The study about the use of the natural fibres in composite materials

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Abstract: The current technological development, the crises of raw materials and energy, the increased aggression towards the environment have led to the development of the new materials and unconventional technologies. The composite materials have both many important advantages compared to the traditional materials and provide many functional advantages: low weight, mechanical resistance, low maintenance costs. The main advantage of the composites lies in their ability to combine the physical properties of components to achieve new structural functionalities, so the modulation of the properties and finally, to obtain a wide variety of materials which may be used in all areas of activities. Some biodegradable fibers, flax, hemp, may provide the specific mechanical properties compared to those of the glass fiber, due to their high strength and low density of their volume. To make the right choice, even if the natural fibers have very low power consumption compared with the synthetic fibers, such as glass or carbon, it should be considered a careful assessment of the environmental impact. The present study shows that the validity of the replacement of the synthetic fibers with natural fibers, depends on the reinforcement type and the complexity of the problems due to the processing of natural fibers.

1. Introduction
The main advantage of composites lies in their ability to combine the physical properties of the components to achieve new structural functionalities. Current technology is moving towards obtaining materials which satisfy both the structural strength of the final product and functionality. Composite materials market is moving towards fields where the cost is a strong decision maker. An important goal of research in composite materials is to integrate biodegradable materials to strengthen composite materials as much as possible.

The vegetable fibers are a renewable and recyclable, completely combustible and the manufacturing process requires less energy consumption than that for developing the mineral fibers [1-3].

Especially, some biodegradable fibers, eg flax and hemp can provide specific mechanical properties comparable to those of glass fiber in terms of resistance and their low volumetric density [4-8]. Fibreglass is a hard fiber and the flax and hemp fiber are light. The composites reinforced with
natural fibers and polymers have been developed significantly in recent years due to significant processing advantages, biodegradability, low costs, relatively low density, high specific strength and a renewable nature [9-12].

These composites are designed for many uses, especially in Europe, where there are both the market and legislation pressure [11-13]. Due to the environmental problems caused by the large volume of waste, the world is moving towards composite materials reinforced with natural fibers [13-16]. Until recently the only choice for enhancing polymer composites have been the synthetic fibers like glass, carbon, aramid, due to their superior mechanical properties. A reduced adhesion to the natural fiber-matrix interface, a low degradation temperature and the weak resistance to a high humidity caused the use of the natural fibers in reinforced composites at a rate lower than the synthetic fibers [16-18].

The equipment which are using thermoplastic and thermosetting composites reinforced with flax and hemp are technical and environmentally friendly, having a significant market potential in the sports and leisure fields.

The fiber components may be used either 100% or in combination with the carbon fibers and the thermosetting resins to produce structural parts (eg frames in the sports sector), and the benefits have been demonstrated [19-21]. There are many possibilities because nowadays, only 8% of European production of flax and hemp is used in composite materials [22-25].

Making composites reinforced with synthetic fibers and matrix requires a large amount of energy that is only partially recovered by the incineration of the fiber reinforced composites. This has turned attention back to the natural fibers, due to their biodegradability which satisfies the requirements on the environmental protection [26-29]. It has been found that the energy required to produce the natural fibers is much less than the amount required producing glass or carbon synthetic fibers for the reinforcement of composites [30-33].

2. Methods and materials

The materials used in this study were flax and hemp fibers in the form of flax (oakum) and tow. Stretching properties of flax and hemp which are to replace glass fibers in composite used in transport field were determined on the H5K-T Tinius Olsen dynamometer and using a specialist QMAT TEXTILE computing software, according to ASTM D3822-01 Standard, the distance between the clamps dynamometer 10 cm for tow and 3 cm for oakum. Principal characteristics of the flax and hemp to replace glass fibers in composites transport structure are presented in Table 1.

| Characteristics                  | flax fibers | hemp fibers |
|----------------------------------|-------------|-------------|
| The average diameter of the fibers, µm | 44.9 µm    | 48.1 µm     |
| The average length of fiber, cm   | 10.98 cm    | 6.46 cm     |
| Standard deviation               | 4.5         | 2.78        |
| Degree crimping 25 mm            | 6.4         | 2.9         |
| The content of impurities, %      | 1.8         | 2.3         |

Through a qualitative and quantitative analysis of stress-strain diagrams were highlighted the following: the variation limits of the pressure properties and the factors that determine the differentiation of the appearance and the minutiae of the stress-strain diagram.

It was also determined the flax and hemp flexibility, taking into account their ability to bend under its own weight, expressed by the amount of deflection of a bundle of fiber length and mass, conventional established (l = 270 mm, m = 420 mg).

In the framework of this study, it was to determine the density of the fibers used in composite materials using the pycnometer method.
3. Experimental part
The composite materials offer a number of advantages compared to homogeneous materials due to rigorous control of properties (high strength, lightweight, folding possibility) and biocompatibility. Given the technical process of making them, through a layered settlement layered, the composites containing fibers can be divided into [34-36]:
- Singlelayer composite ("single-layer");
- Multilayer composite ("multilayer").

Singlelayer composites are made up of several distinct bands but having the same orientation of the filament components and the same properties. In the case of composites made of discontinuous fibers, by the process of casting in shape, although the plane orientation of the fibers varies across the strip, there are no distinct layers, so the composite is a monolayer.

As the rule, the natural fibers cannot provide the same mechanical properties as carbon fibers, but if some of them can get a similar behavior at mechanical stress like the glass fiber. The natural fibers, before being used in the preparation of composite materials are prepared for operations amending their contact surface.

Following these operations, the fibers must have: a good adhesion between fiber and matrix; an appropriate degree of polymerization and crystallization; moisture resistance; must be non-flammable and have uniform physical properties.

Due to the properties of the flax and hemp fibers, both as tow (oakum) and flax, they can be used to make composites for automotive applications, sporting goods, musical instruments and transport equipment being worked on various processes such as compression molding, injection molding, or hybrid technology.

Stretching properties of the yarns are expressed by indicators that are defined by the characteristics of torque, force and elongation at break and the indices deducted by the stress-strain diagram which shows the correlation between the two measures. Test results about the average value of indicators for assessing the stretching properties of flax and hemp which are to replace the glass fibers in composites used in transport field, are compiled in Table 2.

| Table 2. Mechanical properties of flax and hemp. |
|-----------------------------------------------|
| Torque characteristics | Flax tow | Flax oakum | Hemp tow | Hemp oakum |
| Breakout force, \( F_r \) (N) | 230 | 150 | 285 | 125 |
| Relative elongation at break, \( \epsilon \) (%) | 6.7 | 1.8 | 3.6 | 3.2 |
| Specific resistance, \( \sigma \) (N/tex) | 37.5 | 42.86 | 51.8 | 27.8 |
| The modulus of elasticity, \( E \) (N/mm\(^2\)) | 26.86 | 3.89 | 20.8 | 2.6 |
| Flexibility, \( f \) (mm) | 30 | - | 44 | - |

From the analysis of the stretching properties of flax and hemp yarns, studied by investigating stress-strain diagram, shown in figure 1, 2, 3 and 4, results the following general comments:
- variation limits of the indicators for assessing the stretching properties depend on the conditions of soil, climate, plant (stalks) maturity at harvest and their methods of extraction and processing;
- growth strains conditions are recognized as the most influential parameter on the variability of the fiber mechanical properties;
- indicators value for assessing the stretching properties influence the further processing of the fibers;
- specific resistance of the hemp fibers is higher than flax fibers because the fibers in a bundle of hemp fibers are stronger consolidated between them, due to its higher lignin and pectin substances;
- because the elasticity module shows the response mode of the fibers and expresses the rigidity of the material subjected to stretching, it is found that the flax fibers have their value higher than the fibers in the form of oakum.

![Figure 1. Stress-strain diagram for bundle flax tow.](image1)

![Figure 2. Stress-strain diagram for bundle hemp tow.](image2)

![Figure 3. Stress-strain diagram for flax oakum.](image3)

![Figure 4. Stress-strain diagram for hemp oakum.](image4)

Flexibility is the ability of the fiber to bend under its own weight: the flax tow bundle, \( \bar{f} = 30 \text{ mm} \) is less than hemp tow bundle \( \bar{f} = 44 \text{ mm} \). Flexibility depends on the nature of the fibers and some external factors such as the increases of humidity of fibers (which increases their flexibility). Thus, by treating the fibers with oily substance, it decreases their hardness.

The increased energy prices, especially oil, makes the oil extracted fibers for reinforcing to be more expensive, so finally, the cost and the excellent properties of flax fibers allow us to use these fibers in composite materials. Thus, polypropylene or glass fiber used to reinforce cement or plaster can be replaced with flax fiber in the composite materials.

From figure 5 we may find that the natural fibers used for composite materials have a volumetric density much less than glass fibers. The elasticity modulus (called Young’s modulus), hemp fiber price is about half the price of glass fiber, timing for pouring the hemp fiber composite is lower than glass fiber composite show that natural fibers are better than glass fibers.
To make the right choice, even if the natural fibers have a very low energy consumption compared with synthetic fibers, such as glass or carbon, should be considered a careful assessment of the environmental impact.

4. Conclusions

In these times of great environmental requirements, the biodegradability and recycling are priorities that must be taken into account in the design of the tracks, so the flax and hemp composite will evolve inevitably, in the short term.

The use of the natural fiber composites depends on the cost of production and their functional properties.

It results that even if the use of flax and hemp fibers to reinforce composites represents a friendlier solutions to the environment, only the weaving is, in terms of energy technology, a "green" technology, while producing flax and hemp yarn includes a high energy quantity.

The validity of replacement of the synthetic fibers with the natural fibers depends on the type of reinforcement and complexity issues of the processing of natural fibers.

A parameter that describes better the environmental impact is the incorporated energy calculated with reference to all materials and farming operations needed to obtain the proper strains: from plowing to harvesting, the processes for extracting fibers from stalks: retting and decorication, operations for preparation of fibers (combing and carding), spinning or finishing.

The use of embedded energy parameter shows that not any kind of natural fiber reinforcement is superior to the "green" synthetic fibers. Thus, the use of flax and hemp fibers extracted in an industrial molten stems way requires the need to build some tanks for recycling water used for cleaning so this involves using of expensive pools so, finally, the cost price for natural fibers and yarns are higher than using the synthetic fibers.

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