MICROSTRUCTURE AND WEAR RESISTANCE IN HYBRID ALUMINIUM COMPOSITES WITH SiC WHISKER AND CARBON NANOTUBES

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1 Introduction
Incorporation of carbon nanotubes (CNTs) into metals significantly improves the mechanical, physical properties as well as wear resistance of the matrix alloys [1]. In order to make full use of the excellent properties of CNTs, homogeneous dispersion and good bonding between CNTs and metals are necessary. However, CNTs are prone to form aggregation and react with metals such as aluminum [2,3], which makes it difficult to disperse CNTs into metal matrix and control their interface. Here, silicon carbide whisker (SiCw) and CNTs hybrid composite was prepare by pressure infiltration [4] and its mechanical and wear properties were investigated. Addition of SiCw increased the compressive strength of the hybrid preform and thus attributed to the complete infiltration. On the other hand, the high content of CNTs (10 vol%) significantly improves the mechanical and wear resistance of the composite.

2 Experiments
SiCw (diameter 0.1-1 µm) and CNTs (diameter 70-100 nm) were used as reinforcements to fabricate the 2024Al matrix composites. Both reinforcements were purified and dispersed in distilled water, blended with silica binder and compressed into a hybrid preform. The content of SiCw and CNTs in the preform was 10 vol%. Pressure infiltration process of the preform was similar to Ref. [4]. The as-cast composite ingot was hot-extruded at 450°C into a rod with a ratio of 16:1.

SEM, TEM and XRD were used to study the distribution, reaction and interface of CNTs. Tensile test of the composite was carried out at various temperatures of 25, 200 and 350 ºC. Un lubricated wear test was carried out on a pin-on-disk wear test machine.

3 Results and discussion
Fig.1 shows the distribution state of CNTs in the composite. In Fig.1a, fine CNTs distribute homogeneous in the composite and interlock with coarse SiCw. The micro-scale homogeneous distribution state of CNTs is also demonstrated in Fig.1b, in which CNTs and their bundles distributed in the matrix and around SiCw. In addition, there is no reaction between CNTs and Al, showing that formation of Al4C3 was effectively prevented by the rapid solidification after pressure infiltration [4].

Fig.2 shows stress-strain tensile plots of the composites at ambient and high temperatures. When test at 25 ºC, the composite showed low elongation of 0.83 % and high ultimate tensile strength (UTS) of 420.1MPa. The elongation of the composite increased to 5.55 and 7.40% at 200 and 350 ºC, but with decreased UTS of 363.7 and 161.6 MPa.

Fig.3 show friction coefficient and wear rate of the composite tested at 200ºC. As shown in Fig.3a, the friction coefficient of the decrease with increasing applied load. The friction coefficients shift little at loads of 15 and 20N, but contain a transition stage at when the distance is small.

The wear rates (tested at 200ºC) of the composite and its matrix alloy (2024Al) under various loads were plotted in Fig.3b. As expected, the wear rate of the composite is much smaller than that of the matrix alloy, especially at small load end. With increasing load, both wear rates increase, but with different slopes: the slope of the matrix alloy is much larger than that of the composite. This implies that the composite exhibits superior wear resistance over 2024Al matrix alloy, especially under high applied loads.

It is also interesting to find that the addition of CNTs improves the wear resistance of 2024Al even...
compared with SiCw mono-reinforcements. This may be attributed to better plasticity and toughness of the hybrid composite, which resulting in the transition from serious wear to slight wear.

4 Summary

Hybrid 2024Al matrix composite reinforced with SiCw and CNTs (10 vol%) was prepared by pressure infiltration. The coarse SiCw prevents the aggregation of CNTs and thus contributes to the homogeneous dispersion of the latter in the composite. No reaction between CNTs and Al was detected due to the rapid solidification after molten Al infiltration. The composite exhibits the best compensation of strength and elongation at 200 °C. Wear tests carried out at 200 °C demonstrated the superior wear resistance of the composite over 2024Al and composite reinforced only with SiCw. This indicates that CNTs may act effectively as wear reduction agents in metal matrix composite.

Fig.1. (a) SEM and (b) TEM microstructure of 2024Al composites containing homogeneous distributed SiCw and CNTs.

Fig.2. Tensile stress-strain plots of the 2024Al composites carried out at 25, 200 and 350 °C.

Fig.3 Friction coefficient (a) and wear rate (b) of the composite tested at 200°C.

References
