ABSTRACT

Rapid advancement in manufacturing industries and increasing demand for micro-parts has given rise to advancement in micro manufacturing techniques. In recent years, numerous developments in micro-EDM focus on the fabrication of micro-holes, micro-tools and micro components. Although micro-holes are formed by different manufacturing methods, micro-EDM proves to be one of the most promising manufacturing technologies. Even though, micro-EDM is found to be capable of manufacturing micro-holes regardless of hardness, the study on quality and integrity of discharge machined surface is shown important as it has a significant impact on the product performance.

Since an electrode with micro features is employed to cut its mirror image in the workpiece, it is necessary to investigate the machining efficiency of the electrodes used. Furthermore, to improve the machining efficiency, it is momentous to consider the effect of various influencing input and output parameters.

In this study, a series of experiments were conducted with various electrodes such as tungsten, copper, copper tungsten and silver tungsten of 300µm diameter as a tool and EN24 die steel as workpiece to machine blind holes of 500µm depth on the workpiece using RC type generator. The
combination of gap voltage, capacitance, feed rate and threshold setting were considered for maximum Material Removal Rate (MRR), lower Tool Wear Ratio (TWR), Surface Roughness (SR), constrained circularity error and overcut. The main aim was to identify the electrode which could enhance the production of quality micro-holes and to have a significant contribution for modern industrial requirements.

From the experimental analysis, it was found that gap voltage and capacitance exert more influence on MRR and copper followed by silver tungsten exhibited better MRR. To achieve lower TWR, lower discharge level was appreciable and tungsten proved to show good performance followed by silver tungsten. For high machining precision, the low surface roughness is essential and it was observed from the study that the lowest surface roughness could be achieved with lower gap voltage, capacitance and feed rate. And it was also observed that silver tungsten provided lower surface roughness. In addition, to obtain good surface quality micro-hole, a detailed study was made on micro-hardness, heat affected zone features such as recast layer, and micro-cracks, circularity error and overcut.

Moreover, a comparative study on the machining performance of all the electrodes with the most influencing parameters such as MRR, TWR and surface roughness using Taguchi-based grey relational analysis was made. From the observation, it was identified that the significant machining parameters value was gap voltage in the range of 80-100V, capacitance 0.1nF, feed rate 2-6µm/s and threshold 20-60%.
Finally, non-linear multi regression mathematical equations were generated for MRR, TWR and surface roughness using SPSS software. Consequently, gap voltage and capacitance were found to be the most influencing parameters of the machining performance. The results show that the thermal and electrical properties of the electrodes play a significant role in determining the machining performance of die-sinking micro-EDM.