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Optimization of EDM process parameters using Taguchi Method with Copper Electrode

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Abstract - *Optimization is the action of making the best or most effective use of a situation or resource. Optimization is on essential requirement for industries towards manufacturing of various types of quality product at cheap amount or cost. Electrical discharge machining (EDM) is also known as spark machining, spark eroding burning, die sinking, wire burning or wire erosion. This process is based on thermo electric energy which acts between the work piece and an electrode. This paper deals with the optimization model to investigate the effects of peak current, pulse on time, pulse off time and flashing pressure in Electrical Discharge Machining (EDM) . In this experiment, Material Removal Rate (MRR) and Tool Wear Rate (TWR) in machining of mild steel utilizing copper as electrode with negative polarity have been calculated. Based on the experiments and using Taguchi's design of experiments response tables and graphs are made. For high MRR, the most significant factor is pulse on time and for low TWR, the most significant factor is found to be peak current. We got the optimum result at peak current 12amp, pulse on time 15µs, pulse off time 3µs and flushing pressure 0.3 kg/cm², where the material removal rate (MRR) becomes high and at peak current 14amp, pulse on time 5µs, pulse off time 7µs and flushing pressure 0.3 kg/cm² the tool wear rate (TWR) reduces significantly.*

***Key Words*: EDM Process, MRR, TWR, Taguchi Approach etc…**

1. INTRODUCTION

Electrical Discharge Machining (EDM) is one of the latest Processes, where electrically conductive material is removed by controlled erosion through a series of electric sparks of short duration and high current density between the electrode and the work piece, both is submerged in a dielectric bath, containing kerosene or distilled water. During this process thousands of sparks per second are generated, during this action. Each spark produces a tiny crater in the material along the cutting path by melting and vaporization. Generally the material is removed by erosion process. The top surface of the work piece subsequently resolidifies and cools at a very high rate or fast as possible. The important output parameters of the process are the material removal rate (MRR), tool wear rate (TWR). Optimization of the EDM process is concerned with maximizing MRR while minimizing TWR, the finish should be as smooth as possible. This paper describes an investigation of EDM process optimization using copper electrodes. Whenever sparking takes place between two electrical contacts a small amount of material is removed from each of the contacts. This fact was realized and the attempts were made to harness and control the spark energy to utilize it for the useful purpose, say for machining of metals. It was found that spark of short duration and high frequency is needed for efficient machining. Further, it was formed that if the discharge is submerged in dielectric, the energy can be controlled into a small area and it does not bad effect the side area it only acts on the metal only.

1.1 Working principal of EDM

EDM is a thermo electric process in which heat energy of spark is used to remove the material from the work piece (1). The work piece and tool should be made of electrically conductive materials (3). In this process electrical spark is created between an electrode and a work piece. The EDM process usually does not affect the heat treat below the surface with EDM the spark always takes place in the dielectric fluid or kerosene shown in figure1.

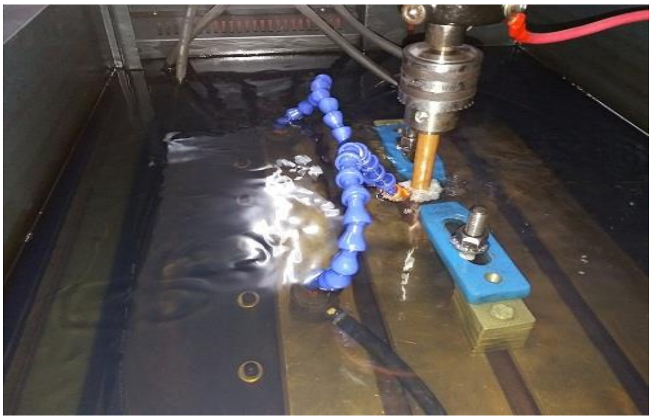

Fig -1: EDM process and flushing dielectric fluid

2. Experimental work

The experiments were conducted using a Die-sinking EDM machine, model ZNC25 manufactured by J. K. Machine India shown in figure 2(3). The electrode is fed downwards into the Die Mild steel work piece under servo control in this EDM machine. The work-piece material was mild steel which is a rectangular shaped work-piece material (50 mm length, 10 mm width and 4 mm thickness). In this experiment are using Taguchi's methods L_9 Orthogonal Array. After you determine which factors affect deviation, that are find to settings for controllable factors that will either reduce the deviation, make the product insensitive to changes in (noise) factors, (Minitab15).

Fig -2: ZNC25 Die Sinker EDM machine setup with tool

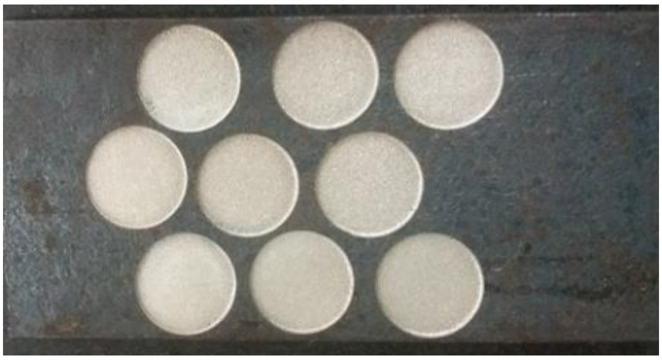

Fig -3: After machining work piece

In this experiment mild steel of size 50×10×5 mm³ plate is chosen for conducting the experiment. It is the most versatile applications and greatest use of mild steel, offered in an extensive variety of good products, practices and qualities than any other. It has wonderful welding and forming characteristics (4). Variance of work uses in the manufacturing, construction as well as automobile fields.

Table -1: Machine parameter and level

Peak current (A)	10	12	14
Spark on time (μs)	5	10	15
Spark off time (μs)	03	05	07
Flushing pressure (kg/cm²)	0.2	0.3	0.5

In this experiment is use copper electrode rod of 10×100 mm² Copper electrode products is famous for their heat resistance, toughness and good machinability (5). In shown in figure 4

Fig -4: Copper electrode using experiment

2.1 Expression of MRR and TWR

MRR is calculated as the proportion of the change of weight of the work piece before and after machining to the product of machining time.

$$MRR = \frac{Wbm - Wam}{t} \text{ gm/min}$$

Where,
Wbm= Weight of work piece before machining.
Wam= Weight of work piece after machining.
t = Time

TWR is calculated as the proportion of the change of weight of the electrode before and after machining to the product of machining time.

$$TWR = \frac{Wbm - Wam}{t} \text{ gm/min}$$

Where,
Wbm= Weight of work piece before machining.
Wam= Weight of work piece after machining.
t = Time

Table -2: Observation table input parameter or factor

I_P (A)	T_{on} (µs)	T_{off} (µs)	F_p (kg/cm²)	Machine Time (Min)	MRR (gm/min)	TWR (gm/min)
10	5	3	0.2	27	0.0000370	0.01458
10	10	5	0.3	20	0.00005	0.0176
10	15	7	0.5	22	0.0000454	0.01589
12	5	5	0.5	32	0.0000312	0.01745
12	10	7	0.2	26	0.0000384	0.01925
12	15	3	0.3	9	0.000111	0.03958
14	5	7	0.3	35	0.0000285	0.01576
14	10	3	0.5	12	0.0000833	0.04625
14	15	5	0.2	11	0.0000909	0.04163

3. RESULT AND ANALYSIS

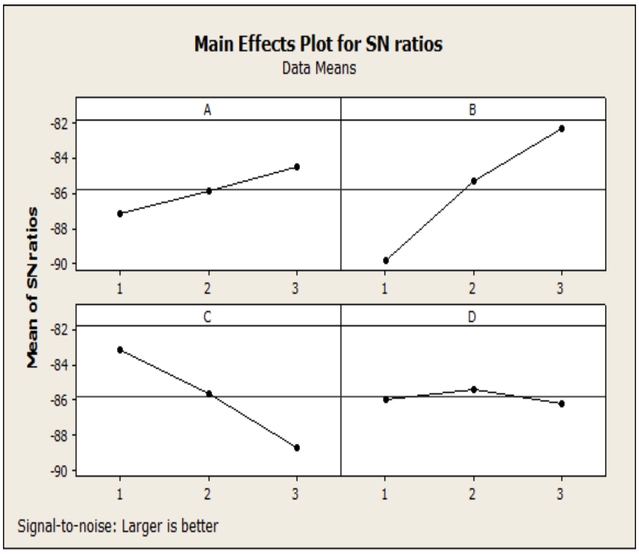

Fig -5: Main effect of SN ratio of MRR

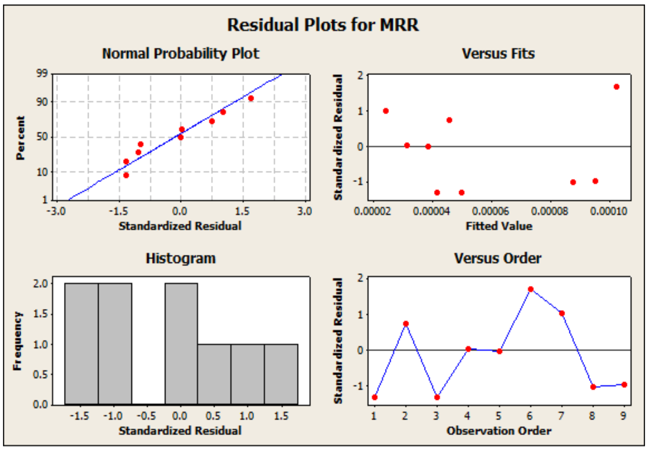

Fig -6: Residual plots for MRR

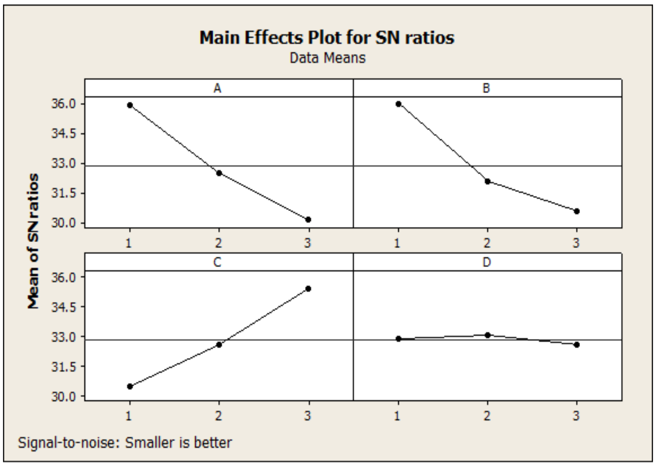

Fig -7: Main effect of SN ratio of TWR

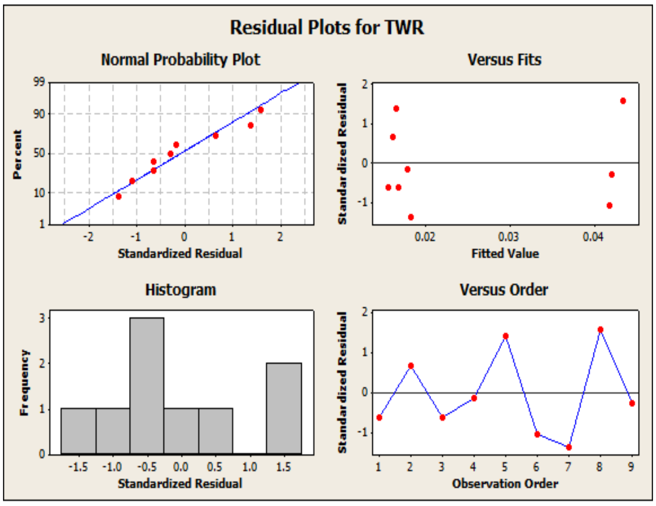

Fig -8: Residual plots for TWR

4. CONCLUSIONS

In this whole thesis the effect of input parameter such as peak current, pulse on time, pulse off time and flushing pressure on output parameter as material removal rate (MRR) and tool wear rate (TWR) have been studied which is based on EDM machining process. The Experiments were conducted under various parameters by considering Taguchi L_9 orthogonal array and taking mild steel as work piece and copper electrode as tool material. From the result it is considered that:

1. For MRR, the most significant factor is found to be pulse on time followed by pulse off time.
2. With change in input parameter the material removal rate changes accordingly.
3. At peak current 12(A), pulse on time 15(μs), pulse off time 3(μs) and flushing pressure 0.3(kg/cm^2) it is observed that the material removal rate becomes high.
4. For TWR, the most significant factor is found to be peak current followed by pulse on time.
5. With change in input parameter the Tool wear rate changes accordingly.
6. At peak current 14(A), pulse on time 5(μs), pulse off time 7(μs) and flushing pressure 0.3(kg/cm^2) the tool wear rate reduces significantly.

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