DEVELOPEMENT OF NATURAL FIBER REINFORCED POLYMER COMPOSITES

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Abstract

In the recent past, considerable investigations have been made in natural fibers as a reinforcement in polymer matrix. Manufacturing companies are in constant search of new materials to lower costs and profit margins. Natural fibers are low-cost fibers with high specific properties and low density. Performance characteristics that predestine polymer use in automotive applications include corrosion resistance, low density, good impact toughness and chemical resistance.

The article reviews the recent development of natural fiber reinforced polymer composites, including an experiment on composites reinforced with hop fibers.

Key words: composites, hop fibers, polyester resin, tensile test

INTRODUCTION

New plant fiber based composite materials are being increasingly used in the automotive and building industry. Plant fibers such as hemp, jute, flax can be used as a reinforcement for thermoset or thermoplastic polymers instead of synthetic fibers.
Both thermoset and thermoplasics are attractive as matrix materials for composites. In thermoset composites, formulation is complex because a large number of components are involved such as base resin, curing agents, catalysts, flowing agents and hardeners. The composite materials are chemically cured to a highly cross-linked, three-dimensional network structure. These cross-linked structures are highly solvent resistant, tough and creep resistant.
Thermoplastics offer many advantages over thermoset polymers. One of them is their low processing costs. Another is design flexibility and ease of molding complex parts. Thermoplastic composites are flexible, tough and exhibit good mechanical properties. [1]

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NATURAL FIBER COMPOSITES FOR AUTOMOTIVE INDUSTRY

Natural fiber composites are being used for manufacturing many components in the automotive sector (Taj et al., 2007; Xin et al., 2007; Saxena et al., 2008, 2011). Typical market specification natural fiber composites include elongation and ultimate breaking force, flexural properties, impact strength, acoustic absorption, suitability for processing and crash behaviour. Plant fibers are mainly used in the part of car interior and truck cabins. The use of plant fiber based automotive parts such as various panels, shelves, trim parts and brake shoes are attractive for atomotive industries worldwide because of its reduction in weight about 10%, energy production of 80% and cost reduction of 5%.

The major car manufacturers like Volkswagen, BMW, Mercedes, Ford and Opel now use natural fiber composites in applications such as those listed in table 1.

Tab.1 Current well-established applications of natural fibers in automotive industry, source: [2]

Automotive manufacturer	Model applications
AUDI	A2, A3, A4, A6, A8, Roadster, Coupe Seat backs, side and back door panels,boot lining, hat rack, spare tyre linig
BMW	3, 5, 7 series Door panels, headliner panel, boot lining, seat backs, noise insulation panels
CITROEN	C5 Interior door paneling
FIAT	Punto, Brava,Marea, Alfa Romeo 146, 156
FORD	Mondeo CD 162, Focus
LOTUS	Eco Elise Body panels, Spoiler, Seats, Interior carpets
PEUGEOT	406 Seat backs, parcel shelf
RENAULT	Clio, Twingo Rear parcel shelf
ROVER	2000 and others Insulation, rear storage shelf/panel
SEAT	Door panels, seat backs
TOYOTA	Brevis, Harrier, Celsior, Raum Door panels, seat backs, spare tyre cover
VOLKSWAGEN	Golf, Passat, Bora Door panel, seat back, boot lid finish panel, boot liner
VOLVO	C70, V70 Seat padding, natural foams, cargo floor tray

BMW has been using natural materials since the early 1990´s in the 3, 5 and 7 series models with up to 24 kg of renewable materials being utilized. In 2001, BMW used 4 000 tonnes of natural fibers in the 3 series alone. The combination here is a 80% flax with 20% sisal blend for increased strength and impact resistance. The main application is in the interior door linings and paneling. Wood fibers are also used to enclose the rear side of seat backrests and cotton fibers are utilized as a sound proofing material.

Recently, Volvo has started to use soya based foam linings in their seats along with natural fibers. They have also produced a cellulose based cargo floor tray which resulted in improved noise reduction.

The present level of car production in Western Europe is about 16 million vehicles per year, what equates to a current usage of 80 000 to 160 000 tonnes of natural fibers per year. German automotive manufacturers continue to lead the way, with Daimler-Chrysler for example, having a global natural fiber initiative program that benefits third nations by developing products made from indigenous agricultural materials.

One of the recent developments within the automotive industry has been the release of the Lotus Eco Elise.

Another development announced in 2008 at the EcoinnovAsia 2008 event, related to the Mazda 5. In this application the manufacturer is using PLA in the interior consoles along with kenaf and PLA in the seat covers.

The two most important factors now driving the use of natural fibers by automotive industry are cost and weight, but ease of vehicle component recycling is also an ever increasing consideration to meet the requirements of the end of life vehicle directive. [2]

EXPERIMENTAL DETAILS

The hop fiber reinforced polyester composites were prepared by the hand lay-up method. The stems have been smashed to allow the tender plant tissues to separate from plant fibers. After extraction, these fibers have been naturally air dried. cut into pieces with length varying from 20 to 40 mm to allow better impregnation when producing the composite plates.

Matrix material(polyester resin, No.25 and hardener, class 3, 31- UN No 1866) was prepared in a proportion 100g of polyester resin and 5g of hardener. These two materials were mixed and stirred at low speed until it become uniform. The matrix material was poured into a bowl with the cut fibers, thoroughly mixed and poured into the mould. Subsequently the mould was pressed. The composite was left to cure at room temperature for 2 days until it was completely dry.

The first composite signed B was prepared prepared from polyester resin and 20 g of hop fibers (Fig. 1).

Fig. 1 Sample from hop fiber composite B

The plate was cut into pieces with the dimensions plotted in tab. 1

Tab.2 Specimen dimensions of composite B

Sample number	Width b(mm)	Thickness t(mm)
1	14,2	3,1
2	15	3
3	16,2	2,2
4	15,2	1,5
5*	15,4	1,8
6	14,7	1,5
7	14,7	1,5

*sample broken out of the marked lines

The other composite sample was made from polyester resin and 45 g hop fibers (Fig. 3).

Fig. 2 Samples from hop fiber composite D

Tab. 3 Specimen dimensions of composite D

Sample number	Width b(mm)	Thickness t(mm)
1	15,9	4,7
2	14,2	5,7
3	14,4	5,2
4	15	5,3
5	15	5

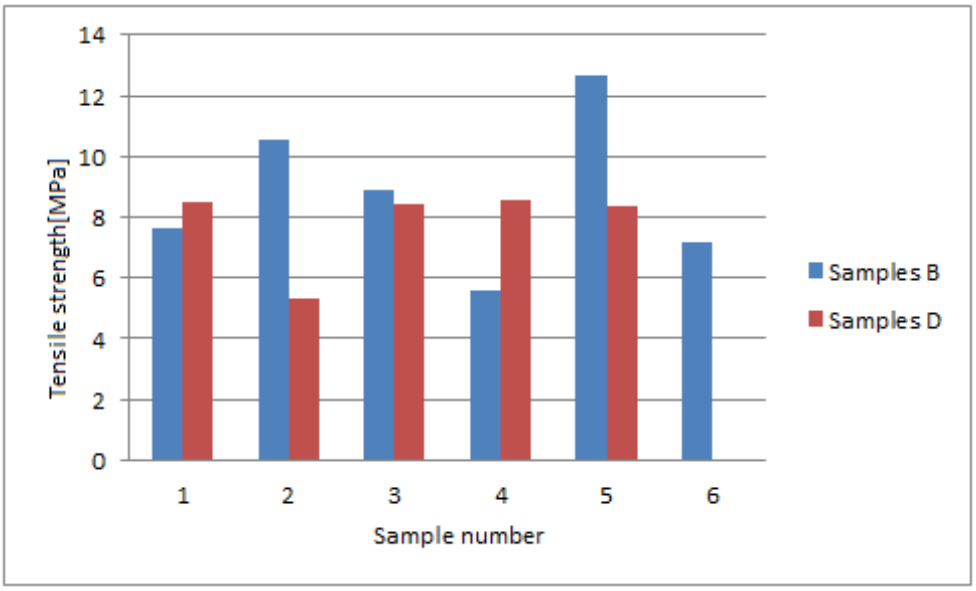

Fig. 3 Comparison of tensile strengths after the tensile test

The tensile test specimen were prepared(fig.1 and fig.2) according to ISO TC 71/SC 6N; the details dimension(tab.2 and 3), gauge length and cross-head speed can be found at ISO TC 71/SC 6N[3]. The specimen was mounted in the grips of the INSTRON 4485 tester with 50 mm gauge length.

After performing the tests, typical stress-strain graphs were plotted.

RESULTS AND DISCUSSION

The experimental investigation on mechanical behavior of hop fiber reinforced polyester composites led to the conclusions, that the tensile strength of samples proved to be similar (fig.3). The produced polymeric hop fiber composite has adequate properties for lots of industrial applications.

CONCLUSION

The use of natural fibers has increased significantly in the range of industrial applications. Now there are numerous examples where natural materials have found application in a number of diverse sectors from automotive and construction industries, to packaging and leisure based products. Further improvements can be expected, so that it might become possible to substitute technical fibers in composites quite generally.

References

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[3] ISO TC 71/SC 6N – Non-traditional reinforcing materials for concrete structures,
ISO 10406-1:2008: Fibre-reinforced polymer (FRP) reinforcement of concrete . Test methods. Part 1: FRP bars and grids.