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Topic of Research: Investigation on Machining of Hard-to-Machine Material using EDM

Findings

In order to model the wire EDM of insulating ceramic material, an experiment-based investigation was conducted and the results are presented in this study. The zirconia workpiece was machined by sticking (a) copper AE and (b) stainless steel AE plates with a thickness of 0.96 mm to the top and bottom. The successful machining of zirconia was accomplished by utilising a hybrid AE-WEDM process. The addition of alumina powder and ethylene glycol to the dielectric when machining zirconia in the presence of an assisting electrode enhances the machining. From the results of the experimentations following conclusions can be drawn:

- Rising the value of either pulse on time (T_{on}) or peak current (I_P) significantly increases the value of length of cut (L_C) and average surface micro hardness (MH) because rising the value of either T_{on} or I_P increases the discharge energy.
- However, due to the I_P and T_{on} being dependent on the discharge energy. The thermal energy that might be involved in the formation of the carbon layer is also decreased when these two parameters are reduced, which leads to reduce the erosion of material and hence decreases the Kerf and Ra.
- It was witnessed that copper AE causes for lower Kerf, and Ra in compared to stainless steel AE, however stainless steel AE results in higher L_C and MH, when compared to copper AE.
- Results of the CRITIC based EDAS method confirmed that experiment No. 1 with control parameter setting of $(AE_M)_1(T_{on})_1(I_P)_1$ provides the optimum value of various responses (Rank 1). Where, the optimal value of multiple responses were noted as Kerf = 202.767 µm, L_C = 891.846 µm, Ra = 5.065 µm, and MH = 1360.350 HV.
- Illustration of SEM image displayed that due to the low T_{on} (60 µs), low I_P (4 amp), and Cu AE stable and low intensity spark was generated during machining that causes for the formation of micro voids on the zirconia specimens with less embedment of alumina particles from dielectric fluid.
- The EDS analysis confirms the need for a secondary electrically conducting layer to be made in order to machine the insulating ceramic. As it illustrated the presence of foreign element from AE and dielectric fluid on the surface of zirconia specimen.

Moreover, in case of WEDM of aluminium oxide it was witnessed that;

- The machining of insulating alumina ceramic using AE based WEDM process is performed successfully.
- The addition of Al_2O_3 powder and ethylene glycol affectively stabilizes the flow of discharge and advances the dimensional accuracy. Non-conducting powder mixed dielectric fluid increases the dielectric strength of dielectric fluid and decrease the spark length that leads to produce small sparks that causes for the uniform and small erosion of material.

- Experimental results concluded that increase in I_P significantly increases the average Kerf and L_C. As increasing the value of I_P significantly enhances the spark energy that leads to increase the erosion of material.
- It is observed that increasing the value of T_{on} improves the average Kerf and L_C. Rising T_{on} provides more time to absorb heat energy that leads to enhance the melting and vaporisation of work material, which leads to an increase in MRR.