POLYMERIC COMPOSITE MATERIALS REINFORCED WITH ARAMIDE FABRICS

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In spite of the fact that during recent decades the number of researches devoted to investigating the properties of aramide yarns from domestic manufacturing has risen considerably as well as that of reinforcing materials, organic plastics, and organic reinforced textiles based on them, the expansion in the regions of application of such polymeric composite materials (PCM) has been limited by the lack of their industrial production. This is explained by the high cost of the reinforcing materials and also by difficulties in the mechanical processing of semifinished articles and plastics in making articles from them.

In the present article, we describe the results of a study performed with the objective of obtaining noncombustible PCM for construction purposes which retain high physico-mechanical properties at service temperatures up to 470 K. Such materials are cheaper than the thin-sheet organotextolites which are put out by industry [1].

We selected binders of two classes to prepare incombustible organotextolites at assigned operating temperatures: epoxies and polyimides. To prepare the epoxy binder, we used chlorine-containing epoxy resin plus a hardener. As the polyimide binder, we used a polyimide based on a bis-maleimide, which hardens by a polymerization mechanism; this made it possible to considerably lower the pressing temperature of the preparation (approximately 180°C) and to avoid the formation of hollows in the polymeric material as a result of volatile products evolved in the hardening of polyimides of the condensation type.

We used fabrics of SVM aramide fibres and terlon as the reinforcing fillers in making the PCM. The terlon fabric was prepared by a satin weave from terlon fibre having a linear density of 58.8 tex and a breaking tension of 4500 N along the warp. Based on the SVM aramide fibres, a new reinforcing material was developed, type OTA-S [2] (unidirectional aramide — SVM fabric), which consisted of aramide tow of 1000 tex linear density along the warp [3] and of 58.8 tex SVM complex yarn along the fill. The use of tow made it possible to reduce the cost of the reinforcing material and to increase the productivity of labor in assembling packages for pressing by a significant increase in the thickness in the reinforcing material. Production of OTA-S reinforcing fabric was worked out in the experimental works of the LenNII "Khimvolokno." It was found that to prepare OTA-S reinforcing fabric it was possible to use either a spun or twisted tow; however, the latter should be subjected to additional twisting on a twisting machine.

The use of fabrics made of SVM tows as the reinforcing filler makes it possible to considerably reduce the cost of the resin-filled fabric. A tentative calculation of the cost of an epoxy organoplasic reinforced with OTA-S fabric has shown that in the preparation of this material under experimental manufacturing conditions, its cost is 140 rubles/kg, which is considerably less than the cost of organotextolites produced by industry from thin aramide fabrics [1].


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Specimens of the organotextolites were made up on standard equipment by the method of hot-pressing packages from prepreg layers prepared by impregnating the reinforcing fabric with an acetone solution of the epoxy binder or an acetone-furfural solution of the polyimide binder. The binder content of the PCM specimens was 30-35% by wt.

Physico-mechanical properties of the PCM specimens were determined by standard methods by the appropriate All-Union State Standard. The combustibility of the materials was evaluated from their oxygen index (OI) and the combustibility coefficient ($K$) as measured by the calorimetric method. The thermal resistance of the starting components and of the organoplastics was investigated by a nonisothermal (thermogravimetric) method on a derivatograph of the Paulik—Paulik—Erdei system, and also by an isothermal method from the weight loss and strength in bending after thermostating specimens for 1000 h at temperatures of 423-473 K.

The studies performed made it possible to conclude that there is a considerable effect of the ratio of the linear densities of the fabric along the warp ($\Pi_0$) and along the fill ($\Pi_u$) (Figs. 1 and 2) on the physico-mechanical properties of the organotextolites (Table 1).

In Figs. 1 and 2, it is evident that to attain the highest physico-mechanical organotextolite properties, one should select optimum ratios between the densities of the reinforcing fabric type OTA-S along the warp and along the fill.

Analysis of the data in Table 1 allows one to draw the following conclusions:
- the use of a unidirectional fabric of SVM tow as the reinforcing filler ensures higher physico-mechanical properties of the PCM as compared with high-strength fabric from terlon fibres (see specimens 1, 2, 6, and 3, 4);
- the physico-mechanical properties of organotextolites reinforced with OTA-S fabric in specimens with a parallel disposition of the prepreg layers along the warp direction (specimen 1) prove to be significantly higher than that for specimens with an alternating (at an angle of 0.90° disposition of the prepreg layers (specimen 2);
- the epoxy organotextolites are characterized by higher strength characteristics as compared with those from polyimides (see specimens 2, 3 and 5, 6);
- in specific strength properties (figures refer to the density of the material), the organotextolites which have been reinforced with fabric from SVM tows considerably excel the fiberglass plastic structures.