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INVESTIGATION ON EDM OF SS316 ALLOY MATERIAL USING COPPER ELECTRODE FOR IMPROVING MRR AND TWR

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ABSTRACT

This paper demonstrates an investigation on Electro Discharge Machining of Stainless steel 316 using copper electrodes having different shape such as Square, Rectangle, Hexagon, Pentagon, Diamond. The essential input parameters are peak current, pulse on time, pulse off time and dielectric pressure due to these effect and the output parameters are Material removal rate (MRR), Electrode wear rate (EWR) and with tolerances namely Parallelism. This demonstration was carried out by L_9 orthogonal array. This paper demonstrates that machining performance is improved effectively by EDM process.

Keywords: *EDM, Parallelism and L9 Orthogonal Array.*

1. Introduction

Now a day's industries require good surface finishing from the manufacturing process, and hence it focuses on the use of unconventional machining process such as EDM. In this process Electrical spark is generated that will remove the material. EDM is mainly used in machining the difficult materials with high temperature application .In this demonstration brass electrode tool is made hexagonal shape and is machined by EDM to obtain the good surface finish with good accuracy.

2. Literature Review

E. Ferraris [1] shows that micro level drilling process is very stable by employing wire EDM process,which can prevent spark generation. By this process tool wear rate is minimum, shape quality is good and process timing is minimum. Tool is insulated by coating while machining. Fábio N. Leão [2] investigates that technology making a fast hole drilling using brass electrode. Due to high consumption of electrodes high production costs from this process reduces the tool wear rate, and we obtain good surface finishing and high accuracy. The process generally has a hole size of 0.3mm and 3mm, and temperature of spark is between 900 K to 3000 K. A. Krishnamoorthy [3] the technology shows that using L_{21} orthogonal array method to perform the drilling process on (CFRP) composite materials by EDM. It improves the quality of drilling holes. They can be analysed by grey related analysis method. During this process the input parameters are thrust force, torque and it affects the good surface finishing and more accuracy.B. Mohan [4] demonstrates that SiC/6025 Al (MMC) undergoes machining with brass electrode tube because MMC are highly abrasive in nature EDM is not having chemical energy, thus resulted to decreases in MRR and increases in EWR are reviewed by genetic algorithm method. B. Mohan [5] article evaluates those Al-SiC composite are machining by EDM using brass electrode. The results show an increase of volume percentage of SiC which leads to less MRR. TWR was less when volume % of SiC is less. Surface roughness is decreased with decrease in pulse and increased with increase in volume of percentage of SiC. Kuang-Yuan Kung [6] paper proposes that machining of Cobalt-bonded tungsten carbide by PMEDM. The MRR and EWR are carried out by discharge current, pulse on time, grain size and concentration of aluminium powder particle. This is planned by central composite design. Thus concluded to mach inability efficiency is improved by using dielectric fluid with conductive aluminium powder. When powder

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concentration increase, MRR is also increases. EWR decreases, powder concentration is minimum. P. Kuppan [7] states that small deep hole drilling of Inconel 718 using EDM process. It is planned by (CCD) Central Composite Design. In this process MRR is influenced by Peak current, duty factor and electrode rotation, whereas DASR is strongly influenced due to Peak current and pulse on time. Finally, the surface roughness is optimized by using desirability function approach method.

Che Chung Wang [8] demonstrate shows that using Taguchi methodology optimizes the blind hole drilling of Al2O3/6061 and it composite by Rotary EDM blind hole drilling with rotational eccentric through hole electrode reaches higher MRR. The MRR and SR are largely affected by polarity of Electrode. EWR is affected by peak current of EDM by increasing the rotational speed of electrode ,which may increase MRR. S. Dhanabalan [9] illustrates that EDM of Inconel 718 with Copper electrode investigated by Taguchi Method based grey analysis. This method is used for solving manufacturing problems improving productivity reduce surface roughness finally shows that machining performance on multiple characteristics are improved by this approach. P.Karthikeyan [10] describes that machining analysis of Inconel 718 material on EDM by employing copper electrode. In this process parameters are pulse on time, pulse off time, peak current, along with tool geometry which affects MRR, TWR, SR. The pulse on time and peak current are directly proportional to MRR and inversely proportional to TWR, SR. From this Literature Review SS316 alloy Material using Copper Electrode are not improved.

3. Experimental Methodology

In this research, SS316 plate is chosen as work piece material. The parameters which are required for the experimentation are arranged by means of Taguchi table and Taguchi's L_9 orthogonal array is constructed. Table 1 is shows the properties of SS316 austenitic stainless steel and Table 2 show the operating condition of EDM for SS316 Stainless steel.

Figure.1. Experimental set up of EDM drilling machine

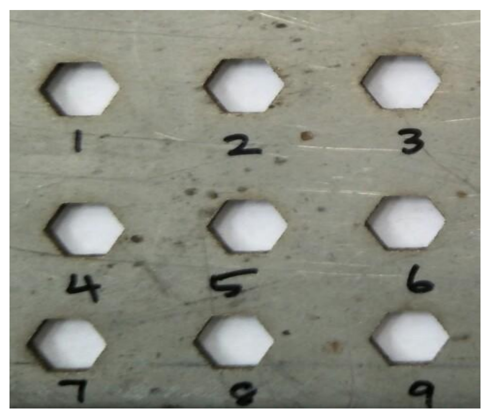


Figure.2. SS316 work piece material

Table 1. Properties of SS316 steel

Properties	SS316 Steel
Density	8000 (kg/m^3)
Thermal Expansion	18 (10^{-6}/k)
Melting Point	1673 (K)
Thermal Conductivity	17 (W/m - k)
Specific Heat	530 (J/Kg - k)
Resistivity	81 (10^{-8} ohm.m)
Tensile Strength	620 (Mpa)
Atomic Volume	0.0072 (m^3/kmol)
Poisson's Ratio	0.275
Bulk Modulus	152 GPa
Ductility	0.51

Table 2. EDM operating conditions for SS316

Working conditions	Description
Electrode material	Diamond Copper electrode
Dimension of square hole	5 mm(Each Side)
Depth of Square drilling	2 mm
Electrode polarity	Positive
Workpiece polarity	Negative
Specimen material	SS316 Stainless Steel
Type of current	DC Power Supply
Discharge current (I, A)	3 - 10amps
Pulse on time (t_{on}, µs)	3 - 40µs
Pulse off time (t_{off}, µs)	1 - 5µs
Dielectric fluid	EDM oil
Fluid pressure (kg/cm^2)	1-5

Table.3. Machining parameters and levels of EDM Drilling.

Factor	Parameter	Units	Level 1	Level 2	Level 3
A	Current	A	8	9	10
B	Pulse on time	µs	40	41	42
C	Pulse off time	µs	5	6	7
D	Spark gap voltage	V	55	60	65

Table 4 Process Parameter of SS 316 Material

EX. NO	Electrode shape	Current(amp)	Pulse on Time(micro second)	Pulse off Time(micro second)	Dielectric Pressure(kg/cm²)	Spark gap voltage(v)
10	Hexagon	8	40	7	7	75
11	Hexagon	8	41	5	5	80
12	Hexagon	8	42	6	6	70
13	Hexagon	9	40	6	7	70
14	Hexagon	9	41	7	5	75
15	Hexagon	9	42	5	6	80
16	Hexagon	10	40	7	6	80
17	Hexagon	10	41	5	7	70
18	Hexagon	10	42	6	5	75

The input parameters were current, pulse on time, pulse off time, dielectric pressure, spark gap and corresponding output were Material Removal Rate and Tool Wear Rate. The Graph is used to analyze the effect of process parameters on the machining characteristics.

The outputs are measured using CMM machine. The Material Removal Rate and Tool Wear Rate are calculated using following expressions.

Material Removal Rate = $(W_i - W_f)$ /t g/min

Tool Wear Rate = $(T_b - T_a)$ /t g/min

W_i : Workpiece initial weight

W_f : Workpiece final weight

T_b : Weight of the tool before machining

T_a: Weight of the tool after machining

4. Result and Discussion

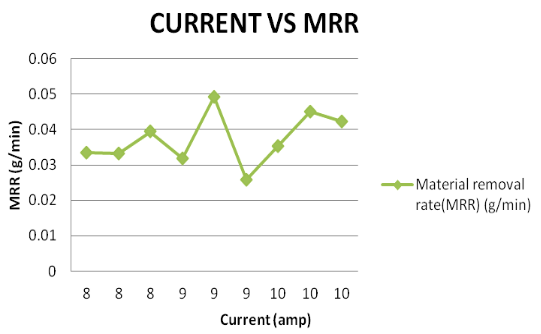
The Machining Time, Material Removal Rate, Electrode Wear Rate, Wear Ratio, parallelism are shown in the Table 5.

Table5. Response parameters of Experiment Results

	Output Parameters						
					Geometrical Tolerance Parallelism		
S. NO	Time (sec)	MRR g/min	TWR g/min	WR %	1	2	3
1	12.83	0.0335	0.0016	21.5	0.0809	0.0249	0.0385
2	12.60	0.0333	0.0016	21	0.0625	0.0475	0.0216
3	12.18	0.0394	0.0016	24	0.0312	0.0426	0.0225
4	11.65	0.0318	0.0017	18.5	0.0752	0.0326	0.0279
5	11.38	0.0492	0.0018	28	0.0516	0.0216	0.0367
6	11.25	0.0258	0.0018	14.5	0.0425	0.0612	0.0479
7	10.73	0.0354	0.0019	19	0.0555	0.0726	0.0206
8	10.45	0.0450	0.0010	47	0.0298	0.0710	0.0203
9	10.13	0.0424	0.0010	43	0.0412	0.0498	0.0516

Now the relationship between input and output parameters can be studied. First we discuss the relationship with respect to current is studied in Figure.3 (a,b,c,d,e,f).

a)



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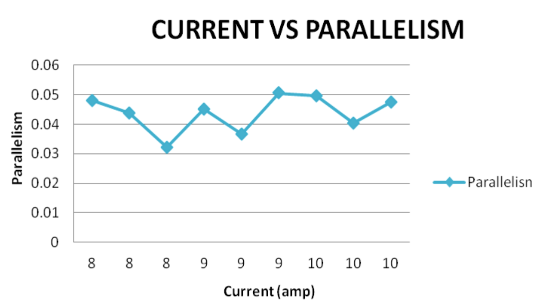

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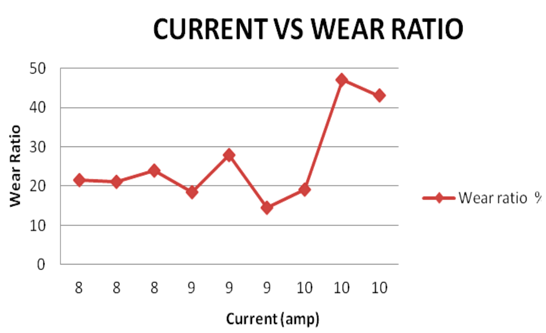

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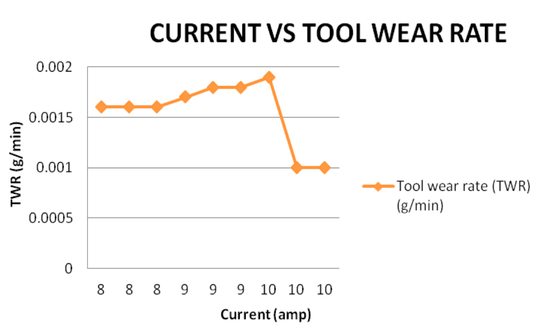

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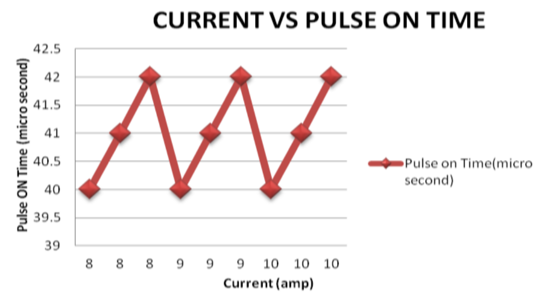


f)

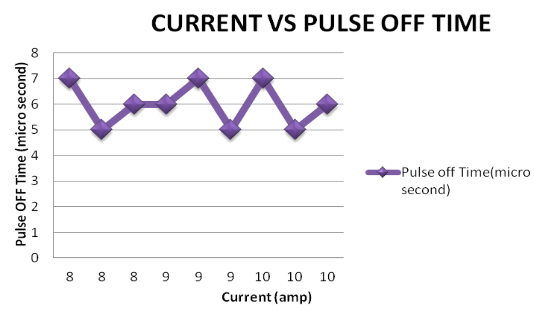
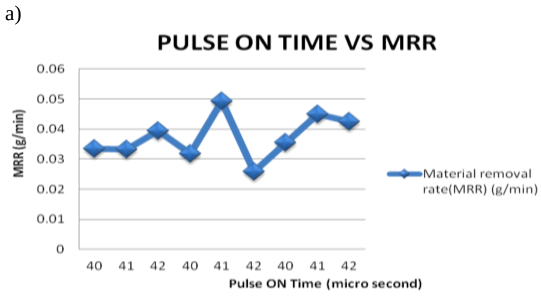


Figure 3 (a) Relationship between Current and MRR. (b) Relationship between Current and Parallelism. (c) Relationship between Current and Wear Ratio. (d) Relationship between Current and TWR. (e) Relationship between Current and Pulse on Time. (f) Relationship between Current and Pulse off Time.

The material Removal Rate increases with increasing current. (Hole 5 at 9amps Material Removal Rate is high for SS316 material). The geometrical tolerances like Parallelism increase with respect to current at a very gradual manner. It is also observed that the wear ratio decreases with current and current decreases with decrease in Tool Wear. Pulse on Time increases with respect to current increases. Thus pulse off time is decreases with respect to decrease of current.

a)



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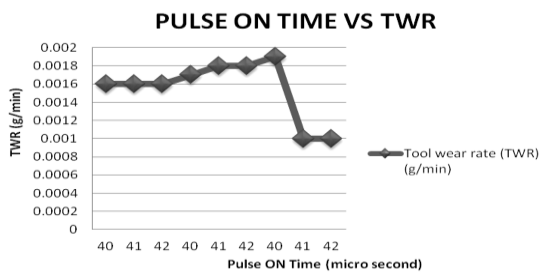

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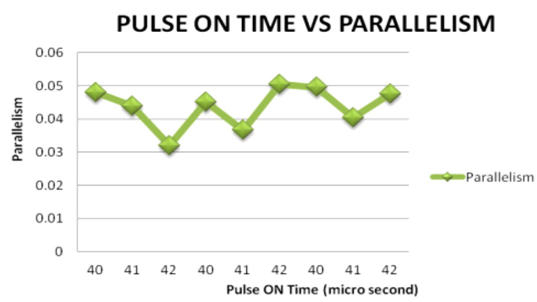
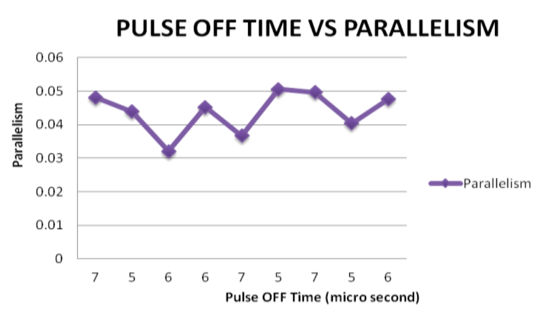


Figure.4 (a) Relationship between Pulse on Time and MRR. (b) Relationship between Pulse on Time and TWR. (c) Relationship between Pulse on Time and Parallelism.

The pulse on time is increases with respect to Material Removal Rate. Tool Wear Rate is increases due to pulse on time.

a)



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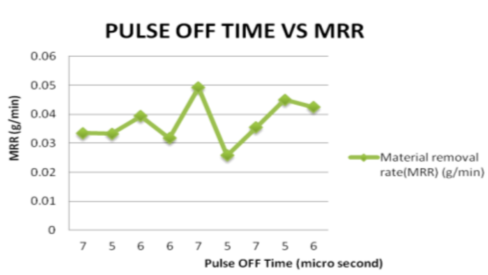

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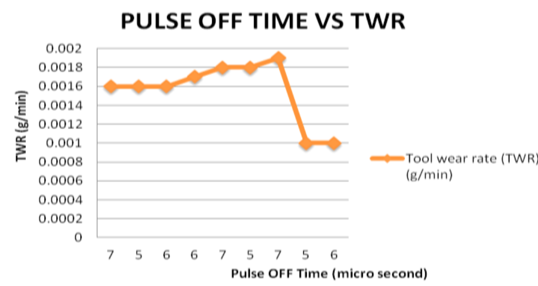

Figure 5 (a) Relationship between Pulse off Time and MRR. (b) Relationship between Pulse off Time and TWR. (c) Relationship between Pulse off Time and Parallelism.

The Material Removal Rate is decreases with respect to pulse off time. Tool Wear Rate is decreases due to increases of pulse on time of SS316 using Copper Electrode.

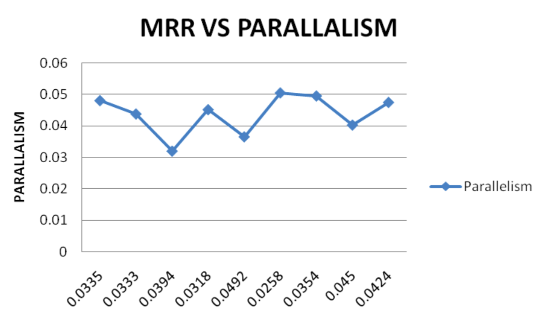

Figure. 6 Relationship between TWR and Parallelism.

The Tool Wear Rate is decreases with respect to parallelism of SS316 using Copper Electrode.

4. Conclusions

The three main significant factors affecting the value of the MRR are the current (amps), pulse on time and the pulse off time. The MRR increases with increase in current (amps), pulse on time (µs) and decrease of pulse off time (µs). A maximum MRR is obtained for a current 9amps, Pulse on time 41 µs, pulse off time up to 7 µs and Dielectric pressure 5 kg/cm^2.

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