TENSILE AND ABRASION ANALYSIS OF AUTOMOTIVE CAR SEAT FABRICS

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Abstract: The paper reports on the abrasion and tensile tests conducted on five automotive car seat fabrics manufactured in Malaysia. The work would mainly focus on how much fabric tensile would change after being exposed to some period of abrasion work on fabric surface. In the work, fabrics were exposed at five different abrasion levels that increased progressively. Tensile test was conducted on all the abraded samples to measure on how much fabric strength has detoriated or changed. The data was recorded in terms of percentage of tensile loss from its original strength. The work recorded very strong correlation of determination and coefficient of correlation values. This would indicate that fabric strength can be determined by abrasion process. This would provide a useful tool to engineer suitable fabric properties especially for automotive fabric application since abrasion performance is one of the crucial requirement in car.

Keywords : Fabrics, Tensile, Abrasion , Technical textiles, Automotive fabrics

INTRODUCTION

Textile materials have developed tremendously over the years from traditional and commodity based textiles to competitive technical or non-commodity textiles with the use of high performance fibers, yarns and fabrics. Western Europe and USA showed consistent growth of technical textiles sector from year 1998 to 2000. The growth for both regions will be expected to be in the range of 5-8% of technical textiles market for the next five years. Technical textiles are applied in many areas where high performance is required. Technical textiles applications include filtration, health, transportation, recreation, construction, aviation, protection and communication. One of the important areas of technical textiles is automotive textiles. Main factor that drive the fast growth of automotive textiles sector is the high volume of cars produced each year.

The use of textiles in automotive is strictly based on several distinguished factors such as design, technical performance, capacity availability and price. In the years to come, textile materials in automobiles must satisfy the highest requirements, where the fabrics are expected to have better technical specification and with consistent price reduction in tandem with reduced car prices. Textiles in automobiles are also expected to maintain their appearance and performance in cars for a long period of time.

Overview of Worldwide Automotive Segments

Automotive textiles progress is driven by the huge amount of cars being produced and sold globally and annually. Every year, many models are introduced into the market offering a variety of appearance, functionality and reliability. Car sales volumes are expected to advance steadily for the years to come. Fung [3] described that car sales advanced from 39 million units in 1998 to nearly 44 million units in 2001. See figure 1.

High volume in car sales has drastically extended the demand of main raw material for fabric production, which is fibre. The consumption of textiles being used in cars will be generally dependent on several factors such as market trends for certain group of cars, competition from other car manufacturers or customer preferences [3]. Mukhopadhyay [10] states that an average family size car requires 12-14 kg of textile materials . The overall consumption of textile fibres in the car alone will reach 500,000 to 650,000 tons per year. Textiles are used in many areas in car. The areas where textiles are extensively used include seating, side panels, carpets, roof liners, filters, belts, hoses and airbags. According to Mukhopadhyay [10] in his book "Automotive Textiles", textile usage in cars are divided into several categories as shown in figure 2.

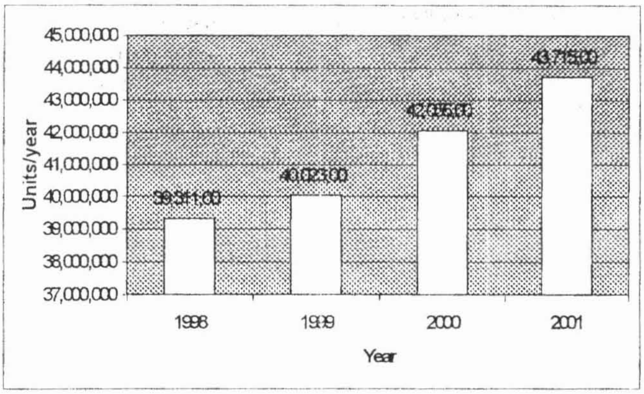

Figure 1: Worldwide car consumption

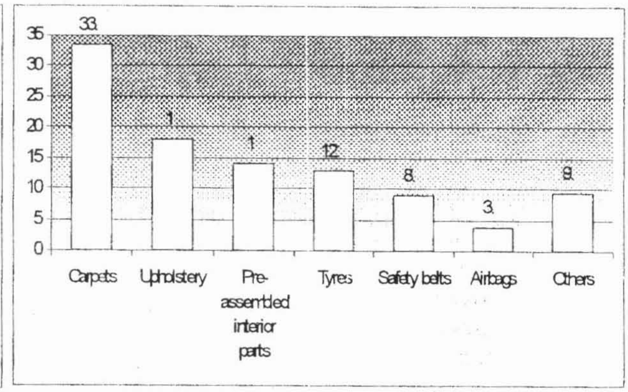

Figure 2: Textile applications in car

Research Background

The research is prepared to develop some understanding of mechanical properties of automotive or car seat fabrics. The main component in the research will involve a study of the durability performance such as surface (rubbing or abrasion) and mechanical (tensile) properties and their relationships to fabric structural properties. Numerous researches and industrialist have consistently reviewed tensile and abrasion durability of car seat fabrics such as Fung W and Hardcastle M [3], Mukhopadhyay S.K [10], Horrocks [7] and Grebe [11]. Grebe specifically listed durability which is abrasion and tensile as the prominent factor in car seat fabric quality [11]. In addition to that, car seat fabrics are confined to many stringent rules and test regulations. Such strict tests are necessary to ensure that not only car seat fabrics have good appearance, feel and handle but also excellent mechanical properties for safety reasons for long period of time.

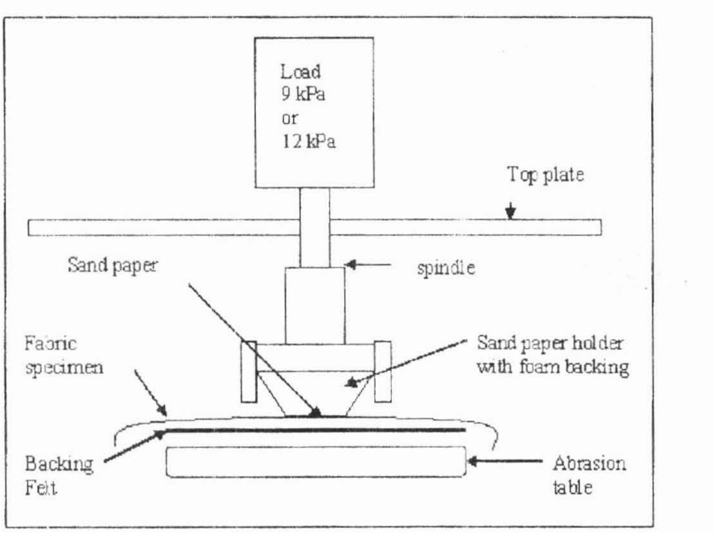

Figure 3: Abrasion apparatus

The term "abrasion" and "serviceability" have been interchangeably used to describe the mechanical destruction of textiles during application Abrasion resistant is referred "should be restricted in the meaning to the ability of the fabric to withstand direct rubbing under conditions of intended use". Hamburger [4] describes "abrasion is definitely a repeated stress application, usually caused by forces of relatively low orders of magnitude which occur many times during the life expectancy of the material. Fabric abrasion would result a gradual breakdown of the fibers accompanied by loss of short fibers, and has significance relationship with yarn and fabric construction features.

Tensile is another important textile mechanical properties. Tensile refers to the ability of textile material to absorb load during deformation period, whether in laboratory test or actual use. Backer [1] comments that, a textile may have all the qualities and properties needed to fit it for some particular purpose, but unless it is strong enough to resist the forces it will encounter in use it is of no value. With exposure to external load, textile materials would first exhibit some form of Hooke's law and as it moves towards maximum load, it yield non-linear curve derived of its viscoelastic characteristics [2]. Hearle writes that fabric strength is a reflection of yarn strength and of the fabric structure [5]. He explains that, the greater yarn modulus, strength and elongation, the higher fabric tenacity would be. Grossberg writes that, during the strength deformation period, an extension in fabric plane will occur when load is imposed on the fabric [6]. During the first phase of deformation, an extension in either warp or weft direction has generated interfibre friction and threads compression to occur or also referred as "initial decrimping" phase. High initial modulus is produced in this region. As the extension progresses, "full decrimping" phase start to occur in fabric structure. This is the stage where, the crimp in load direction is removed and causing the crimp in another of yarn to aggravate. In addition, yarn not only going through decrimping but also some in unbending motions. Thread frictional resistance upon load would primarily determine the rate of yarn decrimping and unbending. When decrimping stage completed, the yarn structure now has to respond to the extensional load. As yarn structure going through extensional deformation, fiber structure would also start to extend.

MATERIALS AND METHODS

Five woven fabrics made by Malaysian automotive fabric makers were selected for this work. Some basic fabric analyses were done to obtain several fabric properties identification such as yarn linear density, fabric density and crimps. Upon completion of the analysis, each fabric specimen was cut according to 150 mm x 150 mm specimen dimension for abrasion test. Each of this fabric was abraded for five consecutive abrasion cycles namely 500, 1000, 1500, 2000 and 2500. Fifty samples of fabric were prepared for every abrasion cycles. The abrasion test was done according to Martindale-BS/ISO standard [8]. A total of 1500 specimens were required for this test. Then, the abraded images of these specimens were recorded after 2500 cycles using simple image analysis unit. This step was very important as it allowed visual record of fabric wear on its surface. Upon completion of the image processing work, the abraded specimens were then cut into smaller dimension of 35 mm x150 mm for tensile test. Tensile test was conducted in accordance with British Standard strip method test [9]. Graphical illustration is outlined in figure 4 and 5 for clarification.

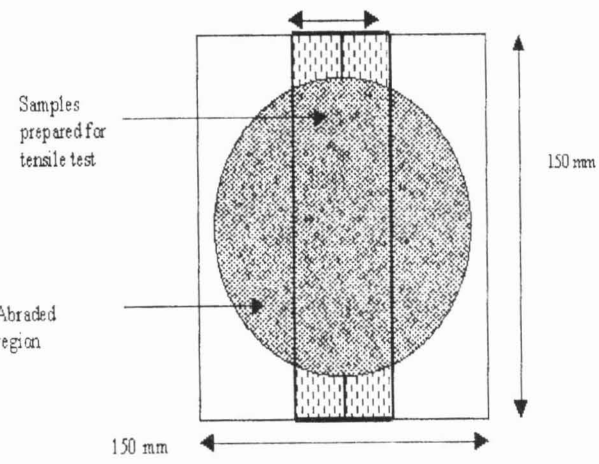

Figure 4 : Abrasion area on fabric

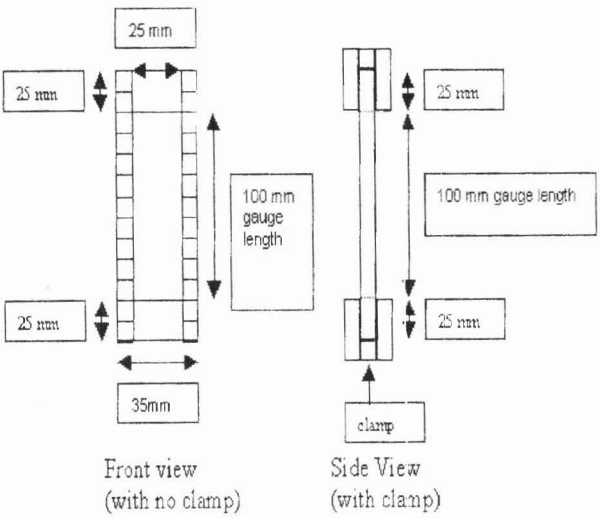

Figure 5 : Specimen dimension for tensile

RESULTS AND DISCUSSIONS

Tensile loss data for five different fabric samples were constructed for further analysis from the described experimental method earlier. The data is simplified in the following table;

Table 1: Tensile loss data in percentages (%)

	Abrasion Cycles				
Sample	500	1000	1500	2000	2500
1	72.95	49.36	40.43	30.64	32.36
2	81.36	64.18	64.21	37.65	54.81
3	49.44	44.11	34.12	25.06	15.23
4	86.84	94.35	90.46	86.84	81.84
5	38.86	31.52	18.74	15.81	10.69

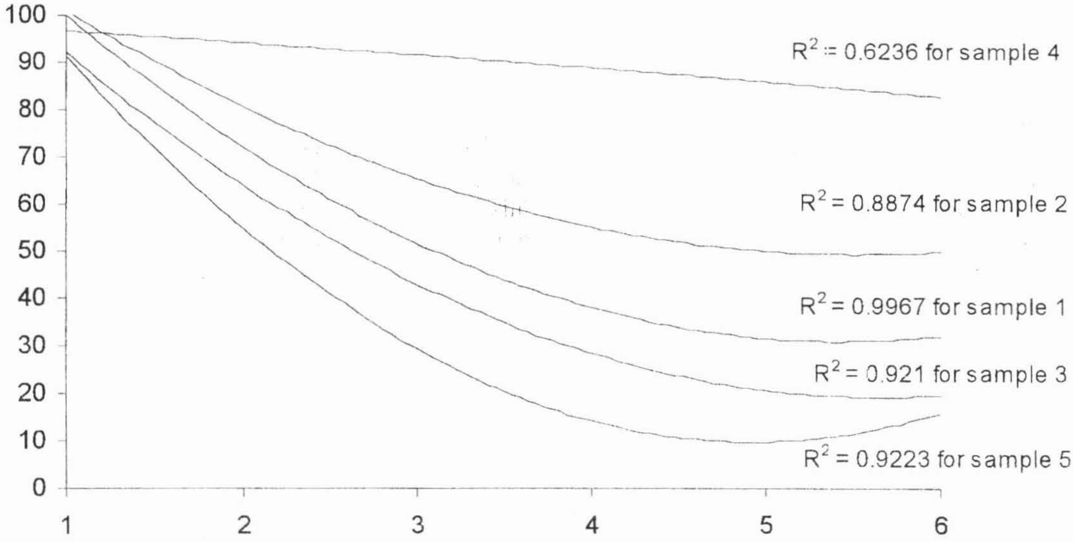

Figure 6: Tensile Loss graph with R^2 values of polynomial functions

The polynomial function graph presented in the page has clearly signaled that, fabric tensile loss will be systematically reduced if the number of abrasion process is continuously applied on the fabric surface. By reviewing the graph, sample number 5 recorded the highest tensile loss followed by sample number 3,1,2 and 4. It is however, very important to note that, each fabric types would give different tensile loss graph even though in general all the fabric reduce their strength after series of abrasion cycle. This is mainly attributed to the fabric properties especially its weight, densities, crimps, thickness and yarn linear densities variability existed in the fabric. For example, sample 5 has the lowest value in fabric density, weight and thickness. Therefore, with the abrasion work imposed on the fabric surface, more fibers can be easily removed from yarn surfaces, in which if the sufficient time for abrasion is given would reduce overall yarn strength as well as crimps removal from fabric surface. When the abraded fabric was sent for tensile test, the uniaxial tensile force applied to the sample structure would easily extend the fiber morphological structure, decrimping the excess crimp in fabric structure and deform the overall fabric structure.

The strength of these associations is further developed by using R^2 and r values. R^2 is often termed as coefficient of determination and r is referred as coefficient of correlation. The averages of these values are summarized in the following table. The average values indicated that, 87% of tensile loss mechanism for automotive car seat fabric can be attributed to abrasion work. The result is considered to be very useful as it allow further simple correlation to be done. By squaring R^2 values, the r value can be determined. In the research, coefficient of correlation or r value is evaluated at 0.93. This has again indicated very strong relationship between tensile losses as abrasion cycle. The best correlation is always attributed to the values to that 0.9 to 1. Thus, r value has clearly supported the statement that, a continuous exposure of on fabric surface due abrasion work would strongly promote fabric to reduce its mechanical strength.

Table 2 : Summary of R^2 and r value

Sample	R^2	r
1	0.997	0.998
2	0.887	0.942
3	0.921	0.959
4	0.624	0.789
5	0.922	0.96
Average	0.870	0.93

CONCLUSION

In this work, it is concluded that abrasion and tensile relationship can be proven by using tensile loss data of abraded fabrics. Abrasion and tensile deformation process can be brought together for quantitative analysis. The research conducted provides evidence that tensile loss in the fabric can be predicted by increasing the abrasion process. This can be useful tool for automotive manufacturers to design appropriate fabric structures to meet high tensile loss performance. The work is very important as it raises further research possibilities. The second part of work will be published in other journals that discuss investigation of several other more detailed aspects in the area such as energy required to deform the textile structures and fabric properties affecting such behavior and performance.

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