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Comparative analysis of thrust force, roughness and roundness error in drilling of aluminium composites using RSM, ANN and fuzzy logic

S. Senthil Babu, C. Dhanasekaran

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Abstract

Making holes without any defect in a solid product made of hybrid Aluminium composite material, is a difficult job in assembly industries. Hybrid composite of Aluminium 7075 reinforced with ceramic materials like silicon carbide, boron carbide, graphite and mica are used in automobile and structural industries due to their excellent mechanical properties. Thrust force developed during drilling, Error in the circularity and poor surface finish of the drilled holes are some of the common problems faced in the drilling process. Hence, to optimise the quality of drilling, analysing these responses under various conditions of drilling by varying the drilling factor become essential. This study discusses the development of various models to predict the thrust force developed, roughness and circularity error in the holes drilled on a hybrid metal matrix composite. Testing of drilling is conducted in CNC vertical machining centre using Titanium aluminium nitride (TiAlN) coated carbide drill tool of 5 mm diameter. Various drilling factors considered in our study are point angle of the drill tool, drilling speed and feed rate. Multiple regression equations using RSM, Artificial neural network (ANN) and Fuzzy Logic algorithms are used to develop the prediction models. The predicted values of thrust force, surface roughness and circularity error from these models are found to be matching with the observed experimental values.

Introduction

Hybrid metal matrix composites structure a gathering of materials that have been drawn in by number of analysts as a result of their superior properties when contrasted with monolithic materials.

More trials have been made to create mechanical parts utilizing these composite materials, but some proportion of completing ought to be done to finish the assembly cycle. Regardless, for assembly and joining, extra machining process like drilling is required. Due to hard reinforcement materials, drilling of hybrid composites turned into a difficult task in the manufacturing ventures.

Different variables of drilling process influence the nature of drilled holes. Circularity error and surface roughness in drilling hybrid metal matrix composite materials have been seen to be impacted by different boundaries like shaft speed, geometry of the twist drill, drilling speed and the tool coatings.

Our objective in this work is to conduct different drilling experiments on the prepared hybrid composite specimen of Al7075 using TiAlN coated carbide drill by varying the mentioned drilling parameters and to formulate three different predictive models using RSM, ANN and Fuzzy Logic and to compare them with the experimental values.

Section snippets

Literature review

Murthy et al. [1] analysed the impact of various factors involved in drilling like axle speed, feed rate, drill diameter, point angle, and material thickness on the roughness of the drilled hole surface in Glass Fiber Reinforced Polymer utilizing uncoated carbide tools and anticipated the relationship between the drilling force and the surface roughness. They utilized Taguchi and Surface Response Methodology. Similar to that Raviraj et al. [2] used Taguchi and Surface Roughness Methodology in…

Materials and methods

For the experimentation the specimen is prepared by using the Stir Casting Process. Stir Casting is a liquid state technique for the preparation of composite materials used first by A.Tony Thomas et al. [12], in which the reinforce materials are blended homogeneously with the molten aluminium (Al7075) matrix with the help of stirring by ceramic stirrer. The Al7075 alloy in the form of long bar was cut into number of small sized pieces and in a graphite crucible they are heated and softened. The …

Results and discussion

The following mathematical models (1), (2), (3) were developed using Response Surface Methodology (RSM) for Specimen 1 and the predicted values have been calculated using the coded factors of −1, 0 and 1 for the levels 1, 2 and 3 respectively and then tabulated in Table 3.

$$\textbf{Thrust force} = 202.74 - 16.02A - 72.83B + 41.83C + 10.65AB - 22.77AC - 24.2BC - -49.66A^2 + 4.47B^2 - -6.65C^2$$

$$\textbf{Roughness} = 7.17 - -0.91A - -0.7B + 0.96C + 0.19AB - -0.17AC + 0.16BC + 2.42A^2 - -0.28B^2 - -0.32C^2$$

$$\textbf{Circularity Error} = 0.062 + 2.156 \times 10^{-3}A + 9.55 \times 10^{-3}B + 0.014C - -1.893 \times \ldots$$

Conclusion

Various experiments are conducted to develop models for predicting the thrust force developed, roughness and circulatory error in the drilled holes on the hybrid composite of Al7075. The following conclusions are made from the developed three different prediction models. It has been found that the desirable point angle of the tool for the drilling operation taken into consideration is 118°. It can also be concluded that the responses of the composite material specimen become poor as the point…

CRediT authorship contribution statement

S. Senthil Babu: Conceptualization, Methodology, Investigation, Validation. **C. Dhanasekaran:** Supervision.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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