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QUASICRYSTALLINE PARTICULATE REINFORCED ALUMINUM COMPOSITE

I.E. ANDERSON, S.B. BINER, D.J. SORDELET AND O. UNAL
Ames Laboratory, Iowa State University
Ames, Iowa 50011 U.S.A

In this study, the composites having 6061 aluminum matrix and reinforced with 20vol% quasicrystal and SiC were produced by using conventional powder metallurgy routes. The results indicate that both composites have similar tensile mechanical properties. However, the quasicrystal reinforced composites exhibit superior processing ductility owing to the spherical nature of the gas atomized quasicrystals.

INTRODUCTION:

Particulate reinforced aluminum and aluminum alloy composites are rapidly emerging as new commercial materials for aerospace, automotive, electronic packaging and other high performance applications. However, their low processing ductility and difficulty in recycleability have been the key concern[1].

In this study, two composite systems having the same aluminum alloy matrix, one reinforced with quasicrystals and the other reinforced with the conventional SiC reinforcements were produced with identical processing routes. Their processing characteristics and tensile mechanical properties were compared.

PROCESSING OF THE COMPOSITES:

In the production of the composites, both the gas atomized quasicrystal (with the nominal composition in wt%: 40%Al, 40%Cu and 20%Fe) with the mean particle size of 15μ and 6061 aluminum alloy powder with the mean particle size about 10μ were purchased from the Valimet Inc. The SiC powders used in the production of the SiC reinforced composites were purchased from Exolan-Esk Co. In both composite systems, the volume fraction of the reinforcements were about 20 percent. After blending, the billets about 6.3cm in diameter and 10cm in height were isotatically cold pressed (CIP) at 290-310 MPa pressure and canned into stainless steel cans. The electron beam welding of the cans was carried out in vacuum at about 475°C for degassing. After hot isostatic pressing (HIP) at 475°C and about 300 MPa, for six hours, the resulting billets were canned again into copper cans for extrusion. The

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hot extrusion temperature was the same as the HIP temperature(475°C) and a 2:1 reduction in cross-sectional area was achieved in a single pass. The hot rolling experiments were carried out at 425°C with ten minutes soak time and about 1.25mm thickness reductions in each pass. After the processing, both composites were subjected to final T6 heat treatment which was achieved by soaking at 525°C for two hours, water quenching followed by eight hours holding at 175°C.

RESULTS AND DISCUSSION:

After the extrusion step, the hot rolling characteristics of the composites can be seen from Fig.1. Although the processing steps were identical the extensive cracking in the conventional composite, reinforced with SiC, during the early stages of the rolling process is apparent in the figure. On the other hand composites containing quasicrystal reinforcements were successfully deformed up to 35% reductions in thickness during the rolling.

The summary of the tensile properties of the both composites is given in Table-I. As can be seen from the table, both composite have similar stiffness and tensile ductility characteristics, but the quasicrystal reinforced composite has slightly better tensile strength. The failure mechanism associate with the composite containing quasicrystal reinforcements is highlighted in Fig.2. which shows the polished cross-section below the fracture surface of the tensile specimen. The figure also shows the general appearance of the microstructure of the quasicrystal reinforced composite. While SiC reinforcements in conventional composites have irregular shapes and containing sharp corners[1], the quasicrystalline reinforcements are spherical in nature. A higher tensile ductility was expected in the composites containing quasicrystal reinforcements than the one seen in here, owing to the spherical nature of the reinforcements. Although the size distribution of the quasicrystal was fairly uniform, nevertheless the presence of the quasicrystal particles in the order of 30μ or larger can be seen from Fig.2. In two phase systems, the failure of the second hard phase is inversely proportional to its size[2,3]. In other words, failure in the form of interface separation or particle cracking occurs first in the larger particles. After the first crack formation in the large particles, failure

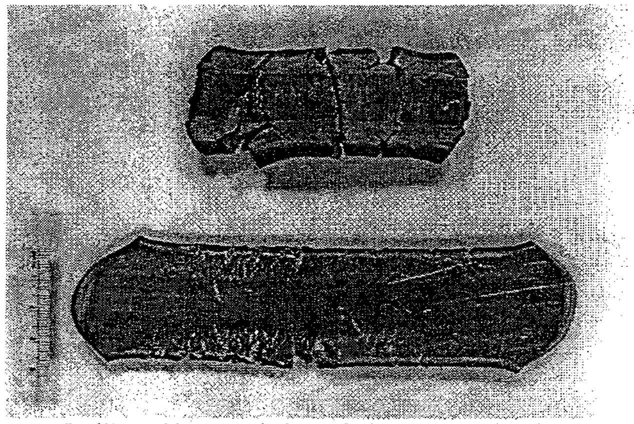

Fig.1 Hot Rolling Characteristics of the 6061 Aluminum Reinforced Composites. Top 20 vol% SiC reinforced composite and bottom 20vol% Quasicrystal reinforced composite.

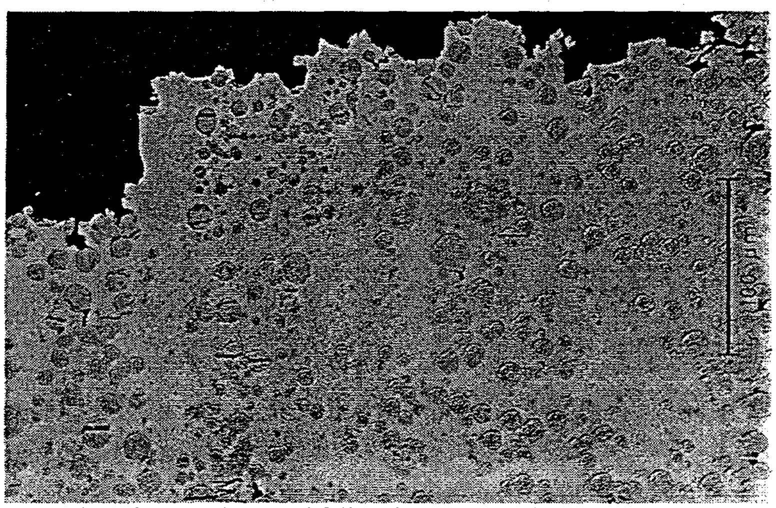

Fig.2 The microstructure and failure behavior of the 20vol% quasicrystal reinforced 6061 Aluminum composite.

usually becomes imminent owing to formation of large strain localizations in the matrix. The failure of the large quasicrystal

Table-1 Summary of the mechanical properties of the composites.

	6061Al + SiC	6061Al + Quasicrystal
Young's Modulus (GPa)	119	121
Proportinal Limit (MPa)	273	313
Yield Strength (MPa)	363	386
Ultimate Strength (MPa)	388	404
Strain To Failure(%)	1.1	1.07

particles, as far as distances 500 micron below the fracture surface, are apparent in Fig.2. This premature failure of the large quasicrystals is believed to be the reason for the limited tensile ductility seen in this composite.

CONCLUSIONS:

In this study, the composites having 6061 aluminum matrix and reinforced with 20vol% quasicrystal and SiC were produced by using conventional powder metallurgy routes. The results indicate that, the both composites have similar tensile mechanical properties. However, the quasicrystal reinforced composites exhibit superior processing ductility owing to the spherical nature of the gas atomized quasicrystals. Moreover; quasicrystal reinforced composites offer easy recycling characteristics, since the quasicrystal is an Al-Cu-Fe alloy with a melting temperature of 890°C

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