ABSTRACT

Stiff market competition and ever-growing demand for better, durable and reliable products has brought about a material revolution, which has greatly expanded the families of difficult-to-machine materials namely high carbon high chromium die steel, stainless steel and super alloys. Advanced materials play an increasingly important role in modern manufacturing industries especially in automobile, metal forming and aerospace applications. Conventional machining of the above materials proves to be uneconomical. Electrochemical Machining (ECM) offers solution to the expanding need for machining of the above materials. However, it lacks in performance like poor surface finish, high power consumption and higher operating cost.

This investigation attempts to improve the performance of ECM by achieving an improved Material Removal Rate (MRR) and surface roughness. In order to improve the performance of ECM, new electrolyte jet patterns and rotating tools are introduced. The present investigation considers five electrolyte jet patterns namely straight jet in circular pattern, inclined jet in circular pattern, straight jet in spiral pattern, inclined jet in spiral pattern and inclined jet in square pattern for experimentation. Also, investigations have been made on the effects of non-rotating and rotating tools on the MRR and surface roughness. The performance consistency of the electrolyte jet patterns have been evaluated by using three different materials viz. commercially available High Carbon High Chromium (HCHC) die steel with hardness of
63 HRC, AISI 202 Austenitic stainless steel with poor machinability and AISI 1035 Medium carbon steel.

The effects of the influencing parameters namely; tool feed rate, applied voltage, electrolyte discharge rate and rotary tool speed on the MRR and surface roughness have been reported.

Straight jet in spiral pattern performs satisfactorily in obtaining better MRR and surface roughness under non-rotating and rotating conditions of tool with NaCl aqua electrolyte solution. Inclined jet in spiral pattern performs better in obtaining improved surface roughness under non-rotating and rotating conditions of tool with NaNO₃ aqua electrolyte solution.

Optimization of influencing parameters has been carried out using Response Surface Methodology (RSM), which leads to development of mathematical models for MRR and surface roughness.

Experimental results analyzed by ANOVA indicate the improved performance of ECM. The developed mathematical models provide a good relationship between the selected influencing factors and the objectives due to higher values of $R^2$. Linear and interaction effects are significant on the objectives, when compared to that of square effects.

The confirmatory experiments were conducted and results reveal that the actual performance deviates from the predicted RSM model by 4 to 6 % only. Hence, the developed mathematical models can be used for obtaining maximum MRR and minimum surface roughness.