A conceptual study of Material removal rate and Electrode wear rate towards the machining Capabilities for the combination of Tool steel and copper using Electro Discharge Machine

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Abstract — **Electro discharge Machine (EDM) is one of most applicable machine for the machining of hard and conductive material. Electro discharge machine is working on the principle of erosion of material due to spark established between electrode and work piece. The aim of this review paper is to explore the electro discharge machining processes using copper and tool steel. The sequence of the review paper is discussion about electro discharge machine in introduction section followed by literature review and concluding remarks have been discussed.**

Index Terms — **EDM, Copper, die steel, surface roughness, MRR**

I. Introduction

Electro discharge machine is a nontraditional manufacturing process based on material removal from the base material by the repetitive spark from electrode. Electro discharge machine is widely used in industrial application of die and mould making of complex shapes. The electro discharge machining has been invented during 1940. [1]

As shown in fig.1, Electro discharge machine set up, which includes dielectric tank, fixture for work piece, electrode holder, dial gauge for alignment, micrometer for depth of cut, control panel or Digital read out (DRO) for parameter variation in current, pulse on time, pulse of time, depth of cut etc.

Electro discharge machine shown in fig is sparkonix made machine along with the capacity of maximum 25 Amp. The range of pulse on time is 0 to 10 micro seconds, and range of pulse of time is also 0 to 10 micro seconds. The researcher can use the shown electro discharge machine for the machining of hard and conductive material for the manufacturing of die and mould. The material used in electro discharge machines are copper, brass, graphite. In general copper electrode material find the wide application in industries.

As shown in fig.2, electro discharge machine set up which contains dielectric tank, dielectric fluid, work piece, movable electrode, and servo control mechanism. When small voltage is applied to the electrode and work piece, dielectric medium will get ionized and due to ionization of dielectric medium current will pass in form of spark. High temperature will generate in the region of spark and metal will melt as well as vaporize. Flushing of dielectric ensures the removal of melted metal form the machining region and cavity is crated as the shape of electrode.

Figure. 1: Electro-discharge machine

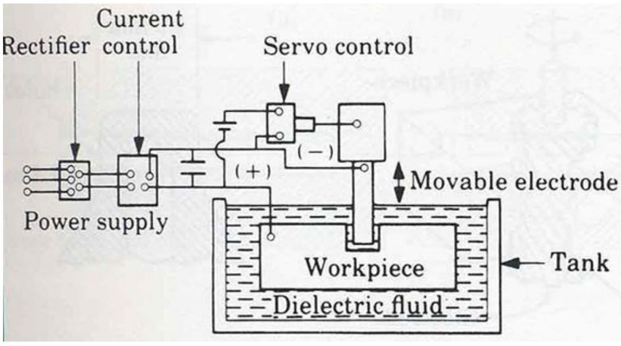

Figure. 2: Electro discharge machine set up.

Source: Nikhil Kumar et al., [2]

The die sinking electro discharge machining process (EDM) is a thermal process, in which material is removed by the action of high electrical sparks. The main advantage of EDM process is hard and conductive materials can be machined into desired complex shapes without any contact between the tool and the work piece. The paper flow is as follows, at the outset introduction regarding the electro discharge machine has been discussed followed by literature review and at last concluding remarks have been revealed.

II. LITERATURE REVIEW.

Habib S, et al., stated that, the experimental investigation of the observations revealed that the metal removal rate, tool wear ratio, gap size and roughness in electrical discharge machining are greatly influenced by the various crucial process parameters considered in the research. However, the metal removal rate increases with an increase in pulse on time, current and relatively with gap voltage. Metal removal rate decreases with increase of silicon carbide percentage. Electrode wear ratio increases with an increase of both pulses on time and peak current and decreases with increase of both of silicon carbide percentage and gap voltage. The gap decreases with the increase of silicon carbide percentage and increases with increase of pulse on time, peak current and gap voltage. Finally, the surface roughness increases with increase of pulse on time, SiC percentage, peak current and gap voltage.

Furthermore, Roy, K, et al., suggested that the influential effect of the different input parameters such as Pulse on time, Pulse off time, Peak Current and potential differences over the surface roughness for an EN41 material. It has been observed that the discharge current had a great impact over the surface roughness parameter. The effect of the other parameters was critically less and can be avoided. The interaction plots also showed negligible effect over the Surface Roughness value. The entire result was calculated at 95 % confidence level and the experimental value so obtained was found very near to the predicted value and hence, the entire work is validated.

In support to above reviewer, Kumar, V., et al., [4] mentioned that, material removal rate plays a significant role in the manufacturing area as it decides on the time and cost. In this research current, pulse on time, cycle time and pulse off time were taken as an input process parameters, Taguchi method was mentioned for maximization of MRR of two different materials namely EN19 and EN41. The optimal process parameters have been found for maximum MRR for EN19 i.e., current 24 amps, voltage 40 V and pulse on time 400 µs while the same for EN41 are 24 amps, 40V, 400 µs and 2100 µs respectively. The predicted and measured value from confirmation test was compared by checking the variation in the percentage error. The minor variation percentage error was found during research. The experimental investigation value was validated with the analytical valu . It has been observed that the experimental data for EN19 and EN41 that the material removal rate for any particular combination of input parameters was higher for EN41 than that of EN19. This was due to the carbon percentages, as depicted in table II and III, decreases from EN19 to EN41 which increases the ease of material removal rate and hence the machining.

However, Mr. Shankar Singh et al., [6] stated that En-31 work material, copper and aluminium electrodes provide higher valu of material removal rate and lesser valu of electrode wear rate.. however, overcut has been produced on En-31 is comparatively low when using copper and aluminium electrodes, which may be preferred for En-31 when low overcut is the requirement. Copper and copper–tungsten electrodes provide comparatively low electrode wear for the tested work material. Aluminum electrode established good results while brass wears the most, of all the tested electrodes. Copper–tungsten electrode offers very low values of surface roughness at peak currents giving good surface finish for respective work material. Copper is comparatively a better electrode materials as it gives better material removal rate, low wear rate, for En-31 work material, and aluminum is next to copper in performance analysis.

Milan Kumar Das et al.,[7] described that the optimization of the input process parameters is carried out in ECM of EN31 tool steel for maximum material removal rate and minimum surface roughness. Grey relational analysis is effectively employed in combination with Taguchi design of experiments to optimize the multiple response problems. The optimal parameter combination is obtained as A1B2C2D1. A confirmation test is carried out to validate the obtained results. They [7] also described that more than forty precent of improvement in grey relational grade from initial to optimal stage. Thus, grey relation based Taguchi method optimizes the process parameters fairly well. ANOVA showed that electrolyte concentration has great influence on metal removal rate and surface roughness.

Furthermore, M.A. Ali, et al.,[7] claimed that the performance of die-sinking electro discharge machine process parameters on the response parameters such as material removal rate of Beryllium Copper was investigated. The machine voltage is the less significant factor, while peak current is the most significant factor. The higher value MRR can be obtained with combination of high level setting of peak current and t-on time. The changes of discharge current and t- on time have contributed to a great influence of MRR. It can be concluded that a storage spark with higher energy is produced when increasing peak current, subsequently more heat is generated and substantial quantity of heat utilized in material removal.

However, Puertas, I, et al., [9] described the most influential factor was once again peak current intensity, followed by the duty cycle factor, the pulse on time factor and the interaction effect of the first two. As shown in fig.3, the value of material removal rate increased, as would logically be expected,

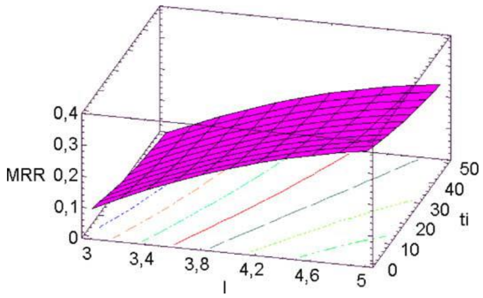

Figure. 3: Estimated response surface of MRR vs. *I* and *ti*.[9]

When intensity and duty cycle were increased, while an increase in pulse time and decrease in material removal rate.. Therefore, in order to obtain high values of material removal rate for the WC, within the work interval considered in their study, one should use, above all, high values for intensity and duty cycle. Furthermore, a lesser extent, low values of the pulse time factor should also be used.

Luis, J, et al., [10] stated that the material removal rate is only the influential factors, for 95 percentage confidence level. as shown in fig.4. It is clearly observed that the peak current and pulse on time increases the material removal rate is also increases significantly.

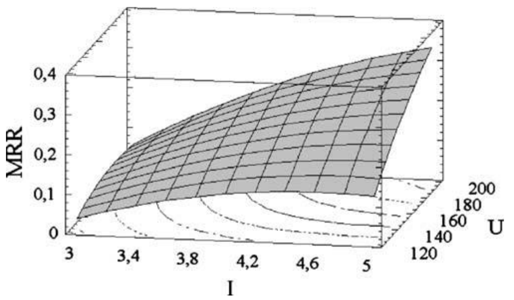

Figure 4: Estimated response surface of MRR vs. I and U.

The variation tendency of EW obtained in the case of intensity was the one that was expected in advance, whereas the opposite behavior was obtained in the case of pulse time. Moreover, in the case of flushing pressure, it was verified that an increase in the latter resulted in a decrease in the wear on the electrode.

Furthermore, Mane, V, et al.,[11] concluded that from the results of MRR we conclude that the Voltage is most significant or influencing factor then current and at last t- on time on the given input. Maximum material removal rate obtained was 2.8321 mm3/min and was obtained at 33A Current,25 Voltage and 5.75 µs Pulse on time. MRR increased linearly with some extent of current and Voltage and decreases slightly with pulse on time. Tool wear rate is mostly influence by pulse on time followed by voltage and lastly by current. TWR was found to have an increasing trend with the increase of pulse on time and voltage and reduced with increasing current. Minimum tool wear rate obtained is 0.0133 g/m and is obtained at 25A Current, 25v Voltage and 5.75 µs pulse on time.

The current is the most effective parameter after that voltage and followed by Ton related to surface roughness. Minimum Surface roughness obtained was 1.013µm and obtained at 30A current, 30 Voltage and 4µs t- on time. Electrode wear rate increased linearly with discharge current and Voltage and decreases slightly with t- on time. Predicted optimum setting obtained for maximizing material removal rate and minimizing electrode wear rate and SR is 23.52A current, 30v Voltage and 1.83µs pulse on time and predicted values of responses MRR, TWR and SR are 22.7033, 0.01426, 1.0116 and experimental values are 2.8520, 0.01340, 1.023 respectively.

In addition of above Lee, et al., mentioned that the effect of discharge current , it was observed that for all value of pulse duration, material removal rate increase with increase peak current in range of low current setting, and becomes constant when machining at higher value of peak current, the relative wear ratio first decrease slightly with the current and increase with further increase of the peak current as shown in fig.5

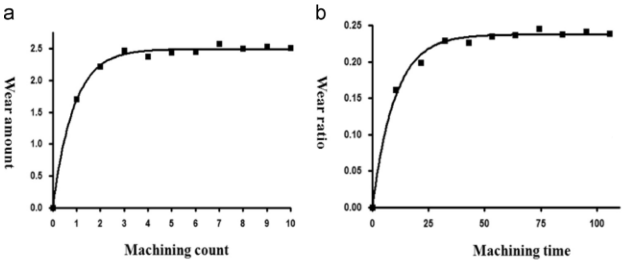

Figure.5: Curve of Wear ratio

There were an optimum peak current, at which the relative wear ratio was minimum for all setting of pulse duration. The surface roughness of work piece increases steadily with increasing peak current. Graphite electrode gives higher MRR.

However, Raghuraman S, et al., stated thatTaguchi's Signal – to – Noise ratio and Grey Analysis were applied in their work to improve the multi-response characteristics like as Material Removal Rate, TWR (Tool Wear Rate) and Roughness of mild steel IS 2026 during EDM process. They concluded that the optimal parameters combination was determined as A3B2C1 i.e. pulse current at 26A, pulse ON time at 55 µs and pulse off time at 5µs.The predicted results were checked with experimental results and a great agreement was found. This work demonstrates the method of using Guinichi Taguchi methods for optimizing the electro discharge machine parameters for multiple response characteristics.

CONCLUDING REMARKS

Electro discharge machine (EDM) is one of the most influential 'non-traditional manufacturing machining process' This study aims to explore the basic understanding of non-conventional machining processes of electro discharge machining in context to tool steel. From the thoroughly literature review we can infer that the material removal rate are very low while the electrode wear rate is also considerable amount in non-conventional machine. We also concluded that with use of proper sating of process parameter one can achieve higher material removal rate and lower tool wear rate. From the in-depth literature review we can suggest that the influencing parameters are peak current and spark on time. However, machining voltage and spark off time have less influence on the output parameter. We would also like to mentioned that spark 'ON' time should be greater than spark 'OFF' time.

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