"Comparative Study & Optimization of EDM Process Parameters Using Different Shape of Tool"

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ABSTRACT

The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. 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 moulds and dies and sections of complex geometry and intricate shapes. The workpiece material selected in this experiment is Stavex taking into account its wide usage in industrial applications. In today's world Stavex contributes to almost half of the world's production and consumption for industrial purposes. The tool material is copper & brass. The input variable parameters are current, pulse on time and pulse of time. Taguchi method is applied to create an L9 orthogonal array of input variables using the Design of Experiments (DOE). The effect of the variable parameters mentioned above upon machining characteristics such as Material Removal Rate (MRR), Tool Wear Rate (TWR) and Overcut (OC) study and investigate.

Keyword : - MRR, TWR, OC, DOE, EDM, OA

1. INTRODUCTION

Electric Discharge Machining (EDM) is a nontraditional machining process in the sense that they do not employ traditional tools for metal removal and instead directly by means of electric spark erosion [5]. It is developed in the late 1940s, has been accepted worldwide as a standard process in manufacture of forming tools to produce plastics molding, die castings, forging dies etc. New developments in the field of material science have led to new engineering metallic materials, composite materials, and high tech ceramics, having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion [1].

The recent developments in the field of EDM have progressed due to the growing application of EDM process and the challenges being faced by the modern manufacturing industries, from the development of new materials that are hard and difficult-to-machine such as tool steels, composites, ceramics, super alloys, hastalloy, nitralloy, carbides, stainless steels, heat resistant steel, etc. being widely used in die and mould making industries, aerospace, aeronautics, and nuclear industries. Many of these materials also find applications in other industries owing to their high strength to weight ratio, hardness and heat resisting qualities. EDM has also made its presence felt in the new fields such as sports, medical and surgical instruments, optical, dental and jewellery industries, including automotive R&D areas [1].

The adequate selection of manufacturing conditions is one of the most important aspects to take into consideration in the die-sinking electrical discharge machining (EDM) of conductive steel, as these conditions are the ones that are to determine such important characteristics: Overcut(OC), Surface Roughness (SR), Tool Wear

Rate (TWR) and Material Removal Rate (MRR) [2]. In this paper, a study of Overcut performed on the influence of the factors of Current, Pulse on Time & Pulse off Time.

2. LITERATURE REVIEW

Shankar Singh et. al. [1] evaluate that Electric Discharge Machining (EDM), a 'non-traditional machining process', has been replacing drilling, milling, grinding and other traditional machining operations and is now a well-established machining option in many manufacturing industries throughout the world. This paper reports the results of an experimental investigation carried out to study the effects of machining parameters such as pulsed current on material removal rate, diameteral overcut, electrode wear, and surface roughness in electric discharge machining of En-31 tool steel (IS designation: T105 Cr 1 Mn 60) hardened and tempered to 55 HRc. The work material was ED machined with copper, copper tungsten, brass and aluminium electrodes by varying the pulsed current at reverse polarity. Investigations indicate that the output parameters of EDM increase with the increase in pulsed current and the best machining rates are achieved with copper and aluminium electrodes. After analysing the results of the experiments on En-31 tool steel with different electrode materials, the following conclusion are arrived at: For the En-31 work material, copper and aluminium electrodes offer higher MRR. Diameteral overcut produced on En-31 is comparatively low when using copper and aluminium electrodes, which may be preferred for En-31 when low diameteral overcut (higher dimensional accuracy) is the requirement. Copper and copper–tungsten electrodes offer comparatively low electrode wear for the tested work material. Aluminium electrode also shows good results while brass wears the most, of all the tested electrodes.Of the four tested electrode materials, Cu and Al electrodes produce comparatively high surface roughness for the tested work material at high values of currents. Copper–tungsten electrode offers comparatively low values of surface roughness at high discharge currents giving good surface finish for tested work material. Copper is comparatively a better electrode materials as it gives better surface finish, low diameteral overcut, high MRR and less electrode wear for En-31 work material, and aluminium is next to copper in performance, and may be preferred where surface finish is not the requirement.

Othman Belgassim et. al. [7] used L9 orthogonal array based on Taguchi method to conduct a series of experiments to optimize the EDM parameters. Experimental data were evaluated statistically by analysis of variance (ANOVA). The EDM parameters are Pulse current (I_p), Pulse –on- time (T_{on}), Pulse –off- time (T_{off}), and the Gap voltage (V_g) , while the machining responses in concern are the surface roughness of the machined surface and the over-cut. The experimental results have given optimal combination of input parameters which give the optimum surface finish of the EDM surface.

S.H.Tomadi et. al. [2] evaluate that the influence of operating parameters of tungsten carbide on the machining characteristics such as surface quality, material removal rate and electrode wear. The effectiveness of EDM process with tungsten carbide, WC-Co is evaluated in terms of the material removal rate, the relative wear ratio and the surface finish quality of the workpiece produced. It is observed that copper tungsten is most suitable for use as the tool electrode in EDM of WC-Co. Better machining performance is obtained generally with the electrode as the cathode and the workpiece as an anode. In this paper, a study was carried out on the influence of the parameters such peak current, power supply voltage, pulse on time and pulse off time. The surface quality that was investigated in this experiment was surface roughness using perthometer machine. Material removal rate (MRR) and electrode wear (EW) in this experiment was calculated by using mathematical method. The result of the experiment then was collected and analyzed using STATISTICA software. This was done by using the design of experiments (DOE) technique and ANOVA analysis.

Subramanian Gopalakannan et. al. [3] study the effect of pulsed current on material removal rate, electrode wear, surface roughness and diameter overcut in corrosion resistant stainless steels viz., 316 L and 17-4 PH. The materials used for the work were machined with different electrode materials such as copper, cop-per-tungsten and graphite. It is observed that the output parameters such as material removal rate, electrode wear and surface roughness of EDM increase with increase in pulsed current. The results reveal that high material removal rate have been achieved with copper electrode whereas copper-tungsten yielded lower electrode wear, smooth surface finish and good dimensional accuracy.

V.Balasubramaniam et. al. [4] used different electrode materials namely copper, brass and tungsten while EDM of Al-SiCp Metal Matrix Composite. Material Removal Rate (MRR), Electrode Wear Rate (EWR) and Circularity (CIR) are considered as the performance measures. Artificial Neural Network is used for optimization of the machining parameters such as current, pulse on time and flushing pressure. Investigations indicate that the current is the most significant parameter. Among the three electrodes copper yields better performances. Machining time is reduced with better performances.

Praveen Kumar Singh et. al. [5] focused on the effect of Copper and Brass electrodes on material removal rate (MRR) and tool wear rate (TWR) for AISI D2 tool steel by using Die- Sinker EDM. The current was varied from 4 to 10 amp, the voltage and flushing pressure were constant, the MRR for copper electrode was in the range of 4.8139 -22.6580 mm3/min whereas the range of MRR for brass electrode was 7.2213-9.8203 gm/min. The trend of TWR as shown in results increases with current for both the electrodes. The effect of voltage on MRR and TWR for both the electrodes was analyzed. The MRR for copper electrode was continuously decreasing with voltage whereas MRR for brass don't follow any specific trend. The TWR for both the electrodes decreases with voltage. It has been observed that copper electrode is the best for machining AISI D2 tool steel by using Die- Sinker EDM.

S. Assarzadeh et. al. [7] research on model and optimize process parameters in Electro-Discharge Machining (EDM) of tungsten carbide-cobalt composite (Iso grade: K10) using cylindrical copper tool electrodes in planing machining mode based on statistical techniques. Four independent input parameters, viz., discharge current (A: Amp), pulse-on time (B: μs), duty cycle (C:%), and gap voltage (D: Volt) were selected to assess the EDM process performance in terms of material removal rate (MRR:mm3/min), tool wear rate (TWR: mm3/min), and average surface roughness (Ra: μm). Response surface methodology (RSM),employing a rotatable central composite design scheme, has been used to plan and analyze the experiments. For each process response, a suitable second order regression equation was obtained applying analysis of variance (ANOVA) and student t-test procedure to check modeling goodness of fit and select proper forms of influentially significant process variables (main, two-way interaction, and pure quadratic terms) within 90% of confidence interval (p-value ≤ 0.1). It has been mainly revealed that all the responses are affected by the rate and extent of discharge energy but in a controversial manner. The MRR increases by selecting both higher discharge current and duty cycle which means providing greater amounts of discharge energy inside gap region. The TWR can be diminished applying longer pulse on-times with lower current intensities while smoother work surfaces are attain able with small pulse durations while allotting relatively higher levels to discharge currents to assure more effective discharges as well as better plasma flushing efficiency. Having established the process response models, a multi-objective optimization technique based on the use of desirability function (DF) concept has been applied to the response regression equations to simultaneously finda set of optimal input parameters yielding the highest accessible MRR along with the lowest possible TWR and Ra within theprocess inputs domain. The obtained predicted optimal results were also verified experimentally and the values of confirmation errors were computed, all found to be satisfactory, being less than 10%. The outcomes of present research prove the feasibility and effectiveness of adopted approach as it can provide a useful platform to model and multi-criteria optimize MRR, Ra, and TWR during EDMing WC/6%Co material.

A.K.M.N. Amin et. al. [8] research on influence of the properties of work and tool materials on material removal rate (MRR), tool wear ratio (TWR), thickness of the recast layer, surface roughness and accuracy of machining in EDM process has been investigated. Copper brass, stainless steel, mild steel and grey cast irou have been used in various combinations as work and tool materials. From the experimental results it is found that MRR slows down with machining time. Apart from that it has been found that MRR and TWR are inversely proportional to the melting points of the work and tool materials respectively. Electrical conductivity of the tool material also has appreciable influence on tool wear ratio. Wear ratio was found to be minimum in the case of the copper electrode having maximum electrical conductivity. It has been also observed that for all combinations of work and tool materials, a recast layer is formed on the machined surface. It has been observed that the micro cavities formed in the cases of lower melting point electrode materials like copper and brass having higher electrical conductivity are comparatively smaller in size (2-3 □m) as compared to the sizes of the micro cavities (8-20 □m) formed in the cases of high melting pointer electrodes having also lower electrical conductivity. Consequenty the machined surface roughness produced in the latter cases is higher. It has been also observed that the debris concentration increases due to side sparking of the electrode. The tendency of debris concentration is the maximum at the middle of the tool job interface resulting in high bottom surface inaccuracy, specially when high melting point work materials are machined with electrodes like brass having low melting point and relatively lower electrical conductivity. From the

point of view of MRR, brass electrodes have been found to be the most suitable tool, but from the point of view of machining accuracy and surface finish copper electrodes were found to yield the best result for the given set of job materials. So it was concluded that brass electrodes should be recommended for rough machining and copper electrodes for finish machining of the given work materials.

3. CONCLUSION

From Literature Review & detailed study below conclusion is derived.

The analysis in this area of EDM performance is generally find out on the basis of MRR, OC, TWR and SR. The performance is affected by discharge current, pulse on time, pulse off time, voltage, arc gap, duty cycle, and flushing pressure. The current is most significant parameters for MRR in EDM. Pulse on time is most significant parameter for surface roughness followed by current, shape and Toff respectively. Current is most significant parameter for TWR, followed by T off, T on and shape of electrode respectively. Current is most significant parameter for Overcut. Cavities made by EDM die sinking may have intricate shapes and it is difficult to achieve high accuracy at the sharp corner of the cavities. The single irregular electrode contains several geometries such as flat, round, square surface, pointed tip, etc. which removes materials with different effectiveness. The review paper evaluates the areas and subareas where optimization techniques are used. It works on identifying parameters for optimization and also suitable techniques for EDM mechanism. The researchers used latest optimization techniques such as Taguchi, GA, ANN, GRA, RSM, SA, fuzzy logic, desirability, and utility are mostly focused on multi response optimization. The application of latest optimization techniques in optimizing performance parameters of EDM process positively gives good results compared to conventional techniques as proven from the existing work mentioned in this paper. So, the latest optimization technique used in the electric discharge machining (EDM) processes for maximize the Material Removal Rate (MRR), reduced the Tool Wear Rate (TWR), reduced the Over cut (OC), improve the Surface Roughness (SR).

4. REFERENCES

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