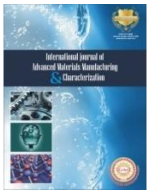

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Optimization of Geometrical Errors in EDM process parameters using Taguchi Technique

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ABSTRACT

Electrical Discharge Machining is a process of shaping hard materials and forming complex shapes by using erosion in all kinds of conductive materials.EDM researchers exploit a number of ways to improve EDM process parameters such as Nonelectric parameters, electrode-based parameters, powder-based parameters and electrical parameters. This research, optimizes the square hole drilling of SS316 Austenitic Stainless Steel composites by using the Taguchi technique. The Results reviews that the reconsider copper electrode with an aberrant through square hole has the superlative performance for machining from various aspects. Considering basic parameters such as dielectric pressure, pulse on time, pulse off time for machining the effect of these basic input parameters. Finally, the parameters of output results like Material Removal Rate (MRR), Perpendicularity (PER), Parallelism, Electrode Wear Rate (EWR) and Wear ratio (WR) were optimized.

Key Words: Electrical Discharge Machining (EDM), Material Removal Rate (MRR), Perpendicularity (PER), Electrode Wear Rate (EWR), Wear ratio (WR)

1.0 Introduction

In the twenty-first century, EDM is one of the best nontraditional methods of machining, which has been widely used to produce dies and moulds. This machining process developed in late 1940's [1]. Based on the electrical discharge, the material removal depends on electrical discharge between the electrode and the workpiece in the presence of dielectric fluid [2].The discharge generated for short duration in the dielectric gap, which separated by an electrode and the workpiece.MRR with the erosive effect of the electrical discharge from the electrode and workpiece [3].However the current EDM research on machining techniques, dry EDM machining, EDM with powder additives and ultrasonic vibrations with EDM and predicting EDM performance and optimizations of EDM parameters, the researchers developed the area to bring it be a current trend [4].And the material SS316 improve the application of making prototype production parts for defense, automobile industries, aerospace, electronic industries and nuclear power plant components [5]. The final quality and efficiency of the product related to surface integrity achieved by the end of the machining [6]. SS316 is a type Austenite. Which is currently available in the composition of 18/8 (18% Chromium, 8% Nickel) [7]. Due to variable temperature 600-6250^{0}c strain controlled cyclic load is found in thermal cycling, where a material expands and contracts in response to variable operating temperature or in a reversed bending between fixed displacements were investigated by Martin-Meizoso et al [8]. Investigation of Parallelism and perpendicularity of a material reveals the heat affected zone of the material with this research using the input parameters considered are Current (A), Pulse on/off time (µs) and Dielectric pressure (kg/cm^2). This research will increase the propensity to success in terms of accuracy and surface finishing using L9 Taguchi Technique.

2.0 Workpiece Materials and Application

There are many different types of materials mainly used in aerospace, automobile and marine industry. But

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SS316 grade austenite stainless alloys contain molybdenum to resist the corrosive effects of water and heat. It is not completely rustproof; the alloys are more resistant to corrosion compared to the other common stainless steel. Now SS316 available in varying concentration. The purpose of common grade stainless steel 316 for food industry, textile dyeing equipment industry, nuclear fuel industry, chemical storage industry [9]. 316L is a low carbon grade steel. It is used for handling paper pulp as well as, a production of high-temperature industrial equipment. Low carbon grade of 316L is a most usable grade for the medical industry, as it is resistant to sensitization. 316N is a special type of stainless steel. It will contain more nitrogen atoms. It is used for chemical handling accessories [10]. The various compositions of SS316 are shown in the table.

Table 1. Stainless steel designations

SAE	316	316L	316F	316N
% Cr	16-18	16-18	16-18	16-18
% Ni	10-14	10-14	10-14	10-14
% C	0.08	0.03	0.08	0.08
% Mn	2	2	2	2
% Si	0.75	0.75	1	0.75
% P	0.045	0.045	0.2	0.045
% S	0.03	0.03	0.10	0.03
% N	0.10	0.10	-	0.10-0.16
% Mo	2.0-3.0	2.0-3.0	1.75-2.5	2.0-3.0

3.0 Experimental Methodology and Research plan:

In this research, an SS316 plate is chosen as workpiece material. The parameters which are required for the experimentation are arranged by means of Taguchi table and Taguchi's L9 orthogonal array is constructed. Table 2 shows the properties of SS316 austenitic stainless steel and Table 3 show the operating condition of EDM for SS316 Stainless steel

Figure.1. Experimental set up of EDM drilling machine

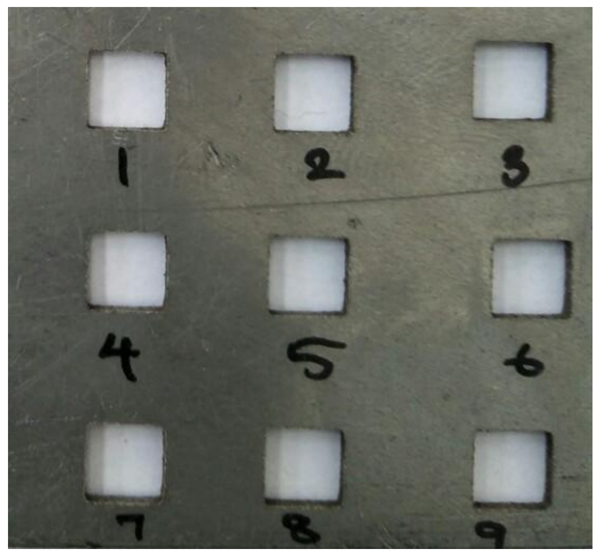


Figure.2. SS316 workpiece material

Table 2. 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 3. EDM operating conditions for SS316

Working conditions	Description
Electrode material	Square Copper electrode
The Dimension of square hole	5 mm(Each Side
The 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)	9-11
Pulse on time (t_{on}, µs)	43-45
Pulse off time (t_{off}, µs)	6-8
Dielectric fluid	EDM oil

The input parameters considered are current, pulse on time, pulse off time, dielectric pressure, spark gap are used for experimental work. ANOVA method is used to analyze the effect of input process parameters on the machining characteristics. The MRR and TWR are calculated using the digital balance of accuracy 1mg and 1microsecond.

Table.4. Machining parameters and levels of EDM Drilling.

Factor	Parameter	Units	Level 1	Level 2	Level 3
A	Current	A	9	10	11
B	Pulse on time	µs	43	44	45
C	Pulse off time	µs	6	7	8
D	Spark gap voltage	V	55	60	65

The outputs are measured using a CMM machine. The MRR and TWR are calculated using following expressions.

MRR= $(W_i - W_f)$ /t g/min
TWR= $(T_b - T_a)$ /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

Table 5. Response parameters of Experiment Results

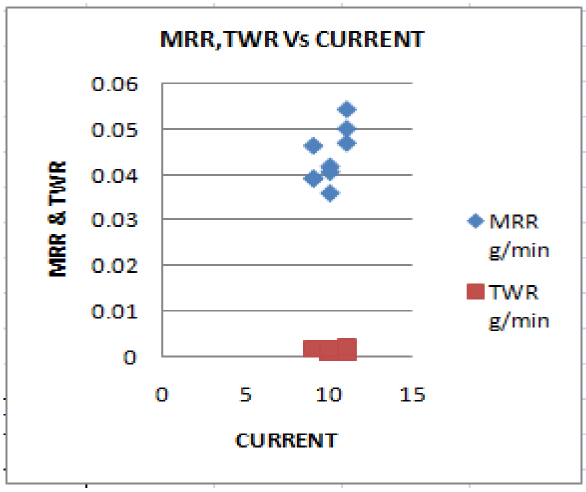
Output Parameters							
S. NO	MRR g/min	TWR g/min	WR %	Geometrical Tolerance			
				Parallelism		Perpendicularity	
				1	2	1	2
1	0.0393	0.0017	23	0.0087	0.0112	0.0987	0.0567
2	0.0393	0.0017	22	0.0987	0.0321	0.0897	0.0987
3	0.0464	0.0018	26	0.0324	0.0221	0.0556	0.0436
4	0.0419	0.0009	45	0.0233	0.0321	0.0654	0.0210
5	0.0361	0.0019	19	0.0087	0.0564	0.0874	0.0876
6	0.0407	0.0019	21	0.0098	0.0132	0.0124	0.0798
7	0.0470	0.0010	46	0.0965	0.0087	0.0324	0.0342
8	0.0501	0.0021	24	0.0764	0.0921	0.0798	0.0876
9	0.0543	0.0022	17	0.0985	0.0945	0.0776	0.0957

Now the relationship between input and output parameters can be deeply studied. Firstly relationship with respect to current is studied in Figure.3 (a, b, c, d).

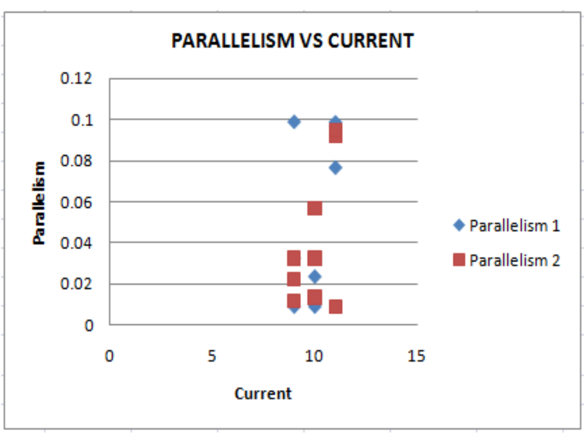
4. Result and Discussion

The knowledge of the contribution of every individual factor is important to control the final response. The Machining Time, Material Removal Rate, Wear Ratio, Geometrical tolerance is shown in the Table6.

(a)



(b)



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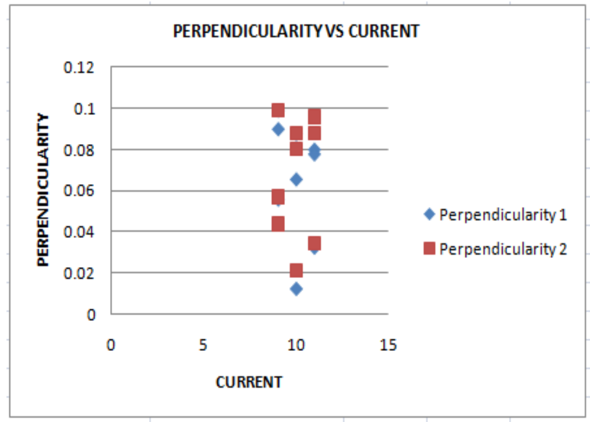

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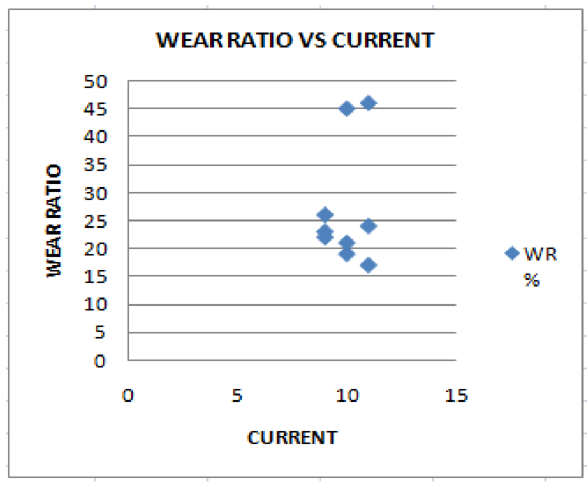
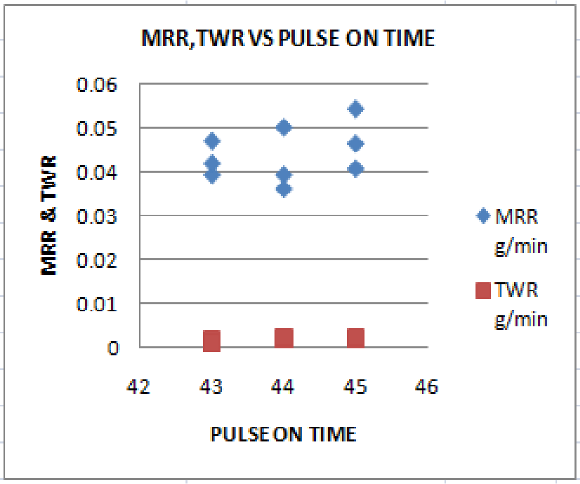


Figure.3 (a) Relationship between Current and MRR & TWR (b) Relationship between Current and Parallelism (c) Relationship between Current and Perpendicularity (d) Relationship between Current and Wear Ratio

As shown in Fig 3 (a): that as the current increases MRR also increased. The maximum metal removal rate attained at 11 amperes. The maximum level of metal removal is 0.0543 and minimum tool wear level is 0.0009 at 10 amperes. Figure 3 (b) clearly explained that the minimum parallelism value of 0.0087 and 0.086 attained at 10 and 11 amperes. The lower perpendicularity value is also created at the same ampere and the wear ratio will be increased by increasing of current at 11 amperes. The wear ratio value is 17 shown in figure 3 (d).

The relationship of performance characteristics with respect to pulse on time is shown in Fig.4 (a, b, c).

(a)



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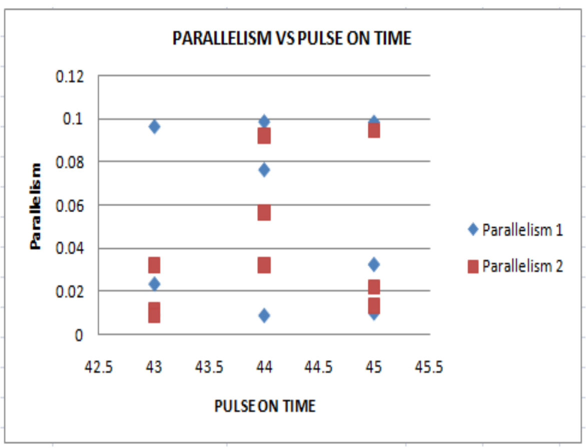

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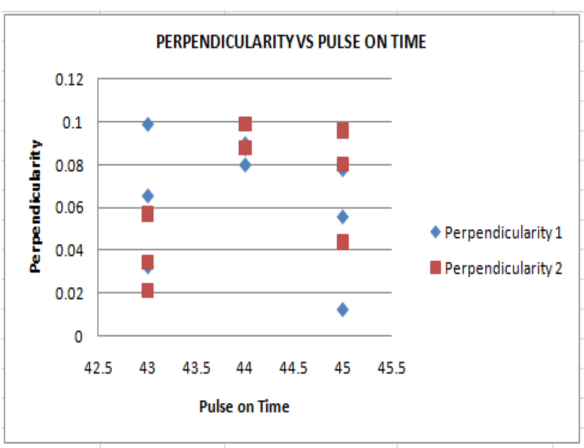


(d)

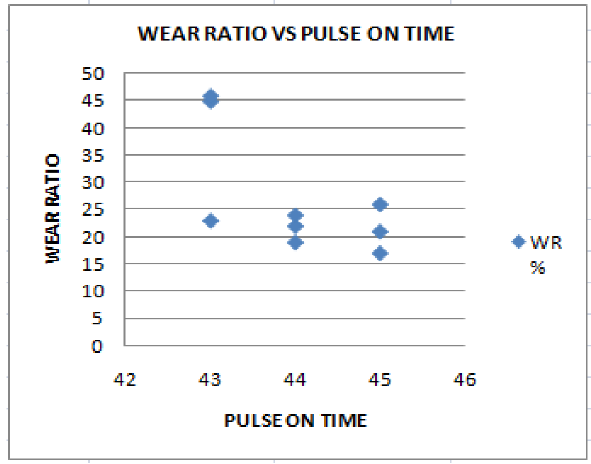
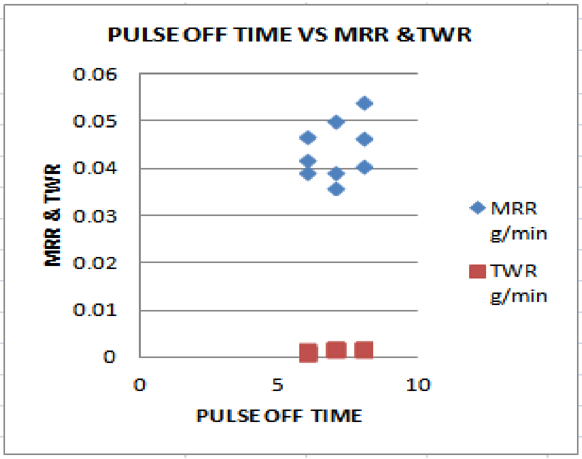


Figure.4 (a) the Relationship between pulse on time and MRR & TWR (b) The Relationship between pulse on time and Parallelism. (c) The Relationship between pulse on time and Perpendicularity. (d) The Relationship between pulse on time and Wear ratio.

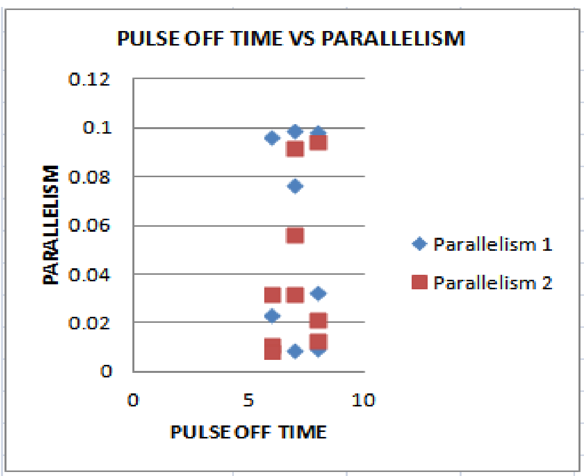
It is clear that increasing the pulse on time has a very small effect of MRR and TWR. Although an increase in pulse on time leads to an increase the perpendicularity and parallelism. It is observed that, as shown in fig 4(a) MRR increases with increases in pulse on time. But tool wear is reduced to reduce in pulse on time. The maximum metal removal is attained at 45 µs and minimum tool wear is attained at 43 µs. The minimum parallelism value occurs at 43 and 44 µs shown in fig 4 (b). The minimum perpendicularity value is obtained at the same pulse on time. The minimum wear ratio is reached at 45 µs. TWR increases as shown in fig 4 (d) because as the current increases higher power is available for the electrode. This will create more and more erosion developed.

The relationship between output characteristics and pulse off time is shown in Fig.5 (a, b, c).

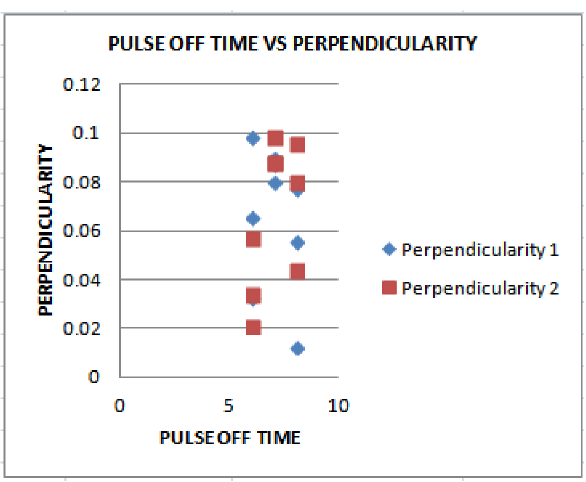
(a)



(b)



(c)



(d)

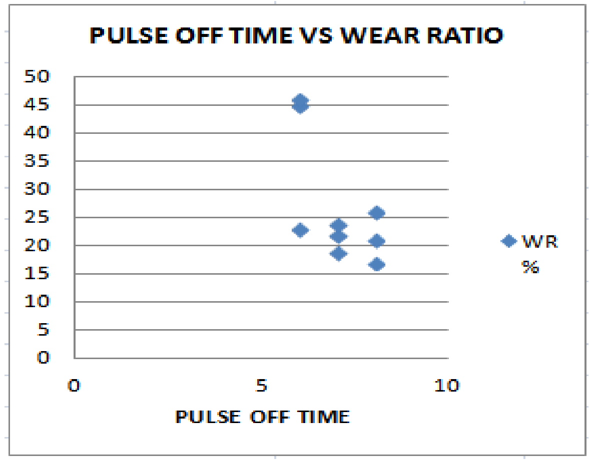


Figure.5 (a) The Relationship between pulse off time and MRR & TWR (b) The Relationship between pulse off time and Parallelism. (c) The Relationship between pulse off time and Perpendicularity. (d) The Relationship between pulse off time and Wear ratio.

From Fig 5 it is clear that MRR is increased with an increase in pulse off time, but the increase is less as compared to pulse on time. The tool wear rate is decreasing with an increase in pulse off time.

5. CONCLUSIONS

Influences of EDM process on MRR of SS316 were investigated in this paper. The Graph shows that pulse on time has the maximum contribution on MRR. It is also concluded from this research that with an increase of pulse off time MRR decreases. Finally, the optimized parametric combination of the present research is given below. Optimum parametric combination: Current: 11 amps, Pulse on time: 45 µs, Pulse off time: 7 µs, Dielectric pressure: 8 kg/cm^2

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