INTERFACES AND CREEP IN MAGNESIUM HYBRID COMPOSITES

Vaclav Sklenicka[1], **Kveta Kucharova**[1], **Milan Svoboda**[1] **and Ivan Saxl**[2]

[1] Institute of Physics of Materials, Academy of Sciences of the Czech Republic, Zizkova 22, CZ-616 62 Brno, Czech Republic

[2] Faculty of Mathematics and Physics, Charles University, Sokolovska 83, CZ-186 75 Prague, Czech Republic

Introduction

Short fibres, whiskers or ceramic particulates reinforced Mg based composites, which are conventionally known as discontinuous magnesium composites, represent a class of advanced materials that exhibit the attractive properties, like high specific strength and stiffness, low density, excellent castability, etc. [1-3].
The creep resistance of magnesium alloys is rather limited at temperatures above 400 K. However, a marked improvement in the creep properties of magnesium monolithic alloys can be potentially achieved through the production of composite materials with matrices consisting of conventional magnesium alloys strengthened by the introduction of non-metallic fibres or particulates (metal matrix composites – MMCs) [4-9]. The present paper concentrates on this approach and presents results of creep experiments on two representative magnesium alloys (AZ91 and QE22) and their various discontinuously reinforced composites in order to compare directly their creep resistance.

Experimental materials and procedures

Materials
All the experimental materials used in the study were fabricated at the Department of Materials Engineering and Technology, Technical University of Clausthal, Germany. The hybrid AZ91 and QE22 composites were produced by liquid infiltration of the fibre-particle preforms by matrix alloy melt via squeeze casting. Details of the compositions of the selected hybrid composites, containing short carbon fibres Sigrafil (C_f) and SiC particles (Si_p), are shown in Table 1.

Table 1 Magnesium hybrid composites

Composite	Matrix alloy	Preform (vol.%)
A – AZ91	AZ91	$7C_f + 4Si_p$
A – QE22	QE22	$7C_f + 4Si_p$
B – AZ91	AZ91	$8C_f + 16SiC_p$
B – QE22	QE22	$8C_f + 16SiC_p$

Apparatus and Procedures
The creep tests were carried out at temperature 473 K and at the applied stresses from 35 to 100 MPa in tensile creep testing machines. Metallographic and fractographic investigations were conducted after creep testing using either transmission electron microscope (TEM Philips CM12) with an operating voltage of 120 kV or scanning electron microscope (SEM Philips 505).

Results and Discussion

The creep data of the unreinforced AZ91 alloy and its composites are shown in Fig. 1a.

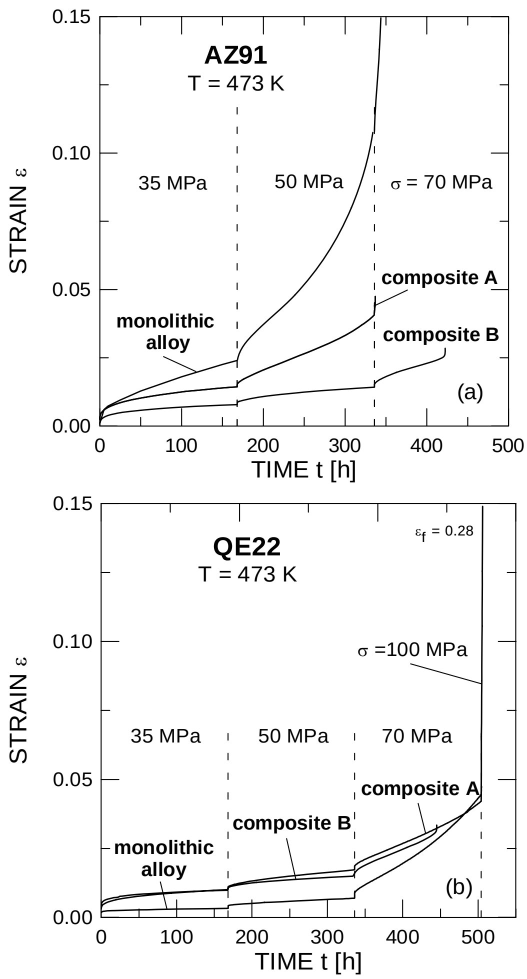

Fig. 1 Creep curves for: (a) the AZ91 alloy and their hybrid composites; and (b) the QE22 alloy and their hybrid composites.

The composite exhibits a better creep resistance than the unreinforced AZ91 alloy over the stress levels used. By contrast, no beneficial effect of the hybrid reinforcement on the creep rate and thus marked improvement of the creep resistance were found for QE22 base composite (Fig. 1b). Metallographic investigation revealed substantial difference in the microstructure of the both composites. Whereas no intensive precipitation was found in the SiC/AZ91 matrix interface, the Nd-rich phases were frequently formed at the SiC/QE22 matrix interfaces during creep. Further, needle shape precipitates containing Mg, Si and Nd were often observed in the close proximity of the MgO/QE22 matrix interfaces. Fractographic investigation of the crept and fractured specimens revealed another difference between the creep fracture surfaces of the composites (Fig. 2).

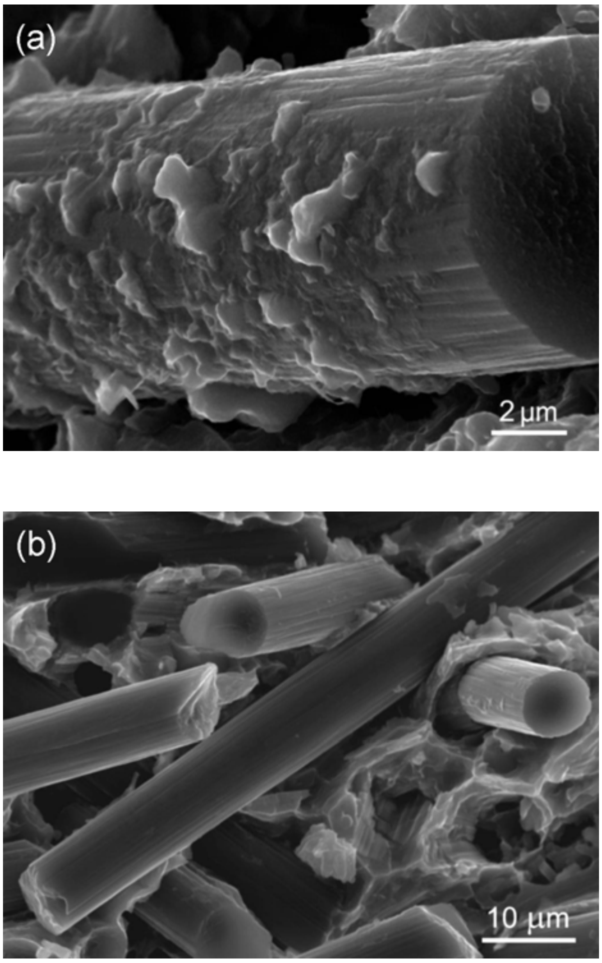

Fig. 2 SEM microfractographs showing carbon fibre surface after creep: (a) composite A – AZ91, (b) composite A – QE22.

Whereas debonding in the AZ91 composite occurs between the reaction MgO zone at the carbon fibre surface and the matrix it appears that debonding in the QE22 composite is the result of a separation along carbon fibre/reaction zone interface. A strong bonding between carbon fibre surfaces and MgO reaction zones and SiC/matrix interfaces implies very important role of the load transfer in creep strengthening of magnesium alloys.

Conclusion

Whereas the creep resistance of the reinforced AZ91 alloy is considerably improved by comparison with the unreinforced matrix alloy, no beneficial effect of hybrid reinforcement on the creep resistance of QE22 was found. The results indicate a paramount importance of the optimum choice of the composite matrix alloy and the reinforcements for a marked improvement in the creep properties of magnesium hybrid composites.

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