ABSTRACT

Metal matrix composites (MMCs) are commonly used today in many aerospace and industrial applications. MMCs possess significantly improved properties including high specific strength, specific modulus, damping capacity and good wear resistance compared to unreinforced alloys. Most of the research has been carried out to produce metal matrix composites based on the conventional particulate reinforcement such as Al₂O₃, SiC, TiC and B₄C particles. There has been increased interest in composites containing low density and low cost reinforcements. Among various discontinuous dispersoids used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. The high electrical resistivity, low thermal conductivity and low density of fly ash may be helpful for making a light weight insulating composites. The utilisation of fly ash reduces the production of aluminium. This reduces the generation of green house gases as they are produced during the bauxite processing and alumina reduction.

In this investigation, Aluminium (Al) - 12% Silicon (Si) alloy - Fly ash composites were developed using powder metallurgy technique. Al-Si alloy powder was homogenously mixed with various weight percentages of fly ash (5-15%) and uniaxially cold pressed at pressures ranging between 200
and 515 MPa, and the green specimens were sintered at temperatures of 848, 873 and 898 K. Scanning electron microscope was used to examine the microstructural characteristics of the composites. The physical, mechanical and electrical properties such as density, hardness, compressive strength and electrical resistivity were studied and compared with that of base alloy. The wear and corrosion behaviour of Al-Si alloy and Al-Si alloy - Fly ash composites were also studied.

Drilling experiments were conducted by drilling holes of 8 mm diameter on Al-Si alloy and newly developed Al-Si alloy - Fly ash composites in a drilling machine. The drilled hole quality parameters such as surface roughness, diameter error and roundness error of Al-Si alloy and Al-Si alloy - Fly ash composites were studied. The sintering process parameters of Al-Si alloy - Fly ash composites were optimised using Taguchi method and grey relational analysis.

The microstructure reveals that the fly ash particles are randomly distributed along the grain boundary. X-ray diffraction pattern was used to identify various phases present in Al-Si alloy - Fly ash composites. The density of Al-Si alloy - Fly ash composites was lower than that of the base alloy. The green and the sintered density of Al-Si alloy - Fly ash composites increased with compacting pressure whereas it decreased with weight percentage of fly ash present in the composites.
The hardness of the Al-Si alloy - Fly ash composites was higher (90 HRA) than that of base alloy (52 HRA) and it increased with the increase in weight percentage of fly ash content (upto 12 wt%). Compressive strength of the composites is lower than that of base alloy and it decreased with increasing weight percentage of fly ash.

The electrical resistivity of Al-Si alloy - Fly ash composites increased \((3.456 \times 10^{-3} - 8.228 \times 10^{-3} \text{ Ohm-m})\) compared to the base alloy and it increased with increasing the weight percentage of fly ash particles present in the composites. The wear rate of Al-Si alloy - Fly ash composites is lower \((13.5 \times 10^{-7} \text{ gm/m for 1.5 m/s, 2000 m})\) than that of Al-Si alloy \((17 \times 10^{-7} \text{ gm/m for 1.5 m/s, 2000 m})\). The wear rate increased with increasing load and sliding speed. The coefficient of friction decreased with increasing load and sliding speed.

The rate of corrosion increased with increasing the weight percentage of fly ash in the composites. The weight loss in the Al-Si alloy - Fly ash composites with high fly ash content is higher \((5.96\% \text{ for 15 wt% fly ash})\) than that in the composites with low fly ash content \((0.86\% \text{ for 5wt% fly ash})\). The corrosion rate of the composites is higher than that of base alloy.

The surface roughness, diameter error and roundness error of the drilled hole in Al-Si alloy - Fly ash composites increased with an increase in speed, feed and fly ash content. The best surface finish, diameter and roundness values are obtained at low speeds and feeds.
The optimal process parameters combination for sintering process was obtained using grey relational analysis, and significant parameter was determined by analysis of variance (ANOVA). The experimental results indicated that multi performance characteristics such as density and hardness could be improved effectively through grey relational analysis.