COMPOSITE MATERIALS

IMPROVING THE STRUCTURE OF TRANSITION DIFFUSION ZONES IN COMPOSITES OF NICHROME + ALLOYED MOLYBDENUM

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The physicochemical interaction of components at interfaces in metallic composites has a great effect on their structural and strength characteristics [1-5]. In existing composite materials with a scale resistant matrix (mainly Ni-Cr alloys) and heat resistant filaments (tungsten, molybdenum, and their alloys) one often observes solution of the filaments at elevated temperatures, the formation of coarse crystallite rims in the reinforcing filament, and intermetallic layers at the matrix-filament interface. These undesirable processes can be slowed down and kept to the minimum in some cases by creating diffusion barriers between the filament and the matrix.

This work concerns the possibility of eliminating these undesirable processes in composites of the Nichrome—molybdenum alloy type by adding a powdered mixture.

The matrix, prepared by welding [6], was a sheet 0.5 mm thick of scale resistant alloy KhN78T (É1435) reinforced with unidirectional filaments (diameter 500 μ) of experimental molybdenum alloy ChZM (0.18% W, 0.071% Ti, 0.11% Zr, and 0.054% C) or the complex molybdenum alloy VMZP. The powdered

Fig. 1. Microstructure of transition zone in composite materials annealed at 1100°C (×500). a) KhN78T—ChZM, annealed 10 h; b) KhN78T—(Cr + W + Mo)—VMZP, annealed 100 h.

Fig. 2. Change in linear parameters of contact zone of KhN78T—ChZM composite in the process of annealing at 1100 (1), 1200 (2), and 1250°C (3). — — Width of intermetallic zone; ---- width of coarse crystalline rim.


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mixture (80% Cr, 13% W, 7% Mo) serving as a barrier layer in zones of contact between the filament and the matrix was added during preparation of the composite between sheets of the matrix and the filament by the method described in [6]. All composites were subjected to diffusional annealing in an electric chamber furnace at 1100, 1200, and 1250°C for 10, 50, and 100h.

The microstructure of the composite materials in the annealed and unannealed conditions was examined in light and electron microscopes (MIM-8M and UEMV-100A).

The distribution of nickel, chromium, and tungsten in the reinforcing filament was investigated by means of a scanning electron microscope (REM-P-2) and by measurements of the microhardness in the PMT-3 apparatus under a load of 50g.

No changes were observed in the microstructure of unannealed composites, the microhardness of the grains being somewhat lower than that of the material as-received (see Table 1). However, the scanning electron microscope revealed a thin intermetallic layer in the matrix-filament transition zone, which was formed during welding of the elements of the composite material.

Annealing of composites to which the powdered mixture was not added induced considerable structural changes in the molybdenum filaments and in the matrix-filament contact zones. In filaments of alloy ChZM annealing at 1100° for 10h led to the formation of coarse crystalline rims and intermetallic layers (Fig. 1a), the microhardness of which was Hs 1050. Holding for 50h led to secondary recrystallization and also to considerable thickening of the intermetallic layer. After holding for 100h at 1100° secondary recrystallization was completed throughout the reinforcing filaments of the experimental alloy (Fig. 2). In the highly alloyed VMZP molybdenum filament the structural changes were similar. Annealing at 1200 and 1250° induced still more rapid growth of intermetallic layers in both types of filaments and considerable acceleration of the secondary recrystallization process (Fig. 2).

Analysis of the structural changes indicates that secondary recrystallization of the molybdenum filament (regardless of the degree of alloying) develops by means of rapid movement of the coarse crystalline zone from the matrix-filament interface into the center of the filament.

Such intensive secondary recrystallization in alloyed molybdenum filaments, leading to a substantial drop in the strength of the composite, is induced by nickel, which diffuses along dislocation pile-ups and