

Identifying Strengths of Polylon Based Woven Fabric as an Automotive Passive Restraint System Fabric

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ABSTRACT: Airbag is an automotive safety restraint system, consisting of a flexible fabric envelope designed to inflate rapidly during an automobile collision. Its purpose is to cushion occupants during a crash and provide protection to their bodies when they strike interior objects and lower the number and seriousness of injuries by reducing the force exerted at any point on the body. Important fabric characteristics needed to meet these objectives of an airbag are high impact resistance and tearing strength, low air permeability, faster unfolding of the airbag well at the time of collision and high heat resistance for preventing damage to and rupture of the airbag itself, and flexibility for reducing the impact provided to occupants. Even though costlier and difficult to manufacture, being Nylon 6, 6 possess all these desired characteristics remains the material of the choice since long. Polylon is the newly introduced composite yarn of Nylon 6 and High Tenacity Polyester in the market. Its constituents themselves are strong claimers for Nylon 6, 6 position and also complementary to each other in terms of characteristics. Such a newly engineered polymer was evaluated for its cost and fabric characteristics, woven as per guideline of MERCEDEZ BENZ standards for equivalent size Nylon 6, 6 yarn only, for identifying its strengths in airbag fabric application field. The woven fabric has shown good inclination in meeting desired standards for physical, mechanical and comfort properties of an airbag fabric. Although constitute of finer dpf filaments, costing of Polylon has shown considerable price relaxation. Thus it has retained its strong claim for airbag fabric application.

KEYWORDS: Automobile, Impact resistance, Tear strength, Air permeability, Airbag, Polylon

I. INTRODUCTION

The comfort associated speedy movement demanded for multitasking service class as well as business class during touring has boomed automobile industry well in last decade. Safety of the people becomes a major constrain for the manufacturer as well as government in such travel conditions. Airbags along with seat belts are thereby become a compulsory safety feature in most new generation vehicles [1]. Design of an Airbag includes a flexible fabric envelope which can inflate by injected hot nitrogen gas rapidly during an automobile collision to cushion occupants and provide protection to their bodies by reducing the force exerted by steering wheel and the dashboard or any point on the body to lower the number of injuries or rather serious injuries[2]. Fabric used in airbag manufacturing must possess quality characteristics to successfully survive in hostile working conditions; especially good impact resistance, air sealing but air permeable etc. Nylon 6, 6 in the deniers ranging from 420 to 840 is used invariably in the manufacturing of airbag fabric due to its required favourable characteristics. Airbag fabric is normally woven on rapier looms at the speed of 400 m/min and coated by neoprene, but recently silicon coated as per MERCEDEZ BENZ standards [1, 3]. However,

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Nylon 6,6 lags behind in terms of its higher cost, further added by import duties in countries other than USA and China, even more sophistication involved in its manufacturing process. Thereby blooming automobile market is in continuous search of an option; either material or innovation in the form of material (woven/ nonwoven/ composite etc.). Today, the latest research on potential airbag materials includes High tenacity polyester, Nylon 4, Nylon 6, etc. HT polyester is found better substitute for Nylon 6,6 amongst them, and also possess additionally favourable characteristics like better humid heat resistance, light resistance, shape stability apart from cost on Nylon 6, 6. However, it steps back due to low elasticity. On the contrary, similarly enriched in all characteristics, cheaper Nylon 6 found inferior in terms of its low impact resistance to Nylon 6, 6. Polylon is the core-sheath composite yarn of Nylon 6 and HT polyester respectively, engineered for utilizing favourable characteristics of both in one. It was found compatible when verified for its strengths on Nylon 6, 6 in terms of cost and quality [4]. However, realization of its strength and weaknesses in meeting the safety purpose can be justify on fabric stage evaluation only.

II. EXPERIMENTAL

The present experimentation is designed to elaborate on fabric stage comparative study of innovative Polylon composite material with MERCEDEZ BENZ standards used for commercially successful Nylon 6, 6.

Materials

Polyon yarn of 420D/200 filaments is used. Yarn fineness was kept identical to commercially used Nylon 6, 6 one. However, finer denier filament (2.1 D) was used based on the availability as well as realizing finer filaments impact on fabric performance in terms of stiffness and air permeability characteristics.

Methods

Miniature rapier loom line (figure 1) was used for producing desired fabric sample for the study. Binder twist was given to prevent fraying of constituent filaments during weaving. CCI Mini warper was used for converting single end package to multi end package desired for warp supply on the loom. Evergreen sample loom operating with rapier based weft insertion system, similar to commercially adopted system was used for fabric manufacturing. The same binder twisted polyon yarn was used as weft also.

Fabric weave count value was kept same as Nylon 6, 6 standards, for getting valid ground for comparison [3, 4]. Woven fabric quality parameters were measured as per standard test methods and compared with MERCEDEZ BENZ standards true for equivalent size Nylon 6, 6 air bag fabric.



Fig 1. Miniature Rapier Loom Line

Fabric samples were conditioned at standard atmosphere for 24 hours before testing. Test methods and standards for air bag fabric followed during the study are listed below:

Thickness of Airbag fabric – ASTM D 1777

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Air permeability of Airbag fabric – ASTM D 737

Breaking Strength & Elongation of Airbag fabric – ASTM D 5034

Shrinkage of Airbag fabric – ASTM D 1776

Stiffness of Airbag fabric – ASTM D 4032

Tear strength of Airbag fabric – ASTM D 2261.

Apart from these fabric weight (GSM) based on 10 cm x 10 cm sample was also checked, one of the supplementary characteristic for stiffness.

III. RESULTS & DISCUSSION

Comparative status of test results obtained for Polyton fabric with Mercedes Benz standard for Nylon 6, 6 are given in table 1.

Table 1 Comparative status of Polyton fabric characteristics with Mercedes Benz standard

Properties	Polyton Fabric	MERCEDEZ BENZ standards
Yarn Specifications	420d/200 fils.	420d/68 fils.
GSM (gm/m ²)	203	220-260
THICKNESS (mm)	0.31	0.42-0.32
BREAKING STRENGTH (N)		
WARP	2785.6	>2500
WEFT	3062.24	>2500
ELONGATION (%)		
WARP	35.86	>33
WEFT	37.77	>23
TEAR STRENGTH (N)		
WARP	151.06	>115
WEFT	233.87	>115
AIR PERMEABILITY (m ³ /m ² / min.)	9.9	<10
BURSTING STENGTH (Kg/cm ²)	>70	>60

Physical Properties

Polyton fabric has executed favorable low mass per unit area (GSM) as well as thickness as compared to desired standards [table 1]. This is mainly attributed to the use of low density (1.216 g/cc), very close to Nylon 6, 6 (1.14 g/cc) and also fine denier filament yarn [4].

Mechanical properties

This includes tensile strength, breaking extension, tearing strength and bursting strength of fabric. Innovative yarn fabric mechanical parameters have shown good agreement with the required standards values [table 1]. These are the outcome of combined influence of stronger High Tenacity Polyester at sheath and more elastic Nylon 6 in the core of composite yarn structure [4]. However, suitability of the fabric for airbag is judged on the basis of its toughness more than tensile strength- elongation values. Fabric with superior toughness is preferred for an air bag. If the toughness of the fabric for an airbag is low, the resistance of the fabric that can absorb the momentary expansion impact of the inflator having a high temperature and high pressure becomes low and thus it brings about a result that the fabric for an airbag is easily torn when the airbag is unfolded. Therefore, when the toughness of the fabric is below 3.5 kJ/m, it becomes difficult to apply it as the fabric for an airbag [5]. Fabric toughness (or work of rupture) has been calculated as the area of the tenacity-elongation curve for tested sample in (KJ/m). Nylon 6, 6 has retained its domination in terms of toughness over innovative yarn fabric [figure 2]. Although lower than commercial air bag, tested fabric has executed toughness well above the minimum admissible for being employed as an airbag fabric [5].

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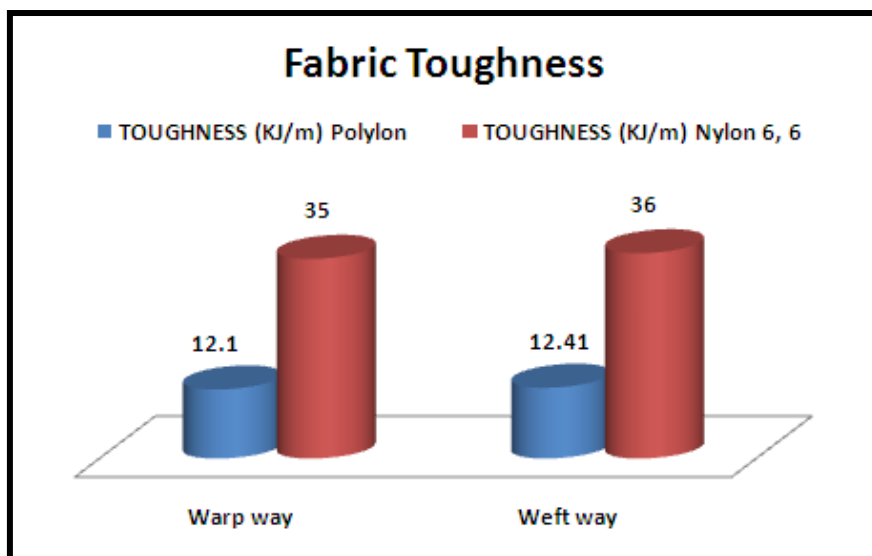


Fig 2. Comparison of Fabric Toughness

Similarly superior tearing strength of an airbag fabric is equally important according to a stress concentration when the airbag is expanded by a momentary strong force of a high temperature and high pressure gas while the airbag is unfolded. If the tearing strengths of the non-coated fabric and the coated fabric for an airbag are below 18 kgf (180 N) and 30 kgf (300 N) respectively, the airbag may burst when the airbag is unfolded and it may cause a huge danger in function of the airbag. On the contrary, if the tearing strengths of the non-coated fabric and the coated fabric for an airbag are over the upper limits, that is, over 30 kgf (300 N) and 60 kgf (600 N) respectively, it may be undesirable because the edge comb resistance of the fabric becomes lower and the air-tightness deteriorates rapidly when the airbag is unfolded [5]. Comparing tear strength values of Polyton fabric warp way and weft way tear strengths meet well with prescribed standard limits [table 1]. However, lower warp way tear strength (151 N) as compared to minimum admissible (180 N), required for non-coated fabric to prevent bursting of an airbag at the point of unfolding demands further investigation.

Air permeability

Low air permeability is the preferable feature for any airbag. Polyton fabric although composed of fine denier filaments yarn, was unable to show low air permeability than commercial air bag, mainly due to its higher density. The value of $9.9 \text{ m}^3/\text{m}^2/\text{min}$ is too close to upper allowable upper limit of $10 \text{ m}^3/\text{m}^2/\text{min}$ for air bag fabric. This can further become objectionable at the point of collision due to low shrinkage of Polyton at 177°C [4]. Coating can improve this figure, but also adds to fabric cost and stiffness [6, 7].

Comparative Cost Evaluation

Nylon 6, 6 yarn used for commercially available airbag; 420 D/68 fils. has selling cost/kg of Rs.260. It is further added by 5% custom duty and 12.66% of import duty for all the countries other than manufacturing one, viz; USA and China. On an aggregate the cost/ kg realized at fabric manufacturer's end in these countries including India is Rs.306/kg. On the other hand newly designed local product of composite Polyton yarn 420 D/ 200 fils., has market price of Rs. 185/Kg in India. These price figures are obtained from one of the reputed industry in the field of yarn manufacturing. It is quite apparent from these data that Polyton cost 40% less to the Indian manufacturer and 29 % to USA and China. This cheaper rates are true for comparatively much finer filament yarn and also giving promising performance well within applicable limits set up by MERCIDIZE BENZ standards. However, its density (1.216 g/cc) is 6% higher than Nylon 6, 6 (1.14 g/cc) makes it accordingly costly at the point of procurement. But still difference of 34% (23% for

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USA and China) exist between two materials cost. Thus airbag fabric produced under identical manufacturing conditions cost less by 34% than Nylon 6, 6. Thus, economy point of view innovative yarn samples have an upper hand over the commercially used material.

IV. CONCLUSION

Safety airbags rely on permeable woven fabrics as their principal material of construction. In this regard, the material properties of the fabric can significantly contribute to the safety of the vehicle occupant as he interacts with the deployed airbag. This work describes an airbag fabric made of an innovative synthetic yarn. The synthetic yarn is a composite of 70% high-tenacity polyester and 30% nylon 6, viz; Polylyon yarn having filaments of 2.1denier and a yarn count of 420 denier.

Fabric sample was woven on 20 inch sample Rapier loom and for getting reliable ground of comparison; weave count for the fabric was kept same as suggested by standards. The fabric was tested in uncoated state. The fabric made up of Polylyon yarn has executed preferable low thickness of 0.31 mm as well as weight per unit area of 203 gm as per expectation. It can able to meet the standards for tensile strength, extension, tear strength, bursting strength as well as permeability. No doubt air permeability value lies near about allowable upper limit. Toughness of the fabric is found well above the minimum required of 3.5 KJ/m. Similarly tear strength in weft direction is well within the stated limit of 180 N to 300 N for uncoated fabric. However, warp way tear strength found little bit below this specified limit. These need further investigation.

Economy point of view innovative yarn samples have an upper hand over the commercially used material. Thus an innovative Polylyon yarn fabric has shown a potential to be used in the field of airbag in both qualitative as well as economic aspects. So, further experimentations in checking the performance of innovative yarn fabric by making airbag and exposing collision test condition can be fruitful.

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