ABSTRACT

Aluminum metal matrix composites have received considerable attention due to their unique combination of light-weight, good corrosion resistance, high electrical conductivity and excellent mechanical properties. Some of the typical reinforcement particulate phases used in aluminum-based MMCs are graphite, mica, silica, zircon, alumina, silicon carbide, boron carbide, quartz, etc. Among them, silica particle-reinforced aluminum composites are used for manufacturing pistons, brake rotors, calipers and liners, which exhibit good strength and high wear resistance. But these reinforcements are much expensive; therefore their usage is somewhat restricted in practical applications. So, the development of low-cost reinforcements for metal matrix composites has been one of the major innovations in the field of materials in the past few decades.

Low-cost and low-density silica-rich waste materials are generally analyzed as replacements for relatively high-cost reinforcements. Among them, Rice Husk Ash (RHA) is an agriculture waste by-product abundantly available in India. Also RHA contains around 85 - 90 % amorphous silica. On thermal treatment, this silica converts to crystobalite, which is a crystalline form of silica. Again, under controlled burning conditions that crystalline silica is converted into micro-silica. So, the present research is focused to utilize these rice husk ash (micro-silica) as reinforcement for aluminum matrix composites.

Initially, rice husk ash of three different particle size ranges (50–75, 75–100 and 100–150 μm) in 3, 6, 9 and 12% by weight was reinforced with an aluminum alloy (AlSi10Mg) using the liquid metallurgy method. The microstructure and mechanical properties of the fabricated composites were

analyzed. The result reveals that the tensile strength, compressive strength and hardness of the aluminum alloy composites improved with RHA reinforcement. But increase in the weight fractions of RHA particles decreases the ductility of the composite. Then, dry sliding wear behavior of the composites in the cast conditions was examined using the pin-on-disc tribotesting machine for three different loads (20, 30 and 40 N) and with three different sliding velocities (2, 3 and 4 m/s). The relationship effect between particle sizes, percentage reinforcement, sliding speed and applied load with the corresponding wear rate and coefficient-of-friction was found. The results reveal that the composite reinforced with the coarse rice husk ash particles exhibits superior wear resistance compared to the fine rice husk ash particles. The wear rate of the composite decreased with an increase in the weight percentage of rice husk ash particles for all size ranges. Finally, the wear mechanism was investigated with the worn surface using a scanning electron microscope.

Also, an attempt was made to find the influence of wear parameters like applied load, sliding speed and percentage-of-reinforcement on the dry-sliding wear behavior of Al–RHA composites using Taguchi's plan of experiment techniques. The interactive effect of the above-mentioned parameters was investigated with analysis of variance (ANOVA), and a regression equation was developed for each response. ''Smaller-the-better'' characteristics were chosen to develop a predictive model for analyzing the dry-sliding wear resistance. The result reveals that the wear rate and coefficient-of-friction were influenced by percentage-of-reinforcement followed by applied load and sliding speed. Finally, the confirmatory test was also carried out to verify the predictive model with the experimental results.

Then, Artificial Neural Network (ANN) model was developed to predict the wear rate and coefficient of friction for the RHA reinforced aluminum alloy composite. The experiments were conducted based on orthogonal array (L_{27}) generated through the Taguchi's Technique and their results were used to train the ANN model. The input parameters assigned to develop an ANN model were applied load, sliding speed, RHA particle size and weight percentage of RHA reinforcement. A four-layer perception network having 4-7-8-2 architecture was found to be the optimum network. Finally, confirmatory test was done to verify the predictive model with the experimental results. A predictive model was found to be in good agreement with the predicted and experimental values.

After that, the effect of machining parameters on surface roughness of pure aluminum alloy and aluminum alloy (Al) reinforced with Rice Husk Ash (RHA) composite produced by stir-cast route was investigated. Initially, the obtained samples were carefully turned using a CNC lathe by varying three different cutting speeds (250, 300 & 350 m/min), feed rate (0.1, 0.2 & 0.3 mm/rev) and depth of cut (0.5, 1.0 &1.5 mm) and their surface roughness values were identified. In this study, a cubic boron nitride insert KB-90 tool was used to optimize the objective function subject to the machining constraints. All the experiments were conducted based on the plan-of-experiment (L_{27} orthogonal array) generated through the Taguchi's technique. Experimental results were collected and analyzed with the help of commercial software MINITAB 16. The optimum machining parameters were identified to minimize the surface roughness of the composite by using signal-to-noise ratio and analysis of variance approach. The result showed that the surface roughness is influenced highly by feed rate, followed by cutting speed and depth-of-cut. This occurs due to the enhancement of brittleness property, thus the Al-RHA composite produced a better surface finish. Finally, the morphology of machined surfaces was analyzed using scanning electron microscope and the chip formed during the machining process was also investigated.