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Artificial Neural Network Model for Friction Stir Processing

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Abstract— ***Friction stir processing (FSP) is an effective means of refining grain size of aluminum alloys. An artificial neural network model (ANN) is made for predicting the grain size of alloys which are processed by FSP. The simulated results from the model show how grain size varies with the process parameters.***

Keywords—**Friction stir processing, ANN, grain size, grain refinement**

I. Introduction

Friction stir processing (FSP) [1,2] is a surface modification technique developed on the principles of friction stir welding. FSP can result in grain size refinement because of the intense plastic deformation at the processed zone [3]. In case of aluminium alloys, recrystallized grain sizes in 1100 [4], 6061 [5,6] and 7075 [7] alloys ranged from 2 µm to 10 µm which were approximately 10 to 100 times smaller. Therefore FSP technique is effective for producing a fine-grained structure, a significant strengthening mechanism in metallic materials.

Most of the literature available in FSP is experimental. Considerable work has been there especially in aluminium alloys [5-8]. In this paper, artificial neural network analysis (ANN), a prominent soft computing method is used for predicting the grain size of aluminium alloys which are processed using FSP, at various working conditions, with the available data in the published literature [9]. Parameters such as rotation speed, traverse feed and the composition of the alloy are given as input and grain size is taken as the output. A parametric study involving the variables is also done after developing the neural network model..

II. Model Overview

The mechanical properties of aluminium alloys after stir processing depend upon the microstructure. In order to get the desired mechanical properties it is important to understand the correlation between the processing parameters and properties. In the present work, an ANN model have been used to simulate the grain size of the alloy processed using FSP.

The input parameters are rotation speed, traverse feed, and chemical composition of various aluminium alloys. The major alloying elements taken into consideration are Silicon, Copper, Magnesium, Zinc, and Manganese. 28 set of data for modelling and six set of data for testing were selected. The datasets are taken from published literature which have been summarized by Mishra et. al in Table 2, Friction stir welding and processing [9].The overview of the model showing the input and output parameters is shown in Fig 1

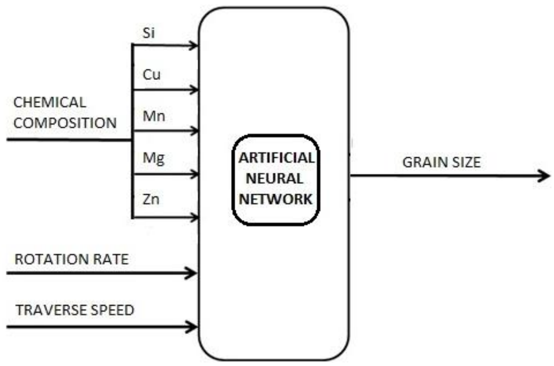

Fig. 1 ANN model overview

In this work the ANN is designed and trained using MATLAB® 7.4.0.287 (R2007a) package. Standard multilayers feed-forward networks were created. Before training the data set was divided into two groups. Six data were selected randomly for testing the model set. All other data were selected for training. For the created ANN the general structure of input, one hidden and one output layer was used. In order to determine the optimal architecture, the ANN was trained with different number of neurons in the hidden layer and different transfer functions. The best result from the ANN was taken. For all cases a linear transfer function (*purelin*) was used in the output layers and tangent sigmoid transfer function (*tansig*) was used in the hidden layer. The networks were automatically initialized with the default parameters.

III. Results and Discussion

Using the model the output values were simulated and compared with the experimental data. The comparison between experimentally observed and computed grain size for the training data is shown in Fig.2 and for test data is shown in Fig. 3.

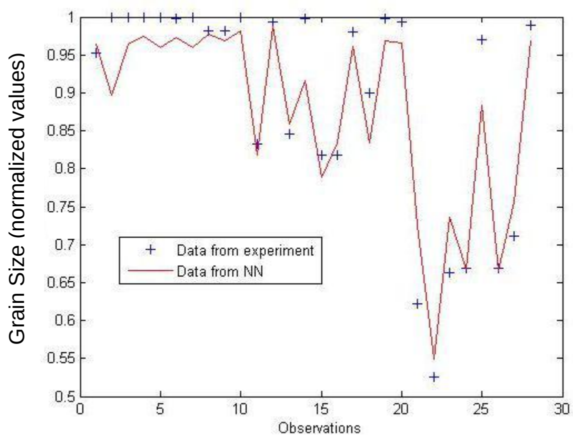

Fig.2 Comparison between experimentally observed and computed grain size

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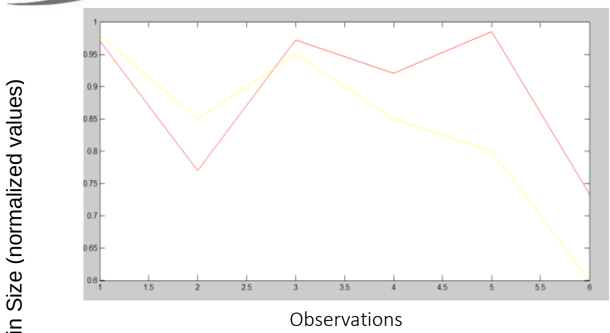

3._Comparison between experimental values and values generated by ANN model.(Red line represents values generated by ANN model and yellow line represents experimental values)

The model could simulate the values with a fair bit of accuracy. More than 90% of the data were below the 10% error limit. A parametric study with the values simulated from the model was also done to observe the variations of grain size with the input parameters such as rotation speed of the tool and feed. Fig. 4, Fig.5, Fig.6, and Fig.7, shows the variation of the grain size with the variation in speed and feed for the alloys 6013Al-T4, 7010Al, 2024Al, and 7075Al respectively.

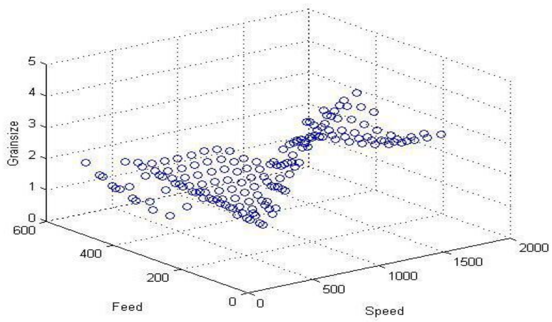

Fig 4. (6013Al-T4)

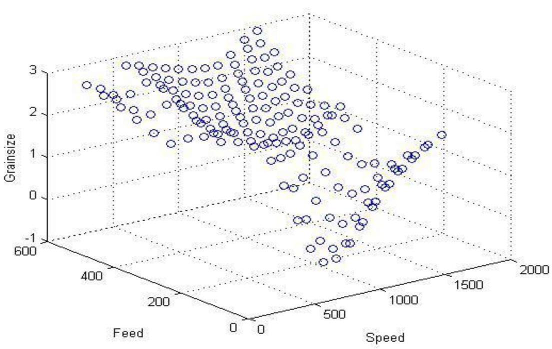

Fig.5 (7010Al)

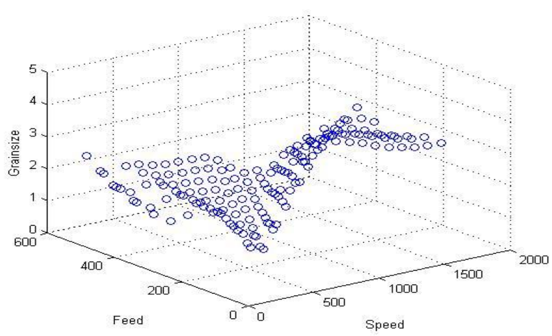

Fig 6 (2024Al)

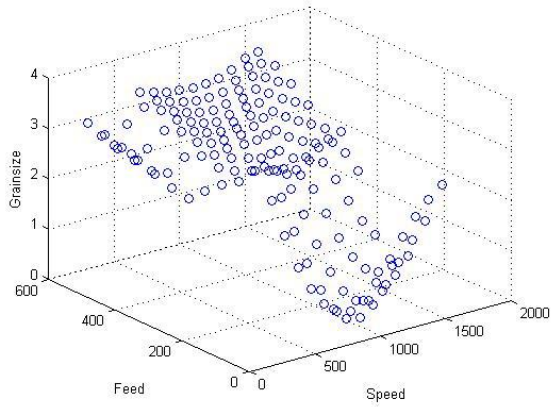

Fig 7 (7075Al)

It can be observed from the plots that the optimum grain size is for lower feeds and speeds. The reason for this can be attributed that when the feed is low it favours localized heating and then the rapid cooling causes dynamic recrystallization [10] resulting in a fine grained structure. When the speed is further increased it might result in grain growth owing to a higher temperature.

IV. Conclusion

The goal of the present work was to develop a model connecting various stir processing parameters such as feed, speed, chemical composition of alloy and grain size. An ANN model was developed for the same. Comparison between ANN predicted values and experimental values shows good agreement. It has been observed from the simulated results that grain refinement is better at lower feeds and speeds..

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