Chapter 6

Optimizing the Electrical Discharge Drilling Process for High Aspect Micro Hole Drilling in Die Steel

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ABSTRACT

Electric discharge drilling (EDD) is a thermo erosion process used to produce holes in high strength materials for various applications such as fuel injectors, medical devices, turbine blades cooling channels etc. In this chapter, high aspect micro holes are drilled in die steel (of thickness 15 mm) using tubular electrodes of diameter 500µm. Using Taguchi' design of experiment method, four process parameters namely electrode material, discharge current (Ip), pulse on time (Ton) and pulse-off time (Toff) are investigated and optimized for two performance characteristics namely drilling rate (DR) and electrode wear rate (EWR). DR and EWR are opposite in nature, i.e. DR is higher the better type of characteristics while EWR is lower the better type of characteristics. Using Grey relational analysis (GRA) along with Taguchi method, both the characteristics are optimized simultaneously. Through GRA, grey relational grade has been computed as a performance index for predicting the optimal parameters setting for multi machining characteristics.

1. INTRODUCTION

Micro-holes are now becoming integral part of several components especially micro devices such as micro nozzles, micro-electro mechanical system (MEMS), inkjet printer nozzles, medical equipments, and aerospace applications such as drilling in turbine blades for cooling purpose etc. (Yu et al. 2009, D’Usro 2014). Drilling of micro holes with tight geometric tolerance relies on the micro technology used. Currently to produce micro geometries on different kind of materials, there are different manufacturing methods including micro-electrical discharge machining (EDM), electron beam machining.
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(EBM), laser machining, lithography, chemical etching, electro-chemical machining (ECM) and micro ultrasonic machining (MUSM) etc (Vaezi et al., 2013).

The micro-EDM is one of the most important technologies for fabricating micro 3D shapes such as micro holes, micro dies, micro shafts on variety of materials (Cho et al., 2008). Micro-EDM is highly preferred over other processes because of its comparatively better drilling rate, ability to machine hard and composite materials, burr free surface etc. EDM is a non contact machining process involving electrical thermal energy by repetitive sparks between tool electrode and work material (Kuppan et al., 2008).

Electrical discharge drilling (EDD) is a modified electrical discharge machining (EDM) process to produce high aspect macro to micro holes with tight tolerance in hard and composite conductive materials. EDD employs rotating tubular electrode of small diameter ranging from 0.2 mm to 3mm for drilling as represented in Figure 1. In case of tubular electrodes, the dielectric fluid is pumped through the hollow cavity of the electrode at very high pressure under the work material and tool electrode. The combination of very high dielectric pressure, rotation of electrode and servo controlled feed of electrode magnifies the material removal rate in EDD as compared to micro EDM. In EDM, there are many factors affecting the process performance; these can be related either to the process parameters such as voltage, peak current, pulse duration, spark gap and flushing conditions or to the system such as type of dielectric fluid, tool properties, chemical and physical properties of material (D’Urso and Merla, 2014).

In this chapter, Taguchi’s design of experimental (Ross, 1996; Roy, 2001) approach is presented to determine the influence of electrode material, discharge current (Ip), Pulse-on time (Ton) and Pulse-off time (Toff) on performance characteristics of micro electrical discharge drilling. Drilling rate (DR) and electrode wear rate (EWR) are the performance characteristics while EDD in die steel. For drilling micro holes, copper and brass tubular electrodes of diameter 500µm are utilised. Taguchi method is designed to optimize the single performance characteristics only. The grey relational analysis (GRA) has been

Figure 1. Schematic diagram of EDD (modified I nYilmaz et al. 2010)
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