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THE ABRASION RESISTANCE OF WARP-KNITTED FABRICS USED IN CAR SEAT COVERS

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ABSTRACT

Car seats are the most important part of its interior decoration, and polyester is the most widely used material in car seat covering. Abrasion resistance tests are used to quantify the duration of car seat upholstery in normal usage, and this is one of the most important requirements. This paper presents an experimental study of the abrasion resistance properties of a various warp-knitted constructions which are specially developed for automotive application as car seat covers. Warp-knitted fabrics have highly heterogeneous and directionally structures and exhibit high abrasion resistance properties. The main elements which determine the characteristics of warp- knitted structures are; gauge; courses per inch; yarn type; stitch type and guide bar movement. This study provides some useful information for designing warp-knitted fabrics for automotive application.

Keywords: Abrasion Resistance, Automotive Textiles, Chain Notation, Tricot Machine, Warp-Knitted structures.

I. INTRODUCTION

Along with the growth in the number of vehicles worldwide , the amount of textile materials used in motor vehicles has increased [1]. Textiles for automobiles must satisfy very strong requirements for both security and competing demands. The seat constitutes the most important part of the interior decoration. Its security and comfort are studied by automobile manufacturers, seat makers, fabric producers, and textile research centers and universities. Polyester is the most widely used material in car seat coverings. Woven, weft knitted (circular machine), and warp knitted fabrics (tricot and double needle bar machine) are the most used fabric structures [2]. The seat can be divided into two main parts, a frame and a covering. The covering of the frame is divided into two parts, usually a polyurethane foam cushioning and a cap. The three layers composing the "complex" are a surface polyester fabric (weaving or knitting, etc.), a thin polyurethane foam and a polyamide knitting or nonwoven that improve cap slip on the cushioning [3].

The use of natural fibers in the production of textile materials for automotive interiors is limited in the main to wool, due to minimum performance requirements for light fastness, abrasion etc but also due to the comfort and added value which wool is perceived as imparting to the product. It has been the introduction of synthetic fibers which led to the growth in products which found their way into automotive end uses for reasons mainly to do with performance, cost and versatility. Most synthetic fibers and yarns and certainly the ones used in automotive fabrics are thermoplastic in nature [4]. Polyester is the most acceptable fiber for automotive trim fabric used in over 90% of all car seats world-wide. Intense research into new variants of polyester to achieve specific results such as stretch, variable dyeing, different luster, and color extrusion of the polyester filaments, has contributed to consolidate its position as the dominant fiber for automotive decorative trim fabrics. The popularity of polyester largely stems from its durability and compatibility with cotton blend. Its very low moisture absorbency, resilience and good dimensional stability are additional qualities [5].

Fabrics are characterized by a large variety in design, stable shape retention and high mechanical resistance [6]. The three main fabric- forming structures which have a place in automotive manufacturing are; woven, knitted and non-woven. Knitted fabrics with raised surfaces are most softener to the touch than flat woven [7]. The technology which has the largest overall share in most car producing area is the warp knit technology. There are two main warp knit technology which have had a major influence the automotive textile market and those are; Tricot knit (including pile sinker styles) and double needle bar Raschel machines. The compound needle is the major needle used on both Tricot and Raschel machines. Common gouges for the types of fabrics produced for automotive end-uses would be between 20 and 28 gauge [8].

Warp knitting has many unique advantages over other fabric formation systems; higher production rates than weaving, wide variety of fabric constructions, large working widths, low stress rate on the yarns which allows the use of fibers such as glass, aramid, and carbon, fabrics can be directionally structured and three dimensional structures can be knitted on double needle bar Raschel machines[9]. Three or more guide bars refers to multi bars warp-knitted machines, the construction of these types of fabrics increases the versatility and enlarges the pattern scope of these machines. The increasing swinging movement of the guide bars decreases the production of these machines. However, the increased patterning possibilities offer important advantages; better control of dimensional and mechanical properties, improved pile fabrics because of a more stable ground structure, greater use of color and visibility of color on the fabric surface, more elaborate part set threading designs to produce a wide range of mesh or lace fabrics and improved elasticity fabrics with more patterning possibilities and less transparency of the fabric knitted [10].

Abrasion is the physical destruction of fibers, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface [11]. Textile materials can be unserviceable because of several different factors and one of the most important causes is abrasion. Abrasion occurs during wearing, using, cleaning or washing process and this may distort the fabric, cause fibers or yarns to be pulled out or remove fiber ends from the surface [12]. Abrasion ultimately results in the loss of performance characteristics, such as strength, but it also affects the appearance of the fabric [13]. Abrasion resistance of the textile materials is very complex phenomenon and affected by many factors, mainly classified as follows: Fiber, yarn, fabric properties and finishing processes [14].

Therefore, the main objective of this study is to investigate how typical warp-knitted fabric for automotive application as car seat covers behave when tested with abrasion resistance test. It is expected that such a study can provide some useful information for designing warp-knitted fabrics for high abrasion resistance.

II. MATERIAL AND METHODS

In order to investigate the effect of structural parameters on the abrasion resistance, five different warp-knitted structures with, or without foam were used. They all produced in Tricot warp-knitted machines, Two structures are laminated with foam with scrim lining on the back. Tricot machines are available in a number of different versions. Depending on the intended end-use and fabric construction, we can choose between machines equipped with two, three or multi guide bars.

The two-bar Tricot machines are designed to operate at an exceptionally high production rate. They are specialist machines for producing simple, lightweight, plain fabrics with distinction between high-speed machines with carbon bars for processing stretch and non-stretch fabrics. HKS 2, Two guide bars Tricot machine with high performance for universal application, from light tulles to heavy raised velour. This model is also suitable for very low stitch densities and coarse gauges as well.

Tricot machines equipped with three guide bars are flexible production machines. They are designed for the production of stretch and non-stretch plain fabrics, slightly patterned fabrics and pile fabrics. HKS 3 M (P), High performance Tricot machine with three guide bars with medium stroke of needle to produce wide range of applications. When equipped with an elastan device, the HKS 3-M, Tricot machine can also produce elastic articles. A simple and quick retrofitting of the machine with pile device is possible, because the compound sinker remains unchanged. (HKS 3 M (P)), The letter (P) on HKS 3 M signify that the machine equipped with pile sinker bar to produce pile fabrics.

Tricot machines with four or five guide bars are extremely flexible. They are producing a wide range of patterns to suit quite specific requirements, such as the production of terry and pile fabrics. The four guide bars enable different yarns to be combined. The range of patterns can be extended by using electronic guide bars (EL). HKS 4 / HKS 4 P, High performance four bars Tricot machine without Pile Sinker (HKS 4) and with Pile Sinker (HKS 4 P) for produce wide range of applications. HKS 5 EL, High performance five bars Tricot machine without Pile Sinker. The range of patterns can be extended by using electronic guide bars (EL). Table (1) shows the specifications of the Tricot warp-knitted machines which used in the production.

Table 1 The Specifications Of The Warp-Knitted Machines

Sample No.	Machine Type	Gauge Needle /inch	Machine Width inch	No. of Guide Bars	Production rpm
1	HKS 2	28	84	2	2500
2	HKS 3-M P	28	170	3	1500
3	HKS 4 P	28	136	4	1200
4	HKS 4	28	136	4	1000
5	HKS 5 EL	28	136	5 (4 in action)	800

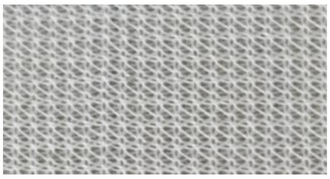
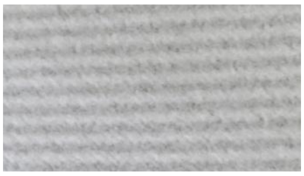
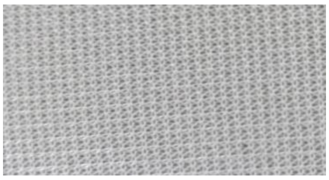
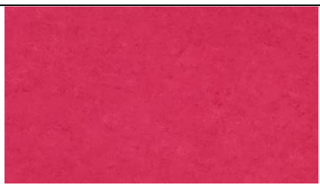
Table (2) shows the characteristics of produced samples, the fabric characteristics include the yarn type , yarn count and arrangement, wales / inch, courses/ inch, fabric width and weight and finishing process.

Table 2 The Characteristics Of Produced Samples

Sample No.	Yarn	Wales/ inch	Courses/ inch	Fabric Width inch	Fabric Weight g/m^2	Finishing Process
1	50% 167/48 dtex 50% 76/24 dtex polyester	44	66	84	190	Washing-dyeing-drying- back side raising - heat seating
2	25 % 110/34 dtex 47% 167/48 dtex 28% 100/20 dtex polyester	28	48	136	215	Shearing-thermo brushing-polishing-shearing-laminating
3	20% 110/34 dtex 39% 167/48 dtex 20%100/20 dtex 21% 76/24 dtex polyester	28	48	136	268	Shearing-thermo brushing-polishing-shearing-laminating
4	77 % 167/48 dtex 23% 76/24 dtex polyester	35	62	109	389	Washing-dyeing-drying- finishing-both side raising – tipping
5	66% 83/72 dtex 34% 76/24 dtex polyester	33	60	115	212	Washing-dyeing-drying- both side raising - heat seating – wet printing and print after treatment

Table (3) shows the structures of produced samples including the chain notation.

Table 3 The Structures of Produced Samples

Sample No.	Chain Notation	Front Side	Back Side
1	GB1: 1-0/1-2// GB2: 1-0/3-4//		
2	GB1: 1-0/0-1/3-2/2-3// GB2: 1-0/0-1/3-2/2-3// GB3: (1-0/1-2)//×2 Pile sinker adjust 3 mm 0-0/1-1//×2		
3	GB1: 1-0/1-2//×4 GB2:1-0/0-1/3-2/2- 3//×2 GB3:1-0/0-1/3-2/2- 3//×2 GB4: 1-0/0-1/7-6/6-7/13-12/12-13/7-6/6-7// Pile sinker adjust 3 mm 0-0/1-1//×4		
4	GB1: 1-0/4-4// GB2: 5-5/0-0// GB3: 0-1/1-0// GB4: 1-0/3-4//		
5	GB1: 1-0/4-4// GB2: 5-5/0-0// GB3: 0-1/1-0// GB4: 1-0/3-4//		

The measurement of the resistance to abrasion of textile fabrics is very complex. The resistance to abrasion is affected by many factors that include the inherent mechanical properties of the fibers; the dimensions of the fibers; the structure of the yarns; the construction of the fabrics; the type, kind, and amount of treatment added to the fibers, yarns, or fabric; the nature of the abradant; the variable action of the abradant over the specimen area abraded; the tension on the specimen; the pressure between the specimen and the abradant; and the dimensional changes in the specimen. This test was carried out for all samples, according to the ASTM D3885 - 07a (2015) [15]. Weariness or abrasion resistance is expressed as the decrease in weight percent after abrasion (10000 rubs of abrasion). The weight test was carried out according to the ASTM D3776 / D3776M - 09a [16].

Lose in weight (%) = [(original weight – weight after abrasion)/ original weight] x 100

In ASTM D 3885, abrasion resistance is measured by subjecting the specimen to unidirectional reciprocal folding and rubbing over a specific bar under specified conditions of pressure, tension, and abrasive action by Flex Abrasion Testing Machine. This test method is useful for pre-treating material for subsequent testing for strength or barrier performance. The pressure and tension used is varied, depending on the mass and nature of the material and the end-use application. Testing machine consist of Balanced Head and Flex Block Assembly that has two parallel, smooth plates. The balanced head is rigidly supported by a double lever assembly to provide free movement in a direction perpendicular to the plate of the flex block. A positioning device is provided to position the flexing bar and yoke assembly while loading the specimen such that the edge of the flexing bar is parallel to the fold of the specimen during the test (ASTM D3885). During testing, the resistance to abrasion is also greatly affected by the conditions of the tests, such as the nature of the abradant, variable motion of the abradant over the area of specimen, the tension of the specimen, the pressure between the specimen and the abradant, and the condition of the specimen[15].

The using of finer fibers in the production of yarns causes increment in the number of the fiber in cross section with higher cohesion which results better abrasion resistance. So abrasion retention is better for fabrics with finer fibers[17]. Yarn structure, count, twist and hairiness are the main properties which affect abrasion of the textile fabrics. Increasing linear density at constant fabric mass per unit area increases the abrasion resistance of the fabrics [18]. As yarn got thinner, abrasion resistance values of knitted fabrics decrease and breaking occurs in lower cycles [19]. Fabric construction, thickness, weight, the number of yarn and interlacing per unit area are the fabric properties affecting abrasion. Structure type has a significant effect on abrasion resistance of the fabrics, Like as woven structure, knitting structure has also an important effect on abrasion characteristics of knitted fabrics. Average abrasion resistance values of tight structure are higher than loose opened. The reason of that is more stabile, thicker and voluminous structure of the tightly locked structure [20]. Course length for the knitted fabrics is so important that the weight loss percent after abrasion increases with increasing course length. Open, slack knitted fabric structure is abraded more than denser fabrics ([19]. The fabric mass per square meter and fabric thickness that are the main structural properties of fabrics have an effect on abrasion resistance. Higher values of these factors ensure higher abrasion resistance. Fabric type has an important effect on abrasion resistance of car seat covers. The warp knit double bar Raschel was found more resistant to abrasion than flat woven, circular knitted flat and warp knit flat fabrics [21].

III. RESULTS AND DISCUSSION

Abrasion resistance is one of the most important properties in automotive textile products. Car seat is one of the most important parts of the interior of a car and abrasion resistance of the seat fabric is an important parameter for the usage. It is composed of metal structure, filling (molded polyurethane foam) and seat cover including exterior fabric, foam and support material (reinforcement material). The foam has influence on the abrasion resistance of car seats upholstery; increased height and weight of the foam, causes less weight and thickness loss. Non-usage of foam reduced the abrasion resistance significantly [22].

The aim of this study is to determine if there is any difference among the various warp- knitted constructions with respect to abrasion resistance by comparison of weight change values after the abrasion test. In Figure (1), a main effects diagram for the rate of weight change is given. As can be seen in this figure, sample (1) has the highest rate of change in weight, while sample (3) has the lowest change.

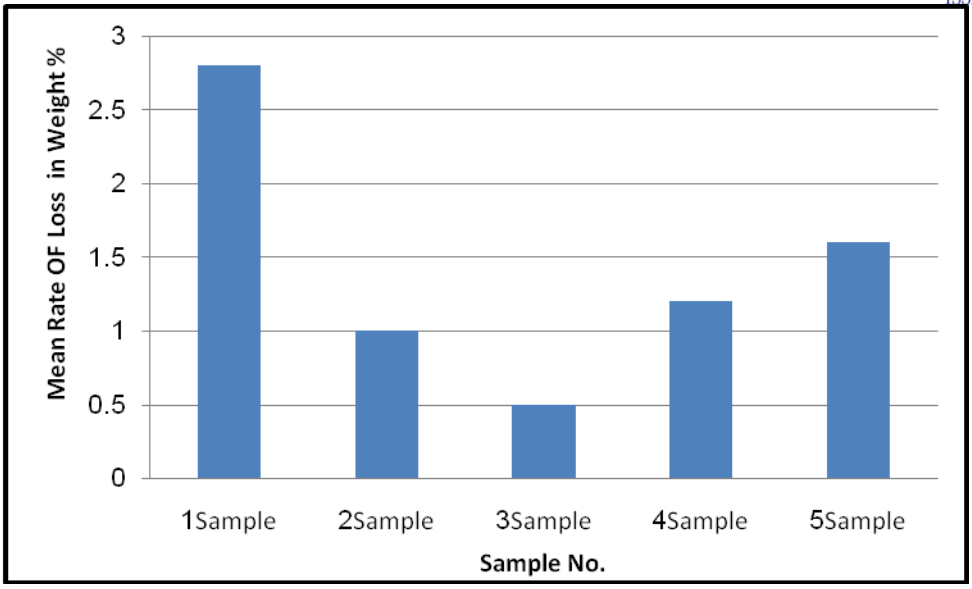


Figure 1 The Rate of Weight Change After The Abrasion Test

As illustrated in Figure (1), The results for abrasion resistance revealed that the effect of knit structure is highly significant in produced fabrics. Double bars knitted sample (1) has weaker abrasion resistance performance compared with four bars knitted sample (3) due to the increasing swinging movement of the guide bars which offer important advantages; better control of dimensional and mechanical properties, more stabile, thicker and voluminous structure. Abrasion results are usually slightly better when the fabric has been laminated to polyurethane foam (samples 2 and 3), compared to abrasion results carried out on the base fabric alone (samples 1,4 and 5). This is because the foam helps to lock the fibers together in the fabric.

Both samples (4) and (5) have the same chain notation but varied in yarn type and fabric weight which cause different abrasion resistance properties. As yarn got thinner, abrasion resistance values of knitted fabrics decrease. Higher values of fabric mass per square meter ensure higher abrasion resistance. In these samples, some of the guide bars do not knit the yarn into the fabric, the yarns are threaded through guide bars (GB2 and GB3) but the bars only insert the yarn ends into the fabric and are referred to as laid-in. The inlaid yarn shogs only on the back side of the needle; thus, an underlap is produced but the yarn does not enter the hook of the needle causes fewer limitations and less abrasion resistance.

IV. CONCLUSION

The automotive manufacturing industry is a key user of technical textiles. Cars consume a large amount of material, and the textiles are not an exception. In this research, we are interested in how the abrasion resistance varies among five different structures of automobile seat cover fabrics. All the samples were exposed to 10,000 rubs of abrasion. The main aim was to compare the different warp-knitted constructions in terms of abrasion resistance. Abrasion is influenced by the fabric structure, yarns used and finishes applied. The results for abrasion resistance revealed that; the effect of knit construction is highly significant in produced fabrics, yarns of higher dtex/filament generally have better abrasion than yarns made from finer filaments and higher values of fabric mass per square meter ensure higher abrasion resistance. Fabric structures can have a substantial effect on surface abrasion, the constructions with long ‘floats’ or laid-in which otherwise provide points for frictional stress, have the poorest abrasion. The warp knit multi-bar fabrics were found more resistant to abrasion than warp knit two bars Tricot fabrics. Abrasion results were slightly better when the fabric has been laminated to polyurethane foam because the foam helps to lock the fibers together in the fabric.

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