Composite Materials Reinforced with Fabric from Used Tyres

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Keywords
- Composite
- Thermoplastic Matrix
- Fabric
- Used Tyres

Abstract
The paper deals with testing of composite materials reinforced with fabric, which are obtained after the recycling process of used tyres and matrix is polyvinyl butyral (PVB). PVB is a product of windshields recycling. Fabric, that makes up the composite filler material benefits in various proportions of polyvinyl butyral, which is a matrix of the composite. It is possible to produce various designs material with percentage from 1 % to the 80% of fabrics. The advantage of this material is the primary resource conservation, the use of recovered (waste) materials, and thus generally contributes to environmental protection.

INTRODUCTION

Used tyres, or tyres, those parameters do not meet the requirements specified by the relevant rules of the road safety are recovered or disposed of in accordance to law. From used tyres we can obtain a valuable raw material - crushed rubber. Is widely used as an ingredient in asphalt, concrete filler, layers base of roads, rail crossings, coatings, paints, running tracks, playgrounds etc. Separate steel parts are also used in engineering and metallurgical industries. The last component of used tyres is fabric. Important properties are sound absorption, sorption capacity, thermal insulation, flexibility and elasticity [1]. On the present are known different technical solutions for processing of used tyres and their components. Rubber materials are separating devices processed into small pieces or granules, which are added to asphalt, concrete, or in railway sleepers. The disadvantage of these solutions is inefficient recovery of rubber materials and possible environmental hazards at their disposal. The current state is known that technology dedicated to the processing of used tyres and their disintegration, separation of individual components using mainly rubber crumb [1,2]. In traditional technological progress is achieved by separation of 3 major components: granulated rubber, steel wire and fabric fraction.

Mentioned technologies do not directly treat fabrics or their subsequent use in various fields of industry. Fabrics from tyres can under certain conditions quite well as briquettes. Through this process we obtain compacted materials suitable for energy recovery. Briquetting greatly reduces negative "drifting fabrics" free fabrics from tyres while the business can dispense conventional devices such material mixed with coal.[4] Briquettes have high calorific value (2 x higher than coal) and low ash content. Are capable of binding to each other waste liquids (rinses tanks faulty batch of production, etc.) and may therefore be used as a "carrier liquid waste" to the fluidized bed boilers. The use of briquettes technology does not require changes or special dosage adjustments. [3, 5] Fabrics from tyres in the form of briquettes are an excellent alternative fuel. High value and low price saves users significant funding. Briquettes of fabrics from used tyres are designed for industrial furnaces and boilers.

According to previous described recovery solutions of used tyres we can say that the biggest share in the use have rubber pellets. But not to forget the use of fabrics components from used tyres. Although this ingredient is used as a filling for noise barriers, an ingredient in concrete, asphalt, etc. [6]. Due to the excellent properties begins increasingly used in the road industry, construction and other industries. Mixing fabrics with different thermoplastics gives us a new perspective on the use of these components.

Problem definition: The paper deals with the production of composite materials which using secondary raw materials. The main problem is "number of used tyres- yearly" and "unused fabric from used tyres". Use of this material is mainly in the field of construction, garden and automotive engineering, as finished product or in semi-manufactured forms - granules. Saving the primary raw material in the production process is currently at the forefront of sustainable development of each country. The effort is used to produce materials with comparable properties and characteristics.

Materials definition: Fabrics from used tyres are characterized by high sorption capacity, flexibility and elasticity, excellent sound absorption and thermal insulation properties. At present it is known the use of this raw material in many fields of industry, for example, the production of noise elements in construction, transport (asphalt) and in agriculture (floors in stables). Matrix is a thermoplastic polyvinyl butyral (PVB). PVB is typically used for applications requiring strong chemical bonding, optical properties (transparency), and adhesion to the surface of various materials, strength and flexibility. Separation methods there to perfect grinding of windshields using the input line, which is equipped with a highly functional shredder [4,5]. After reduction comes the conveyors and separators that sorted out metals and other impurities contained in car-glass. Small fragments are further transported to the system of optical sensors, with their help remove debris from the rubble, scrap foils, rubber, etc. displacement [6,7]. Line of raw material is
mixture of crushed glass, which is fully applicable in the glass industry and foil, which is used as an ingredient in mixed plastics. PVB film ensures safety feature in car-glass. PVB film is in the flakes form (Fig. 1 a), which are actually crushed and chopped recycled foil size approx. 20-30 mm. Fabric (Fig. 1 b) we obtain from recovery of used tyres.

The entrance commodities for the technological process of recovery used tyres are passenger tyres without the necessary pre-treatment and expensive “all-steel” tyres. From these tyres must be removed heel rope. Heel ropes are removed to dilute the unbroken and knives input device technology line [3, 5, 7]. Tyres also are cut, broken into size about 250 mm x 250 mm. Slashed tyres of the conveyor belt, proceed to the second part of the technological line, which are cut in half, from 18 mm to 20 mm. At the end of the crusher magnetic separator, this captures the metal deposited in collection containers. Force captured metal is approx. 90 %. The remaining portion which is separated goes along with rubber and cloth in fine granulator. Material passes through a magnetic separator to remove part of the metal residue. When this unit is plugged exhaust system, whose work is to suck fabric section, which is lighter than granules [6, 8]. Cylindrical magnet captures the remaining metal and fabric exhaust system. The preparation of composite materials containing fabric of used tyres and recycled polyvinyl butyral [7, 8].

**EXPERIMENTS**

For preparing of composite was used continuously mixing different blends using twin screw mixing device. It was prepared a mixture of composite materials containing from 10 to 80 weight percent of fabrics to polyvinyl butyral [3]. Kneading machine is warming it to a temperature of 145 °C. In Table 1 is present characterization of mixture homogenization.

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>UNIVERSALPRUEFUNGSMASCHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Zwick 2020</td>
</tr>
<tr>
<td>Software</td>
<td>Test-Expert</td>
</tr>
<tr>
<td>Force max.</td>
<td>20 kN</td>
</tr>
<tr>
<td>Test speed</td>
<td>100 mm/min</td>
</tr>
<tr>
<td>Standard</td>
<td>DIN EN ISO 527-1</td>
</tr>
</tbody>
</table>

After the addition of input material, temperature of the mixture dropped to 100 °C. After completion of homogenization (Fig. 2, Fig. 3) of the first component is gradually adding the specified amount of fabric, mixture temperature dropped, after a period of approx. 3-4 min, increases again to approximately 150 °C, a torsion moment of 100-140 Nm⁻¹. Torsion moment decreases in time, if the mixtures temperature rises. In the Fig. 2 it is to see a material homogenization of 10 % fabrics with 90 % PVB. Threshold use of separated fabric is 80 % by weight of fabric (in terms of both quality homogenizing mixtures) in the composite material [3, 6, 9]. With increasing the share of fabric in composites is Young’s modulus increases and $\sigma_{\text{max}}$ and $\varepsilon_{\text{max}}$ decreases (Fig. 3).

After homogenized of two components material was selected from kneading machine and followed by moulding process (Fig. 4). Press pressure affects the surface quality of moulding and shrinkage in composite and compression ranged from 10 to 60 MPa.

Moulding temperature depend on the kind of plastic, wall thickness, geometry of the product, and the pre-heating
temperature is in the range 130-190 °C. It is important that the temperature of the moulding equipment was the same everywhere. Form tool is filled with a mixture of a precise volume. The process is: after curing, the moulding form is opens, select the moulding, the moulding form is cleaned (usually compressed air and then painted with release agent) and the cycle is repeated [3, 8, 9].

RESULTS AND DISCUSSION

The following table (Table 2) shows mechanical properties of composite materials after tensile test according to standard DIN EN 527-1 [10].

Table 2 Characterization of mixture homogenization

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>$\sigma_{\text{max}}$ [N.mm$^{-2}$]</th>
<th>$\varepsilon_{\text{max}}$ [%]</th>
<th>Young’s modulus [N.mm$^{-2}$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 % F+100 % PVB</td>
<td>17.518</td>
<td>145.961</td>
<td>5.0</td>
</tr>
<tr>
<td>10 % F+90 % PVB</td>
<td>12.625</td>
<td>145.811</td>
<td>18.0</td>
</tr>
<tr>
<td>50 % F+50 % PVB</td>
<td>7.223</td>
<td>13.583</td>
<td>356.0</td>
</tr>
<tr>
<td>80 % F+20 % PVB</td>
<td>9.165</td>
<td>116.490</td>
<td>33.0</td>
</tr>
</tbody>
</table>

From above data, it is seen on the Figure 5, the values differ, due to the fact that the material PVB after homogenization and subsequent pressing is very elastic.

![Diagram of tensile strength $\sigma_{\text{max}}$, tensile strain $\varepsilon_{\text{max}}$ at tensile strength and Young’s modulus on % ratio of fabrics](image)

Figure 5 Diagram of tensile strength $\sigma_{\text{max}}$, tensile strain $\varepsilon_{\text{max}}$ at tensile strength and Young’s modulus on % ratio of fabrics

CONCLUSION AND FUTURE DIRECTION OF RESEARCH

Advantage over the State of the Art: Newly created material, cheaper inputs, mechanical properties are common with other similar material, harmless. Related problems: material lifetime, vibration absorption, fire resistance. Applicability of the composite material in automotive industry:

- In motor section: wheel arches – noise control, mud flaps – corrosion property, resistance to water, snow, insulation hood – control noise, vibration capability, fire resistance.

- In part of the passenger: car interior, rubber car mats – extra edge protection against seepage of water into the base of fabric, door panels – side bar (stainless material property).

- Material application in construction industry: indoor use – the backing layer underneath wood, laminate flooring, protection against impact sound, anti-vibration floor ability; outdoor use – application in garden engineering (curbs, pots, protection against weeds, protection against, undesired growth of roots, pools protection, preventing breakage of the release liner pools.

- Materials application in civil engineering: Rail crossings, cushioning materials under the rails, bumps, noise barriers at busy roads.

- Waste Minimising: aimed enterprises to help solve the problem of tire recycling.

REFERENCES


LIST OF USED SYMBOLS

PVB – Polyvinyl butyral