

Review on Electro Discharge Machine [EDM] and Ultrasonic Assisted Electro Discharge Machine [USA-EDM]

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Abstract : Electrical Discharge Machining (EDM) is a non-traditional machining process used for machining of hard materials. EDM processes are used for cavity machining, producing dies and molds, and intricate machining operations in hard, difficult to machine. In recent years, researchers focused to improve the process performance of EDM processes. This paper reviews the research work carried out by the researchers on EDM and on vibration assisted EDM. The review of this research work enables the better understanding of the vibration assisted EDM process. This study also discusses the influence of vibration parameters such as vibration frequency and amplitude on the MRR, EWR, and surface roughness. The research gap in the respective area of research are also presented in this paper.

Keywords - EDM · USA-EDM, Work piece vibration, Tool vibration, MRR, EWR, Surface roughness

I. INTRODUCTION

It is a non-traditional electro-thermal machining process, in which electrical energy is used to generate electrical spark and material removal occurs due to thermal energy produced by the spark. As such thousands of sparks per unit second generated and each spark produces the tiny crater by heating and vaporization, thereby eroding the shape of the tool into the work piece. The dielectric fluid flushes out the removed material particles and confines the spark. Work material is to be electrically conductive to be machined by EDM.

The most common methods to evaluate machining performance in the EDM operation are based on the following performance characteristics: material removal rate (MRR), Surface Roughness and electrode wear ratio (EWR). A Proper selection of these machining parameters can result in a higher MRR and lower EWR. Earlier, the desired machining parameters are determined based on experience or on handbook values. But these selected machining parameters are not always optimal or near optimal for that particular EDM environment. Therefore in EDM, it is very important to select machining parameters for achieving optimum machining performance. Various techniques, both conventional and non-conventional processes are employed to predict the optimum response parameters of the process. EDM spark erosion is the same as having an electrical short that burns a small hole in a piece of metal it contacts. With the EDM process both the work piece material and the electrode material must be conductors of electricity. As such EDM is mainly used to machine high strength temperature resistant alloys and materials difficult-to-machine. EDM can be used to machine irregular geometries in small batches or even on job-shop basis.

Rationale and significance of the study:-

A static tool (electrode) offers little control on the quality of the surface finish of the work piece. With the introduction of 'vibrations' in the process of EDM, uniformity is realized in the material removal from a given region. The Ra value of the surface roughness is found to be more consistent in the case of EDM machine fitted with an 'Ultrasonic' Head for effecting vibrations in a controlled manner. The static tool does not warrant a satisfactory rate of material removal. A vibratory tool improves the MRR to a substantial extent for the same level of parameters for the process.

The significance for the process using 'Vibration' lies in the fact that the overall process for material removal by Electro-Discharge machining makes a crucial difference to the result achieved. The process could be utilized in applications demanding uniformity in the surface finish as well as high rate of material removal for the roughing operations. In general, the value of the surface roughness is higher while engaging the vibratory attachment (US-EDM). Besides, the Ultrasonic Head attachment for the 'vibrations' could easily be isolated temporarily. This isolation might be required towards the conclusion of the machining cycle in order to secure a lower value for the surface roughness.

II. Literature Review

a) Based on EDM:-

K.M Patel et al., [1] analyzed that discharge current is most significant factor that affects grey relational grade. Increase in discharge current, surface roughness increases. The MRR increases with increase in pulse on time.

Azizul Bin Mohamad et al., [2] investigated and optimization of EDM parameters using Taguchi method. They investigated that discharge current and pulse on time most effective on SR and duty factor least influencing the machining process quality.

Sushil Kumar Choudhary et al.,[3] reviews the research work carried out from the inspection to development of die- sinking EDM, water in EDM, dry EDM and powdered mixed electric discharge machining. From this he concluded that the major research development resulting in improvement in metal removal rate and tool wear.

E. Aliakbari et al., [4]determined the optimal setting of process parameters on rotary.From this experiment they concluded that input parameters of current, pulse on time, electrode rotational speed and electrode geometry are the most effective parameters on MRR, EWR, SR.

BalaMuruganGopalsamyet al.,[5] observed that the width of cut and depth of cut are the most influencing parameters in rough machining. For finish machining the cutting speed is the most influencing parameter.

PR Dewan [6] determines the latest trend in EDM.From experiment he found that higher material removal was achieved with distilled water as dielectric fluid than kerosene.

Shashikant et al., [7]developed model to predict surface roughness in EDM machining operation of EN19 tool steel. From that they state that surface roughness decreases with decrease in peak current as well as pulse on time.

M. Janardhan [8]developed a mathematical model by using RSM for optimization of EDM performance characteristics. The optimal values of process parameters were obtained and performed the confirmation experiments for validation of the results.

P. Balasubramanian et al., [9]from experiment they investigated that EN-8 and D3 material mean value of MRR is high and low TWR value for Cast electrode compared with Sintered electrode and SR value is marginally less for Sintered electrode compared with Cast electrode.

Parveen Goyal [10] observed that copper-manganese (weight ratio: 70-30) composite electrode shows better results than Copper-Manganese (weight ratio: 80-20) electrodes for material removal rate (MRR) while machining the work piece in EDM.

b) Based on Ultrasonic EDM:-

Changshui Ga et al., [11]from experimentally show that the work piece vibration induced by ultrasonic action has a significant effect on the performance of the micro-EDM process. Also show that the efficiency and the aspect ratio of the hole of the ultrasonic-aided micro-EDM are noticeably increased.

Murali M. Sundaram et al., [12]investigated of ultrasonic assisted micro electro discharge machining was performed by introducing ultrasonic vibration to work piece using Taguchi method. From that they concluded that ultrasonic vibration at 60% of the peak power with capacitance of 3300 PF was found to be significant for best MRR.

Alexandru Sergiu Nanu et al., [13] proposed a general model of the removal mechanism at micro geometric level by computer aided finite element method (FEM) of ultrasonic aided electro discharge machining (UEDM) – for steel based work pieces.

Kumar Sandeep [14] work EDM with ultrasonic assisted cryogenically cooled tool electrode has been successfully performed on HSS work piece material. The electrode wear ratio and surface Roughness was significantly lower in Ultrasonic assisted cryogenically EDM process in comparison with conventional EDM process.

Pay Jun Liew et al., [15],concluded that Ultrasonic cavitation assisted micro-electrical discharge machining with carbon Nano fibers added to the dielectric fluid can significantly reduce the deposition of tool material on the work piece surface, which in turn, improves the surface finish of the machined surface.

Z. Qinjian et al., [16]indicated that parameters of pulse width, pulse interval, peak current, ultrasonic amplitude and open-circuit voltage influence the processing effects distinctly in EDM. Ultrasonic vibration has chip removal function and ultrasonic vibration has limited impact on the material removal rate.

Shaaz Abulais [17]conclude that higher efficiency gained by the employment of ultrasonic vibration is mainly attributed to the improvement in dielectric circulation which facilitates the debris removal and the creation of a large pressure change between the electrode and the work piece, as an enhancement of molten metal ejection from the surface of the work piece.

Pradeepkumar et al., [18] reviews of various process parameters for the machining of different kinds of materials in USM. They concluded that MRR and surface roughness depends upon selection of machining parameters.

M. R. Shabgard et al., [19] investigated the influence of copper tool vibration with ultrasonic frequency on output parameters in the electrical discharge machining of Ti-6Al-4V. From that they concluded that tool vibration with ultrasonic frequency enhances MRR via increasing normal discharges and decreasing arc discharges and open circuit pulses.

Jiangtao Che et al., [20] developed new ultra-sonic vibration unit designed with the assistance of finite element method (FEM) simulation for the resonance oscillation of the work piece on the end of the amplitude transformer in horizontal direction. From experiment they investigated that, in comparison with the traditional EDM, HU-EDM increases the material removal rate (MRR) by nearly 3 times, and improves the processing accuracy by 20%.

III. Research Gap

The literature survey has revealed that a little research has been conducted to obtain the optimal levels of machining parameters that yield the best machining quality in machining of difficult to machine materials like die steel H13, D2 and OHNS. The die steel H-13 and D2 are extensively used for forging, extrusion, manufacturing punching tools, mandrels, mechanical press forging die, plastic mould and die-casting dies, aircraft landing gears, helicopter rotor blades and shafts, etc. The consistent quality of parts being machined in electrical discharge machining is difficult because the process parameters can not be controlled effectively. These are the biggest challenges for the researchers and practicing engineers. Manufacturers try to ascertain control factors to improve the machining quality based on their operational experiences, manuals or failed attempts. In this study investigate in detail the Material removal rate, electrode wear and surface roughness produced in EDM and ultrasonic assisted EDM (US-EDM) on H13 tool steel, D2 and OHNS.

IV. Conclusion

- From literature review, it is concluded that Spark gap, Current, Spark ON/OFF time, di-electric fluid, work piece material, electrode material is the input parameters for EDM.
- From literature review, Ultrasonic vibration technique is identified as the potential area of work to be pursued further.
- The response parameters identified through the Literature Review are Material Removal Rate (MRR), Surface roughness (Ra value) & Tool wear.
- Statistical techniques, ANOVA, Regression analysis, RSM are the statistical tools that could be used to obtain optimum levels for the subject parameters for achieving desired responses.

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