International Journal of Computer Science Trends and Technology (IJCST) – Volume 3 Issue 6, Nov - Dec 2015

RESEARCH ARTICLE OPEN ACCESS

Statistical Analysis of Correlations Developed For Parametric Control in Machining With EDM

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ABSTRACT

In this research, investigational and experimental work was carried out on the electric discharge machining (EDM) of a High Speed Steel (HSS) using a copper electrode as the EDM tool. This material is used for cutting tools and forging dies. The HSS is difficult to machine using conventional machining techniques. However, it can be easily machined using a spark EDM process to obtain accurate dimensional and geometric tolerances. The machining parameters, such as the current (I), pulse on time (T-on), pulse off time (T-off), dielectric pressure (DP) and spark gap voltage (SV), were investigated using a Regression Surface Methodology (RSM). The output characteristics, such as the material removal rate (MRR), tool wear rate (TWR), wear ratio (WR), surface roughness (Ra) were examined during the sparking operation. The significance of the machining parameters was obtained using analysis of variance (ANOVA) which showed that the current, pulse on time and spark gap voltage were the most significant parameters. The results were further confirmed using an experiment that illustrated that the spark eroding process could effectively be improved.

Keywords:- EDM, HSS, Optimization, RSM, Spark gap, MRR

I. INTRODUCTION

The history of EDM Machining Techniques goes as far back as the 1770s when it was discovered by an English Scientist. However, Electrical Discharge Machining was not fully taken advantage of until 1943 when Russian scientists learned how the erosive effects of the technique could be controlled and used for machining purposes. When it was originally observed by Joseph Priestly in 1770, EDM Machining was very imprecise and riddled with failures. Commercially developed in the mid 1970s, wire EDM began to be a viable technique that helped shape the metal working industry we see today. In the mid 1980s.The EDM techniques were transferred to a machine tool. This migration made EDM more widely available and appealing over traditional machining processes. The new concept of manufacturing uses non-conventional energy sources like sound, light, mechanical, chemical, electrical, electrons and ions. With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed. 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. Non-traditional machining has grown out of the need to machine these exotic materials. The machining processes are non-traditional in the sense that they do not employ traditional tools for metal removal and instead they directly use other forms of energy. The problems of high complexity in shape, size and higher demand for product accuracy and surface finish can be solved through non-traditional methods. Currently, non-traditional processes possess virtually unlimited capabilities except for volumetric material removal rates, for which great advances have been made in the past few years to increase the material removal rates. As removal rate increases, the cost effectiveness of operations also increase, stimulating ever greater uses of non traditional process. Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas.

Fig.1 is shows the electric setup of the Electric discharge machining

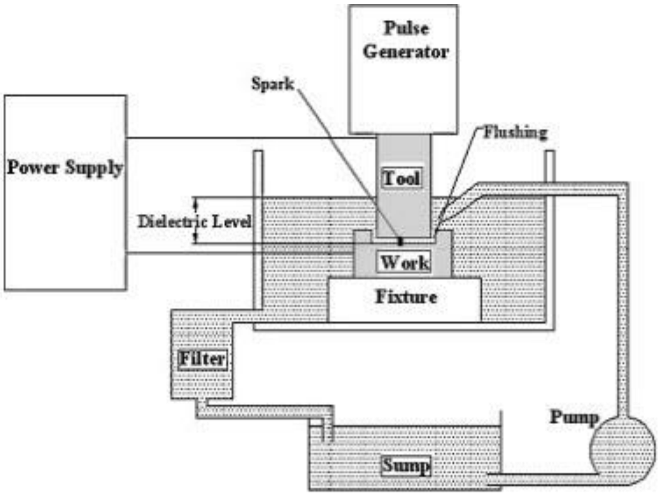


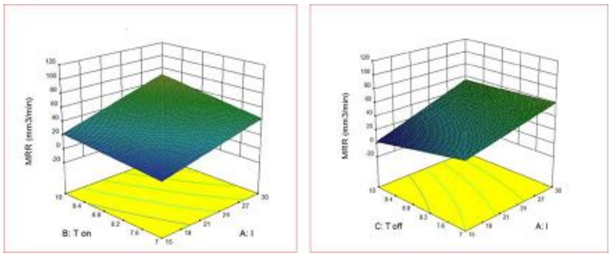
Figure1. Set up of Electric discharge machining

Dhar and Purohit [1] evaluates the effect of current (c), pulse-on time (p) and air gap voltage (v) on MRR, TWR, ROC of EDM with **Al–4Cu–6Si alloy–10 wt. % Si CP composites**. Karthikeyan et .al [2] has presented the mathematical moulding of EDM with **Aluminum-silicon carbide particulate composites**. Mathematical equation is Y=f(V, I, T). And the effect of MRR, TWR, SR with Process parameters taken in to consideration were the current (I), the pulse duration (T) and the percent volume fraction of SiC (25 μ size). Tool electrode material such as **Al–Cu–Si–Tic composite** produced using powder metallurgy (P/M) technique and using work piece material CK45 steel was shown by **Taweel** [3]. The central composite second-order rotatable design had been utilized to plan the experiments, and RSM was employed for developing experimental models. Composite electrode is found to be more sensitive to peak current and Pulse on time then conventional electrode.

B.Mohan and Satyanarayana [4] evolution the of effect of the EDM Current, electrode marital polarity, pulse duration and rotation of electrode on metal removal rate, TWR, and SR, and the EDM of **Al-Sic with 20-25 vol. % SiC**, Polarity of the electrode and volume present of SiC, the MRR increased with increased in discharge current and specific current it decreased with increasing in pulse duration. Increasing the speed of the rotation electrode resulted in a positive effect with MRR, TWR and better SR than stationary. The effects of the machining parameters (MRR, TWR and SR) in EDM on the machining characteristics of **SKH 57** high-speed steel were investigated by **Yan-Cherng** et.al [5]. Experimental design was used to reduce the total number of experiments. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method. P. Narender Singh et al. [6] discuss the evolution of effect of the EDM current (*C*), Pulse ON-time (*P*) and flushing pressure (*F*) on MRR, TWR, taper (*T*), ROC, and surface roughness (SR) on machining as-cast **Al-MMC with 10% SiCp** . Study of parameter in EDM by using the RSM, the parameter like MRR, TWR, gap size and SR and relevant experimental data were obtained through experimentation by Sameh S. Habib[7]. Sohani et al. [8] discussed about sink EDM process effect of **tool shape and size factor** are to be considering in process by using RSM process parameters like discharge current, pulse on-time, pulse off-time, and tool area. The RSM-based mathematical models of MRR and TWR have been developed using the data obtained through central composite design.

II. EXPERIMENTATION

Figure 2. EDM machine

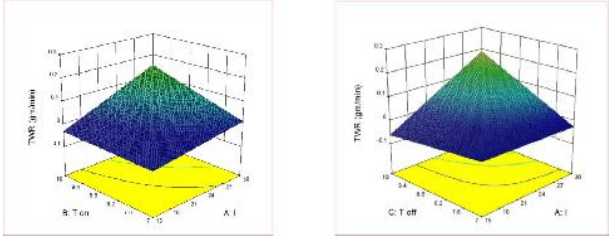


The main objective of experimental design is studying the relations between the response as a dependent variable and the various parameter levels. It provides an opportunity to study not only the individual effects of each factor but also their interactions. Design of experiments is a method used for minimizing the number of experiments to achieve the optimum conditions. The design of experiments for exploring the influence of various predominant EDM process parameters (e.g. pulse on time, peak current, average gap voltage and the percent volume fraction of SiC present in the aluminum matrix) on the machining characteristics (e.g. the material removal rate, electrode wear ratio, gap size and the surface finish), were modeled. In the present work experiments were designed on the basis of experimental design technique using response surface design method. In order to determine the equation of the response surface, experimental design has been developed with the attempt to approximate this equation using the smallest number of experiments possible. In this investigation, experimental design was established on the basis of 2*k* factorial, where k is the number of variables, with central composite-second-order rotatable design to improve the reliability of results and to reduce the size of experimentation without loss of accuracy. The experiments were carried out on S35 model EDM of Sparkonics make which is shown in Fig.2. The specimen after machining at different parameters were shown in Fig.3

Figure 3 After machining on EDM

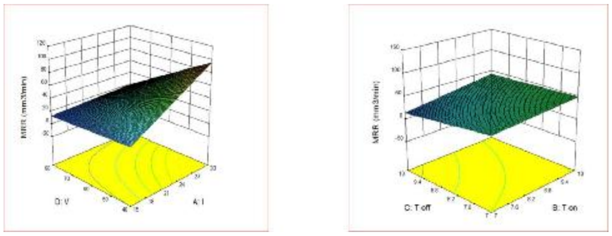
III. RESULTS AND DISCUSSIONS

Effect of parameters on MRR:

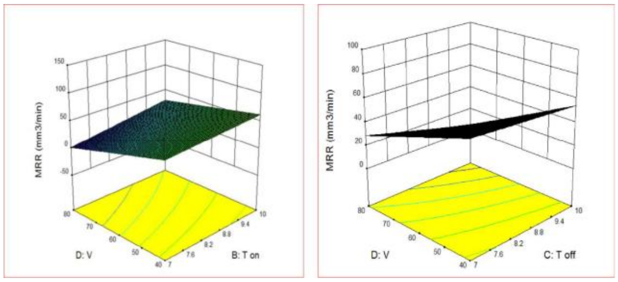


A B

From the fig.4, it is observed that the MRR is increasing with increase in Current , T-on time and decreasing with increase in T-off time. This may be due to the energy dispensed at the sparking zone as it increases with increase in current and T-on time.



C D



E F

Figure 4 Two factor interaction on MRR

From the above ANOVA table we can say that Current and voltage are significant effective on the material removal rate because the P value of current and voltage are 0.0099 and 0.0054, respectively. There is no significant effect of T on and T off on material removal rate.

As shown in the figure A, the processing on MRR was found to be high at 10ms and 30 amp. It was found to be less at 7ms and 15amp.

Figure 4: Interaction of I and T off at processing MRR.

As shown in the figure B, the processing on MRR was found to be high at T off 7ms and 30amp. It was found to be less at 10ms and 15 amp.

Figure c: Interaction of I and V at processing MRR.

As shown in the figure C, the processing on MRR was found to be high at 30 amp and 40v. It was found to be less at 15 amp and 80 v.

Figure d: Interaction of T on and T off at processing MRR.

As shown in the figure D, the processing on MRR were found to be high at 10ms Ton and 7ms T off. It was found to be less at 7ms Ton and 10ms T off.

Figure e: Interaction of T on and V at processing MRR.

As shown in the figure E, the processing on MRR was found to be high at 10ms Ton and 40 V. It was found to be less at 7ms Ton and 80 V.

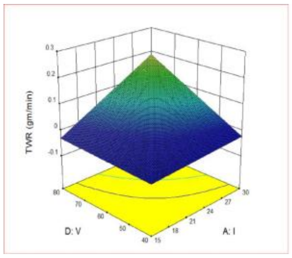
Figure f: Interaction of V and T off at processing MRR.

As shown in the figure F, the processing on TWR was found to be high at 7ms T off and 40 V. It was found to be less at 10ms T off and 80V.

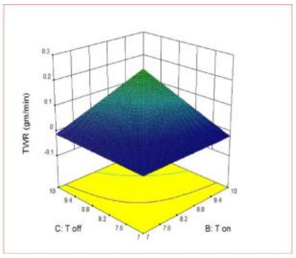
The mathematical correlation generated using RSM is as a multiple parametric optimization in terms of thickness,T-on, T-off and current, I is

$$\mathbf{MRR} = +159.69698 + 3.24057 * I - 25.47255 * T\ on - 23.87574 * T\ off + 1.56135 * V + 0.28816 * I * T\ on + 0.47297 * I * T\ off - 0.11591 * I * V + 1.94988 * T\ on * T\ off + 0.14614 * T\ on * V - 0.14503 * T\ off * V$$

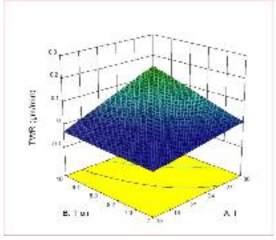
Effect of process parameter on TWR: From the fig.4, it is observed that the MRR is increasing with increase in Current, T-on time and decreasing with increase in T-off time. This may be due to the energy dispensed at the sparking zone as it increases with increase in current and T-on time.



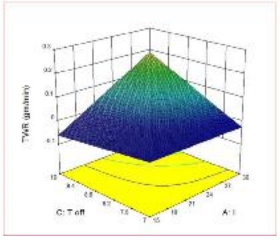
A



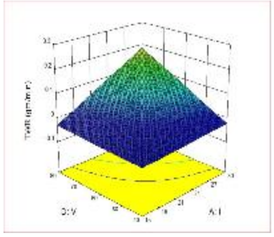
B



C



D



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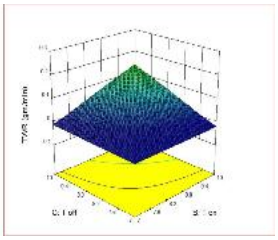

F

Figure 5: Interaction effect of Ton and I processing TWR.

As shown in the figure A, the processing TWR was found to be high at 30 amp and 10ms of T off. It was found to be less at 15 amp and 7 ms of T off.

Figure 5: Interaction effect of T off and I processing TWR.

As shown in the figure B, the processing TWR was found to be high at 15 amp and 10ms T on. It was found to be less at 30 amp and 10ms T off.

Figure c: Interaction effect of V and I on processing TWR.

As shown in the figure C, the processing TWR was found to be high at 30 amp and 80 V. It was found to be less at 15 amp and 80 V.

Figure d: Interaction effect of T off and T on processing TWR.

As shown in the figure D, the processing TWR was found to be high at 7ms T on and 7ms T off. It was found to be less at 10ms T on and 10ms T off.

Figure e: Interaction effect of V and T on at processing TWR.

As shown in the figure E, the processing TWR was found to be high at 10ms T on and 80 V. It was found to be less at 7ms T on and 40 V.

Figure f: Interaction effect of V and T off at processing TWR.

As shown in the figure F, the processing MRR was found to be high at 10ms T off and 80 V. It was found to be less at 7ms T off and 40 V.

The mathematical correlation generated using RSM as a multiple parametric optimization in terms of thickness,T-on, T-off and current, I is

TWR= +2.73145-0.084789* I-0.19240* T on-0.25999* T off-7.59893E-003* V+2.78032E-003* I * T on+5.82031E-003* I * T off+3.27032E-004* I * V+0.017058* T on * T off +1.61099E-004* T on * V+1.95895E-004* T off * V

IV. CONCLUSIONS

The optimization of process parameters namely discharge current, pulse on time, pulse off time and voltage can be done by using RSM for eroding of HSS. The conclusions are drawn from this work is as follow.

HSS:

- The empirical relationship was developed for material removal rate, tool wear rate on EDM with eroding parameter.
- ANOVA was used to identify significant parameters on the out variables in ANOVA for material removal rate voltage and current were found to be significant. In ANOVA for tool wear rate no one was found to be significant.
- The RSM was used for multi response optimization of process parameters. Current of 30amp, pulse on time of 10ms, pulse off time of 8ms and voltage of 40 volts are optimum erosion parameters.

MRR and TWR with process parameter

MRR = +159.69698 + 3.24057 * I -25.47255 * T on - 23.87574 * T off + 1.56135 * V + 0.28816 * I * T on + 0.47297 * I * T off - 0.11591 * I * V + 1.94988 * T on * T off + 0.14614 * T on * V - 0.14503* T off * V

TWR= +2.73145-0.084789* I-0.19240* T on-0.25999* T off-7.59893E-003* V+2.78032E-003* I * T on+5.82031E-003* I * T off+3.27032E-004* I * V+0.017058* T on * T off +1.61099E-004* T on * V+1.95895E-004* T off * V

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