MACHINING STUDIES ON END MILLING OF EPOXY GRANITE COMPOSITES

A ABSTRACT

Submitted by

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ABSTRACT

Machine tool structures manufactured by conventional materials like cast iron and other metals exhibit sufficient strength, stiffness and stability but possess lesser damping capabilities that limit their overall performance and functionality. Several research investigations in the field of materials science during the recent past have led to the invention of alternate and novel composite materials with tailor made properties to meet the desired needs of various applications. Epoxy granite, a particle reinforced polymer composite material with excellent damping characteristics, has evolved as an alternate composite material in the development of machine tool structures without any trade-off among strength, stiffness and stability. Machine tool constructions made from epoxy granite composites are manufactured by molding, and the finished products are not near net form, necessitating supplementary machining processes such as milling, drilling, and tapping for assembly. This research investigation pre-dominantly focuses on the machining characteristics and performance of epoxy granite composites by carrying out end milling under dry machining conditions.

With a full factorial design that included 27 separate experiment trials, the experimental investigations in the first module of the study were carried out using Taguchi's Design of Experiments (DOE). Granite aggregates that ranged in size from 50 to 600 m were coarsely crushed and sieved to create the composites. Epoxy resin was then added to the mixture to further process it into a composite. The studies were carried out with a High Speed Steel (HSS) end mill cutting tool with a 10 mm diameter and machining parameters such as spindle speed values ranging from 600 to 1800 rpm, feed rate ranging from 0.03 to 0.09 m/min, and glass fibre reinforcement ranging from 0 to 4 percent for the composite. Both the thrust and tangential components of the

various characteristics discovered by this experimental research. The choice of an appropriate cutting tool material for end milling epoxy granite composites was made in the first module of this research work. The best machining parameter combination, as derived by the TOPSIS decision-making model, was the basis for experimental research. The trials were carried out, and in relation to the length of the machining, the tool wear was measured. The findings of this investigation show that wear resistance is possible for machining lengths up to 5 metres with a tool wear of 0.3 mm.

Milling, a material removal process that employs a multi-point cutting tool is essentially a complex machining process and incurs lot of resources. Determination of machining responses for every machining parameter combination based on experimental investigations is a time-consuming process and leads to process inefficiency and incurs huge cost for the product development. The prediction of machining responses sufficiently reduces the time and cost involved and leads to process efficiency. The second module of this research project develops the mathematical models for the machining reactions, which are described as functions of the machining parameters spindle speed, feed rate, and fibre content in the composite. These models include the thrust and tangential component of forces as well as surface roughness. Twenty separate experimental trials were used in experimental studies based on Central Composite Design (CCD). With the aid of the Response Surface Methodology (RSM) technique, mathematical models were created. All three reactions have mathematical models that have been developed, and it has been discovered that these models are quite consistent, with projected values that closely match experimental findings.

In the final module of this research work, finite element models are developed and the results are validated with the experimental results of milling of epoxy granite composites. The finite element model is developed based on Johnson-Cook constitutive material model approach and further, the material coefficients of Johnson-Cook constitutive model are determined from the stress-strain plots of static and compressive tests of the epoxy granite composites. The numerical analysis is performed and the cutting force components, thrust and tangential force and equivalent stresses generated are determined. The percentage of discrepancy between the numerical results and the experimental findings in the milling of epoxy granite composites is found to be quite low. Speed is recognised as the crucial element that significantly affects the forces and stresses produced during machining epoxy granite composites.

The research studies performed on the machining characteristics and performance of end milling epoxy granite composites will serve as a clear scope, ideology and knowledge resource for researchers, scientists and metallurgists are pursuing research in the domain of composites machining. This research study on end milling of epoxy granite composites by determining optimal machining parameters, appropriate cutting tool, and identification of Johnson-Cook (JC) material model coefficients has not been attempted previously, and thus provides information to carry out comprehensive and in-depth machining studies.