Chapter 10
Machine Learning Approach of Bio Silica Suspended Dielectric in EDM of Ti6Al4V for Biomedical Application

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ABSTRACT

A machine learning technique, the artificial neural network is used to predict the output responses of Ti6Al4V in electrical discharge machining, using nano bio silica infused vegetable oil methyl ester dielectric fluid and optimizing the operating parameters of electrical discharge machining by using the Jaya algorithm. The input parameters of the experiments are peak current, pulse on time, discharge voltage, and duty cycle, and the measured output responses are the material removal rate, tool wear rate, and surface roughness. The optimal architecture of the artificial neural network model is recognized as 4-10-10-3. The correlation coefficient of the artificial neural network prediction is 0.9626, and the least mean absolute percentage error of the material removal rate, tool wear rate, and surface roughness are 0.8129, 0.3337, and 1.2595%, respectively. The artificial neural network predicted accurate results and the Jaya algorithm optimized the operating parameters of Ti6Al4V in electrical discharge machining.

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INTRODUCTION

Electrical discharge machining (EDM) is the most familiar method of machining and plays a substantial role in modern manufacturing industries. EDM is the unconventional machining technique used in the high precision industries like mold and die manufacturing (Puertas & Luis, 2004). EDM is focused mainly on the work material, electrode, dielectrics and operating parameters (Ayanesh & Anand, 2019). EDM is a thermo-electric process, where the workpiece is machined by the electric spark generated between the tool and workpiece. The tool and workpiece are immersed in the dielectric fluid with high potential difference (Singh et al., 2004). Dielectric plays a vital role in EDM and responsible for the quality of finished product. The various dielectrics used in EDM are water, gaseous and mineral oil-based dielectrics (Chen et al., 1999; Gua et al., 2016; Kuineda et al., 1997). Janak B Valaki et al. (2014) reviewed and reported that these dielectrics developed a negative impact on both human beings and the environment. Many researchers tried to replace these dielectrics with biodegradable dielectric fluids (Nishant et al., 2020; Mishra & Routara, 2020; Kiran et al., 2022). Singaravel et al., (2020) experimented with the Ti-6Al-4V in EDM using various dielectrics such as kerosene, sunflower, canola and jatropha oils and reported that among various dielectrics, the dielectric properties and erosion mechanism of vegetable oil is similar to that of kerosene. Valaki & Rathod, (2016) performed the EDM using waste vegetable oil (WVO) and kerosene as dielectrics and the results revealed that WVO as a bio dielectric fluid used in EDM showed better performance than kerosene. Pragadish et al., (2022) investigated the optimization of the machining characteristics of silicon steel in EDM using a cardanol oil infused water-based dielectric and tool made of nickel-coated brass. The result showed that the higher material removal rate (MRR) and less tool wear rate (TWR) is observed in cardanol oil infused water-based dielectric. The raw vegetable oil is selected as a dielectric medium in EDM due to its exceptional biodegradability and renewability.

Vegetable oils have excellent properties and are used as lubricating oils (Bekal & Bhat, 2012) and dielectric fluids (Ishfaq et al., 2022). The thermo-oxidative stability of vegetable oils has very poor limitations (Sancheti & Yadav, 2022). Pranav et al., (2022) improved the thermo-oxidative stability of non-edible tree seed oil by epoxidation and transesterification techniques. Methyl ester derived from vegetable oil is used as a dielectric medium in EDM applications (Avinash et al., 2021; Basha et al., 2021; Valaki et al., 2016). Jatropha bio diesel (JBD) is used as a dielectric in EDM by Valaki et al., (2021) who exposed that high material removal rate, less surface roughness and better surface hardness is observed in JBD than in kerosene. Furthermore, the melting of the material and mechanism of evaporation in JBD is very similar to that of kerosene. Pallavi & Sikata, (2022) studied the comparative analysis between the Pongamia-pinnata seed oil, bio-diesel and conventional EDM oil by COMSOL software. The result concluded that biodiesel as a dielectric in EDM achieved higher MRR with a higher over cut. The characteristics and performance of various machining techniques are improved by the inclusion of nano additives in the metal working fluid (Jay Vora et al., 2022) and the dielectric fluid (Kumar et al., 2018). Computational techniques are implemented by the various researchers in the manufacturing processes (Gupta et al., 2015). Paturi et al., 2021). The survey of these literatures agreed that very limited published articles are available in the field of EDM using methyl ester from vegetable oil as a dielectric medium. These reviews exposed that none of the research papers reports on the Machine learning technique in EDM using nano bio additive infused vegetable oil methyl ester as a dielectric medium. Hence, this work emphasises on implementing the machine learning of Ti6Al4V in EDM using nano bio silica dispersed canola oil methyl ester. The predicted ANN model is compared with the RSM model and the Jaya algorithm is used to optimize the operating parameters of Ti6Al4V in EDM.

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