World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:10, No:06, 2016

Tensile and Fracture Properties of Cast and Forged Composite Synthesized by Addition of in-situ Generated Al3Ti-Al2O3 Particles to Magnesium

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Abstract : TiO₂ particles have been added in molten aluminium to result in aluminium based cast Al/Al₃Ti-Al₂O₃ composite, which has been added then to molten magnesium to synthesize magnesium based cast Mg-Al/Al₃Ti-Al₂O₃ composite. The nominal compositions in terms of Mg, Al, and TiO₂ contents in the magnesium based composites are Mg-9Al-0.6TiO₂, Mg-9Al-0.8TiO₂, Mg-9Al-1.0TiO₂ and Mg-9Al-1.2TiO₂ designated respectively as MA6T, MA8T, MA10T and MA12T. The microstructure of the cast magnesium based composite shows grayish rods of intermetallics Al₃Ti, inherited from aluminium based composite but these rods, on hot forging, breaks into smaller lengths decreasing the average aspect ratio (length to diameter) from 7.5 to 3.0. There are also cavities in between the broken segments of rods. β-phase in cast microstructure, Mg₁₇Al₁₂, dissolves during heating prior to forging and re-precipitates as relatively finer particles on cooling. The amount of β-phase also decreases on forging as segregation is removed. In both the cast and forged composite, the Brinell hardness increases rapidly with increasing addition of TiO₂but the hardness is higher in forged composites by about 80 BHN. With addition of higher level of TiO₂in magnesium based cast composite, yield strength decreases progressively but there is marginal increase in yield strength over that of the cast Mg-9 wt. pct. Al, designated as MA alloy. But the ultimate tensile strength (UTS) in the cast composites decreases with the increasing particle content indicating possibly an early initiation of crack in the brittle inter-dendritic region and their easy propagation through the interfaces of the particles. In forged composites, there is a significant improvement in both yield strength and UTS with increasing TiO₂ addition and also, over those observed in their cast counterpart, but at higher addition it decreases. It may also be noted that as in forged MA alloy, incomplete recovery of forging strain increases the strength of the matrix in the composites and the ductility decreases both in the forged alloy and the composites. Initiation fracture toughness, J_{IC}, decreases drastically in cast composites compared to that in MA alloy due to the presence of intermetallic Al₃Ti and Al₂O₃ particles in the composite. There is drastic reduction of J_{IC} on forging both in the alloy and the composites, possibly due to incomplete recovery of forging strain in both as well as breaking of Al₃Ti rods and the voids between the broken segments of Al₃Ti rods in composites. The ratio of tearing modulus to elastic modulus in cast composites show higher ratio, which increases with the increasing TiO₂ addition. The ratio decreases comparatively more on forging of cast MA alloy than those in forged composites.

Keywords : composite, fracture toughness, forging, tensile properties
Conference Title : ICACM 2016 : International Conference on Advanced Composite Materials
Conference Location : New York, United States
Conference Dates : June 06-07, 2016