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Artificial Neural Network based Modelling of Wire Electrical Discharge Machining on Tungsten-Copper Composite

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Abstract

Tungsten-Copper (W-Cu) composite is a multifunctional material used in electrical and thermal applications. However, the microstructural properties of W-Cu composite make the cutting process more difficult. In this paper, the authors employed Wire Electrical Discharge Machining (WEDM) of W-Cu composite with the intention to model the process using Artificial Neural Network (ANN). This is achieved by performing the experiments according to central composite design approach of response surface methodology, developing the different ANN models for material removal rate and selecting the most appropriate model.Pulse on Time, Pulse off Time, Peak Current, Wire Tension and Spark Gap Set Voltage are considered as the process variables. The predicted results from ANN model are compared with experimental values and have been observed quite satisfactory.

*Keywords:*ANN; CCD; W-Cu; WEDM; RSM

1. Introduction

Composite materials have gained great importance over the last two decades and their applications havebecome widespread. Due to a unique combination of the high electrical and thermal conductivity of Copper (Cu) and lower coefficient of thermal expansion, high hardness, high melting point, and high arc erosion resistance of Tungsten (W),

Nomenclature

ANN	Artificial Neural Network
I	Input layer
IP	Peak Current
MRR	Material Removal Rate
O	Output layer
SV	Spark Gap Voltage
Toff	Pulse off Time
Ton	Pulse on Time
W-Cu	Tungsten-Copper
WT	Wire Tension

these elements are very good candidates for production of composites having suitable thermo- electrical and arc resistance properties [1-3].As, tungsten and copper have no solid solubility with each other, phasing is observed between tungsten and copper in the microstructure of W-Cu composites. So, W-Cu is not alloys, but considered as a type of composite material.W–Cu composites have been widely used as arc resistant electrodes, electric contact materials, heat sink materials and electrodes for electro discharge machining (EDM), [4,5].Further, the conventional machining methods proven to be unsuccessful to machine these composites due to their microstructure features [6,7].As, W-Cu composites are significantly brittle, they are not suited to be machined by traditional machining approachesThe studies concerning the machining of W-Cu composites are limited and the machinability aspects of W-Cu composites have not fully explored [8,9].Therefore, it is noteworthy, especially to study the feasibility of wire electrical discharge machining of W-Cu composites.

WEDM has become an important non-traditional machining process, widely used in the aerospace, nuclear and automotive industries. Subsequently, WEDM process provides an operational result for machining hard materials with complicated profiles, which are challenging to be machined by conventional machining approaches. Furthermore, WEDM process is more economical, if it is used to cut difficult to machine materials with complex, precise and accurate contours in low volume and greater variety. The most important performance measure in WEDM is material removal rate (MRR)[10]. Therefore, in this paper an attempt has been made to model the WEDM on W-Cu composite using artificial neural network.

2. Materials and method

2.1 Materials and experimental setup

The material chosen for this study is 70W-30Cu composite (70 wt%W, 30 wt%Cu), prepared using powder metallurgy (directly procured). The 70W-30Cu composite was fabricated by mixing tungsten and copper powders to the desired proportion. Subsequently, the mixture was pressurized and moulded into compacts 0.2-0.3 mm larger in every dimension than the final product, after which it was sintered at a temperature higher than 2000° C. An advantage of this method is the efficient use of expensive tungsten, since the machining allowance will be much smaller than required by the infiltration method. Figure 1 shows the homogeneous microstructure of 70W-30Cu composite used in this study.The hardness and conductivity of material are 91-92 HRB and 41% IACS respectively. The density of material is 13.6 g/cm^3.