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EFFECT OF MATRIX MCROSTRUCTURE AND REINFORCEMENT FRACTURE ON THE PROPERTIES OF TEMPERED SIC /AL-ALLOY COMPOSITES

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Abstract: *The results of the investigation revealed a preference for SiC fracture in the short cycled tempered composites and a preference for interface or near-interface failure in the long cycle tempered composites. Clustered regions have been observed as preferred initiation sites in both tensile and notched bend experiments on the SiC / Al-alloy composites.*

1. INTRODUCTION

Metal matrix composites (MMC) have been drawn attention in recent years owing to the need for materials with high strength and stiffness in the field of aerospace applications. The type of reinforcement (viz; particulate, whisker, fibre and filament) depends mainly on the use and requirements [1, 2]. The discontinuous reinforced composites are fabricated by casting and powder metallurgy techniques as well as conventional metalworking processes like extrusion, rolling, etc [3]. It is well accepted that changes in microstructure may change the fundamental deformation and fracture processes in both ferrous [4] and non-ferrous [5] unreinforcement materials. Few studies have focused on the role of microstructure in the deformation and fracture of MMC.

The present work was focused on the effects of matrix microstructure and reinforcement fracture on the properties of Silicon carbide (SiC) reinforced Al-alloy composites.

2. EXPERIMENTAL PROCEDURE

The composition of matrix alloy is given in Table-1. The average size of SiC particulate before blending was 18µm. The matrix alloy was reinforced with 22% by volume SiC particulate. The as-extruded MMC specimens were solution heat treated, cold water quenched and tempered. The solution heat treatment was carried for 4 hours at 480^0C. The specimens were subsequently water quenched. The quenched specimens were in the following two ways: (i) tempering at 100^0C for one hour (short cycle) and (ii) tempering at 100^0C for 24 hours (long cycle). The heat treatments have been designed to vary the matrix microstructure in the composites.

Table- 1: Composition of matrix alloy

Content	%Weight
Zn	7.00
Mg	2.50
Cu	2.00
Zr	0.12
Al	Balance

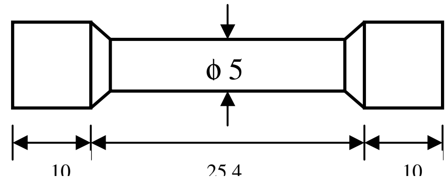


Fig.1 Tensile specimen tested.
Dimensions are in mm.

Tensile testing was carried in the longitudinal orientation on cylindrical specimens of the design shown in fig.1. The notched bars of the design shown in fig.2 were tested in 4-point bending to determine the effect of a stress concentration on fracture initiation.

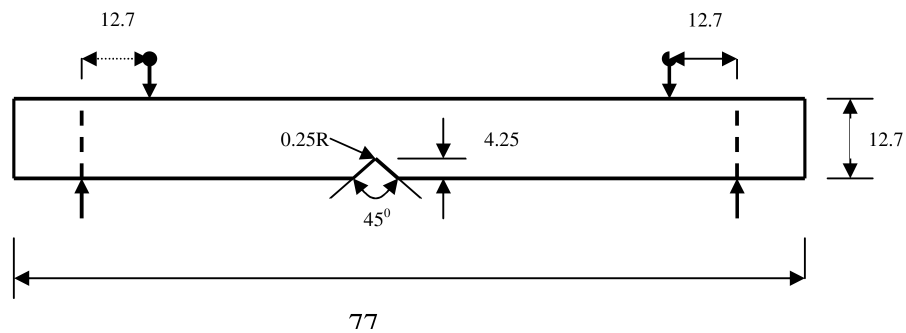


Fig.2 Notched bend bar tested. Dimensions are in mm.

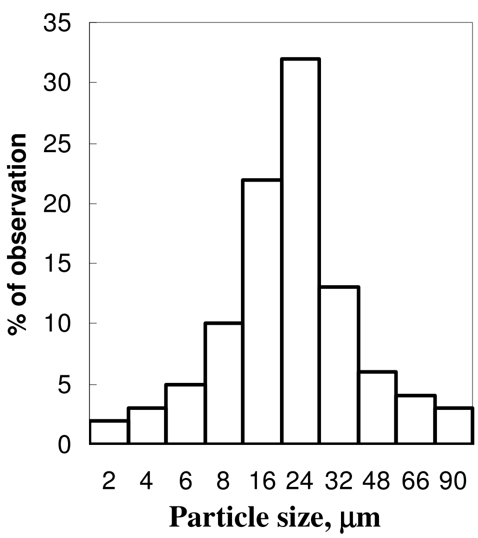


Fig.3 Size distribution of SiC prior to extrusion

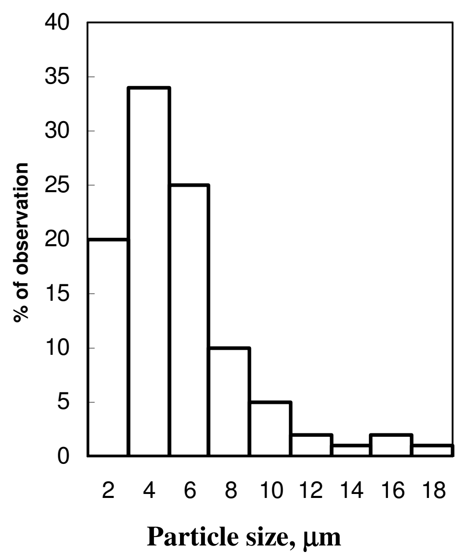


Fig.4 Size distribution of SiC after extrusion

Quantitative metallographic techniques were utilized to characterize the material with respect to average particle size and size distribution using micrographs obtained scanning electron microscope (SEM). Analysis of fractured surfaces was performed by surface fractography as well as by quantification of the area fraction and particle size distribution of SiC present on the fracture surface.

3. RESULTS AND DISCUSSION

The size distribution of SiC particulate before blending and extrusion is shown in fig.3. The average size of SiC particulate was 18µm. As shown in fig.4, the extrusion of composites causes fracture of the SiC, thus reducing the average size to 5µm. The tensile properties for short cycle tempered and long cycle tempered composites are given in Table-2. It can be seen that yield strengths and ductilities were close for the two treatments; but there is a large difference in the amount of fractional SiC present on the fracture surfaces in the two composites. Short cycled composites had large fractured SiC.

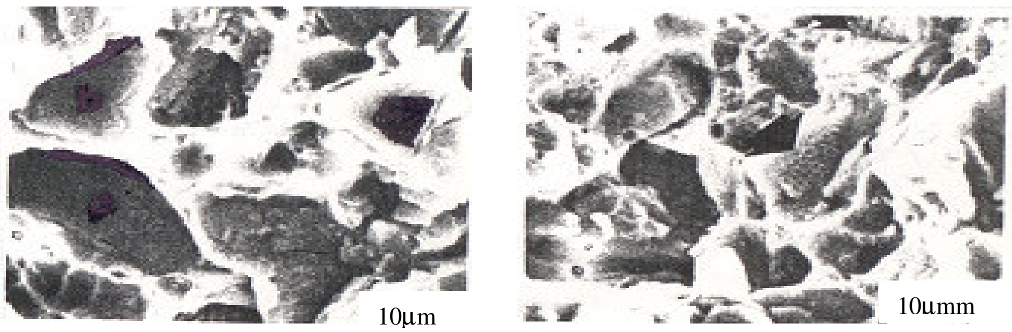
Table-2: Tensile properties

Condition	σ_y (MPa)	%Reduction area	% Area fraction on fracture surface
Short cycle	375	8.10	20
Long cycle	400	7.60	11

Table-3: Notched bend properties

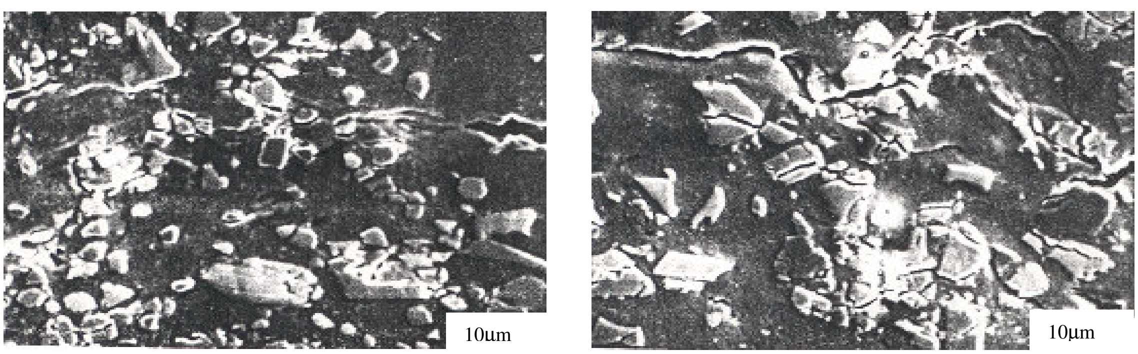
Condition	$\sigma_{Nom} / \sigma_{y}$	Max. Stress Mpa)
Short cycle	1.40	883
Long cycle	0.94	700

Table-3 summarizes the results of the notched bend tests. It can be revealed that long cycle tempered composites failed at lower nominal bending stresses than did the short cycle tempered composites. The surface fractographs in fig.5 illustrates the differences in the fracture morphology in the short cycle and long cycle-tempered composites. In the short cycle tempered composites, SiC is clearly present on the both halves of the fracture surface, indicating a presence for fracture of the SiC. In contrast, evidence of failure near the interface of the SiC and matrix is revealed in the long cycle tempered composites [6].



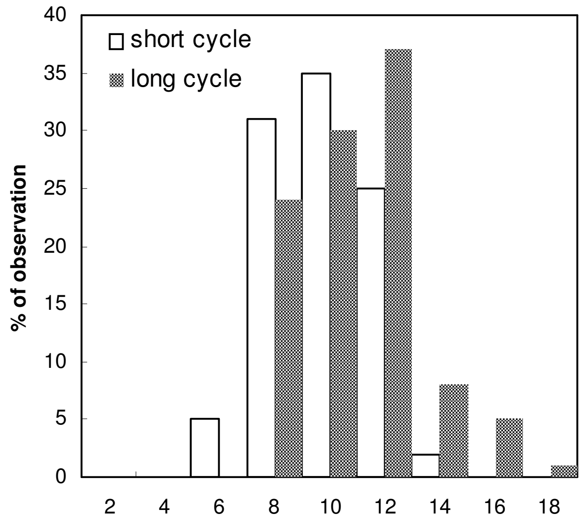
(a) (b)

Fig.5 Surface fractographs of tempered composites.
(a) short cycle (b) long cycle



(a) (b)

Fig.6 Crack tip regions. (a) short cycle (b) long cycle tempered composites



Particle size, μm

Fig.7 Size distribution of SiC present on the fractured surface

4. CONCLUSIONS

Tensile properties of short cycle and long cycle-tempered composites were equivalent for the yield strength and ductility. Notched bend experiments indicated that short cycle tempered fracture at higher nominal bending stresses than did the long cycle tempered composites. Quantitative fractography revealed a presence for SiC fracture in short cycle tempered composites and with a presence for interface or near-interface failure in long cycle-tempered composites.

5. REFERENCES

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