

POLYMERIC COMPOSITES OF CONSTRUCTIONAL APPLICATION BASED ON THERMOSETTING MATRIX AND CHEMICAL FIBERS

ПОЛИМЕРНЫЕ КОМПОЗИЦИОННЫЕ МАТЕРИАЛЫ КОНСТРУКЦИОННОГО НАЗНАЧЕНИЯ НА ОСНОВЕ ТЕРМОРЕАКТИВНОЙ МАТРИЦЫ И ХИМИЧЕСКИХ ВОЛОКОН

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Abstract. The polymeric composites on the basis of a thermosetting matrix, chaotically reinforced chemical fibers with a broad band and high level of operating performances have been developed. The optimum geometrical parameters of a fibrous filler, degree of filling of a matrix at a different dispersibility of a filler ensuring high technological effectiveness and degree of strengthening have been defined. The thermodynamic conditions of obtaining strong adhesive connection of a matrix with a filler have been explored during receiving polymeric composites.

KEY WORDS: POLYMERS, AROMATIC POLYAMIDES, ORGANIC PLASTICS, THERMOSETTING, PRESSCOMPOSITION, ANALYSIS.

1. INTRODUCTION

One of the most perspective types of polymeric composites (PC), firmly considered as constructional materials, are PC, reinforced by chemical fibers [1-3]. A central problem originating at making such materials and articles from them, is the maximal embodying properties of initial components in multicomponent system. Strength properties PC, reinforced by fibers, the technological effectiveness of their processing depends on components relationship, strength and elasticity of a fiber (i.e. on its chemical nature and structure), strength, processing behavior of polymeric bond, interphase interaction including different processes, occurring on an interface, the structure and properties of boundary layers depends on. Also technological parameters exerting influence on properties of each of components, on processes occurring on a interface of phases, on magnitude of stresses originating in a polymeric matrix, on presence of defects of a boundary layer and all film bond [4, 5] are not less important.

The purpose of work was making PC of constructional assignment with a complex of high operating performances, study of regularities of forming of plastics properties on the basis of a thermosetting matrix (epoxy, phenolformaldehyde and their modifications).

2. THE DISCUSSION OF INVESTIGATION RESULTS

Thickness of a bond film in PC, therefore and its properties depend on the content of a filler, and its sizes [6, 7]. The share (mass, volumetric) of filler must be maximal for receiving a high-strength composite, but at the same time share of bond must be sufficient to moisten and imbue fibers, ensure continuity of a polymeric matrix, technological solidity of a material as a whole. With the purpose of definition of an optimum composition of a composite the content of a fibrous filler varied from 0 up to 80 mass % at different lengths of a fiber (from 3 up to 30 mm). The investigations have shown, that the dependence of physico-mechanical properties of organoplastics on the content of a fiber has extreme

When investigating geometrical parameters influence of a filler on properties of plastics length of a fiber varied ranging from 1 up to 100 mm, diameter - from 10 up to 28 micrometers, fibrillation of a complex filament - from 1 up to 400, twist of a complex filament - from 0 up to 200 twisting / m. The analysis of strength characteristics of plastics has shown, that their stability to shock, bending loads at lengths of fibers less than 2-4 mm does not exceed values, typical for unfilled polymers. With elongation of a fiber up to 20-25 mm the sharp growth of the indicated performances and thermostabilities of plastics is observed. The highest indexes of strength at compression were registered for plastics with length of fibers less than 10 mm ($\sigma_c=190-200$ MPa). These plastics differ by the greater

homogeneity, heightened resistance to shear stress. With growth of length of fibers up to 20-25 mm σ_c is noticeably reduced.

The table

Influence of filling degree on anisotropy of chaotically reinforced organoplastics properties

Length of a fiber, mm	Coefficient of anisotropy at degree of filling, mass % $Ka = \sigma_{c } / \sigma_{c\perp}$					
	0	5	20	40	60	80
3	1	1/1	1,01/1	1,13/1,08	1,2/1,37	1,22/1,44
10	1	1/1,01	1,04/1,05	1,12/1,11	1,17/1,27	1,18/1,32
30	1	1,03/1,08	1,07/1,13	1,1/1,2	1,11/1,24	1,12/1,25

The notice: In numerator data for organoplastics on the basis of aramide fibers phenylon, in denominator - terlon.

The increasing of fibers length more than 40 mm practically does not influence strength properties of plastics. It is necessary to mark, that at the length of reinforcing fibers more than 70 mm separating of a composite at destruction at the expense of shearing stresses is observed.

The technological properties of prepregs with growth of fibers length is aggravated. The rheological investigations have shown, that the viscosity of fiber reinforced plastics with heightening of a degree anisodiametricity (1/d) of a filler grows, thus the fluidity of a press-material drops, that is connected with increasing the overlapping fibers area (fig. 3). character with a maximum in the field of 55-70 mass % of a fiber (fig. 1). The magnitude of an optimum amount of a filler is determined also by its length: with increasing length of a fiber the maximum of strength characteristics is shifted in the field of higher concentrations.

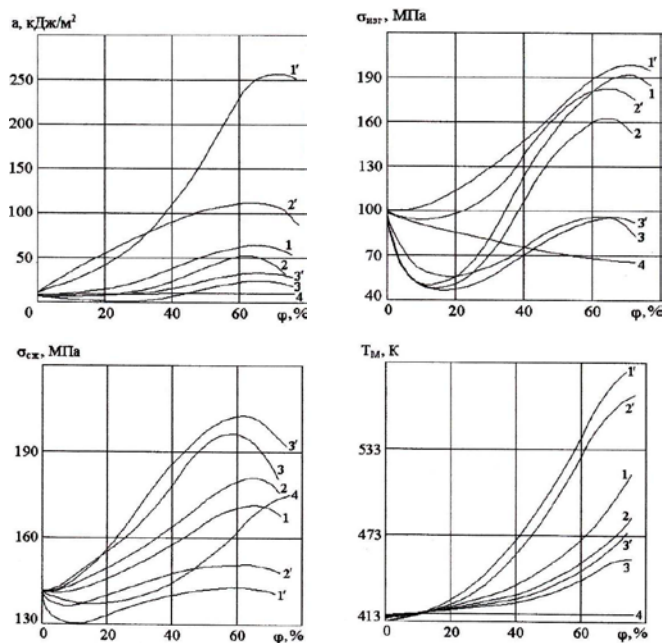


Fig. 1. Dependence of impact strength (a); breaking stress under bending (0); compression (a_c) and thermostability on the Martens (T_M) of epoxyorganoplastics on the basis of phenylon (1-4) and terlon (1-3) on degree of filling (q) at length of a fiber: 1, 1'—30 mm; 2, 2'—10 mm; 3, 3'—3 mm; 4—finely dispersed powder

The presence of porous carbon fibers leads to some growth of water absorption. However, the surface of fibers is screened by a film of polymeric bond and the velocity of magnification increasing water absorption with increasing of density of carbon filaments in an composite is rather small. Further increasing fibers in an composite more than 70 % leads to deficiency of bond for formation of a continuous flawless film of a polymer on a fiber, aggravation of fluidity of a press-material, violation of specimen solidity, to what the sharp growth of water absorption of carbon plastics, lowering of strength characteristics, both carbon, and organoplastics testifies, in particular.

At increasing the content polymeric bond in a composite more than 50 mass % lowering strength of a material is observed at the expense of diminution of an amount of reinforcing fibers, basically carrying the load. An interlayer of a polymeric matrix between fibers is becoming thick, that leads to growth of shrinkage stresses and amount of microfissure, the homogeneity of a material is broken, the presence of defects is boosted, the strength of a plastic is reduced. At the content of fibers lower than 20-40% there is no reinforcing skeleton, that has a negative effect on strengthening (fig. 2).

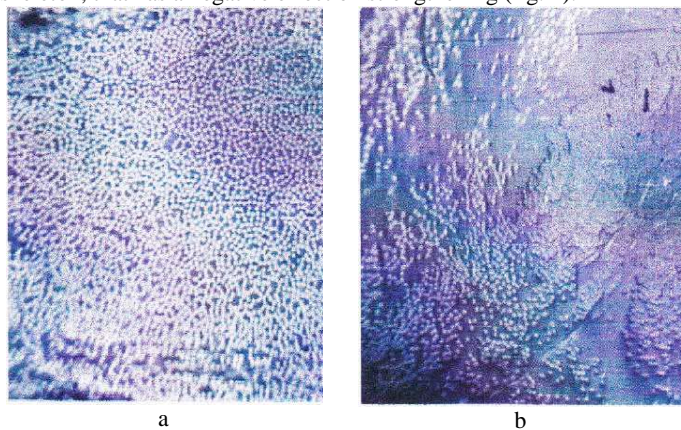


Fig. 2. Microphotographs of plastic microsections at degree of filling 20 (a) and 70 mass % (b,c). Magnification: x40 (a,b); x400 (c)

The analysis of strength characteristics, diagram of compression, thermomechanical of curves has shown, that the higher module of elasticity and length of a fiber, the lower concentrations provide reinforcing effect.

The introduction of a finely dispersed filler (powder phenylon) practically does not influence strength characteristics of a composite. The exception makes resistance of a plastic to compression loads: at the content of filler more than 30 % the ultimate compressive strength of a material increases with growth of finely dispersed phenylon concentration noticeably.

The anisotropy of strength properties of plastics with increasing filling degree grows the more appreciably, the less the length and higher the module of a fiber (table). In the field of the low content of a filler, owing to high fluidity of a material, fractional orientation of fibers in a matrix at a compression molding of specimens, the plastics with reinforcing filler of greater length are more anisotropic.

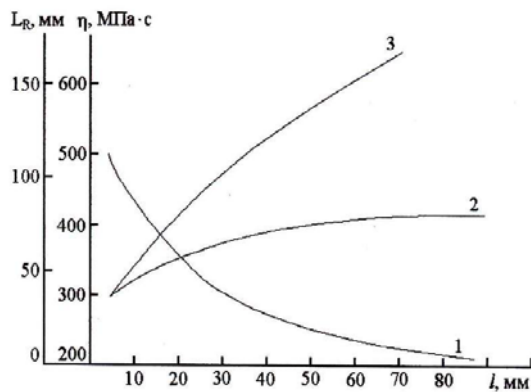
Coefficient of plastics anisotropy filled with powder phenylon, within investigated concentrations of a filler remained equal to zero.

Therefore, with the purpose of receiving high-fined (60-70 mass %) composites on the basis of thermosetting plastics with the chaotic scheme of a reinforcing, with a high level of strength characteristics, isotropy at remaining technological effectiveness of prepregs processing length of a fibrous filler of 10-25 mm, should be considered optimum.

Fig. 3. Dependence of technology characteristics of organoplastics: 1 - fluidity on Raschig (LR); 2, 3 - viscosities, from length of a reinforcing component: 2 - fiber; 3 - complex filament

At diminution of a fiber diameter its strength increases a little (for example, aramide fiber phenylon with d = 10 micrometers 43,3 sm/tex), its surface properties are improved [8], the degree of anisodiametricity of a reinforcing component is augmented, owing to that the thickness of a bond film between fibers is diminished, that boosts effect of reinforcing and leads to increasing of an impact strength, strength at compression. The breaking stress under bending is augmented with increasing diameter of a fiber owing to increasing of resistance to bending loads of fibers themselves.

It is stated, that at transition from a reinforcing by the elementary fiber to a reinforcing by a complex filament sharp heightening of an impact strength, strength under bending (on 50-55 %), thermostability of a plastic is observed. The increasing of the amount of elementary filaments (fibration) in a complex filament up to 300 at rather high magnitude of twist (98-115 twisting / m) leads to growth of values of these performances. At further increasing of fibration, as well as at increasing of twist more than 120125 twisting / m (at a stationary value of fibration), causing also some lowering of strength of the filament, the penetration of bond inside a filament is made difficult, the number of contacts of elementary fibers is augmented, the quality of impregnation is aggravated, the continuity of a bond film is broken and, eventually, the strength of a plastic is reduced. Compressing strength of plastics, reinforced by elementary fibers at the expense of greater homogeneity of a material, its solidity is highest (210-220 MPa). At increasing fibration of a complex filament σ_{сж} is reduced.



Plastometric tests have shown, that at increasing the geometrical sizes of a filler the viscosity of a press-material is increased. So, press-material on the basis of finely dispersed powder phenylon (the grade C-1) has viscosity 176 MPa·с, on the basis of a staple fiber ($l = 10$ mm) - from 266 up to 352 MPa (changing of diameter of a fiber from 10 up to 28 micrometers), on the basis of a discrete complexfilament of the same length - from 448 up to 506 MPa (at increasing fibratioin of a filament from 50 up to 300). At the same time, the transition from a reinforcing by a powder, elementary fiber to a reinforcing by a complex filament causes increasing of plastic-viscous (yielding) state of a presscomposition from 7-8,5 minutes up to 12-12,5 minutes, that creates sufficient conditions for bond spreading on the surface of a fibrous filler, ensures technological solidity, homogeneity of specimens, both at reinforcing by a fiber, and complex filament.

The possibility of using waste of aramide fibers obtained at different stages of technological process as a fibrous filler has been investigated. It is stated, that use of thermopulled waste of a complex filament and staple fiber phenylon as a reinforcing component has allowed to receive composites, which, due to a complex of properties (the ultimate compressive strengths are equal to 170-230 MPa, bending - 130200 MPa, an impact strength - 40-60 kJ/m², thermostability on the Martens 423-473 K, friction coefficient at the presence of water - 0,13-0,18), wear-, water-, chemical-stability have found application as constructional bearing materials.

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