Parameters effecting the EDM drilling of En-5 steel

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Abstract:

The objective of this work is to investigate the effect of three process parameters, namely Peak Current, Pulse On-Time and 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. An L9 orthogonal array (OA), for the three machining parameters at three levels each, was opted to conduct the experiments. The ANOVA analysis indicates that the percentage contribution of peak current, Pulse On-Time and flushing pressure

Keywords: - Electric discharge machining (EDM) Taguchi Method, Orthogonal array, ANOVA, Process Parameters (like Peak Current, Pulse On-Time and flushing pressure), Metal Removal Rate (MRR) and Surface Roughness (SR)

1. 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.

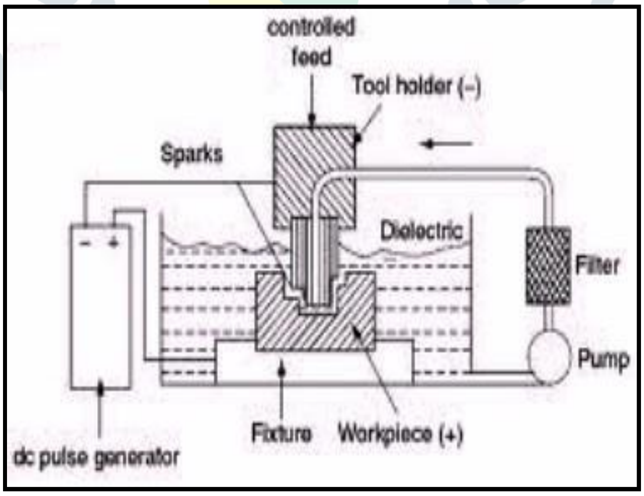

Fig. 1

Fig.1 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: material removal rate (MRR), electrode wear rate (EWR) and surface roughness (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. Biing Hwa Yan et al. (2005) investigated the influence of the machining characteristics on pure titanium metals using an electrical discharge machining (EDM) with the addition of urea into distilled water. Additionally, the effects of urea addition on surface modification are also discussed. machining parameters such as the dielectric type, peak current and pulse duration were changed to explore their effects on machining performance, including the material removal rate, electrode wear rate and surface roughness. 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, 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.

2. Experiments

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. 2 EDM Used for Experimentations

Cylindrical shape electrodes are used in the machining processes which are shown in the Fig.2 . 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.

Fig 3.2: Electrode Used for Experimentations

One of the most important factors in a successful EDM operation is the removal of the metal particles (chips) from the working gap. Flushing these particles out of the gap between the workpiece to prevent them from forming bridges that cause short circuits.

TABLE 1: Electrode material specifications

S. No.	Material Used	Copper
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

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. Fig. 3.3 shows the drilled work piece during experimentation work.

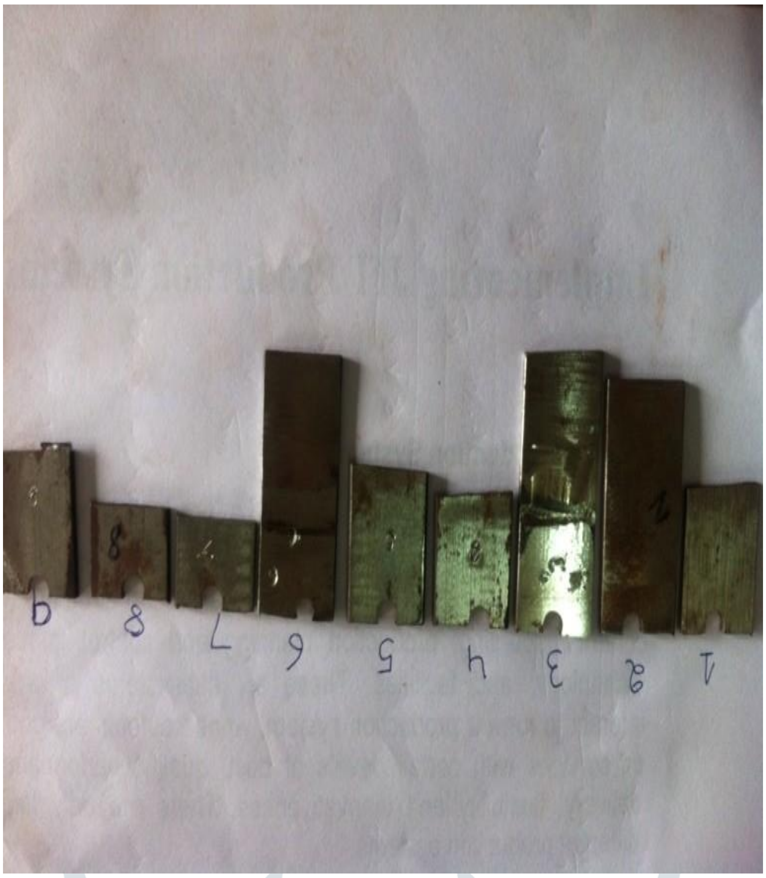

Fig. 3 Work Piece Drilled during Experimentation

3. Result and discussion

Because the experimental design is orthogonal, it is possible to separate out the effect of each process parameter at different levels. And values of S/ N ratio of the MR for each trial run (1 through 9) have been calculated from experimental data and are summarized in Table 2

TABLE 2 Machining rate values and s/ n ratio data

Ip	T ON	JP	W Loss (g)	Time Taken T (S)	MRR (mg/ s)	S/N
8	5	5	0.14	765	0.18	-14.8945
8	7	10	0.14	736	0.19	-14.4249
8	9	15	0.15	734	0.20	-13.9794
12	5	10	0.14	432	0.32	-9.8970
12	7	15	0.15	417	0.35	-9.1186
12	9	5	0.14	386	0.36	-8.8739
16	5	15	0.13	399	0.32	-9.8970
16	7	5	0.15	376	0.39	-8.1787
16	9	10	0.14	335	0.41	-7.7443

The individual effects of the three parameters on MR and are shown in Fig. 2. From the trend of variation of the MR at different Levels of the factors, it can be observed that with an increase in peak current,

MRR Increase with increase pulse duration because longer pulse duration produce bigger creater due to the increase of input energy in high pulse on time duration and this result in higher MRR with poor surface quality [S. Akaslan et.al 2002] and MRR decreased by increase the jet pressure Because flow of dielectric blocks the formation of ionized bridges and reduces the material removal rate. [Velusamy Senthilkumar 2010].

The Table 5.2 shows the analysis of variance (ANOVA) results for the coefficient of friction for three factors varied at three levels.This analysis is carried out for a confidence level of 95%.Sources with a P-value less than 0.05 were condsidered to have a statitstically significant contribution to the performance measures.In table 5.2 the last column shows the percentage contribution (Pr) of each parameter.

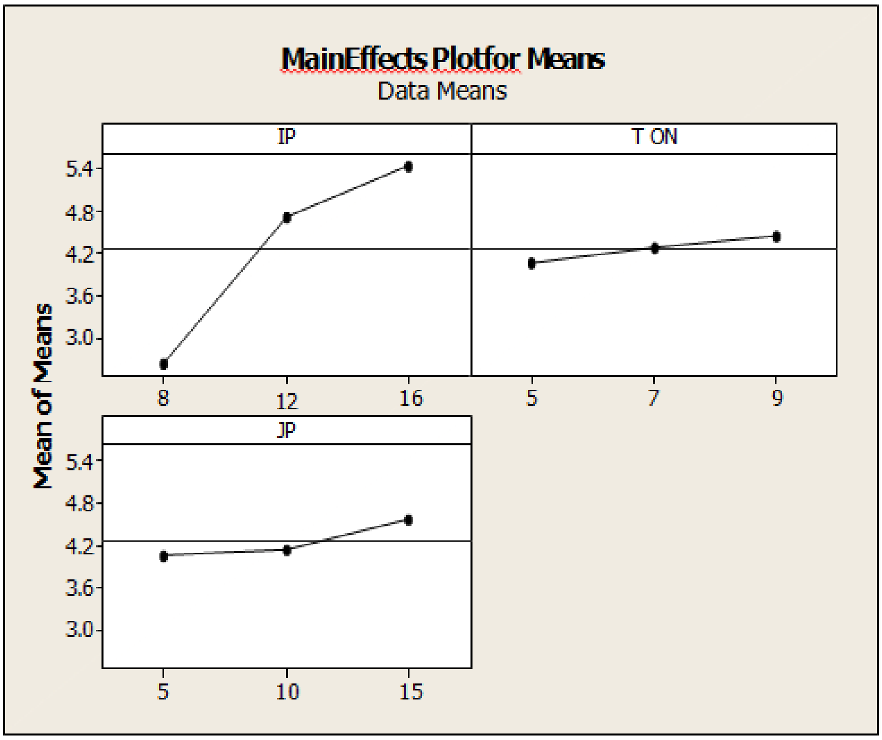

Fig 5.3: Effect of EDM Parameters on SR

It is observed that the mean value of SR is increase by increasing the peak current. Increase the peak current increase the discharge energy and impulsive forces which removing more melted material and generating deeper and larger creater due to this increase the SR. Impulsive force due to the evaporation of dielectric fluid and high discharge energy is causes of large impulsive force. [Biing Hwa Yan et.al 2005]. SR is increased by increase the jet pressure because some material is eroded by jet pressure and some vibration produced by jet pressure on the tool. The Table shows the analysis of variance (ANOVA) results for the coefficient of friction for three factors varied at three levels.This analysis is carried out for a confidence level of 95%.Sources with a P-value less than 0.05 were condsidered to have a statitstically significant contribution to the performance measures.In table 5.3 the last column shows the percentage contribution (Pr) of each parameter.

Flushing is the most important function in any electrical discharge machining operation. Flushing is the process of introducing clean filtered dielectric fluid into the spark gap. Flushing applied incorrectly can result in erratic cutting and poor machining conditions. There are a number of flushing methods used to remove the metal particles efficiently while assisting in the machining process. Too much fluid pressure will remove the chips before they can assist in the cutting action, resulting in slower metal removal. Too little pressure will not remove the chips quickly enough and may result in short-circuiting the erosion process.

4. Conclusion

Electric discharge machining (EDM) has been found to be a promising machining technique for Obtaining desired machining rate and surface roughness from hard and tough die steels like EN-5. The result of the present work identifies the significant process parameters and optimizes the machining conditions. Within the range of parameters selected for the present work, the following conclusions are drawn:

1. It is observed that MRR is increase by increasing the peak current. because increase in discharge energy and impulse force as the peak current increased.
2. MRR rises by increasing the value of pulse on time because increase the machining time
3. MRR decreased by increase the jet pressure. Because flow of dielectric blocks the formation of ionized bridges and reduces the material removal rate.
4. SR is increase by increasing the peak current. Because Increase the peak current increases the discharge energy and impulsive forces which generating deeper and larger creater due to this increases the SR.

5. SR rises by increasing the value of pulse on time. because longer pulse duration expand the plasma channel and decrease the energy density due to this longer pulse duration produces a shallow creater on the surface of the work piece.

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