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A review on performance of process parameters of electric discharge machining with molybdenum

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Abstract
Electrical discharge machining (EDM) is a highly regarded method for producing ultra-Precise mechanical parts. It generally used for all type of electrically conductive materials to create deep holes, cavity and complex geometrical shape and sizes. EDM used for machining turbine components, Engines, Transmission System for automotive industries and mould creation for plastic and rubber industries. EDM process is based on thermoelectric energy between workpiece and electrode. Material removal occurs with spark between the workpiece and electrode through melting and vapourizing. The tool electrode and workpiece are deep under dielectric fluid like kerosene, deionized water and other fluids. The main purpose of this study is to explore the information about electrical discharge machining of molybdenum material using different tools and techniques for optimum result of the experiments. This paper reviews the effect of EDM parameters like peak current, pulse on time and gap voltage for molybdenum machining with flat surface electrode of copper and brass. Output response parameters such as material removal rate (MRR), surface roughness (Ra), Tool wear rate (TWR) analyse after the experiment.

Keywords: EDM, Molybdenum, MRR, TWR, Copper tool, Surface roughness

1. Introduction

Electrical Discharge Machining (EDM) is an advanced and non-contact technique. This machining Method has been widely used to produce ultra-precise mechanical parts, aviation, components and So on. This method has been efficient for fabricating complex mold parts or drilling Small/ultra-small holes with great depth in high-hardness materials that are difficult to obtain using conventional machining methods. EDM employs a controllable discharge sequence in which the discharge process between an electrode and a work piece in a dielectric fluid is continuously repeated. There is no mechanical contact between the electrode and the work piece during EDM. During discharge a large amount of thermal energy is generated between the electrode and work piece surfaces. The generated temperature ranges between 8000 °C and 12000 °C and can reach 20000 °C, resulting in the formation of molten metal puddles on both the electrodes and work piece surfaces. Due to the high temperature, some puddles will directly vaporize, while the remainder will become molten metal debris. The dielectric fluid flow will remove the debris from the space between the electrode and the work piece. For the EDM process, the electrode plays a vital role since it directly and significantly influences the accuracy of the machined parts, machining time, and the economics of the fabrication. Thus precise and high quality electrodes for EDM machining are required. With outstanding properties, including high electrical and thermal conductivity, strong structural integrity, and excellent surface finishes, copper has been widely used as an electrode material in EDM.

2. Literature Review

In this paper Kapil Surani, Shailesh Patel, Ali Jawad Alrubaie, Ankit Oza, Hitesh Panchal, Sandeep Kumar, and Sasan Zahmatkesh (2022) [1] "performance of powder-mixed Electrical Discharge Machining (EDM) and traditional EDM on TZM-molybdenum super alloy" The study utilizes response surface methodology (RSM) to analyze the machining process. Powder-mixed EDM involves adding a conductive powder to the dielectric fluid, aiming to enhance efficiency and surface quality. The paper evaluates parameters such as material removal rate, surface roughness, and tool wear rate. Results suggest powder-mixed EDM outperforms traditional EDM in terms of these parameters the study optimizes process parameters using RSM.

In this paper R. Demellayer and J. Richard (2013) [2] "high-precision Electro Discharge Machining (EDM) techniques applied to molybdenum and tungsten materials" based on the methods for achieving precise machining outcomes on these challenging materials. Topics covered may include the experimental setup, process parameters, surface finish evaluation, and possibly comparison with traditional machining methods. The paper aims to contribute insights into optimizing EDM processes for enhancing precision in machining molybdenum and tungsten materials, which are known for their hardness and difficulty to machine using conventional methods.

In this paper Dhruv H. Gajjar and Prof. Jayesh V. Desai (2015) [3] "optimizing Material Removal Rate (MRR), Surface Roughness, and Kerf Width in Wire EDM(WEDM) using molybdenum wire" They investigates the effects of various process parameters such as voltage, current, pulse-on time, and pulse-off time on the mentioned machining characteristics. Through experimental setups and data analysis, the authors aim to determine the optimal parameters for maximizing MRR while minimizing surface roughness and kerf width in wire EDM using molybdenum wire. This research likely contributes insights into improving the efficiency and precision of wire EDM processes on challenging materials like molybdenum.

In this paper Vijay D. Patel, Dr. D.M. Patel, Prof. U.J. Patel, Biraj Patel, and Nilesh Butani (2014) [4] "phenomenon of surface roughness (SR) in Wire Electrical Discharge Machining (WEDM) utilizing molybdenum wire". They explore the factors influencing surface roughness in EDM processes, such as discharge current, pulse duration, wire tension, and flushing parameters. Through experimentation and analysis, the paper aims to provide insights into optimizing EDM settings to minimize surface roughness and improve machining quality when using molybdenum wire. This study likely contributes valuable information to enhance the precision and efficiency of EDM processes on challenging materials like molybdenum.

In this paper Lin Gua, Yingmou Zhua, Fawang Zhanga, Ahmad Farhadia, Wansheng Zhaoa (2018) [5] explores the "mechanism and parameter optimization of electro discharge machining (EDM) for a specific alloy composed of titanium, zirconium, and molybdenum (Ti-Zr-Mo)"investigate the factors influencing the EDM process for this alloy, aiming to enhance efficiency and accuracy. They analyze parameters such as discharge current, pulse duration, and electrode material to determine their effects on material removal rate and surface quality. It involves experimental testing and analysis to identify optimal machining conditions for the Ti-Zr-Mo alloy.

In this paper K L Wu1, H J Chen, H M Lee and J S Lo (2017) "machining of molybdenum using two different processes: EDM-EP (Electro Discharge Machining with Electrolyte Plasma) and EDC (Electro Discharge Chemical) processes" Discusses the effectiveness and efficiency of these processes for machining molybdenum, a challenging material due to its high melting point and brittleness. They may explore parameters such as discharge current, voltage, and electrolyte composition to optimize material removal rate and surface finish. The study likely involves experimental testing and analysis to compare the performance of EDM-EP and EDC processes in machining molybdenum.

In this paper Shankar Singh, S. Maheshwari, and P.C. Pandey (2004) [7] "electric discharge machining (EDM) of hardened tool steel" specifically exploring the effects of employing different electrode materials. Through their investigations, they aim to discern how the choice of electrode material influences the efficiency and outcomes of the EDM process on hardened tool steel.

In this paper K. Mouralova, L. Benes, T. Prokes, J. Bednar, R. Zahradnicek, and J. Fries "machining of pure molybdenum utilizing Wire Electrical Discharge Machining (WEDM)" investigates the process parameters and conditions necessary for effectively machining pure molybdenum using WEDM, aiming to provide insights into optimizing the machining of this material for industrial applications.

In this paper Kapil Surani, Shailesh Patel, Hitesh Panchal, Naveen Gupta, Tarang Shinde, and Yogita Sharma "mathematical model for predicting radial overcut in powder mixed micro-electrical discharge machining (μ-EDM) of TZM-molybdenum superalloy" employs response surface methodology to develop the model, aiming to understand the relationship between process parameters and radial overcut. By doing so, the research contributes to optimizing the μ-EDM process for machining TZM-molybdenum superalloy with improved accuracy and efficiency.

3. Conclusions

From the above literature review of the research papers, each study shows different aspects of EDM that effect of electrode material, process parameters effect on output result such as material removal rate (MRR), tool wear rate (TWR) and surface roughness. It is obeserv that no more research found on molybdenum material so it is necessary to analyze the MRR and SR and micro internal structure on such kind of material.

It is observe that there is no parameter combination available on internet source neither on any reference book. So it required to focus to more research on such extremely hard and low electrical conductive material and also more research on parameter combination it require to focus on residual stresses generated while machining operation on molybdenum with scanning electron microscopic and x-ray diffraction testing.

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