ABSTRACT

The requirement for materials to possess high strength-to-weight ratio, enhanced toughness, hardness and better mechanical properties has led researchers to investigate further to obtain materials better than alloys. Thus, by reinforcing ceramics, fibres and alloys, metal matrix composites were prepared according to the requirements of the industries and manufacturing sectors.

Aluminium has been used widely for various purposes. Reinforcing aluminium with composites has become popular due to its abundance in nature and remarkable properties. In this research, an attempt has been made to enhance the mechanical and metallurgical properties of Al6061, by reinforcing it with three types of reinforcements: zirconia (ZrO_2), zirconia and alumina (ZrO_2+Al_2O_3) and Fused Zirconia Alumina (FZA). Aluminium Metal Matrix Composites (AMMCs) were prepared by varying the combinations as follows: 95% Al6061 – 5% reinforcements; 90% Al6061 – 10% reinforcements; and 85 % Al6061 – 15 %reinforcements.

Stir-casting method was adopted to fabricate the composites. This process involves melting aluminium in an electric furnace at 900 ˚C and adding the reinforcement for 5 to 10 minutes at 800˚C.Ten different cast specimens were prepared in various proportions for testing, and their properties were compared with those of the cast Al6061.

To find the elemental composition and to determine the crystallographic properties of the prepared Al6061 and its composites,

energy-dispersive X-ray spectroscopy (EDS) and X-ray diffraction spectroscopy (XRD) analyses were performed. Optical microscopy and Scanning Electron Microscopy (SEM) analyses were also performed on the specimens to study the bonding and distribution of reinforcements in the matrix.

Variations in density, microhardness, tensile strength, impact strength, fracture toughness and wear resistance of the AMMCs were identified for the various reinforcement percentages. The experimentally determined densities of the composites, obtained through Archimedes' principles, were much lower when compared with the theoretical densities calculated through the rule of mixtures. The tensile properties of the composites enhanced as the weight% of the reinforcements increased, but it could not reach the tensile strength of Al6061 due to its enhanced ductile nature. Also in the impact analysis, Al6061 was found superior to its composites. But the other properties like hardness, fracture toughness and abrasive wear of the composites were enhanced to higher levels when compared to Al6061. SEM images were taken for visual analysis of the fractured surface for all the specimens prepared to determine the tensile strength, fracture toughness and abrasive wear properties.

Corrosion test was also performed on all the specimens. The specimens were immersed in 0.1M HCl, 0.1M NaOH, 3.5 wt% NaCl, for a period of 28 days to test the corrosion rate of Al6061 and its composites in acid, alkaline and salt environments. Electrochemical tests were also performed on the specimens in all the three environments. To check the rate of corrosion on the surface and on the intergranular regions, SEM analysis was carried out in all the specimens. Corrosion rates for all the composites were drastically reduced when compared with Al6061.

The novel material FZA showed excellent enhancement in all the properties. The results obtained experimentally were used as input to Visual PROMETHEE, a multi-criteria decision aid software, to determine the effectiveness of the prepared AMMCs with respect to the obtained properties. The optimized properties of the composites were identified and recommended for various applications.