ABSTRACT

Particulate reinforced aluminium matrix composites are widely used in automobile and aerospace sectors because of their attractive properties like high strength to weight ratio and good wear resistance. These materials, in addition to be manufactured with many variations, offer an advantage of low cost. However, the difficulties encountered in machining these composites, has become a great challenge to the industry. Researches carried out with conventional and non-conventional methods reveal that there is no particular technique which best suits for machining Aluminium Matrix Composites (AMCs). While tool wear rate is the major issue in conventional method, work piece damage and cost are being the important factors associated with non-conventional machining methods. Electro Chemical Machining (ECM) process, which can machine any conductive material without tool and work making direct contact, can address the first two issues. But the researches carried out so far in ECM has mostly concentrated in improving their process characteristics and very limited work has been reported about machining composite materials.

Hence, in the present study, an investigation is made to optimize the significant parameters in maximizing material removal rate while
machining A356/SiC<sub>p</sub> composite using ECM. In this research work the composite work specimens are prepared with three different proportions of SiC namely 5, 10 and 15 wt%. using stir cast method. The density of the produced components is determined from their mass and dimensions. Hardness of the material is measured using Rockwell Hardness Tester. The micrographs are obtained through scanning electron microscope (SEM) to see the SiC particle distribution in the aluminium matrix. In the present study, applied voltage, electrode feed rate, electrolyte concentration and content of SiC have been identified as critical parameters. The levels of each parameter are decided based on the process capabilities. The combinations of the parameters with different levels are made according to Taguchi’s orthogonal array and two trials of each combination are carried out on an ECM setup. As the scope of this research is limited to rough machining operation, material removal rate is chosen as output response. The observed data are subjected to analysis of variance. The results of F test show that all the parameters chosen in the study are significantly influencing the variations in the measured output and their priority is understood from pareto analysis of variance.

Optimization of parameters value is performed with three approaches namely Taguchi method, integrating Artificial Neural Network (ANN) with direct search and integrating ANN with Genetic Algorithm (GA). In Taguchi technique, parameter settings with the highest signal-to-noise ratio always yield the optimum quality with minimum variance. From the
calculated mean signal-to-noise values for each level, the optimum values are decided.

For the next two approaches, an objective function which can explain the relation between input variables and the output is needed. This is developed by applying a feed forward type ANN with back propagation algorithm. The network is finalized by varying the momentum factor, learning rate and number of neurons in the hidden layer. A 4-7-1 network which resulted with least mean square error is finalized. The number of epochs to train the net is determined based on time taken and accuracy. The total data are divided into two sets as training data and testing data and are normalized before presenting to the neural net. After training the 4-7-1 network with training data, the net is presented with test data. It is found that the average error value between predicted value and the actual value is 6.13%. This trained network can be used to predict the metal removal rate for any combinations of the chosen parameters within the range of values.

Integration of ANN with direct search approach is made by writing a Matlab file that calls the trained neural net. In this approach, the optimized function value is attained after trying with several start point vector which is selected randomly. In the other approach, ANN is linked with genetic algorithm. Again, the trail and error method is used to get the MRR by varying the operators like cross over, mutation, start point vector and
population. A confirmation experiment is conducted with the optimal parameter settings reported by each of three methods. It is found that the value predicted by ANN integrated with genetic algorithm has very close matching with the actual values obtained.

Finally, conclusions are drawn from the present study and it is came to know that SiC content significantly affects the MRR and should be less than 10% to maximize the same. This happens because of the nonconductive nature of the SiC. The developed ANN model can serve to predict the MRR with reasonable accuracy. First time, the integrated approaches are employed for optimization in machining AMC under ECM. Of all three approaches made, the integration of ANN with GA has proved the best method. The study also illustrates that the material removal rate increases with increase in applied voltage and electrolyte concentration and decreases with increase in electrode feed rate and SiC content.