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# SUSTAINABLE RESOURCE OF RAW MATERIALS: FROM TECHNICAL TEXTILES TO TEXTILE-REINFORCED COMPOSITES

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**Abstract:** Increasing market demand for end products made of lightweight composites ranging from automotive parts, aircraft structures, pressure vessels, wind turbine blades and sport products, leads to a fast-growing composite materials market. Technical textiles are fabrics and textiles designed / designed and made primarily for their technical and performance properties, rather than for aesthetic and decorative features. Textiles or composites based on technical textiles are intended to replace many of the current metal or plastic materials used in the leading or consumer industries. Therefore, the latest trends in composites expect the advanced and innovative industries to use new reinforced composites to replace parts currently made with other materials or other types of composites.

**Keywords:** composite materials, trends, composite textiles, new reinforcement materials

## INTRODUCTORY NOTES

Composite materials are made from two or more constituents with diverse physical and chemical properties, which when clubbed together produces a material with characteristics different from their individual materials. Basically, composite materials are engineered to create a new structured material that is chemically and physically different from its individual components, which are mixed together to enhance the properties of composite and to make them suitable for the various applications in the end user industries.

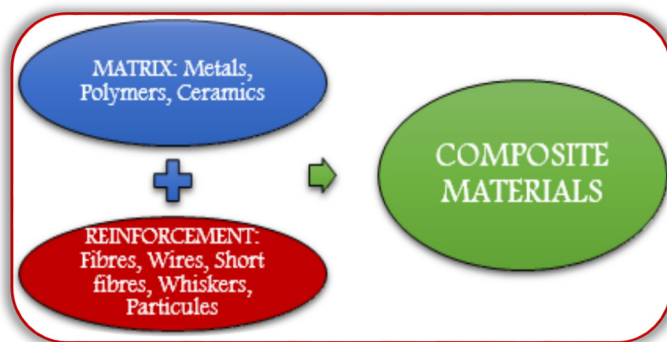


Figure 1. The composite materials

The composite materials keep their separate identity (at least at the macroscopic level), however, their combination generates different properties and characteristics from those of the component materials.

One of the materials is called matrix and it is defined as forming the continuous phase. The other main element is called reinforcing material (reinforcement) and it is added to the matrix in order to improve or modify its properties. The reinforcement is the discontinuous phase, evenly distributed throughout the matrix volume, and is the elements that give the assembly the characteristics of resistance to stress.

The matrix ensures that the fibers break before the matrix breaks down. As a liquid state, the matrix must have the ability to wet the fibers to ensure a good adhesion. If the choice of the matrix is

largely guided by the working temperature, then the choice of the stinging fiber is made for other considerations. Reinforcement fibers have to bear without degrading all the stages of composite manufacturing. The surface of the fibers is also degraded by chemical reactions with the matrix. In polymeric and metallic matrices, the synergy of properties results from the proper bond between the reinforcement and the matrix. However, it should be emphasized that composite material is a unitary assembly, in which the two phases act together.

Unlike metals and polymers, which are normally treated as isotropic materials, composites generally exhibit anisotropic properties, which are determined by the type and format of the used reinforcement. Also, the matrix material and the processing method are further variables which can be tailored to provide the desired properties. Because composites can be tailored in so many ways to the various requirements of a particular engineering component, the key to optimizing cost and performance is a fully integrated design process capable of balancing all of the relevant design and manufacturing variables (matrix and reinforcement's properties, manufacturing processes, analysis of the properties and behaviour of the resulting structure).

## THE MAIN TRENDS

Composites have growth opportunities in the forecast years. In the future, the composites industry will continue growing into more applications and markets. Environmentally friendly composites will incorporate recycled plastic and bio-based polymers to feed the growing demand for stronger, lighter, and more environmentally friendly materials.

The rises of composites have already transformed most of the world's industries and will continue to grow in the years to come. The researches in this area of composite materials will focus on:

- making advanced composites less expensive and energy-intensive to manufacture.
- making composites easier to recycle, and
- develop new fibers and resins to open up even more applications for composite materials.

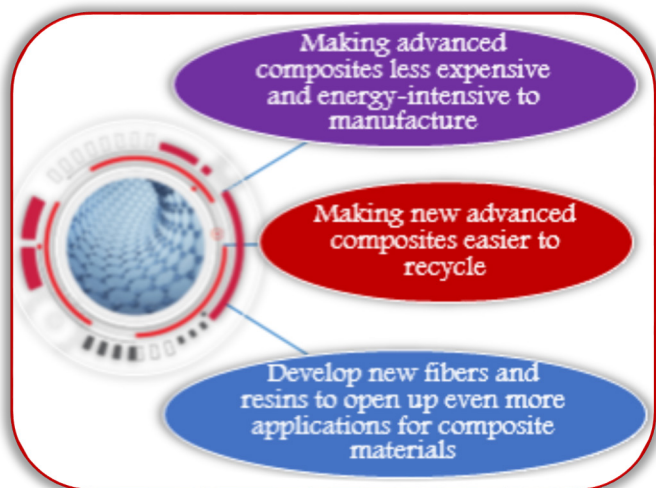


Figure 2. Main researches in area of composite materials

Increasing market demand for end products made of lightweight composites ranging from automotive parts, aircraft structures, pressure vessels, wind turbine blades and sport products, leads to a fast-growing composite materials market, where the main trends are:

- Trends in product and process innovations. Over the past few years there have been a significant developments and innovations in the composites industry across various industries, the composites playing a crucial role in all innovative industries.
- Trends in new fibers and new reinforcements. Companies are continuously investing in innovating and developing high strength natural fibers to improve both mechanical and chemical requirements. Additionally, the recent trends are on developing green materials and natural fibers.
- Trends in resins and matrix components. Companies are launching new resin types that focus on shorter cure time for mass volume applications, in an ecological way.
- Trends in new applications of advanced composites. Companies are launching new hybrid structures, penetrating continuously the areas of automotive, aerospace, construction, energy and various other advanced industries.

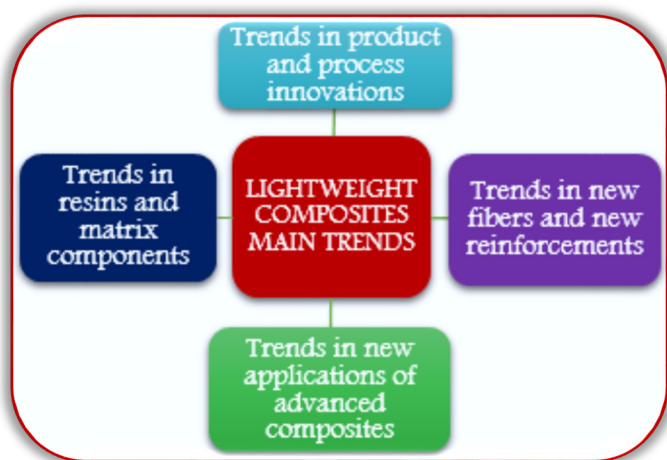


Figure 3. Main trends in area of composite materials

Therefore, the latest trends in composites expect the advanced and innovative industries to use new reinforced composites to replace parts currently made with other materials or other types of

composites. The transport industry has for some time been engaged in the application of new lightweight materials for structural design, with advanced lightweight composites replacing traditional metal materials more and more in both structural and non-structural parts. The rail industry could also benefit from the use of structural new materials. It is a fact that the increased focus on green technology will result in advanced composites made to increase penetration in manufacturing. Resins, together with natural fibers, can create lightweight components for interior/exterior structural components in many sectors. Moreover, in the future, green technology's inspired materials may replace even the traditional composites and come to dominate the industry.

Having in view the previous presented trends, and trying to summarizing, the top business objectives, common to all composites manufacturers, are:

- exploring new materials and new composite solutions (new reinforcements and new matrix components),
- exploring new manufacturing processes (new technologies, new methods, innovated manufacturing, including the automating manufacturing processes),
- improving process and quality control, exploring the lightweight characteristics and cost reduction factor of composites
- reduce material expiration and waste, and
- increase the ecological sustainability and increase focus on green technology.

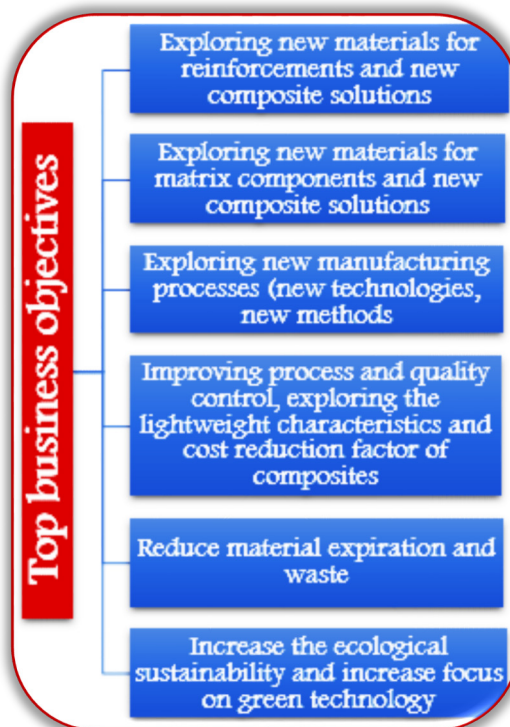


Figure 4. Top business objectives

In response to the growing market demand, and in search of a competitive advantage, leading composite manufacturing companies significantly invest in new technology, research of new materials and innovative manufacturing processes to increase throughput and profitability while improving process and quality

control. Such key business objectives indicate that companies dealing with composites invest in the areas of new materials research, process innovation and increased focus on green technology. Also, they look for ways to increase the composite production throughput while investing in improvement of process and quality control.

Having the background of the need for a sustainable resource of raw materials as well as environmental problems caused by plastics and metallic materials, which are hardly degradable, the leading industries are always looking for new materials, especially those with low impact on the environment, which after end-of-life cycle are easy to recycle.

The applicability of technical textiles in engineering has experienced an exponential growth over the last decades, although in the technical fields requiring mechanical stress is still limited. However, textile materials have particular advantages in terms of formability and dynamic impact properties, and thus composite materials with textile reinforcement are one of the main areas of application of technical textiles.



Figure 5. Technical textiles in engineering

Technical textiles are fabrics and textiles designed / designed and made primarily for their technical and performance properties, rather than for aesthetic and decorative features. Textiles or composites based on technical textiles are intended to replace many of the current metal or plastic materials used in the leading or consumer industries.

### TEXTILE EMBEDDING METHODS

Many high performance composites exist, yet most notable are variations of fiber-reinforced polymers, carbon-fiber-reinforced polymers and glass-reinforced polymers are leaders in the ever advancing materials engineering sectors. Basically, fiber-reinforced polymers are made from a polymer base such as epoxy or polyester infused with a fiber matrix of glass, carbon, aramids or other fibers.

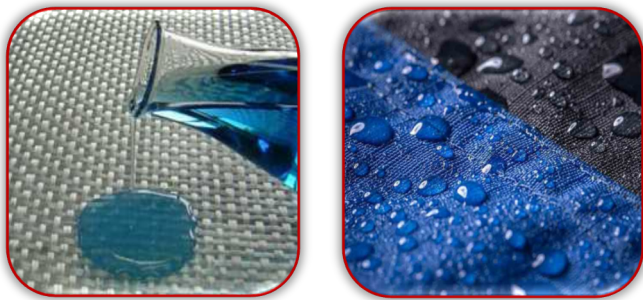


Figure 6. Fiber-reinforced polymers – the principle  
Natural fiber reinforced polymers have been identified as a potential low impact alternative to glass-, carbon- or aramid-reinforced polymers. Although the replacement of glass, carbon or

aramids fibers with natural fibers for reinforcement in polymer composites appears to be a modern phenomenon, natural fiber reinforced polymers are not strictly modern by invention.

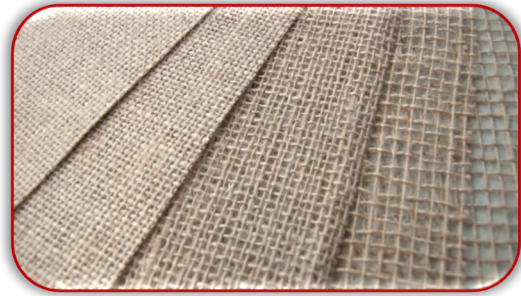


Figure 7. Natural fiber fabrics for reinforcements

The major advantage of composites is the ability to modulate properties and thus obtaining a wide range of materials, the usage of which can be extended to almost all areas of technical activity. Composite materials are the first materials whose internal structural design is conceived by man, not only in their molecular chaining, but by giving them favorable resistances in preferential directions. The initial purpose of composites was to increase the competitiveness of classical materials, whose strength and stiffness properties could no longer be improved by other means. From this point of view, it is understood that the maximum efficiency of the reinforcement of a certain material is obtained by introducing, in its structure, fiber reinforcing elements.

Within the field of composite materials, we find a wide range of processing techniques based on the use of reinforcing materials mainly focused on textile structures and matrices of polymeric materials. The most common processes are hand layup, oven and autoclave curing, resin transfer moulding, vacuum infusion, compression molding and pre-pregging.

Composite textiles with reinforcement materials comprise a wide range of reinforcement material in the form of textile preforms which may be constituted by non-woven, woven or knitted materials. In order to select the optimal technology for preparing textile preforms, it is necessary to consider both the strengths and weaknesses of each technology. Different methods are used to obtain composite structures:

- embedding reinforcement material (woven or knitted material) into a matrix, which may be either a macromolecular substance or a colloidal solution or suspension with coagulation properties;
- consolidation of the base material by means of curing layers, resulting in a laminate.

The textiles are prepared separately and are incorporated into the matrix by one of the following methods:

- simple lay-up process. It is the case of synthetic resin matrices applied in alternating layers of textile layers. The method is used on an industrial scale for the manufacture of fiber composites.
- infiltration of the resin between the layers. The fibers are aligned in a shape corresponding to the part and infiltrate (under vacuum or under inert gas pressure) the matrix material in liquid state.

The very diverse manufacturing technologies of these materials involve specific processes for:

- obtaining the polymer matrix,
- preparing the reinforcement components,
- impregnating or treating the fibers,
- making the reinforcement (in the form of knit, fabric, and braiding),
- making the composite itself and so on.

Imposing these composite materials in the cutting-edge areas of the technique is also due to their technological features: easy machinability, with the possibility of obtaining finite pieces in a single operation or by not very difficult operations, operations in many cases possible mechanized and automated, which determines the location of costs at relatively low, competitive levels. These advantages are an important economic parameter that reduces the direct cost of making parts, structural elements, or building elements.

On the other part, large textile type material lost in landfilling or incinerations are unavoidable in the currently wasteful, linear system which creates negative impacts on the environment. It is important to find innovative solutions to valorize this waste to ensure that it does not add to the already significant environmental impact created by textiles. Therefore, in the field of textile waste, we can mention, according to technical, economic, social, ecological criteria, the following directions of action:

- establishing modalities for waste disposal at the end of life-cycle losing production cycles, using and recycling waste;
- designing and launching new products by improving the quality of materials to extend the life of products made from these materials;
- identification of the various internal and external organizations necessary for practice recovery

## CONCLUSIONS

By processing on classic traditional and nonconventional technologies, the potential uses of recovered technical fibers and/or fabrics can be:

- phono- and thermo-insulating materials / building materials (which are used in the textile branch by the production of non-woven textiles, upholstery wadding for furniture and cars, insulating materials, geotextiles, and representing about 60% of the recovered waste: yarn waste knitted fabrics, knitted fabrics, knitted fabrics, knitted fabrics and strips);
- textile composites (which are used in the automotive, naval, construction, military technique, and so on) industries;

The use of composites will play an increasingly vital role through the manufacture of structures which enable the harnessing of sustainable energy sources. Factors such as the reduced weight compared to metallic structures, lower transportation and erection costs, and most importantly, lower maintenance costs are already positioning composites as a de facto material enabling economical solutions to large scale projects.

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