РАЗДЕЛ XI. ХИМИЧЕСКАЯ ТЕХНОЛОГИЯ

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Disposal of waste products from fibrous composite material

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Abstract

The article proposes a method of processing fiberglass to obtain a fibrous component used as reinforcing filler for the manufacture of secondary composite materials. The obtained analytical dependencies can be used to develop the design of the mill elements, as well as to optimize the grinding process. When disposing of products made of fibrous composite material, the following scheme is proposed. The proposed analytical method for determining the modes of the grinding process solves the problem of choosing the preferred parameters of the mill operation depending on its functional dimensions and properties of components in a fibrous secondary composite material.

Keywords: fiber, polymer matrix, composite materials, product recycling, adhesion.

Аннотация

В статье предложен способ переработки стеклопластиков для получения волокнистой составляющей, применяемой в качестве армирующего наполнителя для изготовления вторичных композиционных материалов. При утилизации изделий из волокнистого композиционного материала предложена схема. Предлагаемый аналитический способ определения режимов процесса измельчения решает задачу выбора предпочтительных параметров работы мельницы в зависимости от ее функциональных размеров и свойств компонентов в волокнистом вторичном композиционном материале.

Ключевые слова: волокно, полимерная матрица, композиционные материалы, утилизация изделий, адгезия.

The development of modern technology requires new structural materials that surpass traditional ones in their strength, elastic and other properties. Among the most interesting and promising are polymer materials (plastics, elastomers, fibers), and first of all filled. Structural polymer materials are increasingly used in modern mechanical engineering, and they are used in cases where no other material meets the increasingly increasing requirements of new technology.

The main technological method for obtaining polymer composites for a long time was the mechanical mixing of the filler and the polymer matrix. Polymerization filling – chemical grafting of a catalyst or initiator to the surface of the filler and subsequent polymerization or copolymerization of monomers on these surfaces – may open a new page in the chemistry and technology of composites. The development of the technology of composite polymer materials is currently determined by scientific research in the field of polymer materials science, since the problem of the interaction of fillers and matrices is very multifaceted [1].

Fiberglass is one of the most widely used composite materials, which is due to their high properties and relatively low cost.

Glass fibers of various types are used for the production of fiberglass. The basis of the glasses is SiO₂ silica. The melting point of silicon dioxide is very high, to reduce it, various additives can be introduced into the glass, while changing the properties of the final product.

Glass is an amorphous material that does not have a crystalline structure. The wide prevalence of glass fibers determines their range of advantages:

- relatively low fiber density of $2.4-2.6 \cdot 10^3 \text{ kg/m}^3$;
- a high level of strength under the action of tensile stresses, the specific strength (the ratio of the ultimate strength to the density) of fiberglass is higher than steel wire;
- good electrical insulation properties;
- the fibers do not burn and do not support combustion;
- possibility of operation at elevated temperatures;
- low coefficient of linear thermal expansion and high coefficient of thermal conductivity;
- chemical resistance, resistance to fungi, bacteria and insects;
- increased moisture resistance, preservation of high strength properties in environments with high humidity.

Fibrous composite materials based on glass fibers and a polymer matrix have high strength, resistance to high temperatures, chemicals, water and atmospheric factors, so they are widely used in the manufacture of vehicles, building structures and other structural products. But these same properties, which are positive for the operation of products, make it difficult to process production waste and dispose of products that have expired. In connection with the expanding volumes of production and use of products from fibrous composite materials and simultaneously increasing environmental requirements, the problem of disposal is becoming increasingly important [2,3].

For economic and environmental reasons, the most attractive technologies for recycling composite materials, providing reuse of components. First of all, high-strength reinforcing fibers are of interest as a filler of thermoplastic polymers for the production of secondary composite materials. These materials are suitable for the manufacture of structural products by one of the known methods - injection molding, pressing, extrusion, etc.

The aim of the study is to increase the strength of the secondary composite material resulting from the disposal of products by optimizing grinding processes and obtaining a high proportion of fibers with a length greater than effective in the crushed product [4,5].

When disposing of products from a fibrous composite material, the following scheme was proposed: the product to be utilized is cut into pieces (dimensions depend on the mill performance, but not more than 100 mm), then they are processed in a centrifugal impact mill with reflectors; the fibrous fraction isolated from the crushed product is combined with the crushed waste of thermoplastic polymers, in particular polyethylene, polypropylene, polyamide, polyethylene terephthalate or mixtures thereof; an article is formed from the plasticized composition obtained in the extruder (secondary composite material).

Contact-formed fiberglass wastes were previously divided into pieces with dimensions of 20–30 mm.

Grinding pieces of fiberglass was carried out in a centrifugal mill with a rotor diameter of 450 mm ($R = 225 \text{ mm}$). The length of the accelerating blades was 150 mm; the length of the reflectors was 100 mm.

Table 1

Indicators of the structure and strength of the secondary composite material

Indicator	Rotor rotation frequency, min^{-1}						
	750	1200	1600	1800	2000	2400	2850
Proportion of fibers whose length is more than effective, wt. %	12,5	34,5	46,5	51,5	48,5	38,5	16,5
Bending stress at failure, MPa	23,5	35,5	41,5	44,5	40,5	38,5	27,5

For experimental testing of grinding regimes, the rotor speed was set at six points in the specified range and, in particular, equal to the average value. Grinding pieces of fiberglass of one batch was carried out for each of the accepted frequency values. The product obtained at the outlet of the mill was dispersed on laboratory sieves, separating the fibrous fractions. Weighing the fractions, we determined the mass of fibers, the average length of which exceeds the above effective length (4 mm).

As follows from the results of the experiment, is the fraction of fibers having a length greater than effective in the crushed product that substantially depends on the rotor speed of the mill, while its maximum value is characteristic in the previously calculated frequency range taking into account the properties of the components.

Data on the proportion of the selected fibrous fraction and the secondary composite material obtained on its basis are given in the table. The table shows that the secondary fiber composition obtained by the proposed method contains the largest (among the investigated options) the proportion of fibers (51,5 wt.%), The length of which exceeds the effective one, and its flexural strength is also the largest (45,5 MPa).

The proposed analytical method for determining the modes of the grinding process solves the problem of choosing the preferred parameters of the mill, depending on its functional dimensions and properties of the components in the fibrous secondary composite material. Theoretically substantiated and experimentally confirmed the dependence of the length of the fibers in the crushed product from the impact energy. Preserving the length of the fibers in the crushed mass makes it possible to double the strength characteristics of the secondary composite material. The obtained analytical dependences of the rotor speed on the properties of the components of the primary composite material and the geometry of the mill make it possible to abandon labor-intensive experimental studies on the refinement of grinding regimes.

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