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Experimental Investigation on Rotary EDM of Stainless Steel Alloy Material Using Pentagon Copper Electrode for Improving Geometrical Errors

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Abstract- **In this research, an investigation and experimental work were carried out on Electric Discharge Machining of stainless steel alloy using copper electrode. Considering the input parameters such as current, pulse on time, pulse off time, Di electric pressure for machining the effect of these following input parameters on output characteristics like material removal rate (MRR), Electrode wear rate (EWR), Wear ratio (WR), Angularity, Parallelism and Perpendicularity (PER). The investigation was carried on with L18 orthogonal array. The effect of each input parameters on output characteristics was studied independently using trend analysis. Form results, Parallelism have been minimized with decrease of current and increase of dielectric pressure. Perpendicularity has been minimized with decrease of current and increase of dielectric pressure. Angularity has been minimized with increase of current and decrease of dielectric pressure.**

Keywords- **Material Removal Rate (MRR), Electrode Wear Rate (EWR), Wear Ratio (WR), Angularity, Parallelism And Perpendicularity (PER).**

I. 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 materials. EDM is mainly used in machining the difficult materials with high temperature application. In this demonstration copper .

II. LITERATURE REVIEW

Literature review is one of the scope studies. It works as guide to run this analysis. It will give part in order to get the information about electrical discharge machine (EDM) and will give idea to operate the test. From the early stage of the project, various literature studies have been done. Research journals, books, printed or online conference article were the main source in the project guides. This part will include almost operation including the test, history, machining properties and results. History of the electrical discharge machine (EDM) will be story little bit in this section. Literature review section work as reference, to give information and guide base on journal and other source in the media.

Ferraris et al (2013)this work presents an innovative method for the Electrical Discharge Drilling of ultra-high aspect ratio (AR > 30) micro holes. It makes use of tools insulated on the sidewall by means of a coating. The concept is to promote the process stability of micro EDM deep drilling by preventing secondary sparks. The performance of standard and customized tools is compared and reviewed against the main criteria of shape quality, tool wear and machining time. Process capabilities are also defined for a given coating. Micro holes within 0.2 mm in diameter and aspect ratio (AR) up to about120 could be obtained within 1 h. A micro punching die is also realized by combining this strategy with micro wire EDM.

A. Krishna moorthy et al (2012) Carbon Fibre Reinforced Plastic (CFRP) composite materials have potential applications in various domains. In machining, drilling is essentially required to join different structures. But CFRP drilling poses many problems that decrease the quality of holes. In this paper, Taguchi's L27 orthogonal array is used to perform drilling of CFRP composite plates.

To improve the quality of the holes drilled, the optimal combination of drilling parameters is chosen using grey relational analysis. Grey fuzzy optimization of drilling parameters is based on five different output performance characteristics, namely, thrust force, torque, entry de lamination, exit de lamination and eccentricity of the holes. Analysis of variance (ANOVA) is used to find the percentage contribution of the drilling Parameters and found that feed rate is the most influential factor in drilling of CFRP composites.

IV. EXPERIMENTAL METHODOLOGY

In this research ,SS316 Plate is chosen as work piece material. The parameters which are required for the experimental are `arranged by means of Taguchi table and Taguchi's L9 Orthogonal array is constructed. Stainless steel and Table 1 is shows the properties of SS316 austenitic stainless steel and Table 2 show the operating condition of EDM for SS316 Stainless steel.

Fig.1.Experimental set up of EDM drilling machine.

V. TOOL MATERIAL SELECTION

- Erosion resistance (a factor of melting point, hardness, and structural integrity) gives electrode a longer service life and lowers the frequency of replacement.
- These properties, which vary almost exclusively by the type of alloy or material used, must be the deciding factors when selecting an electrode.

Fig.2. Work piece selection SS316

Table 1.Properties of SS316 Steel.

Property	Minimum value(S.I.)	Maximum value(S.I.)	Unites (S.I.)
Atomic Volume (average)	0.0069	0.0072	m^3/kmol
Density	7.85	8.06	Mg/m^3
Energy Content	89	108	Mj/kg
Bulk Modulus	134	151	Gpa
Compressive Strength	205	310	Mpa
Ductility	0.3	0.57	
Elastic Limit	205	310	Mpa
Endurance Limit	175	260	Mpa
Fracture Toughness	119	228	Mpa.$m^{½}$
Hardness	1700	2100	Mpa
Loss Coefficient	0.00095	0.0013	
Modulus of Rupture	205	310	Mpa
Poisson's Ratio	0.265	0.275	
Shear Modulus	74	81	Gpa
Tensile Strength	510	620	Mpa
Young's Modulus	190	203	Gpa
Latent Heat of Fusion	260	285	Kj/kg
Maximum service Temperature	1023	1198	K
Melting Point	1673	1723	K
Specific Heat	490	530	J/kg.k
Thermal Conductivity	14	17	W/m.k
Thermal Expansion	16	18	(10/6)/k

1. Dielectricfluidselection

The dielectric fluid selected in this project id EDM oil.While compare with other Dielectric fluid, EDM oil give more efficient and performance. So EDM oil is selected.

- Current (amp) The current represents the different power levels that the EDM generator is capable of supplying. The value of this factor (I) represents, in this case, the maximum value of the discharge current intensity, that is, the peak intensity.
- Pulse OFF Time (µs) The duration of time (µs) between the sparks (that is to say, off-time). This time allows the molten material and to be wash out of the arc gap. This parameter is affecting the speed and the stability of the cut. Thus, if the pulse off-time is too short, it will cause sparks to be unstable.
- Pulse ON Time (µs) The duration of time (µs) that the current is allowed to flow per cycle. Material removal is directly proportional to the amount of energy applied during this on-time. This energy is controlled by the peak current and the length of the on- time.
- Gap Voltage (V) Voltage, also called electromotive force, is a quantitative expression of the potential difference in charge between two points in an electrical field.

Dielectric pressure (kg/mm²) During the EDM process the work piece and the electrode are submerged in the dielectric oil, which is an electrical insulator that helps to control the arc discharge. The dielectric oil, that provides a means of flushing, is pumped through the arc gap. This removes suspended particles of work piece material and electrode from the work cavity.

Table 2. Die sinking EDM factors and levels of SS316.

Work piece				
Parameter	**Units**	**Level 1**	**Level 2**	**Level 3**
Current	A	16	21	24
Pulse on time	Ms	30	60	90
Pulse off time	Ms	3	6	9
Dielectric pressure	Kg/mm²	25	26	27

VI. METHODLOGY

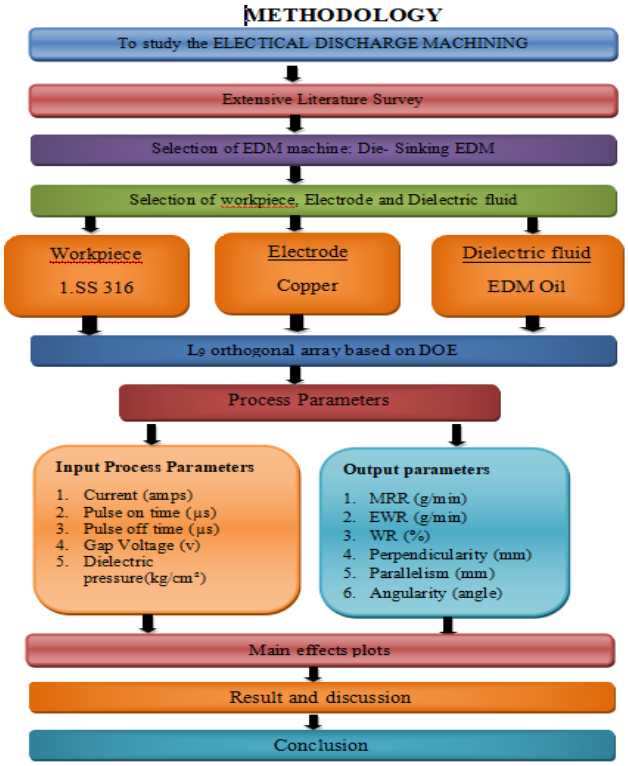

Fig.3. Flow Chart.

VII. RESULT AND DISCUSSION

To find the Material Removal Rate (MRR), Tool Wear Rate (TWR), Wear Ratio (WR), Machining Time (MT), Geometrical tolerance of SS 316 material

Work Piece Material: Ss 316 Toolmaterial: Pentagon Copper Electrode

Calculation Analysis of Material Removal Rate:
Work Piece Material: Ss 316 Tool Material: Pentagon

$$MRR = \frac{Wt\ of\ work\ piece\ before\ machine - Wt.of\ work\ piece\ after\ machine}{Time\ (in\ min)}$$

1. Geometrical Tolerance
Main Effect Plot For Angularitys

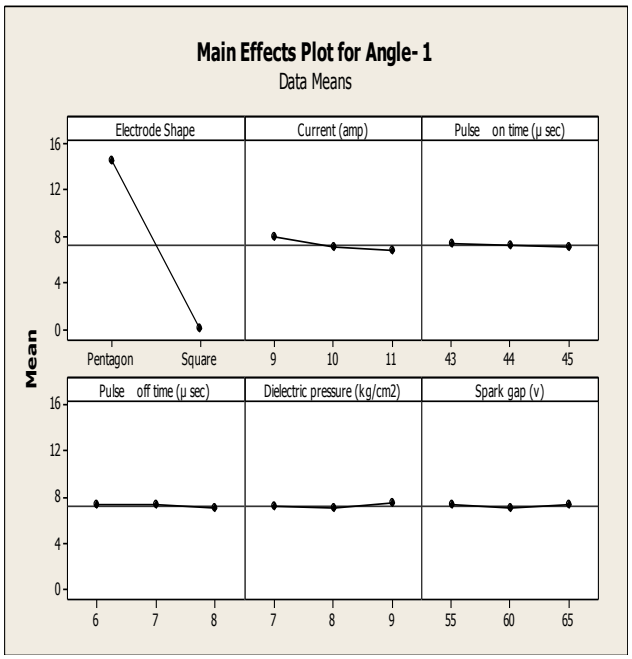

Fig.4. Main Effects Plot for Angularity 1.

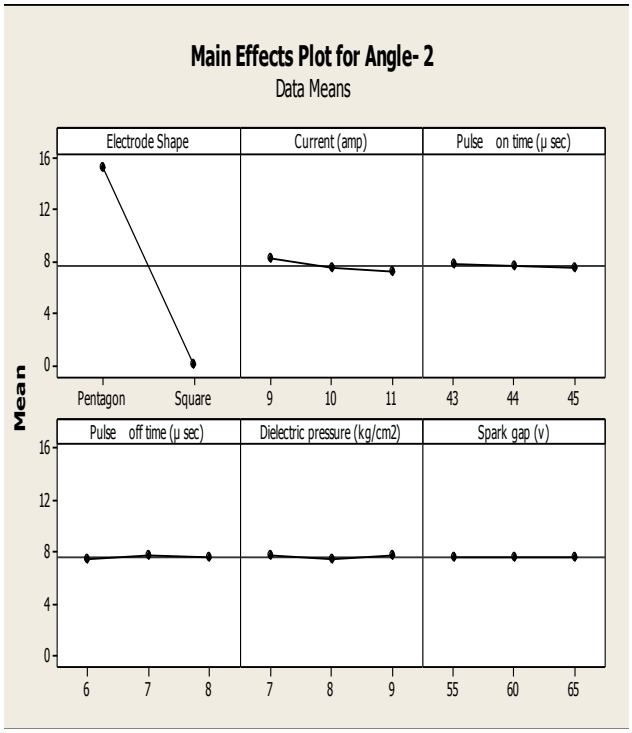

Fig.5. Main Effects Plot for Angularity 2.

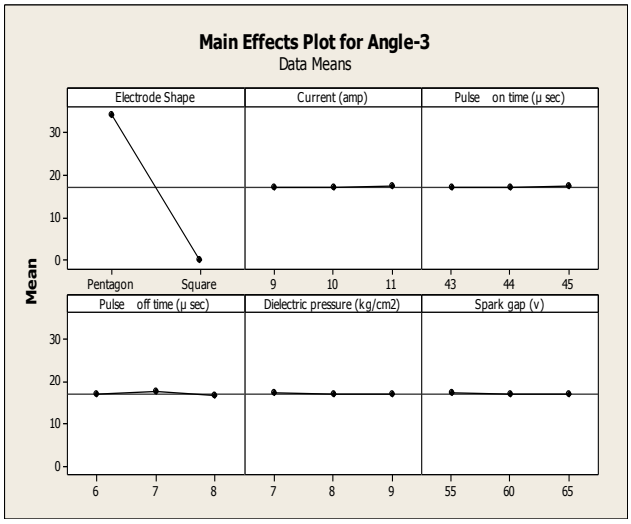

Fig.6. Main Effects Plot for Angularitry 3.

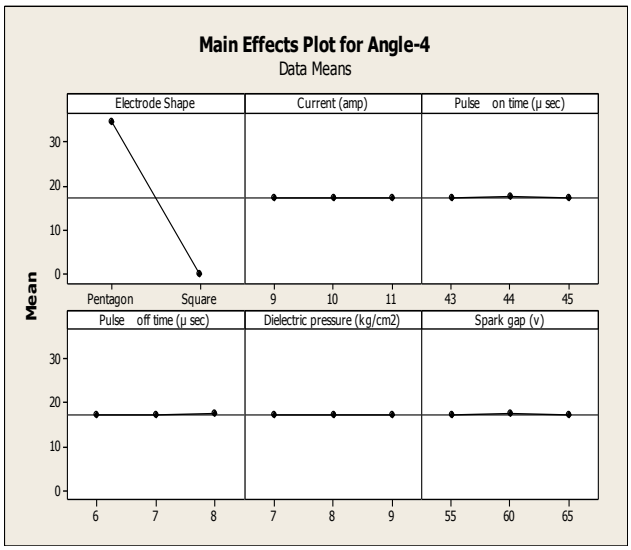

Fig.7. Main Effects plot for Angularity 4.

VIII. OBJECTS

Fig.8.Work Piece.

1. Tool Electrode:
Shape Of Electrode-Pentagon

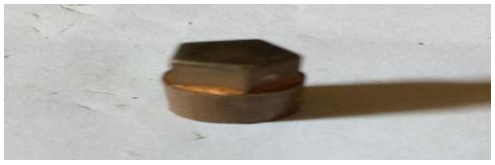

Fig.9.Before Machining

Fig.10.After Machining

IX. CONCLUSIONS

Multi parametric optimization of SS316 ceramic composites using copper electrode were done using Grey relational analysis approach and the following conclusions are drawn:

- The effect on MRR improves when discharge current and pulse on time is increased whereas there is not much influence is observed when pulse off time is increased and there is very little increase improving the fluxing condition.
- The EWR increases when discharging current and pulse on time is increased ,when gap voltage is decreased where as there is no significant change when pulse off time and dielectric pressure are increased.
- The overcut decreases when current decreases ,pulse off time, dielectric pressure increases and when gap voltage decreases.
- Angularity decreases if current is decreased ,dielectric pressure and gap voltage is decreases and if the pulse off time is increased. Angularity is decreased by decreasing by current and dielectric pressure and applying moderate pulse off times. Perpendicularity is reduced by decreasing current ,pulse on time and gap voltage.
- The experimental results for optimal settings illustrated that there was a considerable improving the performances characteristics viz., Material Removal Rate , Tool wear Rate ,Wear ratio , Radial lower cut ,Perpendicularity and Run cut ,during the spark EDM processes.

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