2	0.89	1.1	240	0.9	0.81	20.000	6
3	0.42	1.0	170	0.7	0.81	16.234	2
4	0.34	0.93	250	1.3	0.90	15.969	4
5	0.82	0.78	300	1.2	0.65	22.633	5
6	0.89	0.93	220	1.6	0.31	6.776	1

Table VII

Assessment methods	Fabrics					
	1	2	3	4	5	6
A(THV)	3	6	2	4	5	1
B(SSS)	3	5	1	4	6	2
Rank totals	6	11	3	8	11	3
Final rank	3	5	1	4	6	2

Table VIII

Seat fabrics used in automobiles:	Tested properties							
	Weight (g/m^2)	Tightness $Tex^{0.5}$, Cm^{-1}	Air perm. $cm^3/cm^2.sec$	Hardness $(g/cm^2)/mm$	Softness (mm)	Shrinkage (%)	Co,p.ratio (%)	Bending length (cm)
a-Circular								
knitted	180	19.158	13.9	360	0.125	0.668	51.6	0.61
1 – Jersey	180	20.	22.4	410	0.110	0.893	58.5	0.89
2 – Pique	220	16.234	22.4	333	0.135	0.716	54.7	0.42
3 - Tuck	220	15.969	31.6	192	0.235	0.584	56.8	0.34
4- Rib2*2	235	22.633	199.1	282	0.610	0.763	66.8	0.82
5- Melton	220	6.756	27.4	140	0.320	0.954	56.1	0.89
6- Plush								