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Influence of materials and machining parameters on WEDM of Al/AlCoCrFeNiMo$_{0.5}$ MMC

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ABSTRACT

The current study intends to optimize the wire electric discharge machining (WEDM) parameters while machining the newer AlCoCrFeNiMo$_{0.5}$ high entropy alloy (HEA) particles-reinforced aluminum composites. AlCoCrFeNiMo$_{0.5}$ HEA particles produced through arc melting technique are reinforced here for different weight % (0%, 3%, 6%, 9%, 12%, and 15%) along with pure aluminum by the way of powder metallurgy. WEDM studies were conducted by varying the appropriate parameters, namely, pulse ON time, pulse OFF time, and wire feed. Based on the selected parameters, through Taguchi method L18 orthogonal array is designed; the optimal parameter combination for better surface finish, material removal rate (MRR), and reduced kerf width (KW) is identified. For better understanding, through ANOVA, also the effect of each input variables over these adopted response variables was analyzed. The yielded results reveal that addition of AlCoCrFeNiMo$_{0.5}$ HEA as reinforcement has considerable effect over the response variablessuch that MRR and KW reduces; surface roughness increases with increase in HEA %. ANOVA results confirm that pulse ON time has higher effect over the response variables than any other parameters involved for the study. Multi-objective optimization done through Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methodology answers that MRR and surface finish have improved, whereas KW gets reduced noticeably.

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Introduction

Imperative need for materials that too with exceptional properties always prevails to meet out the emergence of innovative and stringent requirements posed by manufacturing firms. As known, conventional engineering materials are unable to accomplish any such requirements of special properties (like that of hot hardness, high strength, low weight, and temperature resistance) that are suitable for miscellaneous industries as like automotive, aerospace, etc., Consequently, the current arena of newer researches has emerged out composite materials as a new class of engineering materials that can easily outfit the necessitates of the aforesaid industries. Nevertheless, such materials are hard to get machined in a conventional way just because of the existence of high strength reinforcements in the metal–matrix composite (MMC). This would again definitely lead for rapid wear and tear of cutting tools during machining[1] and any such causes as reported earlier will certainly show the way for lower cutting rate and subsequent increase in production cost.[2] In general, it is well known that machining parameters such as surface characteristics, metal removal rate (MRR), geometrical accuracy, and certain other vital factors significantly change the lifetime and economy of a component[3] besides owing to the actuality in modern manufacturing industries that there is a continuous search for accurate and highly complex shaped profiles based on the requirements of different end users.

Accordingly, there is a factual requirement to improve the machining performance for this newer range of emerging materials and therefore, nontraditional machining methods including abrasive jet machining, water jet machining, and electrical discharging machining (EDM) were generally utilized to machine any such difficult-to-cut materials.[2] Among these proven nontraditional machining methodologies, the process that could possibly overcome the hurdles posed by the conventional machining at all times will usually be the wire electric discharge machining (WEDM) process. Hence, nowadays, WEDM has become a preferential process under regular usage to machine those components with intricate profiles and thus attain better MRR besides providing a good surface texture.[4]

WEDM, one of the advanced machining process is commonly used in industries to cut hard-to-machine materials make use of a wire as cutting tool and thermoelectric source of energy to remove the excess material from the subjected electrically conductive specimen material such as steel, copper, etc., and thus attain the desired profile. In WEDM, various factors namely current, voltage, pulse timings, wire feed, wire tension, dielectric flow, etc., always show a significant effect over the

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