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THE USE OF COMPOSITE MATERIALS IN THE AUTOMOTIVE INDUSTRY

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Abstract: *In the present paper is presented an analysis of the structure of composite materials, being described the technologies of obtaining, both of the composite materials and of the parts made of these materials. Composite materials are widely used in the aerospace industry, and their properties make them irreplaceable in the manufacture of aircraft, even if their price is still quite high. In this branch of industry, technology dictates to economics.*
Keywords: *composites, materials, industry*

1. INTRODUCTION

The car manufacturing industry is the largest consumer of materials in the economy. This industry uses and integrates the products obtained in almost all modern industries: metallurgy, chemistry, electronics, textiles, etc. being the main consumer for most of these industries. During operation, motor vehicles are a major consumer of petroleum products and industrial fluids. Thus, technical progress, competition in this field and the requirements imposed on vehicles require knowledge of material properties, development of new materials, new processing technologies.
In the current stage of development of the world economy based on the laws of the market economy, the correct choice and use of materials and their processing processes must be done according to scientific rigor, in order to meet increasing demands. In design, the optimal choice of materials is made according to the conditions of use, the existing requirements, the processing processes, the shape, dimensions and performance of the products, the regulations in force and last but not least the cost.
The composite material is a combination of two or more constituents of the same type, or different, physically and chemically. The materials maintain their separate identity in the composite. Their combination gives the composite material properties and characteristics different from those of the constituents. The basic material is called a matrix. The other constituent is called reinforcement. The reinforcement can be in the form of fibers or particles and is added to the matrix to improve its qualities. In the composition of the composite material we also find technological additions.

2. THE STRUCTURE OF COMPOSITE MATERIALS

The structure of the composite materials is diagrammed in figure1.

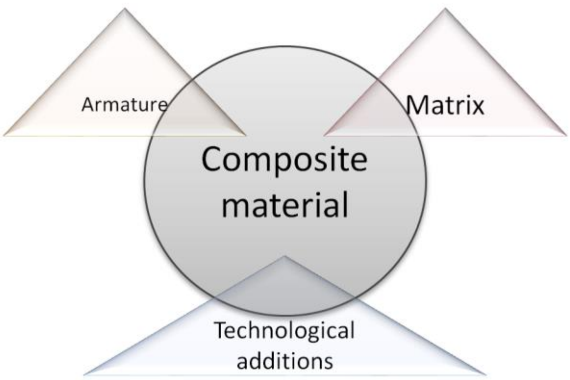

Figure 1. The structure of the composite materials

The choice of materials and their processing processes is a difficult but very important stage for the performance and cost of the product.
The choice is based on the promotion of cheap and easy to purchase materials, the optimal use of technological properties. At present, the share in the car manufacturing industry has metallic materials, but the forecasts show that these materials will be replaced by composite materials.

Table 1: The use of materials in the construction of motor vehicles.

No.	Materials	Products
1.	Steels	Bodies
2.	Alloy steels	Transmissions, suspensions, steering, gearboxes, sprockets, shafts, fasteners
3.	Cast iron	Crankshaft, discs, brake drums, cylinders, camshafts
4.	Lightweight non-ferrous alloys(silicon aluminum, copper aluminum)	Pistons, cylinder head, caliper
5.	Heavy non-ferrous alloys(Based on copper, bronzes, brass, lead, tin, antimony)	Bearings, bushings, bearings, electrical installation
6.	Materials based on silicon dioxide, bottles and silicates	Windshield, rear window, side windows
7.	Polyethylene	Air conditioning pipes
8.	Polypropylene	Bumper bars, dashboards, door panels
9.	Polyamides	Wheel covers, tubing
10.	Rubber	Tires, seals, gaskets, carpets, sealing cuffs
11.	Foams	Seat cushions, parasol, aileron
12.	Brake fluid	Hydraulic fluid in the braking system
13.	Antifreeze lubricants	Engine coolant
14.	Lubricants	Gearbox, differential, engine lubrication
15.	Lubricants	Mechanisms, steering box
16.	Textiles	Upholstery, interior ornaments, tarpaulins, inserts
17.	Composite materials	Bumper bars, body ornaments

3. THE TECHNOLOGY OF OBTAINING COMPOSITE MATERIALS AND COMPONENTS

The methods and procedures for forming composite parts are chosen depending on the nature of the matrix material and the reinforcement. The procedures for obtaining composite materials are varied and depend on several factors: the type of materials used, their properties, the number of parts to be made, the field of use of the built parts, the requirements of the product to be executed, quality conditions, price production, etc.
Reinforcement materials, depending on their nature, have different production processes.
Schematically, the process of obtaining the fiberglass is illustrated in figure2.

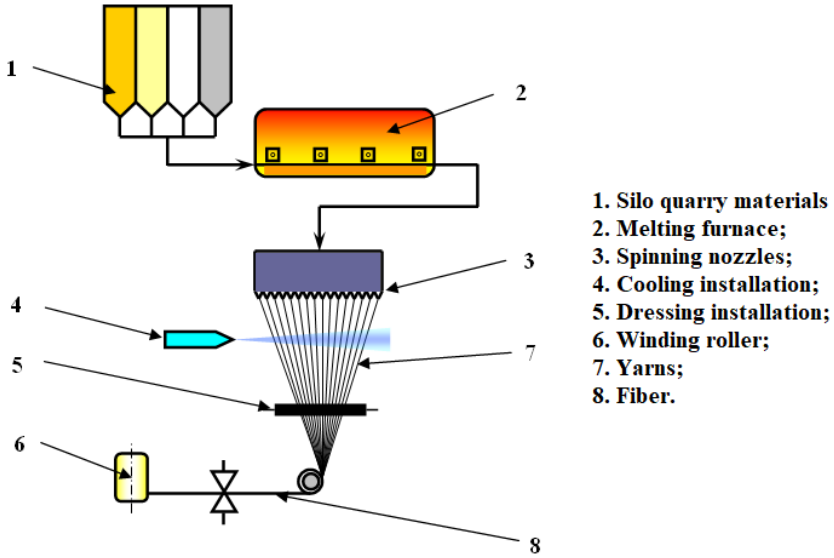

Figure 2. The process of obtaining the fiberglass

Carbon fibers are stronger than steel, stiffer than titanium and lighter than aluminum with the highest specific stiffness. Carbon fibers have a very high resistance to both traction and compression. The impact strength of these fibers is lower than that of glass or aramid fibers, so that the carbon fibers are combined with these fibers to form hybrid layered structures.
The diagram of the carbon fiber production process is diagrammed in figure 3.

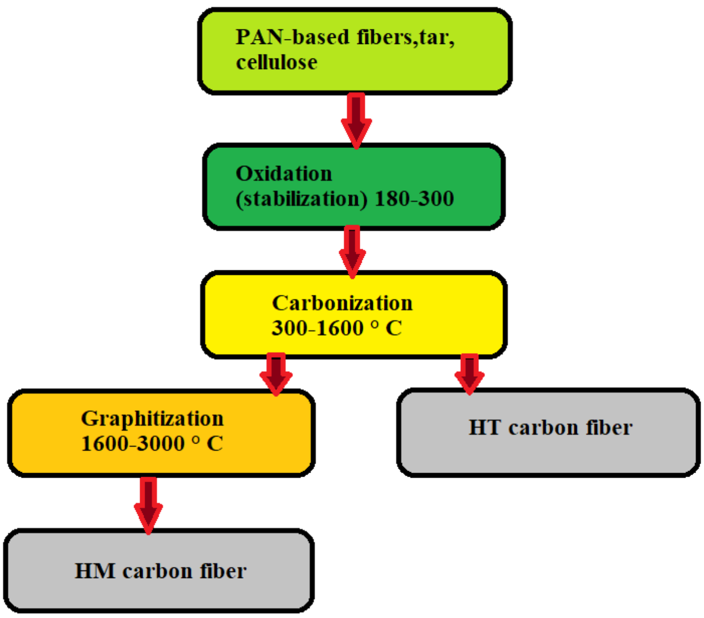

Figure 3. The diagram of the carbon fiber production process

Aramid fibers have an exceptional impact resistance, being used in the production of structures in military technology, aerospace technology, sports equipment, the automotive industry and the navy. Their production starts from a polymer (20% - fraction) and H2SO4 (80% - fraction).
Pre-preg is a composite material made of a reinforcing material that is pre-impregnated with a thermosetting resin. The impregnated reinforcement fabric is placed in an oven where the solvent is evaporated and a partial polymerization of the resin is performed. The pre-preg is cooled, and covered on both sides with a polyethylene film, before being wrapped in rolls.
Obtaining composite materials consists in the process of joining, chemically and mechanically, the layers of the reinforcement material with that of the matrix.

4. INDUSTRIAL USES OF COMPOSITE MATERIALS

Composite materials are used to make high-performance structures. Their main advantage is the high ratio between their strength and their weight.
In figure 4 the consumption of such materials is presented until 2010, compared to classical materials or natural products.

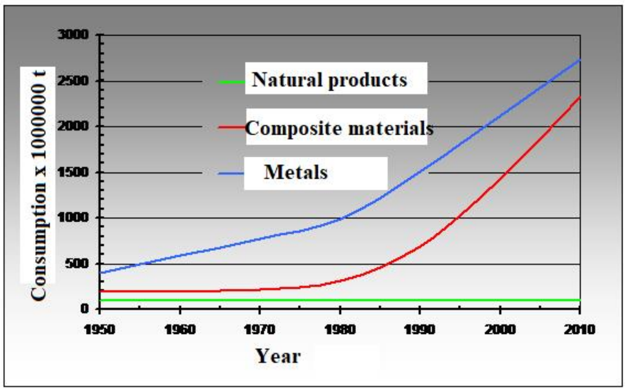

Figure 4. The consumption of such materials is presented until 2010

In the military industry, composites are used for helmets, bulletproof vests, weapons. Vehicles and combat equipment made from these materials are more resistant on the battlefield, have increased maneuverability and may be undetectable by radar installations.
In medicine, more and more composite materials are being used for medical intervention instruments and prostheses. There are polymers for transplants, prostheses and cardiac implants, substances for blood clotting. Prostheses and support devices are made of and composite materials.
Biomaterials have emerged, created to prevent or attenuate tissue reactions on contact with these materials. The use of biodegradable polymers (copolymers of lactic acid) would have the advantage of avoiding the surgery necessary to remove the immobilization plates.
In the chemical industry, composite materials are used for the execution of pressure vessels, containers, tanks, elements for anti-corrosion coatings, extractors, pools, hotels, chimneys, cooling towers, devices working in corrosive environments, pipes, cast valves, bearings, bushings, pistons, rings, seals, etc.
In agriculture, composite materials are used for transparent and thermal insulation panels for greenhouses silos, packaging, parts (dashboards, bodies, armor, valves) for agricultural machinery, irrigation systems, tanks for feed.
In the food industry, cold rooms and showcases, large containers, sealing elements that must withstand the attack of microorganisms, rodents or insects, hygienic interior structures, high pressure pipes and tubes are made of composite structures.
In air and space transport, composite materials reinforced with metal carbides and metal oxides, with carbon fibers, glass fibers and aromatic polymer fibers, boron fibers, aluminum fibers, silicon fibers are used. The matrix of these materials can be polymeric, ceramic, or metallic from nickel and cobalt alloys. By using these materials, the safety of ships is increased and their mass is reduced.
About 40% of the weight of the Airbus 340 aircraft is made up of composite materials. Among the parts built of composite materials can be listed: aerodynamic brakes, landing gear hatches, horizontal tail and depth, drift and direction, interior parts. The markings are made of aramid radon composites (resin) or hybrid composite, some plated with layers of aramid to increase shock resistance. The use of composite materials leads to the simplification of aerospace structures, with favorable consequences for the economy and reliability of aircraft. For example, if only the metal would be used to make the steering mechanism of the Airbus 340, it would need about 7600 parts, and if it is made of composites, 5200 parts are needed.
In shipping, composite materials based on polyester resins, reinforced with glass fibers, carbon fibers and aramid fibers, are mainly used, especially for sports boats and light vessels. These materials have low weights and increased stiffness and have increased the speed and reduced fuel consumption of ships. Yachts, cruise and light vessels are made in proportion of 65% of composite materials.
The automotive industry is one of the most important economic branches and at the same time generates a boost for other industries. Composite materials are the solution for the development of energy efficient vehicles. The replacement of metals with composite materials leads to a reduction in the weight of vehicles, which implies a reduction in its fuel consumption, therefore, a reduction in pollution but also an increase in performance.
Until 2010, about 10% of the car's mass was made of reinforced plastics. The trend is for this percentage to increase in the coming years.

Most uses of polymeric composite materials, 56%, are the construction of car body elements: wings, doors, pavilions, hoods, etc.

Researchers at Imperial College London, including Volvo Corp., have developed a prototype of a carbon fiber electric vehicle that stores electricity in the composite material from which the body is made. The latest nano-materials made of extremely thin and strong carbon fibers replace the steel body panels of the vehicle and can be used to make the ceiling, doors, hoods and floor. The patented composite, made of carbon fiber and polymer resin, could change the construction of hybrid electric vehicles. The material is designed to easily store and supply electricity, but is strong enough to be used to make structural components or body panels. The car itself could become a battery.

The material is able to store and supply large amounts of energy, much faster than conventional batteries. The recharging process does not involve any of the chemical reactions that cause the batteries to degrade over time (figure 5).

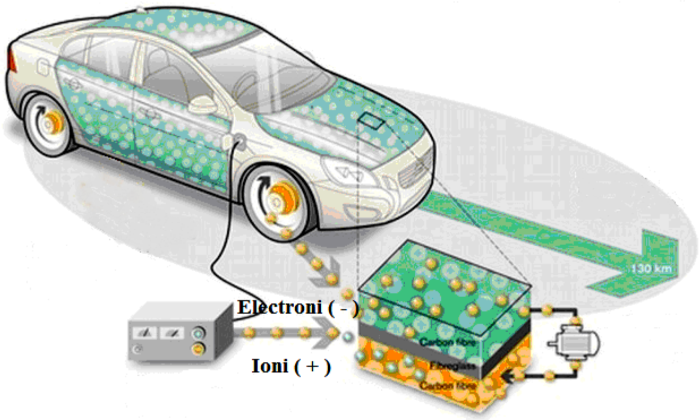

Figure 5. Energy-generating composite body elements

5. CONCLSIONS

Composite materials are being used more and more. Their qualities impose them in front of the classic materials being lighter, more reliable, easy to make. In the automotive industry, the use of these materials increases the strength at the same time as the weight of the vehicles decreases, which translates into reduced fuel consumption and increased performance.

REFERENCES

[1] Alămoreanu,E., Chiriţă,R., Bare şi plăci din materiale compozite. Ed. Tehnică, Bucureşti, 1997.

[2] Boeglin N, Conception de produits et environnement: 90 exemples d'éco-conception, ADEME Ed, 1999

[3] Bostaph, G.M., Elser, W., A fracture mechanics analysis for delamination growth during impact on composite plates, in 1983 Advances in Aerospace Structures, Materials and Dynamics, American Society of Mechanical Engineers, New York, 1983, p. 133-138

[4] Bran Florina, Rojanschi Vladimir- Protecţia şi ingineria mediului; Editura Economică 1997

[5] Chiru, Anghel şi Marincaş, Dumitru Tehnologii speciale de fabricare şi reparare a autovehiculelor, Reprografia Universităţii TRANSILVANIA, 1991

[6] Constantin, N., Jiga, G., Hadăr, A., Numerical modelling of a fibre reinforced composite, Proc. of EUROMAT'95, Padova-Veneţia, 1995, p. 521-524

[7] Cristescu, N., Mecanica materialelor compozite, Vol.1, Universitatea Bucureşti, 1983

[8] Gay, D., Matériaux composites, Editions Hermes, Paris, 1991

[9] Gheorghe V., Bejan C., Sandu V., Lihteţchi I., Determination of coefficient of thermal conductivity on glass fibers-reinforced polymer matrix composites - 5th International Conference ″Computational Mechanics and Virtual Engineering ″ COMEC 2013 24- 25 October 2013, Braşov, Romania

[10] Gheorghe V., Bejan C., Sîrbu N., Lihteţchi I., Influence of temperature on mechanical properties of polymer matrix composites subjected to bending - 5th International Conference ″Computational Mechanics and Virtual Engineering ″ COMEC 2013 24- 25 October 2013, Braşov, Romania

[11] Hadăr, A., Structuri din compozite stratificate, Editura Academiei şi Editura AGIR, Bucureşti, 2002

[12] Hofstee J. and van Keulen V., - Elastic stiffness analysis of a thermo-formed plainweave fabric composite. Part II: analytical models, Composites Sci. Technol., 2000