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Influence of Al Powder on Circularity During Micro-Electro-Discharge Machining of Monel K-500

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ABSTRACT

In the present era, μ-EDM is a promising non-conventional micro-machining process for drilling as well as cutting of electrically conductive materials in the micron range. The objectives of the present research work is to investigate the influence of various parameters such as peak current, pulse ON-time, working time, and aluminium powder concentration on circularity and to find out the significant process parameters based on Taguchi method during micro hole drilling on Monel K-500 with the help of an EDM set-up. Further, a mathematical model has been developed to correlate the relationship between process parameters and circularity based on Response Surface Methodology (RSM). Circularity is increased from 1 to 1.5 A of peak current, from 0.5 to 1.5 sec of working time and from 1 to 4 gm/lit of aluminium concentration. The maximum value of circularity is obtained as 0.976 at the parametric combination of 1.2 A of peak current, 1.8 sec of working time and 3.33 (gm/lit) of Al powder concentration.

KEYWORDS

Al Powder, Circularity, Monel K-500, RSM, Taguchi, μ-EDM

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1. INTRODUCTION

Micro-EDM process is popular alternative to produce precise complex features on difficult-to-cut but electrically conducting materials. It is a competent micro-machining process for fabrication of a micro-holes, which are utilised for several purposes in micro electro-mechanical systems (MEMS), such as inkjet printer nozzles, spinner holes, turbine blade cooling channels, diesel fuel injection nozzles and drug delivery orifices, etc. (Diver, Atkinson, Helmi, & Li, 2004). Also, it is a common feature in different microproducts used in aerospace, automotive, medical, biomedical and nuclear sector, etc., where materials used have to resist wear and bear high temperature and pressure. Uhlmann et al. (2005) represented an overview on the state of the art of micro-electrical discharge machining technologies for applications in the field of micro/miniature die and mould making. Leao and Pashby (2004) observed that the performance of plain water in terms of material removal rate and electrode wear was generally lower when compared to that obtained with hydrocarbon oils in die sink EDM. Distilled water was reported as superior to hydrocarbon oil with a Ti-6Al-4V workpiece and copper electrode. Sing et al. (2004) found that the overcut depended upon the gap voltage and chip size, which varied with the amperage used. The copper and copper-tungsten electrodes had minimal wear. Brass and aluminium attributed a considerable increase in the electrode wear with the increase in the discharge current. Moghaddam and Kolahan (2014, 2015) investigated on the influences of input EDM parameters such as peak current (I), pulse on time, pulse off time, duty factor and voltage on the surface quality of 2312 hot worked steel parts using Taguchi L_{36} design matrix. The relations between input and output parameters were established and the optimal set of process parameters for material removal rate (MRR), tool wear rate and surface roughness were found out with help of genetic algorithm, statistical analysis and simulated annealing algorithm. Suryavanshi et al. (2014) developed a finite element method based thermal model to estimate the surface roughness based on the geometry of crater produced during micro-EDM process using the temperature field in the workpiece. Kim et al. (2007) documented that deionised water would be maintained carefully because its resistivity was decreased by absorption of carbon di-oxide from air otherwise the discharge gap became wide and then precision machining became difficult to carry out. If the resistivity of deionised water was too low, dielectric breakdown occurred even in the large gap between the tool electrode and the workpiece. Uhlmann and Roehner (2008) observed that using novel electrode materials like electrically conductive boron doped CVD diamond (BCVD) and polycrystalline diamond (PCD), the machining performances could be enhanced with minimum relative wear. The workpiece surface was found smoother when machined with B-CVD tool electrode compared to PCD and tungsten copper tool electrodes. Kung et al. (2009) carried out the study on the powder mixed electrical discharge machining (PMEDM) of cobalt-bonded tungsten carbide (WC-Co). Talla et al. (2016) investigated on the influence of various powder-suspended dielectrics and machining parameters on various EDM characteristics at the time of machining of Inconel 625. Karunakaran