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1. International Conference on Quality of Life

CONFERENCE MANUAL

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Faculty of Engineering, University of Kragujevac

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BIOCOMPOSITES – ECOLOGICALLY ACCEPTABLE MATERIALS

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Abstract: *Composite materials are defined as artificially created materials made up from two or more chemically heterogenous and insoluble phases which form a unique structure with clearly defined boundaries. Specific properties of the materials (density, stiffness, hardness, thermal conductivity, etc.) can be obtained by the proper selection of the constituent elements and their volume ratio.The increasing pollution of the environment is the reason why today scientific efforts are directed towards the development of completely biodegradable, ecologically acceptable composites obtained by combining natural fibres with biodegradable resins (biocomposites). The paper will explain the advantages of biocomposites (renewable sources, low price, low density that ensures a high specific hardness and stiffness, lower impact on the environment, and others), because of which they have a continuously increasing application in the automotive and electronic industry, construction, and other areas.*
Keywords: *biocomposites, natural fibres, biodegradable resins, ecology*

1. INTRODUCTION

A lot of effort is being made in the process of constant research of materials which would be more lightweight, with a high resistance and a high elastic modulus. All this leads to the technological development of modern materials.

A composite material is created by combining two or more materials of different structures (metals, ceramics, polymers) and/or shapes (fibres, lamellas, grains) with the purpose of getting a new material with a greater number of beneficial properties (mechanical properties, environmental resistance, life cycle increase and so on). The properties of composites depend on the properties of its constituents, and they can vary depending on the type of the material used, the quantity, the angle of fibre orientation, and so on.

Composites are increasingly taking over new markets, so that the quantity and the possibilities of application of composites are constantly growing. Modern composite materials take up an important place in the market of materials used in engineering. Using composite materials ensures a saving in mass, and at the same time resistance and durability are somewhat higher in comparison with classic metal materials.

From an ecological point of view, special attention is now given to biocomposites obtained by combining natural fibres and biodegradable resins.

The development of biocomposites based on natural fillers in combination with synthetic thermoplastic polymers has been the subject of considerable recent research efforts [1]. In recent years, natural fiber reinforced composites have received much attention because of their lightweight, nonabrasive, combustible, nontoxic, low cost and biodegradable properties [2].

Natural fiber (kenaf, flax, hemp and jute) reinforced composites have been used for many applications including those in the automotive, electronic, horticultural, packaging, consumer goods and construction sectors [3].

To reduce the carbon dioxide amount released into the atmosphere, the car makers are actually looking for extremely lightweight materials in order to decrease the fuel consumption. Flax fibers present a high strength, low density and better environmental impact. Their derived bio-based composites have an advantage over the glass fiber reinforced composites in terms of specific

mechanical properties [4- 5]. Furthermore, flax fibers are cheap and biodegradable materials, coming from a bio-sourced agriculture and widely available over the world.

2. THE DEFINITION OF BIOCOMPOSITES

Composite materials are made from two basic constituents: the matrix (the basic material of certain properties) and the added material, called the reinforcement (adding this material acquires the necessary combinations of composite properties). Biocomposites are those composites in which at least one segment, the matrix or the reinforcement, is made from a renewable material. They can be made from [6]:

- Natural fibres (plant or animal fibres) and non-biodegradable polymers (duromers – for example, epoxy resin, phenolic resin and plastomers: PE, PP, PVC, PS).
- Synthetic fibres and biopolymers (made by processing plants).
- Natural fibres and biopolymers. These composites are the least harmful to the environment, which is why they are often called green composites.

3. TYPES AND PROPERTIES OF FIBRES

Fibres can be [4, 6]:

- Plant fibres:
  - fibres (trees, grass, straw and so on),
  - leaves,
  - seeds,
  - fruit,...
- animal fibres:
  - wool,
  - hair,
  - silk,...

Table 1 presents the basic properties of the most commonly used composite fibres (synthetic and natural).

Table 1 - Physical and mechanical properties of the fibres

Fibre	***Density ρ,*** *kg/m³*	***Yield strength,*** R_m, *MPa*	***Tensile modulus E,*** *GPa*	***Specific stiffness*** $E/\rho \times 10^9$ *m*
Glass	2400-2500	2100-4600	72-86	28,5-34,5
Carbon	1700-2000	2800-4500	260-385	126-205
Flax	1200-1510	357	60-80	43-57
Hemp	1200-1480	826	70	47

Advantages of natural fibres [6]:

- renewable resources,
- low energy consumption during processing,
- easy availability,
- low cost,
- low density (specific weight) which ensures a high specific hardness and stiffness in comparison with glass fibres, for example,
- good acoustic and insulation properties,
- safer handling and production in comparison with synthetic fibres,
- no CO_2 creation,
- decreased waste production,...

A successful aplication of natural fibres, as well as biocomposites, is limited by [6-7]:

- low heat stability,
- unresistance to fungi and microorganisms,
- possibility of rotting,
- high moisture apsorption,
- variability of dimensions and mechanical properties,
- temperature limit set to 200^0C during the processing of composites, because plant fibres are prone to degradation in high temperatures,
- high price of biodegradable matrixes.

4. THE APPLICATION OF BIOCOMPOSITES IN THE AUTOMOTIVE INDUSTRY

In the last 50 years the application of composites in the automotive industry has grown significantly, so that today car parts which are not made from composites are rare [8]. They are characterized by lower weight, which automatically implies lower fuel consumption. In the last 10 years the application of polymer composites in car manufacturing has almost doubled, which can be seen in Figure 1.

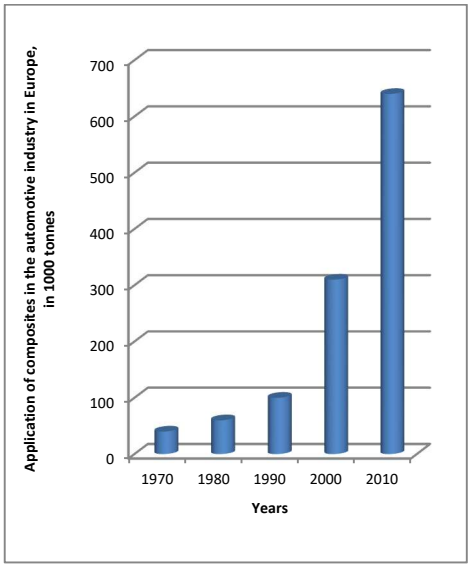

Figure 1*- The increase in the application of polymer composites in the automotive industry*

Glass fibres with a polymer matrix are most commonly used in the production of car parts. However, such composites are difficult to recycle.

On the other hand, carbon fibres have excellent properties (stifness, hardness, thermal conductivity), which make them the closest to an ideal construction material. Also, these fibres are economically viable in terms of recycling.

Considering that a lot of attention has to be given to the protection of the environment, glass fibres are increasingly being replaced by plant fibres, such as: flax fibres, jute fibres, hemp fibres, agave fibres, wood fibres (pine, ash, oak) and others. Plant fibres, when compared to glass fibres, have poorer mechanical properties, poorer resistance to moisture and other environmental conditions. However, their advantages include lower density, lower price and easier recycling.

The first application of natural fibres in the automotive industry dates back to the middle of the last century. Namely, in 1941 Henry Ford manufactured the first car made from hemp which was fueled by hemp ethanol.

In East Germany in the 1950s they started to produce the Trabant (Figure 2) whose chassis was made from cotton fibres in a polyester matrix.

Figure 2. *Trabant – the first car made of natural fibres*

Natural fibres have also been used for the production of interior car parts in the Mercedes S-Class, and in this way more than 23 kg of conventional materials have been replaced by biocomposites.

The application of plant fibres in the automotive sector shows an increase of 20% per year. The advantages of plant fibres are the following: a considerably lower price (from 25 to 50% compared to glass fibres), a decrease in mass while keeping the mechanical properties of composites, greater safety in case of a collision since they do not break, they serve as good heat and acoustic insulators, they do not affect the health of the users in a negative way, and others. From an ecological point of view, they are easy to compost and when burned, they do not release an excess of CO_2 into the atmosphere.

5. CONCLUSION

The automotive industry is an area in which a lot of work is constantly being done regarding the replacement of existing materials by composites with plant fibres. They are considerably more lightweight and in comparison with plastic materials, they possess a higher durability and lower heat deformations. Also, their impact on the environment is also lower. While composites with glass fibres have to be disposed of on a dump, biocomposites can burn practically without any remains.

Due to everything that has been said, a lot of companies own machines for the production and processing of biocomposites in their technological programme.

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