ABSTRACT

A composite is a combination of two or more dissimilar materials having a distinct interface between them such that the properties of the resulting material are superior to the individual constituents. Among the different classes of composites, Metal Matrix Composites (MMCs) are widely used in many industries. Aluminium and its alloys have received major attention as matrix material for MMC's. Aluminium Matrix Composites (AMCs) refer to the class of light weight, high performance aluminium centric material system. The major advantages of AMCs compared to the unreinforced materials are greater strength, significantly higher stiffness, reduced density, improved high temperature properties, enhanced abrasion and wear resistance and increased damping capabilities. Over the years, AMCs have been tried and used in numerous structural, non-structural and functional applications in different engineering sectors.

A reinforcement is a discontinuous second phase which is surrounded by the continuous matrix phase. The reinforcement may in the form of chopped fibers, whiskers, particulates and in-situ dispersion in a metallic matrix are used in AMCs. The reinforcing particles used in the composite material are carbides (SiC, TaC, WC, B_4C), nitrides (TaN, ZrN, Si_3N_4, TiN), borides (TaB_2, ZrB_2, TiB_2, WB) and oxides (ZrO_2, Al_2O_3, ThO_2).

The Al 6061 alloy and its composites reinforced with silicon carbide and graphite particles are fabricated using stir casting method since it is economical and well suited for fabricating particulate aluminium matrix composites.

The factors affecting the properties of composites are type, shape, size, amount and the distribution of reinforcement within the matrix material. During the fabrication of composites by stir casting, the main factors affecting the strength of the composites are stirring speed, preheating temperature of reinforcement particles, stirring time, preheating temperature of die, stirring temperature and melting point of matrix material.

During wear testing, the major factors affecting the weight loss of composites are applied load, sliding distance while keeping the sliding velocity and track diameter as constant. In machining of metal matrix composites using Electric Discharge Machine (EDM) the major factors affecting the machining characteristics such as Metal Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR) are pulse-on-time, voltage, current and flushing pressure of dielectric fluid. In general, specific problems relating to prediction and control of weight loss and factors affecting weight loss in wear testing, prediction and control of machining characteristics and machining parameters in electric discharge machining are encountered in all MMC’s. Most of the engineers often face the problem of selection of appropriate and optimum combination of input factors for achieving the required weight loss, tool wear rate, metal removal rate and surface roughness. Until recently, trial and error methods were used to determine the optimum input factors for the required weight loss, tool wear rate, metal removal rate and surface roughness which results in wastage of cost and time.

With a view to solve the above problems in metal matrix composites, an attempt was made to study the various aspects of composites such as regression and Artificial Neural Network modelling (ANN) of weight loss, regression modelling of metal removal rate, tool wear rate and surface roughness, micro structure, hardness and heat treatment.

Wear tests were conducted using a pin-on-disc apparatus. Influencing factors such as weight percentage of SiC and graphite particles, applied load and sliding distance, which affecting the weight loss were identified. The machining characteristics were studied using an Electric Discharge Machine (EDM).The factors affecting metal removal rate, tool wear rate and surface roughness were identified. The predominant factors are current, pulse on time, voltage and flushing pressure. A five level four factor design matrix based on central composite rotatable design was evolved. Weight loss of the composite was measured using weight loss technique. The metal removal rate and tool wear rate are calculated by dividing the weight loss by time of machining. Surface roughness was measured using a Mitutoyo Tallysurf tester. Second order quadratic regression models were developed to relate the influencing factors with the weight loss, metal removal rate, tool wear rate and surface roughness. The direct and interaction effect of the influencing factors on weight loss, metal removed rate, tool wear rate and surface roughness were studied and presented in graphical forms. Feed forward neural network model with back propagation algorithm was also developed to predict the weight loss of composite during wear testing.

Heat treatment of the composite specimens were carried out with varying ageing times. The wear properties of heat treated composites were studied using pin-on-disc wear testing machine. Hardness measurements of specimen before and after heat treatment were carried out. Microstructure studies on both heat treated and unheat treated composites were carried out using Scanning Electron Microscope (SEM) to identify the distribution of reinforcement particles with in the matrix as well as wear mechanisms.

All the above analysis and results on wear properties, machining characteristics of hybrid composites can be very useful for the manufacturing industries for predicting weight loss and machining characteristics. The results from hardness, microstructure and heat treatment are also very useful for the composite parts manufacturing industries especially for automotive industries for making composite brake drum for cars.