

ABSTRACT

Aluminium Matrix Composites are used as materials in automotive industries owing to their superior strength-to-weight ratio and stiffness.

Aluminium reinforced with conventional ceramic materials such as SiC / Al₂O₃ are gradually being implemented in the production of components in automobile industry. Fly ash (SiO₂, Al₂O₃, Fe₂O₃ as major constituents and oxides of Mg, Ca, Na, K etc. as minor constituents) is one of the most inexpensive and low density material which is abundantly available as solid waste byproduct during combustion of coal in thermal power plants.

The present investigation focused on the utilization of fly ash in useful manner by dispersing it into aluminium to produce composites by a modified two step stir casting method to overcome the cost barrier for wide spread applications in automotive systems.

In view of increasing commercial interest in the production of composites, an attempt was made to study the influence of process parameters such as size and shape of the impeller model, weight percentage of fly ash and wetting agent magnesium on the distribution of fly ash particles in Al matrix and mechanical properties of composites. Composites were fabricated employing a modified two step stir casting method according to Taguchi L 9 technique.

A radial impeller with 0.7 I_{OD}/C_{ID} (Impeller outer dia to Crucible inner dia) ratio was found to ensure uniform distribution of fly ash particles in Al matrix along with a little deposit of the slurry on the wall surface of the crucible. Addition of Mg up to 1.5% by weight to the composite slurry

increases the wettability and thus increases the mechanical properties through strong interfacial bonding between fly ash particles and the matrix.

Investigations on dry sliding wear behaviour of Al and Al - fly ash composites as a function of fly ash particle content at two different load and sliding speed conditions was carried out using a pin-on-disc.

A drastic decrease in wear was observed with the incorporation of reinforcement content to Al. Lowest wear loss was obtained for composite with 20 wt. % fly ash. It was demonstrated that the wear resistance was approximately 7 times higher than that of unreinforced Al at 1 m/s sliding speed and 5N load conditions. This increase in wear resistance can be attributed to the fact that the incorporation of fly ash particles increases the hardness of Al considerably. Moreover, better interfacial bonding between Al and fly ash particles which helps in preventing the damages caused due to sliding action.

A decreasing tendency in wear rate of the Al- fly ash composites was observed when the sliding speed increased from 0.5 m/s to 1m/s at low load (5N) at fly ash concentrations less than 20 wt %. As the sliding speed increased, the surface of the counter face reacts to form ferrous oxide (Fe_3O_4) along with aluminum oxide (Al_2O_3) forms a Mechanical Mixed Layer – MML between the composite pin and the counter face . This MML enhanced the wear resistance of the composites. Scanning Electronic Microscopy (SEM) was employed to analyze the microstructure and also the wear surface profile to study the wear mechanism. Artificial Neural Network (ANN) was also employed to predict the wear rate of composites. The objective was to develop the best Neural Network model with inherent abilities to generalize and predict the wear rate of Al – fly ash composites, as a function of weight percentage of fly ash content and two different combinations of the load and

sliding speed by implementing ANN back propagation algorithm using MATLAB 7.6.0 software.

In this study, training of the network was performed using `trainlm` (Levenberg–Marquardt algorithm) function which updates weight and bias values whereas `learngdm` (gradient descent with momentum) was used as weight and bias learning function.

The proposed Artificial Neural Network model was found to be capable of predicting composite wear rate with reasonable degree of accuracy with lower computational times.

In view of the expanding engineering applications of aluminium matrix composites, influence of feed and step drill geometries (such as step angle and step size) on the exit burr height during machining was investigated during step drilling of pure Al, Al-15wt. % fly ash and Al-15wt. % fly ash-1.5wt.% graphite hybrid composites using Taguchi (L9) optimization method.

Addition of 1.5 wt% graphite to Al-15 wt% fly ash reinforced composite decreased the mean thrust force by about 17 % and the exit burr height by about 54 percent. It can be explained by the fact when the drill passes over these regions, the crushed graphite particles lower the coefficient of friction. The reduction of interfacial frictional force tends to decrease the thrust force and reduce the tendency of work piece material to build up on a cutting tool edge during drilling Al–fly ash- Gr composites.

Surface quality of the machined component plays a vital role due to the increasing demand of precision machining for its functional attributes such as fitness, fatigue, heat transfer, corrosion and wear behaviour. In this study, an attempt was made to minimize the surface roughness by optimizing the machining parameters such as cutting speed, feed rate and depth of cut through the Taguchi and ANOVA techniques during turning Al, Al – 15wt. %

fly ash and Al – 15wt. % fly ash -1.5 wt. % graphite composites. Turning experiments were conducted as per the L27 orthogonal array.

Feed rate and cutting speed were found to be the most significant parameters followed by the depth of cut. Surface roughness of the Al was considerably higher compared to Al- fly ash and Al –fly ash-Gr composites irrespective of choice of machining parameters. Incorporation of 1.5 wt% graphite as additional reinforcement decreases the surface roughness of Al – fly ash composites considerably. It can be attributed to the increased burnishing effect of graphite particles which acts as a lubricating film and reduces the coefficient of friction between the tool cutting edge and the work piece.

Investigations on the corrosion behaviour of unreinforced Al, Al-fly ash and Al-fly ash- Gr reinforced composites in 3.5% NaCl solution at a pH of 7 were carried out using a standard Gill AC series-903 potentiostat. The tested specimens were observed by Scanning Electron Microscopy to find the morphology of the surface.

Electrochemical polarization test showed that the presence of fly ash and graphite lead to pitting corrosion of the composite in comparison with unreinforced Al. The corrosion rate increased with increase in fly ash content in the composites. The corrosion rate is further increased when 1.5wt % graphite was added with the Al-15wt. % fly ash composite.

The present study suggests that by using the correct amount of the fly ash, graphite reinforcement particles and wetting agent Mg, it is possible to obtain a composite for the particular application. The present work provides useful insight to industrial composites' manufacturers especially for automotive industries.