Interface stability in vacuum infiltrated stainless steel and nichrome reinforced aluminium composites

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Reactions at the fibre/matrix interface in the metal matrix composites during service at the elevated temperature degrades the composites and limits the application. One of the factors that influences the reactivity of the interface is the fabrication technique. Vacuum infiltration technique is one of the important and cheaper fabrication routes for metal matrix composites [1].

In the present investigations stainless steel (AISI 304) and nichrome (80 wt % Ni-20 wt % Cr) wires of diameter 152 μm were reinforced in commercially pure aluminium and Al-10 wt % Mg alloy matrix by vacuum infiltration technique. Composites up to 60 vol % fibre were prepared. The composites were exposed to different temperatures (200 to 650°C) for different intervals of time (up to 100 h) and then examined under the

microscope for possible reactions at the metal matrix interface.

Fig. 1 is the typical cross-section of stainless steel fibre reinforced aluminium composite in the as-cast condition. At the fibre/matrix interface no reaction products are observed. The composites exposed to 400°C for 100 h also showed no reaction products (Fig. 2). However, above 450°C interfacial reactions were observed. A typical cross-section of the reactions at the fibre-matrix interface when exposed to 550°C for 24, 50 and 100 h, respectively, are shown in Figs. 3a to c. The reaction products grow at isolated places over the fibre surface. The reaction product covered the entire fibre/matrix interface only when heated at a longer period, e.g. 550°C for 100 h (Fig. 3c) or near the melting point of the matrix (Fig. 4).

Figure 1 Stainless steel-aluminium composite in the as-cast condition.

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Figure 2 Stainless steel–aluminium composite exposed to 400° C for 100 h.

The reactive metals, like magnesium, in the matrix is expected to give better bonding [2, 3]. However stainless steel fibres reacted with the matrix alloy (Al–10 wt % Mg) during the fabrication stage (Fig. 5). The as-cast nichrome–aluminium composites also did not show any interfacial reaction (Fig. 6). Even at 300° C for 100 h of exposure, no interfacial reaction product was observed at the fibre/matrix interface. However at 350° C for 25 h, the reaction product was observed at the interface (Fig. 7a). The reaction product increases with time and completely damages the fibre in about 100 h (Figs. 7b and c). In this system the reaction product grows inwards.

Limited ultimate tensile strength measurements of composites exposed at high temperature and the unexposed composites were made. These experiments showed that the stainless steel–aluminium composites did not lose their strength rapidly when the reaction products formed at the interface. However in nichrome–aluminium system the very appearance of the reaction product at the fibre–matrix interface coincided with the sharp decrease in the ultimate tensile strength (UTS). This is mainly due to the type of the interfacial reaction and the morphology of the reaction product. In the stainless steel–aluminium system the reaction products grow at isolated places [4]

Figure 3 Stainless steel–aluminium composite exposed to 550° C for (a) 24 h, (b) 50 h and (c) 100 h.

Figure 3 Continued.

and the product grows outward, probably by not losing the fibre strength. In the nichrome-aluminium system the entire fibre gets reacted and the reaction product grows inward into the fibre.

These studies show that the vacuum infiltration

technique can be used to prepare the stainless steel and nichrome fibre-reinforced aluminium composites without damaging the fibre/matrix interface. The morphology of the reaction product at the interface significantly affects the strength properties.

Figure 4 Stainless steel-aluminium composite exposed to 650° C for 10 min.

Figure 5 Stainless steel-Al-10 wt % Mg composite in the as-cast condition.

Figure 6 Nichrome-aluminium composite in the as-cast condition.

Figure 7 Nichrome-aluminium composite at 350° C for (a) 25 h, (b) 50 h and (c) 100 h.

Figure 7 Continued.

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