The strength of the composites containing silica gel can be increased by the introduction of slag (Table 2). Also in this case, the optimal composition was obtained at high filling ($\varphi_{b} = 0.173; \varphi_{cr} = 0.351; \varphi_{sl} = 0.476$). The studies on stress relaxation in composites with silica gel showed that the two fillers exhibit a partially independent effect on the binder: when a slag is added, the rate of the relaxation processes decreases more than expected when an inert filler is added to a KF-Zh—silica gel matrix.

LITERATURE CITED


EFFECT OF STRUCTURAL AND PROCESSING PARAMETERS OF THE REINFORCEMENT ON THE STRENGTH OF UNIDIRECTIONAL METAL-FIBER COMPOSITES UNDER DIFFERENT TYPES OF LOADING*

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The strength of structures made of fiber composites (FCP) with a unidirectional structure loaded across as well as along the fibers (such as in the case of pressure vessels) depends to a large extent on the strength of the bond between the fiber and matrix, its properties, and the structural parameters of the reinforcement. Proper allowance for these factors in calculating and making FCP's for such structures makes it possible to more fully utilize the strength of the reinforcing fibers.

Among the factors mentioned above, the strength of the bond between the fiber and the matrix is a parameter which depends mostly on the chosen method of manufacture of the FCP, i.e., the processing parameter of the reinforcement. The volume content of the reinforcement in the matrix and the internal geometry of the reinforcement (determined for unidirectional multilaminate FCP's with a rectangular structure by the ratio of the fiber spacing in the plane of the reinforcement layer to the spacing in the direction normal to the layer) are structural parameters of the reinforcement.

The method of impulsive loading [1-5] is now often used to make metallic FCP's and products made of these composites. One of the characteristic features of this method is the possibility of regulating the strength of the fiber-matrix bond in a fairly broad range of values [3].

Here we examine results of an experimental and analytical study of the strength of impulsively loaded unidirectional FCP's based on aluminum alloy Amg6 and steel fibers. The specimens were tested in uniaxial tension along and across the fibers. We also subjected the tubular specimens of the FCP's to biaxial tension by internal pressure. We varied the volume content of fibers in the matrix $V_f$, the internal geometry of the reinforcement as defined by the parameter $t_2/t_1$, and the technical cohesive strength $\sigma_{m-f}$ of the fiber-

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matrix bond. We also examined mechanisms of failure of unidirectional FCP’s having different fiber–matrix bond strengths.

The FCP’s investigated, in the form of plates and annularly-reinforced tubes, were made by winding and impulsive loading by the method in [3, 5]. The specimens consisted of seven layers of aluminum alloy Amg6 reinforced with six layers of steel wire 0.3 mm in diameter and having a strength $\sigma_m = 3.5$ GPa. All of the specimens were 5 mm thick. The internal structure of the reinforcement in the FCP was close to rectangular (Fig. 1). The value of $Vf$ was regulated by changing the spacing of the reinforcement winding and the thickness of the welded layers of the matrix. The quantity $Vf$ was evaluated from the formula [6]

$$Vf = \frac{N \pi d^2}{N+1} \frac{t_2}{4t_1},$$

where $t_2 = \delta_0 + \pi d^2/(4t_1)$. Here, $N$ is the number of layers of reinforcement; $d$ is the diameter of the fibers; $t_1$ and $t_2$ are the spacing of the reinforcement in the plane of the reinforcement layer and perpendicular to this layer; $\delta_0$ is the initial thickness of the matrix layer. All of the experimental studies of the dependence of the strength of an FCP on $Vf$ were conducted on specimens having a square lay of the reinforcement ($t_1 = t_2$). The effect of the internal geometry of the reinforcement on strength was studied on specimens with a constant value of $Vf$ and a variable ratio $t_2/t_1$.

The value of $\sigma_{m-f}$ in the FCP specimens was changed by varying the process parameters during impulsive loading [3], and its value was determined a method similar to [4] from the results of tests of flat FCP specimens in tension. These specimens were cut in two mutually perpendicular directions $y$ and $z$ orthogonal to the reinforcement direction $x$ (Fig. 2). The value of $\sigma_{m-f}$ was calculated from the formula*

$$\sigma_{m-f} = \frac{1}{2}(\sigma_{m-y} + \sigma_{m-z}),$$

where

$$\sigma_{m-y} = \frac{t_1}{d}[\sigma_0/k - \sigma_m (1-d/t_1)]; \quad \sigma_{m-z} = \frac{t_2}{d}[\sigma_0/k - \sigma_m (1-d/t_2)].$$

Here, $\sigma_m$ is the strength of the matrix; $\sigma_y$ and $\sigma_z$ are the stresses corresponding to the beginning of delamination in the FCP when subjected to tension along the $y$ and $z$ directions, these stresses being determined from the stress–strain curves of the specimens; $k$ is a coefficient equal to 0.85–0.9; $d$ is the diameter of the reinforcing fibers. Also, in some cases we used the extraction method to determine the fiber–matrix bond strength in shear $\tau_{m-f}$.

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*We resorted to metallographic analysis to carefully check for the absence of initial defects in the matrix such as voids and microcracks.

†Equation (2) was written for the case when the lay of the reinforcement is close to rectangular. When the lay is square ($t_1 = t_2$), this equation takes the form proposed in [4]:

$$\sigma_{m-f} = \sigma_m - 0.35[2\sigma_m - (\sigma_y + \sigma_z)/k] [\pi/Vf]^{2/3},$$