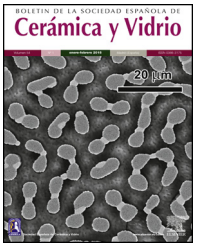
BOLETÍN DE LA SOCIEDAD ESPAÑOLA DE CERÁMICA Y VIDRIO XXX (2017) XXX–XXX

BOLETIN DE LA SOCIEDAD ESPAÑOLA DE
Cerámica y Vidrio
www.elsevier.es/bsecv



Review

Artificial neural network and regression modelling to study the effect of reinforcement and deformation on volumetric wear of red mud nano particle reinforced aluminium matrix composites synthesized by stir casting

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ARTICLE INFO

Article history:
Received 6 March 2017
Accepted 21 September 2017
Available online xxx

Keywords:
Artificial neural network
Red mud
Nano composites
Wear
Deformation
Regression

ABSTRACT

Artificial neural network (ANN) approach was used for the prediction of effect of reinforcement and deformation on volumetric wear of red mud nano particle reinforced aluminium matrix composites synthesized by stir casting. Red mud obtained from alumina processing industry was milled in a high energy ball mill and the particle size was reduced to 40 nm in 30 h. Sliding wear characteristics of the composites were evaluated on pin on disc wear tester at different loads of 10 N, 20 N and 30 N and sliding speeds of 200, 400, and 600 RPM. The wear rate of the composite was decreased with increase in weight fraction of red mud up to 10% and beyond that the wear rate was increased. The interfacial area between the matrix and the reinforcement increases with increase in red mud volume fraction, leading to increase in strength and wear resistance. Mathematical regression model and ANN model have been developed to predict theoretical wear rate of the composite and observed that ANN predictions have excellent agreement with measured values than other models. Thus, the prediction of wear rate of the nano composites using artificial neural network before actual manufacture will considerably saves the project time, effort and cost.

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https://doi.org/10.1016/j.bsecv.2017.09.006

Please cite this article in press as: G. Satyanarayana, et al., Artificial neural network and regression modelling to study the effect of reinforcement and deformation on volumetric wear of red mud nano particle reinforced aluminium matrix composites synthesized by stir casting, Bol. Soc. Esp. Cerám. Vidr. (2017), https://doi.org/10.1016/j.bsecv.2017.09.006

Red neuronal artificial y modelos de regresión para estudiar el efecto del refuerzo y la deformación sobre el desgaste volumétrico de los materiales compuestos de matriz de aluminio reforzada con nanopartículas de barro rojo sintetizados por agitación

Palabras clave:
Red neuronal artificial
Barro rojo
Nanocompuesto
Desgaste
Deformación
Regresión

RESUMEN

Se utilizó el método de red neuronal artificial (RNA) para predecir el efecto del refuerzo y la deformación sobre el desgaste volumétrico de los materiales compuestos de matriz de aluminio reforzada con nanopartículas de barro rojo sintetizados por agitación. El barro rojo obtenido de la industria de procesamiento de alúmina se molió en un molino de bolas de alta energía y el tamaño de la partícula se redujo a 40 nm en 30 h. Las características de desgaste de los materiales compuestos se evaluaron en los probadores *pin-on-disk* de desgaste en diferentes cargas de 10N, 20N y 30N, y velocidades de deslizamiento de 200, 400 y 600 rpm. El índice de desgaste del material compuesto se redujo con el aumento en la fracción de peso del barro rojo hasta el 10% y por encima de este, de manera que el índice de desgaste aumentó. El área interfacial entre la matriz y el refuerzo aumenta con el incremento de la fracción volumétrica del barro rojo, lo que produce un aumento de la fuerza y la resistencia al desgaste. El modelo de regresión matemática y el modelo de RNA se desarrollaron para predecir el índice de desgaste teórico del material compuesto y se observó que las predicciones de la RNA están en excelente acuerdo con los valores medidos si se los compara con otros modelos. Por tanto, la predicción del índice de desgaste de los nanocompuestos cuando se utiliza red neural artificial antes de la fabricación real ahorrará considerablemente tiempo, esfuerzo y coste al proyecto.

Introduction

Aluminium metal matrix composites have been of interest as engineering materials because of their superior mechanical properties compared to monolithic metals and alloys. Particulate composites possess isotropic properties and hence they are gaining more attention compared to fibre reinforced composites. The most interesting materials commercially utilize SiC, Al_2O_3, B_4C, AlN, etc. particles incorporated into the aluminium matrix by a variety of processes such as powder metallurgy, casting, electrical deposition, etc. The cost of these reinforcement particles is higher and is becoming scarce. In addition, tons of red mud solid waste deposits causing environmental related issues and enormous efforts have been directed worldwide towards red mud utilization and disposal. Hence, the utilization of red mud solid waste particles as reinforcement phase will annihilate the environmental issues to some extent, in addition to the reduction in cost of the component. Among the available manufacturing techniques, stir casting has greater adaptability because of its simplicity, flexibility and applicability to large quantity production [1]. It is also attractive because of its suitability for engineering application in terms of production capacity and cost efficiency [2]. The wear resistance of aluminium and its alloy can be increased by reinforcing with different reinforcements like short fibre, whiskers and particulates [3].

Red mud is the caustic insoluble waste residue generated by alumina production from bauxite by Bayer's Process at an estimated annual rate of 115 and 1.7 million tons respectively in the world and India. The disposal and utilization of red mud has become an issue and a clear cut solution is not available till date. The utilization of red mud is restricted only for the recovery of some metal values like titanium, vanadium and zinc. The dry sliding wear behaviour of Al 206 Aluminium alloy containing silica sand reinforcement was studied by Rohatgi et al. [4], and it was found that the addition of silica sand reduces the coefficient of friction. Short carbon reinforced aluminium matrix composites were studied by Liu et al. [5], and a decrease in wear rate was observed with increase in reinforcement fraction. Sawla et al. [6] have reported that wear resistance of the composite increases with increase in volume fraction of the dispersoids. Unlu et al. [7] investigated the effect of Al_2O_3–SiC reinforcement in Aluminium MMC fabricated by casting and powder metallurgy method. It was observed that the tribological and hardness property of the composite improved by the use of reinforcement. Tang et al. [8] have studied the effect of dry sliding wear parameters of Al-B_4C and a decrease in wear rate was observed with increase in wt% of the reinforcement. Daoud et al. [9] have reported that the increase in volume fraction of alumina in aluminium alloy 7075 matrix increased the wear resistance of the composite. Sannino et al. [10] have analyzed the effect of load, sliding velocity, sliding distance, counterpart material, weight % of reinforcement, shape and size on the specific wear and coefficient of friction. Turhan et al. [11] reported that wear resistance is strongly dependent on the sliding velocity.

Regression analysis involves identifying the relationship between a dependent variable and one or more independent variable. A model of the relationship is hypothesized, and estimates of the parameter values are used to develop an estimated regression equation. The model is evaluated for its accuracy using different estimators [12]. More accurate

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