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ELECTRIC DISCHARGE MACHINING TO OPTIMIZE PROCESS PARAMETERS: A REVIEW

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ARTICLE INFO **ABSTRACT** **REVIEW ARTICLE**

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The prediction of optimal machining conditions for the required surface finish and dimensional accuracy related to electrode wear rate plays a very important role in process planning of electrical discharge machining (EDM). The present work deals with the review article of electrical discharge machining of stainless steel. Finally, suggest the responses and factor has been optimized for machining in various methods.

1. INTRODUCTION OF EDM

Electrical Discharge Machining, commonly known as EDM is a non-conventional machining method used to remove material by a number of repetitive electrical discharges of small duration and high current density between the workpiece and the tool. EDM is an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. In EDM, since there is no direct contact between the workpiece and the electrode, hence there are no mechanical forces existing between them. Any type of conductive material can be machined using EDM irrespective of the hardness or toughness of the material.

EDM has become an important and cost-effective method of machining extremely tough and brittle electrically conductive materials. It is widely used in the process of making molds and dies and sections of complex geometry and intricate shapes. The workpiece material selected in this experiment is Stainless steel taking into account its wide usage in industrial applications. In today's world stainless steel contributes to almost half of the world's production and consumption for industrial purposes. Wire-cut EDM, also known as Spark EDM is mostly used when low residual stresses are required, as it does not needs high cutting forces for removal of material.

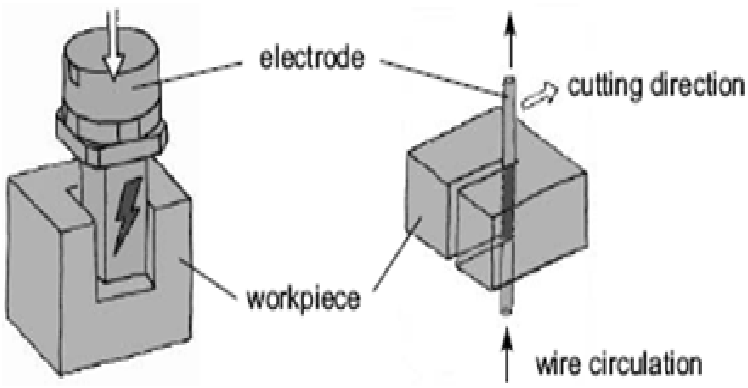

Fig.1. Die sinking & wire cut EDM Process [16]

2. MATERIAL REMOVAL RATE RELATED RESEARCH

Kuppan et al. (2007) [4] derived a mathematical model for MRR of deep hole drilling of Inconel 718 using Response Surface Methodology (RSM) and revealed that MRR is more influenced by Ip, Tau and electrode rotation. For higher MRR, a large pulse current is encouraged to increase electrode wear implanting electrode material onto the workpiece. Wong and Noble (1986) [5] investigated the machining with cylindrical electrodes with microcomputer controllers. In recent times, the MRR improvement technique has been developed by modifying the basic principle of EDM, which delivers single discharge for each electrical pulse. An oxygen assisted EDM system, which greatly improves the MRR was tested by supplying oxygen into the discharge gap by Kunieda et al. (1999) [6], besides MRR can be substantially improved with reduced TWR using a multi-electrode discharging system using without any improvement in surface roughness. Kunieda and Masuzawa (1998) [7] investigated a horizontal EDM is proposed for a more productive and accurate technique than a conventional vertical EDM. Experimental and analytical investigations proved the following characteristics of the horizontal EDM. Eroded particles can easily flow out of the working gap as a result of buoyancy of bubbles. This effect is further significant when both the electrode and workpiece are rotated synchronously.

A FEM model has been developed by Yadav et al. (2002)[8] to approximate the temperature field and thermal stresses due to Gaussian heat flux distribution of a spark during EDM of HSS material. The effects of process variables such as Ip and Tau on these responses have been reported. A single spark produces significant compressive and tensile stresses beneath the spark location and mostly the thermal stresses exceed the yield strength of the workpiece in an extremely thin zone near the spark. Marafona and Chousal (2006) [9] developed a thermal-electrical model using copper and iron as anode and cathode respectively. Sparks generated by electrical discharge in a liquid media and the obtained FEM results were compared with the experimental values of the table of AGIE SIT used by other researchers. The TWR and MRR, as well as surface roughness results, agree reasonably well with them. Allen and Chen (2007) [10] reported a thermo-numerical model for material removal on molybdenum by a single spark. The effects of EDM parameters on the crater dimension and the tool wear percentage are studied. FEM results were also presented to show how the thermal action of the micro-EDM process affected the surface integrity of the machined workpiece.

A FEM base model was reported by Das et al. (2003) [11] using process parameters such as power input, pulse duration, and others, to predict the transient temperature distribution, liquid and solid state material transformation, and residual stresses induced in L_6 steel. The model was able to predict the shape of the crater formed during the material removal was also validated experimentally.

3. TOOL WEAR RELATED RESEARCH

The tool wear is moderately analogous to the Material Removal Mechanism (MRM) in EDM. Mohri et al. [1995] [12] proved that tool wear is affected by the precipitation of turbostratic carbon from the hydrocarbon dielectric on the electrode surface during sparking. Also, the rapid wear on the electrode edge was because of the failure of carbon to precipitate at difficult-to-reach regions of the electrode. From this easy understanding of tool wear, some useful applications exploiting both the advantages and disadvantages of electrode wear have been developed. Bleys et al. [2002] [13] devised an online tool wear compensation method based on the pulse analysis and controlled the tool feed movement in real time. Kunieda and Kobayashi [2004] [14] clarifies the mechanism of determining tool electrode wear ratio in EDM by spectroscopic measurement of the vapor density of the tool electrode material

Longer Ton results in lower TWR and deposition of a thicker carbon layer on the tool electrode surface. Conversely, the density of copper vapor evaporated from the tool electrode surface was found to be lower when the carbon layer was thicker, indicating that tool electrode wear might be prevented by the protective effects of the carbon layer. The well-known machining strategy to recompense the tool wear is the orbiting of the electrode relative to the workpiece, where a planetary motion creating an effective flushing action, provided better part accuracy and process efficiency [Snoeys et al., 1986] [15]. This technique also trimmed down the number of different electrodes necessary for initial roughing and final finishing operations [Staelens and Kruth, 1989] [16]. Dauw and Snoeys [1986] [17] derived the measurement of tool wear from the study of pulse characteristics based on discharge voltage fall time. Yu et al. [1998][18] established a uniform tool wear machining method to compensate the longitudinal tool wear by applying an overlapping backward and forward machining motion.

B.S. Reddy et al. [19] carried out a study on the effect of EDM parameters over MRR, TWR, SR, and hardness. Mixed factorial design of experiments and multiple regression analysis techniques had been employed to achieve the desired results. The parameters in the decreasing order of importance for; MRR: servo, duty cycle, current, and voltage; TWR: current, servo and duty cycle; SR: current; HRB: servo only. M.M. Rahman et al. [20] investigated the effect of the peak current and pulse duration on the performance characteristics of the EDM. The conclusions drawn were: the current and pulse on time greatly affected the MRR, TWR, and SR, the MRR increases almost linearly with the increasing current, the SR increases linearly with current for a different pulse on time, TWR increased with increasing peak current while decreased when the pulse on time was increased.

I. Puertas et al. [21] carried out results which showed that the intensity and pulse time factor was the most important in the case of SR while the duty cycle factor was not significant at all. The intensity factor was again influential in the case of TWR. The important factors in case of MRR were the intensity followed by the duty cycle and the pulse time.

S.H. Tomadi et al. [22] investigated the machining of tungsten carbide with copper tungsten as an electrode. The full factorial design of experiments was used for analyzing the parameters. In the case of SR, the important factors were voltage and pulse off time while current and pulse on time were not significant. For MRR the most influential was a pulse on time followed by voltage, current, and pulse off time. Finally, in the case of TWR, the important factor was pulse off time followed by peak current.

Iqbal and Khan [23] concluded that the voltage and rotational speed of the electrode are the two significant parameters for EDM milling. Optimization is concerned with maximizing the MRR and minimizing EWR along with an optimum Ra.

Norliana Mohd Abbas et al. [24] studied the research trends in dry wire EDM, EDM in water, EDM with powder additives, EDM on ultrasonic vibration and modeling techniques in predicting EDM performances. For every method that was introduced and employed in EDM process, the objectives were the same: to improve the capability of machining performances, to get improved output product and to create better technologies to machine new materials.

Singh and Maheshwari [25] found that the input parameters such as current, pulse on time, the voltage applied and the workpiece material greatly influences overcut. It increases with the increase of current but only up to a certain limit. It also depends on the gap voltage. Kiyak and Cakir [26] found that SR of workpiece and electrode were influenced by current and pulse on time, higher values of these parameters increased the surface roughness. Lower current and pulse time and higher pulse off time produced a better surface finish.

B. Bhattacharyya et al. [27] observed that peak current and pulse on time significantly influenced different criteria of surface integrity such as surface crack density, surface roughness, and white layer thickness. S Dhar et al. [28] came to the following conclusions: with an increase in peak current MRR, TWR and ROC increased significantly in a nonlinear fashion; MRR and ROC increased with the increase in pulse on time and gap voltage was found to have some effect on the three responses.

4. CONCLUSION

Finally, the literature presented research work under various in these areas in the last twenty years, along with possible future trends. The general direction of study relates to machining performance evaluation, for instance, MRR, TWR and surface integrity achieved after machining. However, many investigations were also directed toward monitoring and control of the process parameters. A second-order mathematical model, in terms of machining parameters, was developed for surface roughness and electrode wear rate (EWR) using response surface methodology (RSM).

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