Optimization of Process Parameters of Powder Mixed Dielectric EDM for MRR and Ra by Grey Relational Analysis Method

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Abstract: ***Powder mixed electric discharge machining (PMEDM) is a recent innovation for enhancing the capabilities of electrical discharge machining process. The objective of present study is to realize the potential of silicon powder as additive in enhancing machining capabilities of PMEDM. Taguchi methodology has been adopted to plan and analyze the experimental results. L16 Orthogonal Array has been selected to conduct experiments. Peak current, Pulse on time, pulse off time, voltage, and concentration of fine silicon powder added into the dielectric fluid were chosen as input process variables to study performance in terms of material removal rate surface roughness. The grey relational analysis method is used to obtain the common optimum values for MRR and Ra.***

Keywords: Electrical discharge machining, Machining rate, Spark gap, Silicon powder concentration, Taguchi methodology

1. Introduction

Electric discharge machining is a thermo-electric non-traditional machining process. Material is removed from the work piece through localized melting and vaporization of material. Electric sparks are generated between two electrodes when the electrodes are held at a small distance from each other in a dielectric medium and a high potential difference is applied across them. Localized regions of high temperatures are formed due to the sparks occurring between the two electrode surfaces. Work piece material in this localized zone melts and vaporizes.

2. Principle of PMEDM

The schematic of a PMEDM machine tool is shown in Figure.

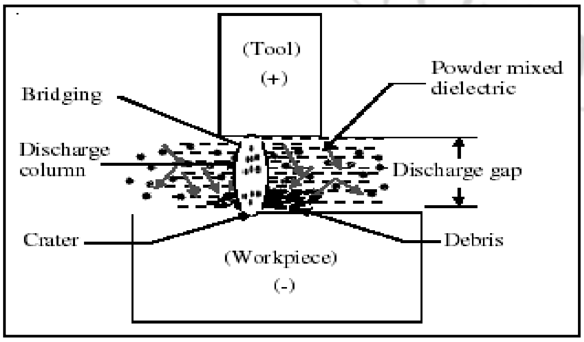


Figure 1: Principle of PMEDM Process.

In this process, the material in powder form is mixed into the dielectric fluid either in the same tank or in a separate tank. When a voltage of 80-320 V is applied to both the electrodes, an electric field in the range 105 to 107 V/m is created. The spark gap is filled up with additive particles, and the gap distance between tool and the work piece increases from 25 μm to 50 μm to many times larger. Under the influence of electric forces, the powder particles arrange themselves in the form of chainsat different places under the sparking area. The chain formation helps in bridging the gap between both the electrodes. Due to the bridging effect, the gap voltage and insulating strength of the dielectric fluid decreases. The easy short-circuit takes place, which causes early explosion in the gap. As a result, the „series discharge" starts under the electrode area. Due to the increase in the frequency of discharging, the faster sparking within a discharge takes place, which causes faster erosion from the work piece surface.

3. Experimental Set Up

Figure 2: Powder mixed Electric discharge machining (PMEDM).

The various input parameters and output parameters (response variables) selected for the experimentation are as follows:

1) Input parameters
   1. Discharge current (Ip)
   2. Spark on time (Ton)
   3. Spark off time (Toff)
   4. Gap voltage (volt)
   5. Concentration of dielectric (C)

2) Output parameters
   1. Material removal rate(MRR)
   2. Surface Roughness (Ra)

Silicon powder- The grain size of silicon powder is 15microns, grade 180

Tool selection-The selected tool is of pure copper. The length of the tool is 80 mm and diameter of tool is 20 mm. In most of the industries for EDM, the tool used is of copper material. Since copper is cheap as compared to graphite and readily available in the market.

Work piece selection- Material EN31

EN31 is a popular grade of through-hardening alloy steel. EN31 is used in components such as gears, shafts, studs and bolts. EN24T can be further surface-hardened to create components with enhanced wear resistance by induction or nitriding processing. The dimensions of selected work piece are 75x25x6 mm.

Dielectric (EDM oil) - The dielectric used in my experimentation work is EDM oil. The concentration of this dielectric is varied by adding silicon powder. This affects the material removal rate and surface finish.

4. Experimental Results

Table 1: Experimental results for Material removal rate and Ra for Material EN31

Exp No	*Ip (A)*	*Ton (µs)*	*Toff (µs)*	*V volt*	*Conc g/lit*	*MRR mm^3/mim*	*Ra um*
1	3	20	2	40	0	1.20275	2.29
2	3	35	5	60	2	2.06186	2.30
3	3	55	8	80	4	1.11684	2.18
4	3	75	11	100	6	1.20275	2.63
5	12	20	5	80	6	2.83505	3.46
6	12	35	2	100	4	6.18557	4.21
7	12	55	11	40	2	3.86598	4.83
8	12	75	8	60	0	2.4055	5.68
9	21	20	8	100	2	18.4708	6.70
10	21	35	11	80	0	15.6357	6.95
11	21	55	2	60	6	12.9725	6.60
12	21	75	5	40	4	13.6598	6.52
13	30	20	11	60	4	18.299	7.22
14	30	35	8	40	6	17.5258	7.12
15	30	55	5	100	0	17.268	7.53
16	30	75	2	80	2	14.1753	7.31

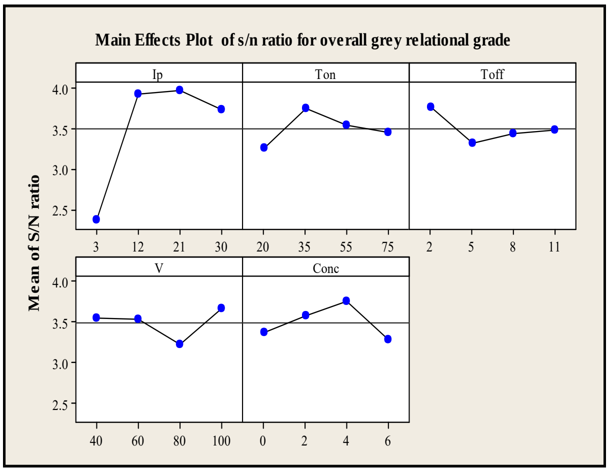
5. Regression Analysis

The calculated mathematical regression equation of MRR for material EN31 is as follows.
MRR = - 1.43 + 0.640 Ip - 0.0473 Ton + 0.142 Toff + 0.0233 V - 0.066 Conc

The calculated mathematical regression equation of Ra for material EN31 is as below.
Ra = 1.73 + 0.189 Ip + 0.0107 Ton + 0.0461 Toff - 0.00121 V - 0.112 Conc

6. Grey Relational Analysis

This approach converts a multiple- response- process optimization problem into a single response optimization situation.



Graph 1: S/N Ratio plot of overall grey relational grade

With the help of the graph 1, optimal parametric combination has been determined. The optimal factor setting becomes $Ip_3, Ton_2, Toff_1, V_4, C_3$

7. Confirmation

Table 2: Results of confirmatory experiment

	Optimal setting	
	Prediction	**Experiment**
Level of factors	$Ip_3, Ton_2, Toff_1, V_4, C_3$	$Ip_3, Ton_2, Toff_1, V_4, C_3$
S/N ratio	3.8433	3.2195
Overall grey relational grade	1.55657	1.4487

8. Conclusion

The material removal of the EDM process is rather low, especially in the case of EDM where the total volume of a cavity has to be removed. If the EDM is operated at the optimum setting of electrical parameters then this drawback can be minimized.
While machining the material EN31, the industrialist can directly use the optimum values so that the material removal rate will be maximum and Ra value will be minimum.

The common optimum values for both MRR and Ra can be easily obtained by the use of grey relational analysis method.

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