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A Review on Optimization of Process Parameters for Improving Performance in Electrical Discharge Machining

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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. From the point of view of industrial applications, SS 410 is a very important material and that's why for the purpose of experimentation SS 410 with copper electrode and EDM oil as dielectric has been used In the present work. I will take input parameter discharge current, pulse on time and pulse off time. Design of Experiment (DOE) with full factorial design has been explored to produce 27 specimens on SS 410 by edm operation. MRR will be calculated from MRR equation and software available for it and then compare it. Collected data related to surface roughness have been utilized for optimization.
***Keywords* –** EDM, orthogonal array, Design of experiments, full factorial.

I. INTRODUCTION

Electrical discharge machining (EDM) is one of the most extensively used nonconventional material removal processes. In this process the material is removed by a succession of electrical discharges, which occur between the electrode and the workpiece.There is no direct contact between the electrode tool and the workpiece. These are submersed in a dielectric liquid such as kerosene or deionised water. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage. The electrical discharge machining process is widely used in the aerospace, automobile, die manufacturing and moulds industries to machine hard metals and its alloy.

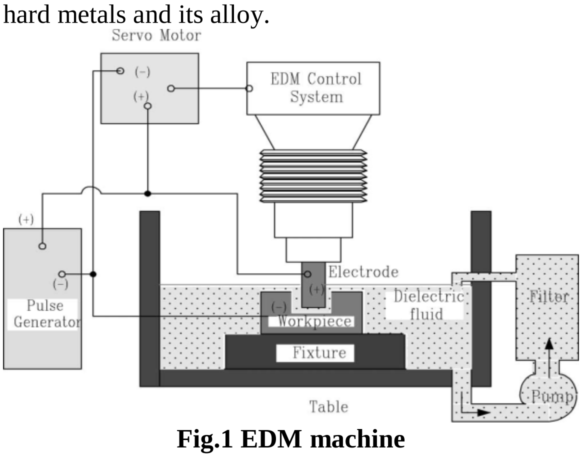

Fig.1 EDM machine

II. MECHANISM OF MATERIAL REMOVAL

The electro sparking method of metal working involves an electric erosion effect in which the breakdown of electrode material is done by electric discharge. The discharge is created by the ionization of dielectric which is spilled up of its molecules into ions and electrons. This discharge is created between two electrodes through a gaseous or liquid medium with the application of suitable voltage across the electrodes. The potential intensity of electric field between them is built up at some predetermined value individual electrons will break loose from the surface of the anode under the influence of the field force. While moving in the inter-electrode space, the electrons collide with the neutral molecules of the dielectric, detaching electrons from them and causing ionization. At some time or other the ionization becomes such that a narrow channel of continuous conductivity is formed.

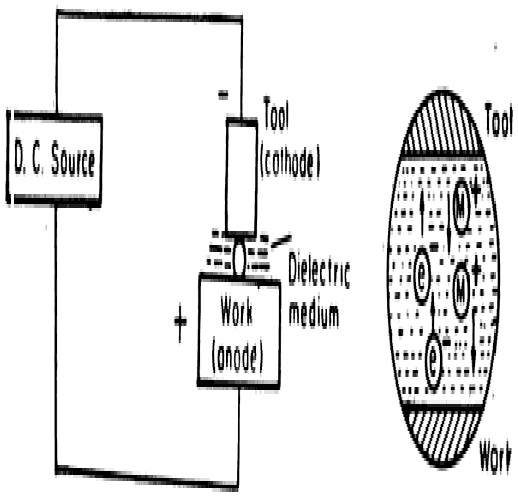

Fig.2 Mechanism of material removal

When this happens there is a continuous flow of electrons along the channel to the electrode, resulting in the momentary current impulse or discharge. The liberation of energy accompanying the discharge leads to generation of high temperature. This high temperature plasma causes fusion or particle vaporization of metal and the dielectric fluid at the point of discharge. This leads to the formation of tiny crater at the point of discharge in the workpiece. Comparatively less metal is eroded from the tool as compared to the workpiece due to following reasons:

a) The momentum with which positive ions strike the cathode surface is much less than the momentum with which the electron stream impinges on the anode surface.

b) A compressive force is generated on the cathode surface by spark which helps reduce tool wear.

III. LITERATURE REVIEW

M.Ghoreishi [1]**,** were carried out "Statistical modeling and optimization of process parameters in electro-discharge machining of cobalt-bonded tungsten carbide composite (WC/6%Co)". In this paper, attempts have been made to 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, pulse-on time, duty cycle, and gap voltage were selected to assess the EDM process performance in terms of material removal rate, tool wear rate, and average surface roughness. 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 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.

M.Dev anand[2]**,** were carried out "Determination of electro discharge machining parameter in AISI 202 stainless steel using grey relation analysis". This paperdescrib the selection of machining parameter Discharge current, Pulse on time, Plse off time in EDM for the machining of AISI 202 Stainless steel material the use of grey relational analysis for optimizing the machining parameter material removal rate use to represent the multi objective model. The eeprimentalwork in this research to know effect on the metal removal rate and surface roughness Grey Relational grade is used to find the optimal parameter.

R. Karthikeyan [3]**,** were carried out "Effect of Electrical Discharge Machining on strength and reliability of WC–30%Co composite.". Tungsten carbide/Cobalt (WC–Co) composite is one of the important composite materials, which is used for manufacturing of cutting tools, dies and other special tools. It has very high hardness and excellent resistance to shock and wear. It is not possible to machine this material easily with conventional machining techniques. Due to the good electrical conductivity of WC–Co, it is usually machined by Electrical Discharge Machining (EDM).

EDM process often results in the surface damage of bulk WC–Co, and the influence of the damage would affect the reliability. It is important to investigate the effect of electric discharge machining process on the properties of WC–Co cemented carbides before applying its engineering application. For these composites, maintenance of proper fracture strength is an important concern and is to be controlled. In this work, an attempt has been made to investigate the fracture strength and the reliability of EDMed WC–Co composite using the Weibull distribution analysis. The comparison of results between the machined composites and un-machined composites is carried out and presented in this study.

R.Rajesh [4], were carried out "The Optimization of the Electro-Discharge Machining Process Using Response Surface Methodology and Genetic Algorithms.".. optimization of operating parameters is an important action in machining, particularly for unconventional electrical type machining procedures like EDM. Since for an arbitrary desired machining time for a particular job, they do not provide the optimal conditions. To solve this task, multiple regression model and modified Genetic Algorithm model are developed as efficient approaches to determine the optimal machining parameters in electric discharge machine. In this paper, working current, working voltage, oil pressure, spark gap Pulse On Time and Pulse Off Time on Material Removal Rate (MRR) and Surface Finish (Ra) has been studied. Empirical models for MRR and Ra have been developed by conducting a designed experiment based on the Grey Relational Analysis. Genetic Algorithm (GA) based multi-objective optimization for maximization of MRR and minimization of Ra has been done by using the developed empirical models. Optimization results have been used for identifying the machining conditions. For verification of the empirical models and the optimization results, focused experiments have been conducted in the rough and finish machining regions.

M.A.Hassan [5], were carried out "Analysis of the Influence of EDM Parameters on Surface Quality, Material Removal Rate and Electrode Wear of Tungsten Carbide" . The objective of this paper is to study the influence of operating parameters of tungsten carbide on the machining characteristics such as surface quality, material removal rate and electrode wear. It is followed by optimizing the machining condition for confirmation test purposes. Then, the conformation test needed to evaluate the error margin between predicted result by software and confirmation result by experiment in terms of the machining characteristics. 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 currrent, 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.

Yang Jin-Bin [6], were carried out "Study of the parameters in electrical discharge machining through response surface methodology approach". Whereas the efficiency of traditional cutting processes is limited by the mechanical properties of the processed material and the complexity of the workpiece geometry, electrical discharge machining (EDM) being a thermal erosion process, is subject to no such constraints. The lack of correlations between the cutting rate, the surface finish and the physical material parameters of this process made it difficult to use. This paper highlights the development of a comprehensive mathematical model for correlating the interactive and higher order influences of various electrical discharge machining parameters through response surface methodology (RSM), utilizing relevant experimental data as obtained through experimentation. The adequacy of the above the proposed models have been tested through the analysis of variance (ANOVA). Optimal combination of these parameters was obtained for achieving controlled EDM of the workpieces.

Yan K. Kanlayasiri [7], were carried out "Effects of wire-EDM machining variables on surface roughness of newly developed DC 53 die steel: Design of experiments and regression model". DC53 is a newly developed cold die steel from Daido Steel, Japan. It is an improvement over the familiar cold die steel SKD11. Because DC53 is a new die steel, only little information is available in literature for its machining characteristics. This paper presents an investigation of the effects of machining variables on the surface roughness of wire-EDMed DC53 die steel. In this study, the machining variables investigated were pulse-peak current, pulse-on time, pulse-off time, and wire tension. Analysis of variance (ANOVA) technique was used to find out the variables affecting the surface roughness. Assumptions of ANOVA were discussed and carefully examined using analysis of residuals. Quantitative testing methods on residual analysis were used in place of the typical qualitative testing techniques. Results from the analysis show that pulse-on time and pulse-peak current are significant variables to the surface roughness of wire-EDMed DC53 die steel. The surface roughness of the test specimen increases when these two parameters increase. Lastly, a mathematical model was developed using multiple regression method to formulate the pulse-on time and pulse-peak current to the surface roughness. The developed model was validated with a new set of experimental data, and the maximum prediction error of the model was less than 7%.

C.J. Luis [8]**,** were carried out "A study on the electrical discharge machining of conductive ceramics". In this work, a comparative study of the electrical discharge machining (EDM) of three different conductive ceramics has been carried out. The ceramics used in the experiments were cobalt-bonded tungsten carbide (WC–Co), hot-pressed boron carbide (B4C) and reaction-bonded silicon carbide (SiSiC). This study has been done only for the finishing stages and the selection of the above-mentioned conductive ceramics was motivated by their wide range of applications: machining and mining for WC–Co, thermal-neutron absorber and nozzles for B4C and wear parts and heat exchangers for SiSiC, among others. The comparative study has been carried out on the influence of the design factors of intensity (*I*), pulse time (*ti*) and duty cycle (*η*) over response variables such as surface roughness (evaluated through the *R*a parameter), volumetric electrode wear (EW) and material removal rate (MRR). This was accomplished through the technique of design of experiments (DOE), along with multiple linear regression techniques, which allowed us to carry out the analysis with only a small number of experiments.

I. Puertas [9]**,** were carried out "Analysis of the influence of EDM parameter on surface qulity,MRR and EW of WC-CO". 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 ceramics, as these conditions are the ones that are to determine such important characteristics as: surface roughness, electrode wear (EW) and material removal rate, among others. In this work, a study was carried out on the influence of the factors of intensity (*I*), pulse time (*t*i) and duty cycle (*η*) over the listed technological characteristics. The ceramic used in this study was a cemented carbide or hard metal such as 94WC–6Co. Approximately 50% of all carbide production is used for machining applications but cemented carbides are also being increasingly used for non-machining applications, such as: mining, oil and gas drilling, metal forming and forestry tools. Accordingly, mathematical models will be obtained using the technique of design of experiments (DOE) to select the optimal machining conditions for finishing stages. This will be done only using a small number of experiments.

P. Narender Singh [10]**,** were carried out "Optimization by Grey relational analysis of EDM parameters on machining Al 10%SiCP composites".Optimization of process parameters is the key step in the Taguchi methods to achieve high quality without cost inflation. Optimization of multiple response characteristics is more complex compared to optimization of single performance characteristics. The multi-response optimization of the process parameters viz., metal removal rate (MRR), tool wear rate (TWR), taper (T), radial overcut (ROC), and surface roughness (SR) on electric discharge machining (EDM) of Al–10%SiCP as cast metal matrix composites using orthogonal array (OA) with Grey relational analysis is reported. Performing the Grey relational generating and to calculate the Grey relational coefficient. Calculating the Grey relational grade by averaging the Grey relational coefficient. Performing statistical analysis of variance (ANOVA) for the input parameters with the Grey relational grade and to find which parameter significantly affects the process. Selecting the optimal levels of process parameters. Conduct confirmation experiment and verify the optimal process parameters setting.

feng-tsai weng [11]**,** were carried out "A study of elecrical discharge machining of semi cunductore Batio3". This paper investigates the machining performance of BaTio3using the electrical discharge machining process. The taguchi orthogonal array technique is used for experimental design. A surface roughness model of the EDM process of semi conductor BaTio3 can be obtain by regression of the experimental data. A genetic algorithm is used to calculate the machining parameter of the optimum surface roughness. To obtain a better surface roughness, positive polarity machining should be chosen in EDM process of BaTio3 whilst the can not be selected at too great a value or the workpiece may be broken during the process.

IV. IMPORTANT PARAMETERS OF EDM

(a) Spark On-time (pulse time or Ton): The duration of time (μs) the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is really controlled by the peak current and the length of the on-time.

(b) Spark Off-time (pause time or Toff): The duration of time (μs) between the sparks (that is to say, on-time). This time allows the molten material to solidify and to be wash out of the arc gap. This parameter is to affect the speed and the stability of the cut. Thus, if the off-time is too short, it will cause sparks to be unstable.

(c) Arc gap (or gap): The Arc gap is distance between the electrode and workpiece during the process of EDM. It may be called as spark gap. Spark gap can be maintained by servo system.

(d)Discharge current (current Ip): Current is measured in amp Allowed to per cycle. Discharge current is directly proportional to the Material removal rate.

(e) Duty cycle ( ): It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the total cycle time (on-time pulse offtime). τ = (pulse on time/pulse off time+pulse on time)

(f) Voltage (V): It is a potential that can be measure by volt it is also effect to the material removal rate and allowed to per cycle.

(g) Over cut: It is a clearance per side between the electrode and the workpiece after the marching operation.

RESPONSE PARAMETERS

Material Removal Rate(MRR)

MRR is measured by difference between weight before cutting and after cutting of workpiece.

Surface Roughness(SR)

Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface. Surface roughness is an important measure of product quality since it greatly influences the performance of mechanical parts as well as production cost. Surface roughness has an impact on the mechanical properties like fatigue behavior, corrosion resistance, creep life, etc. surface roughness tester to measure surface roughness of work piece.

V. CONCLUSION

From the above literature survey we found that most effected parameters to cutting condition are pulse on time, pulse off time and discharge current and they are easily controlled by operator at the machine at same time. Experimental work will be performed on EDM machine. In which input parameters are pulse on time, pulse off time and discharge current and the response parameters are surface roughness and material removal rate. We will use surface roughness tester to measure surface roughness and MRR will measured by mathematical equation. We will use AISI 410 work piece material for turning operation. For Experimental design we will use full factorial method ($L=m^n$) to find out number of readings. To find out percentage contribution of each input parameter for obtaining optimal conditions, we will use ANOVA method.

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