Influence of Process Parameters in EDM Process- A Review

K.S Morankar
Department of Mechanical Engineering
Everest College of Engineering and Technology, Aurangabad, Maharashtra, India

R.D.Shelke
Department of Mechanical Engineering
Everest College of Engineering and Technology, Aurangabad, Maharashtra, India

Abstract- Electrical discharge machining is a nontraditional machining process which removes metal by a series of discrete electrical discharges that cause high temperatures which is enough to melt or vaporize the metal. The process is adopted for the materials which often have special properties that make them difficult to machine by conventional machining. In present study work of different researchers has been discussed which shows the effect of process parameters such as pulse on time, pulse off time, gap voltage , peak current and duty factor on output responses such as tool wear rate (TWR), material removal rate (MRR) and surface roughness (Ra)

Keywords: Electrical discharge machining, Material removal rate, Surface roughness, Tool wear rate

I. INTRODUCTION

Electrical discharge machining is one of the nontraditional machining processes which have been widely used for the production of dies and moulds, finishing parts for aerospace, automotive industry and surgical components. Figure 1 shows principal of metal removal in EDM. In this process the material is removed by means of series of electrical charges between tool called electrode and the work piece in the presence of dielectric fluid. The electrode is moved toward the work piece until the gap is small enough so that the applied voltage is great enough to ionize the dielectric. The material is removed due to erosion. EDM does not make direct contact between work piece and tool. Material of any hardness can be cut as long as material can conduct electricity. The temperatures of the electrodes can be raised more than their normal boiling points [1].

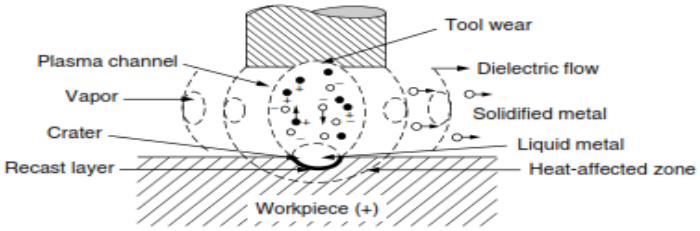

Figure 1. Principal of metal removal in EDM

EDM performance measures such as material removal rate, tool wear rate, and surface roughness are influenced by different process parameters [1]. The different process parameters of EDM are shown in the fishbone diagram (figure 2) with output parameters MRR, TWR and Ra.

The aim of this paper is to study the influence of pulse on time, pulse off time, gap voltage , peak current and duty factor on output responses such as tool wear rate (TWR), material removal rate (MRR) and surface roughness (Ra).

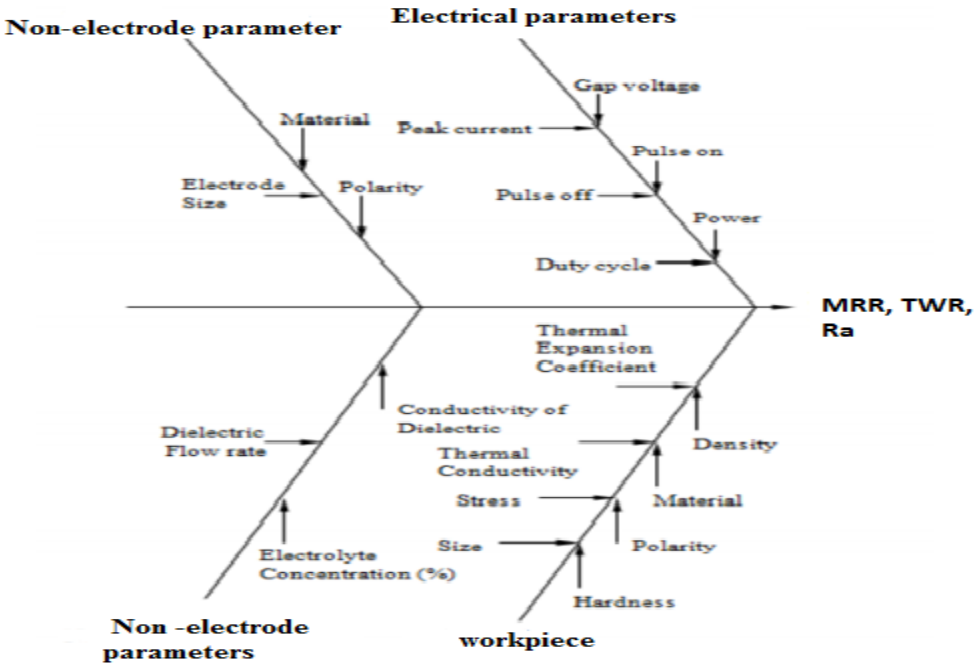

Figure 2 Fishbone diagram showing process parameters affecting MRR, TWR and Ra

II. LITERATURE REVIEW

A. Effect of pulse on time, pulse off time, peak current and discharge current-

Mr. Kurri Rohan Ramesh and Jagtap Shrikant Tukaram have studied the effect of process parameters on Ra. The work piece material was alloy steel (EN-31). They prepared mathematical models using the response surface methodology (RSM) to correlate dominant machining parameters, including the discharge current, pulse on time, duty factor and open discharge voltage in the EDM process of alloy steel. They observed that, the value of Ra first decreases with an increase of pulse on time and then increases with further increase in pulse on time. The value of Ra increases with an increase of discharge current and open discharge voltage but decreases with an increase of duty factor. Ra value reduces with decreasing peak current and reduces with increasing of gap voltage [2].

Chorng-Jyh Tzeng and Rui-Yang Chen investigated influence of process parameters on MRR, TWR and Ra during the manufacture of SKD61 by EDM. A hybrid method including a back-propagation neural network (BPNN), a genetic algorithm (GA) and RSM were used. Specimens were prepared under different EDM processing conditions according to a Taguchi orthogonal array table. The conclusion was that the cutting parameter of discharge current is the most significant factor for MRR and the cutting parameter pulse on time is the most significant factors for Ra [3].

RSM and multilinear regression analysis was used by Sunil Sheshrao Baraskar *et. al*. to observe the effect of process parameters by using medium carbon steel (EN8). The study was carried out with copper electrode. The results for Ra and MRR indicate that discharge current is the most influencing factor [4].

The analysis of crack formation and spherical form of resolidified layer on T90Mn2W50Cr45 tool steel surface was done by S. Rajendran, K. Marimuthu and M. Sakthivel. The crack formation was influenced by the base material properties, TWR and resolidified layer. The resolidified deposit on the machined surface occurs in the case of high pulse current, which causes the rapid vaporization of dielectric fluid. The value of Ra depends on the cooling of the resolidified layer due to spherical grain formation within the resolidified layer which depends on the cooling rate [5].

Horacio T. Sánchez *et. al.* have solved an inversion model, based on the least squares theory and established the values of the EDM input parameters. The inversion model and forward model was constructed from a set of

experiments for AISI 1045 steel. The conclusion was that, the inversion model was intended to be more flexible and simple since EDM parameters were easily worked out as a function of the admissible limits of the Ra, TWR and MRR which can be easily modified by the EDM user [6].

Experiments were conducted for three different work piece materials to see the effect of work piece material variation by P. Sahoo *et. al.* by using RSM. Influence of machining parameters was studied on the quality of surface produced in EDM. Five roughness parameters such as centre line average roughness, root mean square roughness; skewness, kurtosis and mean line peak spacing have been considered. They found from the experiment that, among the different machining parameters pulse current has the maximum influence on the roughness parameters while pulse on time has some effect. Where pulse off time has no significant effect on roughness parameters [7].

B. Effect of current, pulse on time and feed-

Above discussion shows that many of the researchers have worked for effect of combination of input parameters such as current, pulse on time and pulse off time. Less research is done on EDM by using input parameter as feed.

Optimization of MRR and TWR was done on EDM by Suresh Kumar Gurjar and Rajeev Kumar by using Taguchi and ANOVA. They attempted for finding feasibility of machining die steel H13 work piece using circular copper electrode and dielectric flushing. The selected machining parameters were discharge current, pulse on time and feed of the tool. They observed that current have the statistical significance on MRR whereas TWR is influenced by current, feed and pulse on time [8]. Shahul Backer *et. al.* utilized a well-designed experimental scheme to analyze the EDM process on OHNS EN-31 material by using Taguchi method. The signal-to-noise ratios associated with the observed values in the experiments were determined. It was observed that the current have more significance on MRR and TWR. Feed has less significance on TWR [9].

C. Effect of peak current, gap voltage and duty cycle-

Researchers have concluded that feed is a least significant parameter. Some researchers have studied effect of duty cycle and gap voltage for EDM process.

Nibu Mathew *et. al*. have studied the effect of input parameters of EDM process i.e. electrode type, peak current, gap voltage, and duty cycle on material removal rate of H11 steel by using Taghuchi method. Conventional copper (Cu) and powder metallurgy (PM) copper tungsten (CuW) were used as tool materials. It was observed that, with conventional copper tool electrode MRR increases with the increase of gap voltage and duty cycle. For copper tungsten powder metallurgy tool MRR increases with the increase in peak current. Where for powder metallurgy copper tungsten tool electrode it was observed that MRR increases with the increase in gap voltage up to certain value and after that MRR decreases with the increase of gap voltage and duty cycle [10].

M. K. Pradhan has investigated an optimization design of the various machining parameters for the EDM processes on AISI D2 tool steel using a hybrid optimization method. The major responses selected for this analysis were MRR, TWR and radial overcut or gap and the corresponding machining parameters. The experimental results obtained were used in grey relational analysis and the weights of the responses were determined by the principal component analysis (PCA) and further evaluated using RSM. It has been found that duty cycle is the most significant process parameter followed by pulse current [11].

The optimization performance of the BBO algorithm was compared with that of other population-based algorithms, genetic algorithm, ant colony optimization, and artificial bee colony algorithm for EDM of Rajarshi Mukherjee and Shankar Chakraborty have carried out parametric design which involved characterization of multiple process responses such as MRR, TWR, Ra, surface integrity and heat affected zone with respect to different machining parameters. It was observed that the algorithm performs better than the others with respect to the optimal process response values. The increase in pulse on time results in increased value of MRR. The higher value of MRR is only possible at lower gap voltage [12].

Deep hole drilling of Inconel 718 using the EDM process was observed by P. Kuppan and A. Rajadurai and S. Narayanan with the use of RSM. The parameters such as peak current, pulse on time, duty factor and electrode speed were chosen to study the machining characteristics. An electrolytic copper was selected as a tool electrode. The output responses measured were MRR and depth averaged surface roughness (DASR). The conclusion made by them was that, peak current and electrode rotation have significant contributions in MRR model. The MRR increases with the increase in peak current, duty factor and electrode speed. Whereas pulse on-time is insignificant on MRR but strongly influences the DASR [13].

D. Effect of peak current, pulse on time, dielectric pressure, tool diameter and fluid flow

Some researchers have studied for the influence of electrical and non electrical input process parameters for EDM.

Two different materials EN8 and D3 steel were used by P. Balasubramaniana and T. Senthilvelanb as work pieces to analyze the EDM process by using RSM. The cast copper and sintered powder metallurgy copper was used as tool electrodes to machine the work pieces. It was noticed that, for EN-8 material mean value of MRR was high and low TWR value for cast electrode compared with sintered electrode. The Ra value was less for sintered electrode compared with cast electrode. For die steel (D3) which was machined by cast electrode the mean value of MRR was high and TWR was low compared with sintered electrode. The mean value for Ra was marginally lower for sintered electrode than that of cast electrode [14].

B. Bhattacharyya emphasized the features of the development of comprehensive mathematical models based on RSM for EDM of M2 die steel. He studied effects of EDM process parameters on Ra, average white layer thickness and surface crack density. It was observed from the parametric analysis that at lower peak current and pulse on duration minimum Ra can be achieved. It was further concluded that peak current and pulse on duration should be kept as low as possible to minimize the average white layer thickness because too large peak current will lead to cause undesirable effects like high Ra, formations of micro and macro cracks. He recommended that medium value of peak current along with minimum possible pulse on time should be selected in order to minimize SCD [15].

III. CONCLUSION

It can be seen that peak current have more significance on MRR and TWR. Feed has less significance on TWR lower gap voltage tends to give higher value of MRR. The value of Ra increases with increase of discharge current and open discharge voltage but decreases with an increase of duty factor, current and gap voltage. Use of copper electrode contributes for lower value of Ra. It is concluded from above literature review that more research is done by the researchers for EDM process to study the influence of process parameters such as pulse on time, pulse off time and peak current on output responses Ra and MRR. Few of the researchers have worked for the effect of gap voltage and peak current. Thus the process can be carried out using response surface methodology by considering the input process parameters like pulse on time, peak current and gap voltage to find optimized Ra and MRR.

REFERENCES

[1] Abdul-Gawad El Hofy, "Advanced Machining Processes."2nd Edition, Mc-Graw Hill Publication, pp. 115 -139.

[2] Kurri Rohan Ramesh and Jagtap Shrikant Tukaram, "The effects of Machining Parameters on Surfac roughness of Material EN-31 in EDM using Copper Electrode", International Journal of innovations inEngineering Research and Technology, Volume 2, Issue 9, pp.1-8, September 2015.

[3] Chorng-Jyh Tzeng and Rui-Yang Chen, "Optimization of Electric Discharge Machining Process using the Response Surface Methodology and Genetic Algorithm Approach", Springer, International journal of Precision Engineering and Manufacturing, Volume 14, Issue 5, pp. 709-717, May 2013.

[4] Sunil Sheshrao Baraskar, S. S. Banwait, and S. C. Laroiya, "Multiobjective Optimization of Electrical Discharge Machining Process Using a Hybrid Method", Taylor and Fransis, Materials and Manufacturing Processes, Volume 28, pp. 348–354, 2013.

[5] S. Rajendran, K. Marimuthu and M. Sakthivel , "Study of Crack Formation and Resolidified Layer in EDM Process on T90Mn2W50Cr45 Tool Steel", Materials and Manufacturing Processes, Volume 28, pp. 664–669, 2013.

[6] Horacio T. Sánchez, Manuel Estrems & Felix Faura, "Development of an Inversion Model for establishing EDM Input Parameters to satisfy Material Removal Rate, Electrode Wear Ratio and Surface Roughness", International Journal of Advanced Manufacturing and Technology, Volume 57, pp. 189–201, 2011.

[7] P. Sahoo, B .C. Routara and Bandyopadhyay, "Roughness modeling and optimization in EDM using Response Surface Method for different Work piece Materials", Springer, International Journal of Machining and Machinability of Materials, Volume 5, pp. 321-346, 2009.

[8] Suresh Kumar Gurjar and Rajeev Kumar, "Optimization of MRR and TWR on EDM by using Taghuchi's Method and ANOVA Die Steel H13", International journal for Innovative Research in Science and Technology, Volume 2, Issue 3, pp. 22-28, August 2015.

[9] Shahul Backer, Cijo Mathew and Sunny K. George, "Optimization of MRR and TWR on EDM by Using Taguchi's Method and ANOVA", International Journal of Innovative Research in Advanced Engineering, Volume 1, Issue 8, pp. 106-112, September 2014.

[10] Nibu Mathew, Dinesh Kumar, Naveen Beri and Anil Kumar, "Study of Material Removal Rate of different Tool Materials during EDM OF H11 Steel at Reverse polarity", International Journal of Advanced Engineering Technology, Vol. V, Issue II, pp. 25-30, April-June, 2014.

[11] M. K. Pradhan, "Estimating the effect of process parameters on MRR, TWR and radial overcut of EDM_{ED} AISI D2 tool steel by RSM and GRA coupled with PCA", Springer, International Journal of Advanced Manufacturing and Technology", Volume 68, pp. 591–605, 2013.

[12] Rajarshi Mukherjee and Shankar Chakraborty, "Selection of EDM Process Parameters Using Biogeography-Based Optimization Algorithm", Materials and Manufacturing Processes, Volume 27, pp.954–962, 2012.

[13] P. Kuppan, A. Rajadurai and S. Narayanan, "Influence of EDM process parameters in Deep Hole drilling of Inconel 718", Springer, International Journal of Advanced Manufacturing and Technology, Volume 38, pp.74–84, 2008.

[14] P. Balasubramaniana and T. Senthilvelanb, "Optimization of Machining Parameters in EDM process using Cast and Sintered Copper Electrodes", Science Direct, Procedia Materials Science, pp.1292-1302, May 2014.

[15] B. Bhattacharyya, S. Gangopadhyay and B. R. Sarkar, "Modeling and analysis of EDM_{ED} Job Surface Integrity", Science Direct, Journal of Materials Processing Technology, Volume 189, pp. 169–177, 2007.