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ANALYSIS OF THE POLYMER COMPOSITE MATERIALS USE IN HELICOPTER CONSTRUCTION INDUSTRY

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Modern composite materials usually consist of two components: a fiber and a matrix, that is, a continuous phase. As a fiber, fiberglass is usually used, but sometimes Kevlar, carbon fiber or polyethylene can be applied. The matrix is usually a thermosetting material such as: epoxy rubber, polycyclopentadiene or polyimide. The fiber is integrated into the matrix in order to make the matrix stronger. Polymer composite materials are playing an increasingly important role in modern helicopter construction [1].

The following polymer composite materials are distinguished, which are used in the construction of helicopters:

- Fiberglass. Polymer composite materials reinforced with glass fibers, which are formed from molten inorganic glass. Thermosetting synthetic rubber (phenolic, epoxy, polyester) and thermoplastic polymers (polyamides, polyethylene, polystyrene) are most often used as a matrix. These materials have sufficiently high strength, low thermal conductivity, high electrical insulation properties. In addition, they are transparent to radio waves. For example, the Bell 206, which is used for various purposes, including commercial and military operations, has a fuselage made of fiberglass. This allows the helicopter to be lightweight, durable and resistant to corrosion, which makes it reliable and durable in operation [2].

- Carbon fiber composite material. The filler in these polymer composites are carbon fibers. Carbon fibers are obtained from synthetic and natural fibers based on cellulose, acrylonitrile copolymers, petroleum and coal pitches. The thermal treatment of the fiber is carried out in three stages (oxidation, carbonation and graphitization) and leads to the formation of fibers characterized by a high carbon content. The main advantages of carbon fiber plastics compared to fiberglass are their low density and higher modulus of elasticity. Carbon fiber plastics are very lightweight and durable materials. For example, the Airbus Helicopters H160 has a fuselage made of carbon fiber. This allows the helicopter have a high degree of aerodynamic efficiency.

- Boron-fiber plastics. Composite materials containing boron-fibers embedded in a thermosetting polymer matrix as a filler, while the fibers can be either in the form of monofilaments or in the form of bundles braided with an auxiliary glass thread or tapes in which boron filaments are intertwined with other filaments. Due to the high hardness of the filaments, the resulting material has high mechanical properties (boron-fiber have the highest compressive strength compared to fibers

from other materials) and great resistance to aggressive conditions, but the high brittleness of the material makes it difficult to process them and imposes restrictions on the shape of boron-fiber plastic products. In addition, the cost of boron-fiber plastic is very high. One example of using boron-fiber plastics in helicopter blades is the Bell 429. Helicopter uses boron-fiber plastic in the blades of the helicopter. This application of boron-fiber plastics helps to reduce vibration and noise during flight, which makes the helicopter more comfortable for passengers and ensures a smoother flight.

- Organic plastic. Composites in which organic synthetic fillers are used, less often natural and artificial fibers in the form of bundles, threads, fabrics, paper, etc. In thermosetting organic plastic, epoxy, polyester and phenolic rubbers, as well as polyimides, usually serve as a matrix. The material contains 40-70% filler. The filler content in organic plastic based on thermoplastic polymers – polyethylene, PVC, polyurethane, etc. – varies significantly within large limits – from 2 to 70%. Organic plastic has a low density, they are lighter than fiberglass and carbon fiber plastics, relatively high tensile strength; high impact resistance and dynamic loads, but, at the same time, low compressive and bending strength. As an example, the use of organic plastic Organit 11TL in the design of the rotor blade of the Mi-28N can be cited. The sheaths of the tail sections of the blade are made of organic plastic. The 0.45 mm thick sheathing provides the necessary weight and resource characteristics of the blade.

One of the main advantages of polymer composites is their high strength and rigidity with low weight. This reduces the overall weight of the helicopter, improving the performance and the efficiency. In addition, polymer composites are highly resistant to corrosion, which increases the service life of the helicopter and reduces the need for regular maintenance. A lighter helicopter consumes less fuel, has a larger payload and flight range. Furthermore, the use of polymer composites can also reduce wear and increase the life of the helicopter due to its resistance to corrosion and fatigue of the material.

Another important advantage of polymer composites is their ability to be easily molded into various shapes and configurations, which makes it possible to create more efficient and aerodynamic helicopter parts. It also simplifies the manufacturing and assembly process, which can reduce overall production costs. Various technologies and methods are used to create effective aerodynamic helicopter parts from polymer composites. One of them is autoclave molding, in which the composite material is placed in a special autoclave: the polymerization process takes place under pressure and high temperature, as a result of which the material takes the necessary shape. The method of vacuum infusion is also widely used, in which the composite material is located inside a vacuum bag, through which the resin is then passed. This allows you to evenly distribute the rubber over the entire surface and avoid possible voids and inclusions in the material. In addition, composite lamination methods are used to create complex shapes and configurations of helicopter parts, in which layers of composite material are glued together using special adhesives or resins. The use of these technologies makes it possible to create light-

weight, durable and aerodynamically efficient helicopter parts, which contributes to improving its performance and efficiency. In addition, polymer composites have good thermal insulation and sound absorption, which can improve comfort and safety for passengers and crew members.

Let's analyze an example of the use of polymer composite materials in the design of a helicopter. The transmission shaft is designed to transfer the rotational force of the engine directly or by means of a gearbox to the drive axles. In the manufacture of drive shafts, metal alloys are used, which leads to problems with weight efficiency and the possibility of low-frequency transverse resonance. In this case, frequency fluctuations of the drive shaft may occur in the range of maximum engine speed and its destruction due to the low frequency of lateral directional resonance. It is possible to use shortened shafts connected to each other in a single transmission shaft.

To solve this problem inherent in conventional metal shafts, composite drive shafts made of fiber-reinforced composite material are used. Such shafts have higher specific stiffness, specific strength, resonant frequency and the ability to dampen helicopter vibration [3].

The technology used for the production of shafts made of composite materials should ensure the manufacture of a structure of complex geometric shape, with maximum realization of the elastic-strength and operational properties of materials. Composite products made by contact or vacuum molding methods did not meet strict requirements for the strength and weight of aircraft parts, which contributed to the beginning of the development of new molding methods [4].

The production of transmission shafts made of polymer composite materials is carried out mainly using the following technologies:

– laying out of prepreg products with subsequent molding;

– winding of the reinforcing filler on the mandrel with subsequent curing in the furnace;

– pressure impregnation of dry reinforcing fillers (in the form of fibers, bundles, tapes, unidirectional and equally strong fabrics) in a rigid mold using low-viscosity binders (Resin Transfer Molding – RTM).

In general, the use of polymer composite materials in helicopter construction is a promising direction that can lead to the creation of more modern, efficient and safe helicopters. The development of new technologies and materials in this area will contribute to the further improvement of helicopter technology and its capabilities.

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