PLANT FIBERS FOR AUTOMOTIVE APPLICATIONS

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ABSTRAKT: This contribution aims at introducing new plant fibers used as fillers in a polymeric matrix enabling production of lightweight composites for automotive applications. It focuses on the effects of corn, sunflower, chestnut and hop fibers as reinforcement agents in composites. Mechanical testing was performed to qualify the reinforcement properties of these fibers and consequently compared with fiberglass composites.

Selected natural fibers were used as reinforcement in polyurethane (PUR) foam in order to increase the properties of foam. This composite foam specimens were fabricated by using polyurethane molding method. The polyurethane foam specimens reinforced by 4wt% of individual fibers were produced to investigate the mechanical test - three point bending test.

From this testing of polyurethane foam samples were showed, that the addition of natural fibers (corn, chestnut and hop) increase the properties of the polyuretane foam (already in the case of 4wt% of natural fibers). But from results implies, that fibers from sunflower are not so suitable for use as reinforcement of polyurethane foam.

1 Introduction

One of the major reasons of increasing growth of renewable materials use in the automotive industry is the increased awareness for the environment. Apart from the renewable resources as oils for hydraulics and lubrication or as alternative fuels, the use of plant fibers as fillers or reinforcement in polymeric materials is also of great importance.

Natural fibers have many advantages compared to synthetic fibers, like low weight, density and cost. They are renewable and have relatively high strength and stiffness. On the other hand, they have low thermal stability.

Plant fiber composites properties depends on the type of fiber, type of matrix, fiber matrix combination and the manufacturing process.

One characteristic of the plant fibers is their ability to take up and store humidity. This characteristic is desired in seat cushions, but for other applications water absorption must be prevented. For this reason plant fiber applications have been limited to the interior of vehicles, Water absorption can be reduced to a level similar to that of glass fiber compounds by adjusting the compound materials and optimizing the processing.

The use of natural and wood fibers in composite applications in Europe is being intensively investigated. As a result, many automotive components are now produced in natural composites, mainly based on polyester or polypropylene. Natural fiber consumption in European automotive industry is represented in Table 1. A rapid increase in natural fiber consumption is indicated.

Table 1 Natural fiber consumption in the European automotive industry

Natural fiber consumption in the automotive industry in Europe (1996-2010)					
Fiber	**1996(ton)**	**1999(ton)**	**2000(ton)**	**2005(ton)**	**2010(ton)**
Flax	2100	15900	20000	-	-
Hemp	0	1700	3500	-	-
Jute	1100	2100	1700	-	-
Sisal	1100	500	100	-	-
Kenaf	0	1100	2000	-	-
Coir	0	0	1000	-	-
Total	4300	21300	28300	50000-70000	> 100000

2 Description of natural fibers

Natural fibers are complex polymer composites consisting cellulose micro-fibrils in an amorphous matrix of lignin and hemicellulose. These fibers consist of several fibrils, each fibril exhibits a complex layered structure made up of a thin primary wall encircling a thicker secondary layer. The most efficient natural fibers are those that have a high cellulose content with a low microfibril angle, that results in high filament mechanical properties.

The density of most natural fibers is about 1.5 g/cm^3. It is considerably less than that of inorganic fibers such as glass fibers. Typically they have about 30-50% lower density when compared to E-glass fibers. Their low density makes them attractive as reinforcement applications where weight is a consideration. The balance of significant reinforcing potential, low cost and low density is part of the reason that they are attractive to the automotive industry. Interior parts from natural fiber – polypropylene (Fig.1) and exterior parts from natural fiber – polyester resins are already in use.

Fig.1 Interior parts from natural fiber - polypropylene

Ford has a long history of research on new materials. Henry Ford began experimenting with composites around 1940, initially using compressed soybeans to produce composite plastic-.like components. Eastern Germany's Trabant was the first production car to be built from natural fibers. It was equipped with a chassis made of cotton within a polyester matrix. Johnson Controls, Inc. has started production of door-trim panels from natural fiber and polypropylene.

3 Testing of polyurethane composite samples with the addition of selected natural fibers

3.1 Sepecimens preparation

Fibers treatment: Stems of corn, sunflower and hop were immersed in the container with water for two days to soften them. Chestnut fibers were obtained from the skin of chestnuts, which were also put to the container with water for two days for the purpose of softening. After removing the stems from water were tenderized by rubber hamer, thus were created thin fibers. Then this fibers were dried at air temperature, later in the dryer.

Figure 2 Preparation of fibers

Polyurethane foam fabrication: In the first case polyurethane foam was produced by mixing the polyol and isocynate. Then in the second case were fibers of each fibers cut to small size (20 mm) and then placed into the mold. Then were fibers sealed with polyol, mixed together and subsequently were added isocynate. After rapid mixing and conclusion of the container, polyurethane foam left to cool for one day. From polyurethane were then cut specimens for size according to ISO 1926. For testing were used 5 specimens for the case of polyurethane foam with addition of corn, sunflower, chestnut and hop fibers and also 5 specimens for the case of polyuretane foam without fibers.

3.2 Test methods

Three point bending test

The objectives of flexural test are to determine the meximum stress. The dimensions of specimens were 100x20x6 mm.

Fig. 3 Bending device (3-point method) of the testing machine

Determine the maximum shear stress:

The maximum shear stress is given by equation:

$$\sigma = Mf / I \,.\, y^2 \tag{1}$$

where:

σ = maximum shear stress, MPa

Mf = moment flection, N.mm

I = inertial moment, m^4

Equations for moment flection and inertial moment are the following:

$$I = b.h^3 / 12 \tag{2}$$

where:

b = width of sample, m

h = thickness of sample, m

and

$$Mf = F.d / 2 \tag{3}$$

where:

F = load which acts on a sample

d = distance between supports

4. Description of achieved results

Maximum shear stress

The result of maximum shear stress was obtained from the three point bending test on the polyurethane foam and is shown in the following table.

Table 2. The experimental results from bending test in case of the specimen analyse

No.	Kind of fibers	Maximum shear stress
1	Sunflower	4,538
2	Without fiber	5,143
3	Hop	5,553
4	Corn	5,771
5	Chestnut	5,837

At the figure 4 are showed individual results of maximum shear stress from the three point bending test on the polyuretane foam. Polyurethane foam cores consisted of 4wt% particular fibers exhibits. The table shows that by using natural fibers such as hop, corn and chestnut improve the properties of polyuretane foam but by using sunflower fibers leads to deterioration properties of polyuretane foam, compared with polyurethane foam without fibers. The highest maximum shear stress was achieved by using chestnut fibers.

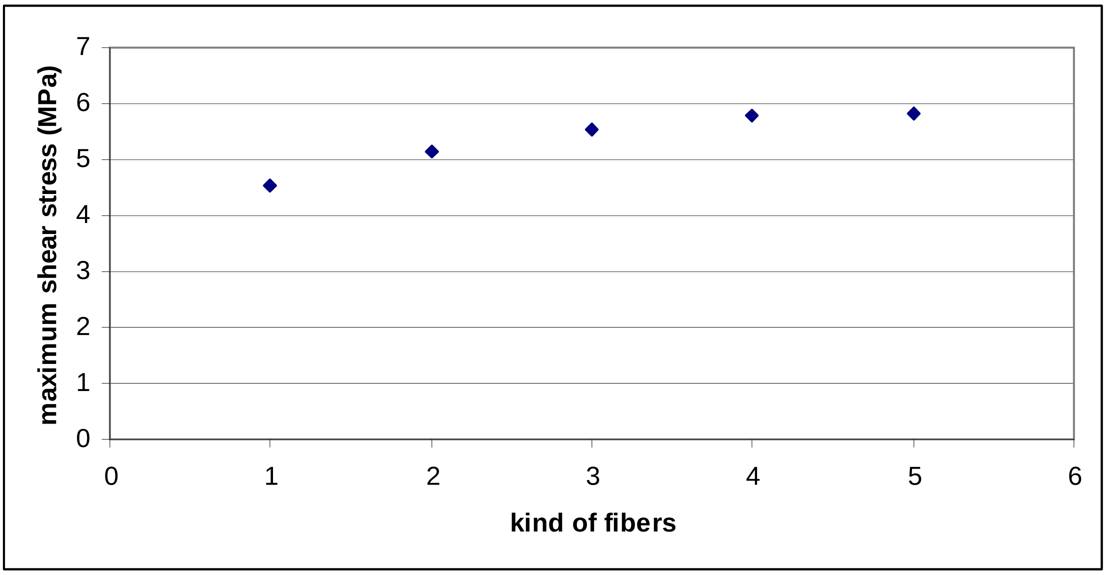

Fig. 4 Shear stress of particular PUR/fibers panel

The tested samples of three point bending testing show that the failure occurred in the middle of the panel, but in few cases the samples broke not exactly in the middle of the panel.

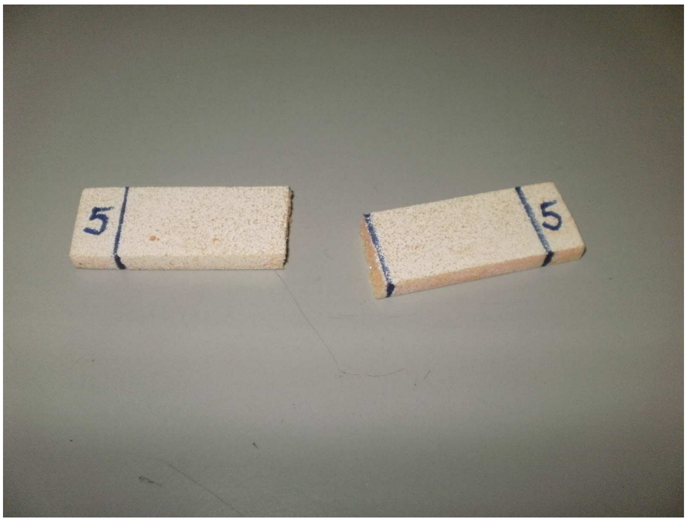

Fig. 5 Failure of individual specimens in the middle of the panel

5. Summary

From the mechanical testing of polyurethane foam samples by three point bending testing was showed, that the addition of natural fibers (corn, chestnut and hop) increase the properties of the polyuretane foam (already in the case of 4% of natural fibers). But from results implies, that fibers from sunflower are not so very well for suitable for use as reinforcement of polyurethane foam.

As a conclusion we can affirm, that the produced polymeric sunflower, corn, chestnut and hop fiber composite has adequate mechanical properties for lots of industrial applications even, as expected, these are lower than glass fiber composites. Using these natural fibers, the products become more ecological substitute and environmental friendly than the traditional polymeric glass fiber composites.

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