ABSTRACT

The present work is concerned with studying the effect of electrical discharge machining (EDM) and powder mixing electrical discharge machining (PMEDM) parameters (pulse current, pulse on time) using copper and graphite electrodes on the induced surface residual stresses, the material removal rate (MRR), the tool wear ratio (TWR), the workpiece surface roughness (SR), the white layer thickness (WLT), the total heat flux generated, the workpiece fatigue life and safety factors.

Response surface methodology (RSM) and the design of experiment (DOE) were used to plan and design the experimental work matrices for four groups of experiments, two EDM groups using kerosene dielectric alone, where the second was treated by the shot blast peening processes after EDM machining. The third and fourth groups were done by adding 5g/lit. SiC or graphite micro powders mixing to dielectric fluid (PMEDM). To verify the experimental results, the analyses of variance (ANOVA) were used to predict the EDM and PMEDM performance models for high carbon high chromium AISI D2 die steel. The total heat flux generated, the workpiece fatigue life in terms of safety factors after EDM and PMEDM models were developed by FEM using ANSYS 15.0 software.

The results showed that copper electrodes and graphite powder reduced the induced tensile residual stresses by (79.3%) and (82.6 %) when compared with using kerosene dielectric alone or with SiC powder, respectively.

Graphite electrodes with graphite powder increased the MRR by (174%) with respect to the value obtained when using copper electrodes with kerosene dielectric alone.

The least TWR were obtained when using the graphite electrodes and kerosene dielectric alone reached (0.1023 %). This result reduced the TWR by (320%) compared with using copper electrodes with kerosene dielectric alone.

SiC powder with copper and graphite electrodes reduced the SR by (134%) and (110%), respectively compared with the using of the same electrodes and kerosene dielectric alone.

The lowest WLT values of (5.0 μm) and (5.57 μm) using the copper and graphite electrodes and the SiC powder, respectivelly. This means an improvement by (134%) and (67%) when compared with the using of the copper and graphite electrodes and kerosene dielectric alone, respectively

The SiC powder and graphite electrodes gave a higher total heat flux than copper electrodes by (91.5 %) and by (285.3 %) and (602.7 %) than using the copper and graphite electrodes and the kerosene dielectric alone, respectively.

Fatigue life and fatigue stresses at (10^6 cycles) were increased with increasing the shot peening time to 60 minutes by (19.10%) and (23.26%) compared with the copper and graphite electrodes without shot peening processes, respectively.

The copper electrodes and fatigue stresses at (10^6 cycles) with graphite powder increased the experimental fatigue safety factor by (30.38 %) compared with the using of graphite electrodes and by (15.73 %) and (19.77 %) compared with results of group (1) using the copper and graphite electrodes, respectively.

These results increase the metal removal rate, decrease the tool wear ratio, increase the fatigue life by reducing the surface residual stresses, the surface roughness and the white layer thickness all of which works to reduce production costs, increase competitiveness and improved the life performance.

Finally, there is a good agreement between the experimental results and the verified by using the optimization process for all cases regarding the input parameters of the EDM and PMEDM processes, and this proves the accuracy of the models developed by the RSM and FEM using ANSYS software.