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Machinability Analysis and ANFIS modelling on Advanced Machining of Hybrid Metal Matrix Composites for Aerospace Applications

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ABSTRACT

Wire Electrical Discharge Machining (WEDM) is a competent method employed for machining intricate shapes in electrically conductive harder materials. Metal Matrix Composites (MMCs) possesses improved properties and considered as an alternate material for various engineering applications. An enduring issue with MMCs is that they are problematic for machining, because of abrasive nature of hard reinforcing phase. This current exploration is dealing the WEDM machinability analysis of LM6/SiC/Dunite Hybrid Metal Matrix Composites (HMMC) fabricated by two step stir casting process and to develop an artificial intelligence decision making model for WEDM the process parameters. The influence of input machining process variables namely Pulse ON, Pulse OFF, Flushing Pressure, Wire Feed and Servo Voltage against the desired output like Material Removal Rate (MRR), Surface finish, overcut, circularity error and perpendicularity error are investigated. Grey Relational Analysis (GRA) method is employed and grey relational coefficient values are given as input values for evolving the Adaptive Neuro Fuzzy Inference System (ANFIS) to predict the desired performance characteristic. A comparative study has been accomplished for validating the outcomes attained from evolved models and experimentation outcomes. The performance analysis of developed model proves that the developed model and this method are efficacious for predicting the desired performance measures.

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Introduction

Metal Matrix Composites (MMCs) proposed better ratio of strength to weight, more stiffness over an extensive range of working situations, leads those materials as a fascinating choice in alternating traditional materials for various engineering usages.[1] MMCs are employed greatly in defense, automotives, aerospace industries, and furthermore in military components. Generally the composite materials demonstrate homogeneousness, non-ductile behavior and anisotropy.[2] Essentially, the metal matrix ingredients of MMCs are Al, Ti, Cu and Mg alloys, along with reinforcement materials are SiC, Al_2O_3, B_4C, etc., especially in the form of whiskers, elements and fibers, which are recurrently employed in production of MMC for numerous applications.[3] Dunite is chiefly obtained as an accompanying product during mining of magnesite. It is a plutonic rock which is an igneous and ultramafic composition with coarse grained structure and rich in magnesia having nearby 40% of magnesium oxide (MgO) and 36% silicon dioxide (SiO_2) which is used in refractory products and adopted as flux for dolomite as a source of MgO in sintering process and moreover in Iron and Steel Industries. In India most of dunites were produced in Karnataka and Tamil Nadu states public sector mines.

Amongst the diverse Hybrid Metal Matrix Composites (HMMC's), Al-based HMMC's become the greatest consideration from analysts, for its characteristics and wider ranges of usages. This strengthened composite offers enhanced mechanical properties contrasted with monolithic alloys.[4] The method of producing the MMC commonly relies on the variety of reinforcements and fabrication methods. Many investigators have been adopted distinct approaches for producing MMC's, i.e. vapor deposition, liquid, solid/semi-solid state and the method of in-situ production.[5] Aravindan et al.[6] fabricated Mg alloy (AZ91D) composite material which is having the reinforcement materials as 'SiC' particles with various proportion of volume by two step stir cast method and evaluated the physical and mechanical properties under heat treated and casting conditions. It was observed that the mechanical characteristics of composite have been getting improved with increase of 'SiC' particles and abate with escalating in size of the particle. Aluminum MMC strengthened with 'B_4C' particulates have been produced by two-step stir cast method. To evade the accumulation of 'B_4C' particulates, halide salt in the proportion of 0.2 was commixed with 'B_4C' particulates and the amalgam was kept in the melt. Improvement in mechanical properties was observed and it was also observed that the 'B_4C' particulates dispersed homogeneously without agglomeration in 6061Al matrix.[7,8]

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