International Journal of Engineering Research & Technology (IJERT)
NCAEM-2013 Conference Proceedings
ISBN: 978-93-83758-09-8

EXPERIMENTAL ANALYSIS OF CONTROL FACTORS OF EDM DRILLING FOR EN-5 STEEL

[1]Amit Garg, [2]Jonny Chaudhary, [3]Ravinder

[1]Lecturer, Mechanical Deptt., SKIET Kurukshetra.
[2] Assistant Professor, Mechanical, BGIET Sangrur
[3] Assistant Professor, Mechanical, SKIET Kurukshetra

Abstract: The objective of this work is to analysis of control factors of EDM Drilling for EN-5 namely Peak Current, Pulse On-Time,Pulse Off time, flushing pressure on Metal Removal Rate (MRR) and Surface Roughness (SR) during electrical discharge machining of EN-5 mild steel. It have widely applications like in making die, shafts, racks, pinions,studs, bolts, nuts, rollers etc. A copper tool of diameter 5 mm was used to drill the specimens. The OFAT approach is used to analyse the control factors.

***Key words*: Electric discharge machining (EDM) , OFAT (one factor time approach),EN5 steel, Process Parameters (like Peak Current, Pulse On-Time and flushing pressure), Metal Removal Rate (MRR) and Surface Roughness (SR)**

I. INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive.

In this process the metal is removing from the work piece due to erosion case by rapidly recurring spark discharge taking place between the tool and work piece. Fig. 1.1 shows the mechanical set up and electrical set up and electrical circuit for electro discharge machining. A thin gap about 0.025mm is maintained between the tool and work piece by a servo system. Both tool and work piece are submerged in a dielectric fluid. Kerosene/EDM oil/de-ionized water is very common type of liquid dielectric although gaseous dielectrics are also used in certain cases.

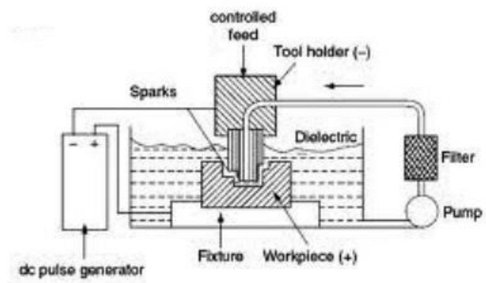

Fig 1.1: Set up of Electric discharge machining

Figure shown the electric setup of the Electric discharge machining. The tool is made cathode and work piece is anode.in Mohan et al. (2002) analysed the effect of EDM parameters namely polarity, current, electrode material, pulse duration and rotation of electrode on metal removal rate (MRR), tool wear rate(TWR) and surface roughness(SR) value in EDM of AL-SiC metal , matrix composites with 20 and 25 vol.% SiC. S.Akaslan et.al (2002) investigated the variaton of tool electrode edge wear & machining performance outputs namely MRR, TWR & relative wear, with the varing machining parameters. George et al. (2003) determined the optimal setting of the process parameters on the electro-discharge machining (EDM) machine while machining carbon–carbon composites. The parameters considered are pulse current, gap voltage and pulse-on-time; whereas the responses are electrode wear rate (EWR) and material removal rate (MRR). A. Rajadurai et al. (2004) worked on SiC/6025 Al composite using rotary electro-discharge machining (EDM) with a tube electrode. Brass was used as the electrode material to SiC/6025 Al composites. Three observed values: (MRR), (EWR) (SR). Peak current, polarity, volume fraction of SiC reinforced particles, pulse duration, hole diameter of the tube electrode, and speed of electrode rotation were used as the input variables to assess the machinability. Kansal et al. (2007) studied the effect of silicon powder mixing into the dielectric fluid of EDM on machining characteristics of AISI D2 (a variant of high carbon high chrome) die steel has been studied. Six process parameters, namely peak current, pulse on time, pulse-off time,

ISBN: 978-93-83758-09-8

concentration of powder, gain, and nozzle flushing have been considered. The process performance is measured in terms of machining rate (MR). The study indicated that all the selected parameters except nozzle flushing have a significant effect on the mean and variation in MR. R.K. Garg et al. (2011) studied the parametric optimization for Material Removal Rate (MRR) and Tool Wear Rate (TWR) study on the Powder Mixed Electrical Discharge Machining (PMEDM) of EN-19 (AISI-4140) steel has been carried out. Peak current, duty cycle, angle of triangular electrode and concentration of micro nickel power added into dielectric fluid of EDM were chosen as process parameters to study the PMEDM performance in terms of MRR and TWR. Most important parameters affecting selected performance measures have been identified and effects of their variations have been observed.

EXPERIMENTAL DETAIL **:** A EDM machine (S-35, Sparkonix) was used as the experimental machine in this study. A Cupper Tool with a diameter of 5 mm was used as an electrode to erode a work piece of EN-5 (flat plate). The gap between work piece and electrode was flooded with a moving dielectric fluid. Machining Experiments for determining the optimal machining parameters for optimizing response characteristics were carried out by using EDM oil as a dielectric fluid. Peak Current, Pulse on Time, Jet Pressure are the various parameters of Electric Discharge machining which are considered for analyzing the machining performance criteria e.g. surface roughness, and material removal rate.

Fig 1.2: EDM used for Experimentations

Cylindrical shape electrodes are used in the machining processes which are shown in the figure 1.3. Copper was used as electrode for EDM to machining of EN-5. The specifications of Cu which was used as electrode material are shown in Table 1.1.

Fig 1.3: Electrode used for Experimentations

1	Electrical resistivity	0.0167 Ωmm2/m
2	Purity	99.8%
3	Melting point	1083°C
4	Density	8.9 kg/dm3
5	Height	40 mm
6	Diameter	5 mm

Table 1.1: Electrode Material specifications

The EN-5 is first clamped on the magnetic bed on the table of the EDM. Then the dielectric is made to flow on to the machining chamber. Drilling is done on the work piece using copper electrode of 5 mm diameter. The erosion button is switched ON and the spark is set. After the sparking is set between the work piece and the electrode, the material starts removing from the work piece in the form of the small micro debris.

II. EXPERIMENTAL SET UP

The purpose of this study is analysing the effect of EDM process parameters on response variable such as Material Removal Rate, Surface Roughness. Also, it is intended to ascertain the range of different parameters required for the experimental design methodology used in this work.

The pilot experiments were performed on model S-35, Sparkonix EDM machine. Various input process parameters varied during the experimentation are pulse on time, pulse off time, peak current, and jet pressure. Apart from the parameters mentioned above following parameters were kept constant at a fixed value during the experimentation

1. Work piece : EN-5
2. Electrode(tool) : Ø 5mm copper
3. Work piece height : 2 mm
4. Dielectric Conductivity : 20 mho
5. Dielectric temperature : 20-240C

Observations are made by fixing some parameters and vary individual parameters one by one with the response variable i.e material removal rate and surface roughness.

ISBN: 978-93-83758-09-8

Material Removal Rate (MRR) is calculated as:
Weighing machine was used to measure the weight of the work piece. MRR is expressed as the ratio of the difference of weight of the work piece before and after machining to the machining time. It is being measured in terms of mg/sec.

MRR = (Mi-Mf) /t

Where:-Mi is the weight of the work piece before machining i.e. initial weight, Mf is the weight of the work piece after machining i.e. final weight, and t is the machining time and Surface roughness is measured with the help of surface roughness testor.

In the first set of experiments:
Effect of Pulse on Time on Response Variable is calculated

The pulse on time (Ton) is varied from 3 machine units to 9 machine units. The values of the other process parameters are given as Toff = 6µs unit; IP= 7A and JP = 10Kgf/cm2. The experimentally observed values of the response variables for different values of jet pressure are given in Table 1.2.

Pulse on Time (µs)	Mrr (mg/s)	Sr (µm)
3	0.09	2.05
5	0.14	2.1
6	0.16	2.12
7	0.17	2.15
8	0.19	2.16
9	0.2	2.19

Table 1.2:Effect of Pulse on Time on MRR & SR

In the second set of experiments: Effect of pulse off time on response variables is calculated
The pulse off time (Toff) is varied from 3 machine units to 10 machine units. The values of the other process parameters are given as Ton = 6µs unit; IP= 7A and JP = 8Kgf/cm2. The experimentally observed values of the response variables for different values of jet pressure are given in Table 1.3.

Pulse off Time (µs) (µs)(µs)	Mrr (mg/s)	Surface Roughness (µm)
3	0.14	2.21
5	0.14	2.2
7	0.14	2.18
8	0.13	2.16
9	0.13	2.15
10	0.12	2.11

Table 1.3: Effect of Pulse off Time on MRR & SR

In the third set of experiments: Effect of peak Current on Response Variable is calculated by considering following values:
The current is varied from 5 machine units to 16 machine units. The values of the other process parameters are given as Ton = 6µs; Toff= 6µs and JP = 10Kgf/cm2. The experimentally observed values of the response variables for different values of jet pressure are given in Table 1.4.

Peak current (A)	Material removal rate (mg/s)	Surface Roughness (µm)
5	0.13	1.98
8	0.23	2.11
10	0.28	3.29
12	0.31	4.2
14	0.36	4.98
16	0.39	5.15

Table 1.4:Effect of Peak Current on MRR & SR

In the fourth set of experiments : Effect of Jet Pressure on Response Variable is calculated
The Jet Pressure is varied from 5 machine units to 16 machine units. The values of the other process parameters are given as Ton = 5µs; Toff= 6 µs and IP = 10A. The experimentally observed values of the response variables for different values of jet pressure are given in Table 1.5.

Jet Pressure Kgf/cm^2	Material removal rate (mg/s)	Surface Roughness (µm)
5	0.2	2.4
8	0.2	2.56
11	0.19	2.68
14	0.18	2.99
16	0.17	3.09

Table 1.5:Effect of jet pressure on MRR & SR

III. RESULT, ANALYSIS AND DISCUSSION

The scatter plots of pulse on time versus response variables are shown in Figure 1.4. it was observed that MRR was low when the electrode was kept as low as well as at high pulse duration because when there is small pulse duration then less vaporisation will be there and when high pulse duration then plasma channel expand due to this energy density decrease on the workpiece decrease thus MRR is increased in the medium range of pulse duration as shown in figure below, as the value of ton is increasing the value of surface roughness is also increasing because longer pulse duration expand the plasma channel which produced a shallow creator on the surface.

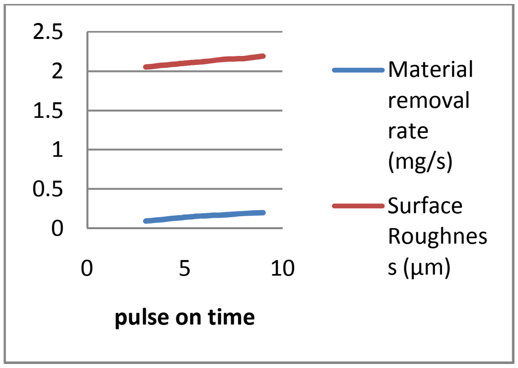

Fig.1.4: The scatter plots of pulse on time versus response variables

The scatter plots of pulse off time versus response variables are shown in Figure 1.5.
As the value of pulse off time increases, material removal rate decreases because with the increase of pulse off time machining time reduced.

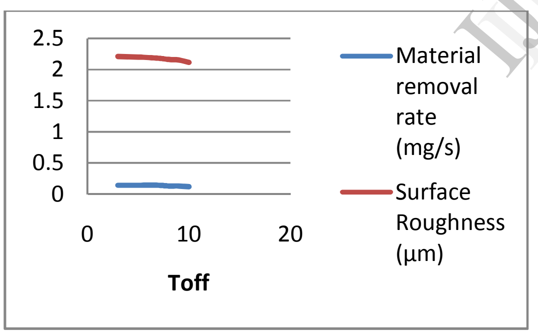

Fig 1.5 : The scatter plots of pulse off time versus response variables

The scatter plots of peak current versus response variables are shown in Figure 1.6. As the value of peak current increase, material removal rate also increases it has observed that discharge energy increases due to which material removal rate increases and with increase in discharge current produced larger creator on the surface and resulting increase in surface roughness .

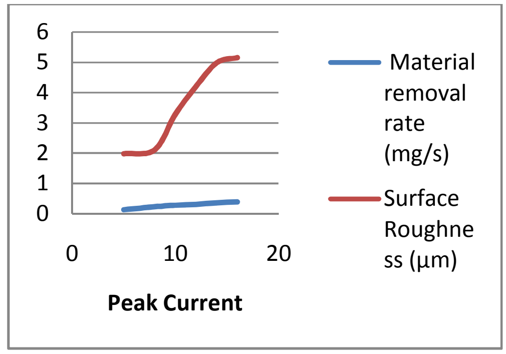

Fig. 1.6 : The scatter plots of peak current versus response variables

The scatter plots of jet pressure versus response variables are shown in Figure 1.7.

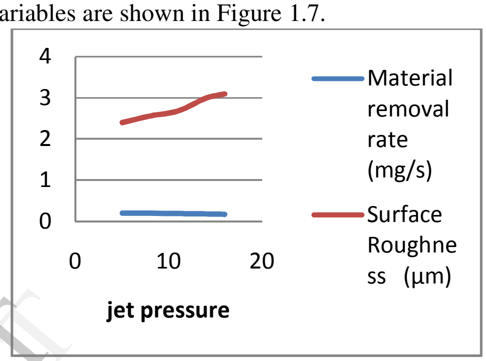

Fig 1.7: The scatter plots of jet pressure versus response variables

High jet pressure blocks the formations of ionized bridges and reduced the MRR. and surface roughness also increase with increase of jet pressure because some metal is eroded abnormally by the jet pressure.

IV. CONCLUSION

From the above study is concluded that :

a) MRR is increase with the increase in pulse on time upto a limit beyond a particular limit of pulse on time MRR start decrease. And surface roughness increase with increase in pulse on time.
b) MRR is decreased with increase of pulse duration because machining time reduced and surface roughness decreased with increase of pulse of time.
c) MRR is increased with increase of peak current because increase in discharge energy and surface roughness also increase with peak current.
d) MRR is Decreased with jet pressure and surface roughness increased with jet pressure.

V. REFERENCES

[1] B. Mohan, A. Rajadurai, K. G Satyanarayana [2002] " Effect of SiC & rotation of electrode on electric

ISBN: 978-93-83758-09-8

discharge machining of Al-SiC composite" Journal of Materials Processing Technology, vol. 124, pp 297-304

[2] Can COGUN,S. Akaslan[2002] " The effect of machining parameters on Tool edge wear & machining performance in EDM" KSME International Journal, vol, 16, No.1,pp 46-59

[3] P.M. George, B.K. Raghunath , L.M. Manocha, Ashish M. Warrier [2003] "EDM machining of carbon–carbon composite—a Taguchi approach "Journal of Materials Processing Technology, vol. 145, pp 66–71

[4] B. Mohan, A. Rajadurai, K.G. Satyanarayana [2004] "Electric discharge machining of Al–SiC metal matrix composites using rotary tube electrode "Journal of Materials Processing Technology, vol. 153, pp 978 – 985.

[5] 5. Biing Hwa Yan, Hsien Chung Tsai, Fuang Yuan Huang [2005] "The effect in EDM of a dielectric of a urea solution in water on modifying the surface of titanium" International Journal of Machine Tools & Manufacture, vol. 45, pp 194–200

[6] H.K. Kansal, Sehijpal Singh , Pradeep Kumar[2007] "Technology and research developments in powder mixed electric discharge machining (PMEDM) "Journal of Materials Processing Technology, vol. 184, pp 32-41

[7] R. K Garg, Kuldeep Ojha [2011] " Parametric Optimization of PMEDM Process with Nickel Micro Powder suspended Dielectric & Varying Triangular Shape Electrode on EN -19 Steel " Journal of Engineering & Applied Science, vol. 6, pp 152-156