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Modelling and Optimization of Hole circularity and Hole Dilation in Electrical Discharge Drilling

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Abstract

Due to thermal nature and electrical discharge, the hole circularity and hole dilation are the main challenging problems during the electrical discharge drilling of different materials. These may be optimized by finding the optimum parameter levels for multi-objective optimization. In this research, hole circularity and hole dilation have been modelled by using experimental data obtained by L_{27} Orthogonal array. For the experimentation, discharge current, pulse on time, pulse off time and dielectric pressure have been used as input process parameters. The theoretical validation of the developed models shows that the models may be used for the prediction of hole circularity and hole dilation satisfactorily. Grey relational analysis has been used for the multi-objective optimization of these quality characteristics as Grey relational analysis minimizes the uncertainty of the experimental data. For the optimization, equal weights of both quality characteristics have been considered. The comparison of optimum results with initial parameter setting shows an improvements of 20% and 35% in hole circularity and hole dilation, respectively.

Keywords: *Electrical Discharge Drilling; Orthogonal Array; Hole Circularity; Hole Dilation; Multi-objective Optimization; Grey Relational Analysis;*

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1. Introduction

Electro Discharge Drilling(EDD) is an electro-thermal non-traditional machining process, where electrical energy is used to generate electrical spark. Material removal mainly occurs due to thermal energy of the spark [1]. Micro-EDD is a machining process that is known to be capable of drilling burr-free holes in a wide range of materials regardless of their hardness as long as the material is electrically conductive. Micro-EDD is a recently developed process which is used to produce micro-parts in the range of 50µm -100µm. In this process, metal is removed from the work piece by melting and vaporization due to pulse discharges that occur in a small gap between the work piece and the electrode. It is a machining process used for fabrication of a micro-metal hole and can be used to machine hard electrically conductive materials. The characteristic of non-contact between the tool and the work piece in this process eliminates the chance of stress being developed on the work piece by the cutting tool force.

EDD is based on the erosion of electrically conductive materials through the series of spatially discrete high-frequency electrical discharges (sparks) between the tool and the work piece. Each spark occurs between the closest points of the electrode and the work piece as shown below in Fig 1. The spark removes material from both the electrode and work piece, which increases the sparking gap (distance between the electrode and the work piece) at that point. This causes the next spark to occur at the next-closest points between the electrode and work piece. The sparking phenomena during micro-EDD can be separated into three important phases named as preparation phase for ignition, discharge phase and interval phase between discharges.

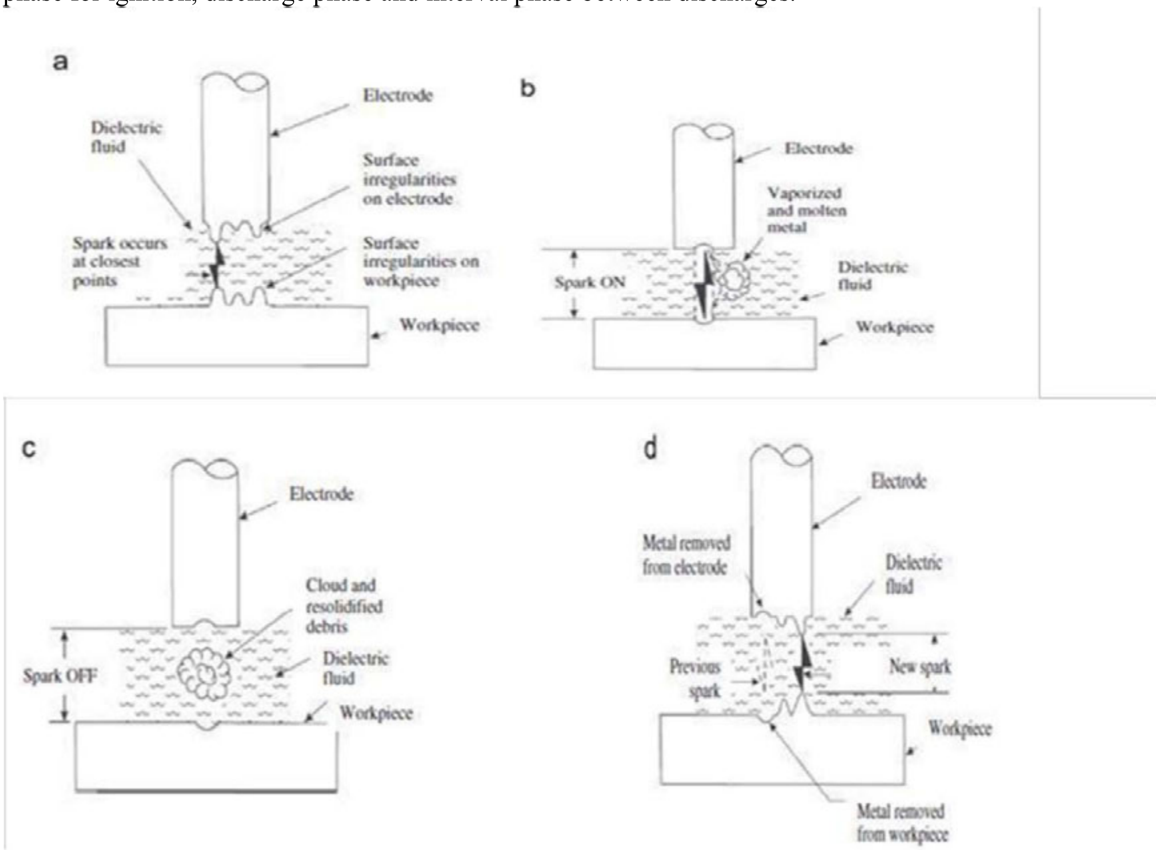

Fig 1: Steps involved in Spark Propagation in EDD, (a)occurrence of spark at the closest point between work piece and electrode,(b) melting and vaporization of work piece and electrode materials during spark on time,(c)vaporized cloud of materials suspended in dielectric fluid, and(d) removal of molten metal and occurrence of next spark