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CLASSIFICATION OF POLYMER COMPOSITES

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Abstract
This article discusses the advantages of polymer composite materials, classifies them, describes the properties and examples of the use of materials in various applications. Composites penetrate our everyday life, are used in construction, medicine, oil and gas industry, transport, sports, aerospace. Advantages of heterogeneous polymer compositions compared to homogeneous polymers. The modern era can be called the age of polymers and composite materials.

Keywords: Composite materials, matrix, component, continuous phases, dispersed phase, stiffness, strength, heat resistance, gas and vapor permeability, thermoplastic matrix, thermosetting matrix, anisotropy.

Introduction

Composite materials have played an important role throughout human history, from the construction of housing for early civilizations to the creation of innovations in the future. Composites have many advantages, the main ones being corrosion resistance, structural flexibility, durability, light weight, and strength.

Composite materials are materials obtained from two or more components and consisting of two or more phases. One component (matrix) forms a continuous phase, the other is a filler. Composite materials are heterogeneous systems and can be divided into three main classes:

1. Matrix systems consisting of a continuous phase (matrix) and a dispersed phase (discrete particles).
2. Compositions with fibrous fillers.
3. Compositions that have an interpenetrating structure of two or more continuous phases.

Advantages of heterogeneous polymer compositions compared to homogeneous polymers:

1. Increased rigidity, strength, dimensional stability.
2. Increased breaking work and impact strength.
3. Increased heat resistance.
4. Reduced gas and vapor permeability.
5. Adjustable electrical properties.

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6. Reduced cost.

It is impossible to achieve a combination of all these properties in one composition. In addition, the achievement of advantages is often accompanied by the appearance of undesirable properties (impediment of flow, consequently, molding, deterioration of some physical and mechanical properties).

A wide variation in the properties of the compositions can only be achieved by changing the morphology and strength of adhesion between the phases. In order to evenly transfer the external effect through the matrix and distribute it to all particles of the filler, it is necessary to have a strong adhesion at the matrix-filler interface, which is achieved through adsorption or chemical interaction.

The existence of such an adhesion between mismatched components in heterogeneous plastics distinguishes them from mechanical mixtures. The matrix can be metal, ceramic, carbon. The filler is presented in the form of particles and fibers that have significantly higher physical and mechanical properties than the matrix. The particles are commonly referred to as dispersed fillers, and they are indefinite, cubic, spherical, or scaly in shape, ranging in size from fractions of a millimeter to micron and nanoscale sizes. An inert filler practically does not change the properties of the composition. Active filler significantly changes the properties of the composition. For example, fibers have elastic strength characteristics that are two orders of magnitude higher than the properties of the matrix. They can be continuous and short. The diameter of thin fibers is 5-15 μm, thick fibers (boron or silicon carbide) are 60-100 μm, the length of short fibers is from 1-2 to 20-50 mm.

The orientation of the fibers determines the transition from filled plastics to reinforced plastics. It is a system of oriented fibers held together by a polymer matrix. Plastics include materials that are an indispensable component of any polymer, which is in a plastic or viscous fluid state during the molding of products, and in a glassy or crystalline state during operation. Plastics can be homogeneous or heterogeneous. Plastics are divided into thermoplastics and thermosets.

Classification of composites:

1. By nature, matrices can be thermoset, thermoplastic, and hybrid.

Thermosetting matrix is a matrix obtained by curing epoxy, ether, imide, organosilicon and other oligomers in the process of making composites. Thermoplastic matrix is a matrix that is melted to impregnate the filler and then cooled. These are PE, PP, polyarylenesulfones, sulfides, ketones. The hybrid matrix can combine thermoset and thermoplastic components

2. By the nature and shape of the filler.

Organic and inorganic substances of natural or artificial origin. The modulus of elasticity of the filler can be lower or higher than the modulus of elasticity of the binder. Low-modulus fillers, which are usually used as elastomers, without reducing the heat resistance and hardness of the polymer, give the material increased resistance to alternating and impact loads, but increase its coefficient of thermal expansion and reduce deformation resistance. The higher the modulus of elasticity of the filler and the degree of filling, the greater the deformation resistance of the material.

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Disperse-filled composites are materials based on short and continuous fibers. The chemical nature of the particles is diverse: chalk, mica, metal oxides, glass spheres, carbon in the form of soot or fullerenes, aerosils, glass or clay flakes, rubber-like inclusions, etc.
3. By the structure of polymer composites.
Matrix structure – for materials based on dispersed and short fibrous particles, laminated (two-dimensional) and bulk for reinforced plastics based on woven and nonwoven fabrics. Gradient materials with variable structure.
4. By the degree of orientation of the filler, anisotropy of the material:
– composites with a chaotic arrangement of particles and fibers, with an isotropic structure;
– composites with unidirectional fiber orientation, with pronounced anisotropy;
– composites with cross, orthotropic orientation (0°, 90°), with a given anisotropy;
– composites with oblique fiber orientation at angles other than 90;
– Composites with a fan structure consisting of layers with different fiber orientations.
5. By methods of manufacturing materials and products:
One-stage methods are extrusion and wet winding, pultrusion (broaching), vacuum forming, two-stage methods of preliminary production of bind-impregnated non-oriented (premixes) or oriented (prepreg) fibrous materials (semi-finished products) with subsequent molding of the material (laminate) by "dry" winding, pressing, autoclave molding.
6. By the number of components:
Two-component, three-component PCMs combining dispersed particles and short fibers, polyfiber hybrid PCMs combining fibers with similar (fiberglass) or significantly different (fiberglass) deformability, polymatrix structures, for example, based on a combination of thermosetting and thermoplastic binders.
7. By the volume of filler content:
With an unoriented structure – 30-40% filler content, with an oriented structure – 50-75%, highly and extremely filled organofibers – 75-95%.
8. By functionality:
One functional (structural), multifunctional, capable of self-diagnosis (smart), multifunctional, capable of self-diagnosis and self-adaptation (intellectual).
Currently, the composite industry continues to develop, with much of the growth now centered around renewable energy. Wind turbine blades, in particular, are constantly pushing the boundaries of size and require advanced composite materials. For example, engineers can design a composite with performance requirements in mind, making the composite sheet very strong in one direction by aligning the fibers, but weaker in the other direction where strength is not as important. Engineers can also choose properties such as resistance to heat, chemicals, and weathering by selecting the appropriate matrix material. In recent years, growing environmental awareness and awareness of the need for sustainable development have increased interest in the use of natural fibers as reinforcing elements in composites instead of synthetic fibers.

Composites have many advantages such as corrosion resistance, light weight, strength, reduced material cost, increased productivity, design flexibility, and durability. Therefore, composite materials and some of their common applications are used in a wide variety of industries.

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