EXPERIMENTAL INVESTIGATION OF MACHINING PARAMETER FOR WET & NEAR-DRY EDM FINISHING

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ABSTRACT

The correct selection of manufacturing conditions and technique is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM).

This paper investigate wet and near-dry electrical discharge machining to achieve the high fine surface finish. In near-dry EDM liquid and air mixture delivered through a tabular electrode instead of only liquid dielectric used in wet EDM. L-9 orthogonal array is applied to investigate the effect of discharge current, pulse on time, gap voltage and pulse off time on surface finish in wet and near-dry EDM. Pulse on time and discharge current are identified as a key factors for improving the surface finish in wet and near-dry EDM. Finally a, comparison for performance of wet and near-dry EDM has been made. It was experimentally found that near-dry EDM exhibits the advantage of good machining stability thus result in smooth surface finish at low discharge energy.

Keyword: Near-Dry electrical discharge machining, Wet electrical discharge machining

1. INTRODUCTION

Electrical discharge machining (EDM) is a prevalent nontraditional precision machining method. The EDM machined surface is composed of discharge craters overlapping each other. To achieve a super surface finish, ultra low pulse energy¹⁾-⁴⁾ and powder mixed dielectric (PMD) EDM are two existing methods. Both methods have their limitations. Luo et al.^{1),2)} demonstrated a super finished EDM surface with 0.04 μm R_a by reducing the pulse energy with a very low discharge duration of t_i less than 0.2 μs . Egashira et al.³⁾ applied the ultra low discharge energy, less than 3 J, to conduct machining with the assistance of

ultrasonic vibration. Okada et al.4) studied the radio-frequency plasma to produce a surface roughness of $0.15 \mu\text{m Ra}$ on aluminum. The disadvantage of the low pulse energy method is the low material removal rate (MRR) and long machining cycle due to the frequent abnormal discharges resulting from the narrow gap distance. The PMD EDM has been recognized as a more practical finishing process to generate very fine surface finish at relatively high MRR5),6). Near-dry EDM, first explored by Tanimura et al. 11), utilizes the liquid-gas mixture as the dielectric fluid. It is found to be beneficial for the finishing process with good machining stability12). Better surface finish was achieved in near-dry EDM than that of wet and dry EDM at the same energy level. It is hypothesized that the liquid particles dispersed in the gas medium has a similar mechanism to promote the finishing process as the additive powders in PMD EDM. The dielectric disposal of near-dry EDM is cleaner than that of PMD EDM. In addition, the EDM milling configuration uses a small tubular electrode to scan over the large working area. In this case, the stray capacitance, which increases with the overlapping area between the electrode and workpiece, is no longer a constraint on the machining area, as it did in conventional die-sinking EDM1). In this study, the near-dry EDM milling is investigated to understand the effect of dielectric fluid, electrode material and pulse energy level. Benefits and potentials of near-dry EDM milling as the finishing process are identified and discussed

2. PLANNING OF EXPERIMENT

OHNS tool steel material having size $5 \times 50 \times 50 \text{ mm}$ with hollow copper electrode 10 mm diameter were used. Separate work piece is used for each experiment. And the PS 50ZNC (die-sinking type) of EDM machine are used. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94°C) and air through a hollow tube was used as dielectric fluid with a pressure of 0.1 kgf/cm^2 and 0.5 kgf/cm^2 respectively. Circular shaped hollow copper tool with internal flushing of air was used to flush away the eroded materials from the sparking zone. In this machining time and duty cycle is kept constant is 7 min and

0.75. For a four factor are tackled with a total number of 9 experiments were performed on wet sinking EDM for finishing condition and 9 experiments were performed on near-dry EDM for finishing condition. The surface finish measurement can be using contact type C3A Mahr Perthen Perthometer (stylus radius of $5 \mu\text{m}$) .

Table 1 Design Scheme of machining parameters and their levels

Parameters	Unit	Levels		
		Level-I	Level-II	Level-III
Discharge current (Ip)	Amp	2	3	4
Pulse on time (Ton)	μs	50	100	150
Pluse off time (Toff)	Position	10	11	12
gap voltage (Vg)	Volt	40	45	50

3. RESULT AND DISCUSSION

The analysis was made using the popular software specifically used for design of experiment applications known as MINITAB 16. Before any attempt is made to use this simple model as a predictor for the measures of performance, the possible of interactions. In the study, because of four factor three level L9 orthogonal array was used for design of experiment.

Table 2 Experimental design matrix & results for Ra in wet and near-dry EDM.

Exp. No.	Ip	Ton	Toff	Vg	Ip	Ton	Toff	Vg	Ra for wet EDM(μm)	Ra for near-dry EDM(μm)
1	1	1	1	1	2	50	10	40	3.83	2.68
2	1	2	2	2	2	100	11	45	3.61	1.87
3	1	3	3	3	2	150	12	50	3.72	2.74
4	2	1	2	3	3	50	11	50	5.6	1.94
5	2	2	3	1	3	100	12	40	5.23	2.51
6	2	3	1	2	3	150	10	45	4.91	4.32
7	3	1	3	2	4	50	12	45	3.98	3.44
8	3	2	1	3	4	100	10	50	6.94	3.12
9	3	3	2	1	4	150	11	40	6.71	3.59

3.1 Influences on surface finish in wet EDM

The response of signal to noise ratio for the factors is shown in Table 3 which is clearly indicates that the Ip has greatest influence on surface finish (SF), Vg has

the next greatest influence, followed by Toff and Ton. The delta values for Ip, Ton, Toff and Vg are 3.71, 1.24, 1.62 and 2.08 respectively, depicted in Table 3.

Table 3. S/N Ratios for wet EDM

Level	Ip	Ton	Toff	Vg
1	-11.41	-12.88	-14.10	-14.19
2	-14.39	-14.12	-14.22	-12.32
3	-15.12	-13.92	-12.59	-14.40
Delta	3.71	1.24	1.62	2.08
Rank	1	4	3	2

Table 4. S/N Ratios for near-dry EDM

Level	Ip	Ton	Toff	Vg
1	-7.585	-8.350	-10.39	-9.219
2	-8.820	-7.771	-7.432	-9.626
3	-10.57	-10.86	-9.160	-8.131
Delta	2.987	3.084	2.954	1.495
Rank	2	1	3	4

For surface finish, case is “Smaller is better”, It is recommended that signal to noise(S/N) ratio is always maximum for optimal result. The response tables show that the S/N ratios were maximized when the Ip was 2, the Ton was 50, the Toff was 12 & Vg was 45. Examining the main effects plots for S/N ratio confirms these results.

Fig. 1 Main effect plot for wet-EDM

Fig. 2 Main effect plot for near-dry EDM

During the process of EDM, the influence of various machining parameter like Ip, Ton, Toff and Vg has significant effect on surface finish , as shown in main effect plot for S/N ratio of surface finish in Fig 1. Increasing in the discharge current from 2 to 4 A the surface finish decreases due to increase in discharge energy.

3.2 Influences on surface finish in near-dry EDM

The response of signal to noise ratio for the factors is shown in Table 4 which is clearly indicates that the Ton has greatest influence on surface finish , Ip has the next greatest influence, followed by Toff and Vg. The delta values for Ip, Ton, Toff and Vg are 2.987, 3.084, 2.954 and 1.495 respectively, depicted in Table 4.

For surface finish, case is “Smaller is better”, It is recommended that S/N ratio is always maximum for optimal result. The response tables show that the S/N ratios were minimized when the Ip was 2, the Ton was 100, the Toff was 11 & Vg was 50. Examining the main effects plots for S/N ratio confirms these results.

During the process of EDM, the influence of various machining parameter like Ip, Ton, Toff and Vg has significant effect on surface finish , as shown in main effect plot for S/N ratio in Fig 2.

4. COMPARISON OF WET AND NEAR-DRY EDM

Experiments were conducted for the same input parameters for wet & near-dry EDM. The results are shown in Figure 3. It can be seen that the SF in near-dry EDM is much better than that of the wet EDM for same parameters in each experiment in finishing.

Fig 3 Comparison of SF in wet EDM & near-dry EDM

A comparison of process performance of wet EDM proven not beneficial for finishing because stable machining conditions are not established at low energy input thus result in a small discharge gap hence depth of cut increases where as in near-dry EDM proven beneficial for finishing operation because liquid phase is dispersed in gas medium is hypothesized to enhance the electric field and thus results in a large discharge gap distance and stable discharge at low energy input. The gases in the air prevent the electrolysis and yield better surface finish.

7. CONCLUSION

The following conclusions are drawn for the effective machining in wet and near-dry EDM for finishing purpose.

- (1). Finding the result of surface finish is most influencing factor and then gap voltage(I_p) and followed by pulse off time(T_{off}) and pulse on time(T_{on}) in wet EDM finishing and T_{on} is most influencing factor and then I_p and followed by T_{off} and V_g in near-dry EDM finishing
- (2). A comparison of process performance of wet EDM proven not beneficial for finishing because stable machining conditions are not established at low energy input thus result in a small discharge gap hence depth of cut increases where as in near-dry EDM proven beneficial for finishing operation.

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