Effect of EDM Process Parameters for Nickel Chromium Alloy Steel-700

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Abstract- **Metal removal mechanism in Electrical Discharge Machining (EDM) is mainly a thermal phenomenon where thermal energy is produced in plasma channel and dissipated though work piece, tool and dielectric. The process is mostly used in situations where machining of very hard materials, intricate parts, complex shapes. The aim of this work is to pursue the influence of three design factors current (I), pulse on Time (Ton) and pulse off Time (Toff) which are the most connected parameters to be controlled by the EDM process over machining specifications such as material removal rate (MRR) and characteristics of surface integrity such as average surface roughness (Ra) and the hardness (HR) and also to quantify them. The experiments were carried out as per L9 orthogonal array. Each experiment was performed under different conditions such as Ampere rating, pulse on time and pulse off time. The optimal factor for INCONEL 700 Surface Roughness were obtained when Pulse on time 5µs, Pulse Off time 8 µs and Amps-16, Machining time & MRR was Pulse on time 5µs, Pulse Off time 9 µs and Amps-14 . Particularly output response was mainly depending on the pulse on time for the output Response.**

Index Terms- **: Optimization, EDM, Inconel-700.**

I. ELECTRICAL DISCHARGE MACHINING

The schematic of an EDM machine tool is shown in Figure 1.1. The tool and the work piece form the two conductive electrodes in the electric circuit. Pulsed power is supplied to the electrodes from a separate power supply unit. The appropriate feed motion of the tool towards the work piece is generally provided for maintaining a constant gap distance between the tool and the work piece during machining. This is performed by either a servo motor control or stepper motor control of the tool holder. As material gets removed from the work piece, the tool is moved downward towards the work piece to maintain a constant inter-electrode gap.

The tool and the work piece are plunged in a dielectric tank and flushing arrangements are made for the proper flow of dielectric in the inter-electrode gap. Typically in oil die-sinking EDM, pulsed DC power supply is used where the tool is connected to the negative terminal and the work piece is connected to the positive terminal.

The pulse frequency may vary from a few kHz to several MHz. The inter electrode gap is in the range of a few tens of micro meter to a few hundred micro meter. Material removal rates of upto 300 mm^3/min can be achieved during EDM. The surface finish (Ra value) can be as high as 50 µm during rough machining and even less than 1 µm during finish machining.

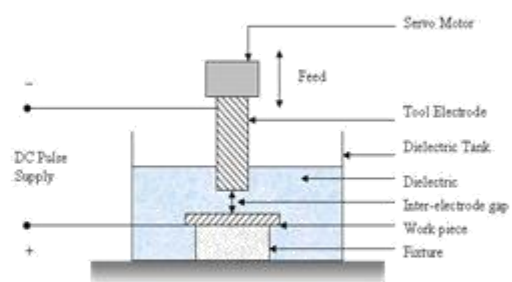

Figure 1.1: Schematic of Electric Discharge Machining (EDM)

II. MATERIALS USED

2.1 Inconel-700

Inconel alloys are oxidation-corrosion-resistant materials well suited for service in extreme environments subjected to pressure and heat. When heated, Inconel forms a thick, stable, passivating oxide layer protecting the surface from further attack. Inconel retains strength over a wide temperature range, attractive for high temperature applications where aluminum and steel would succumb to creep as a result of thermally induced crystal vacancies. Inconel's high temperature strength is developed by solid solution strengthening or precipitation hardening, depending on the alloy.

2.2 Chemical Properties

Ni	Cr	Fe	Mo	Co	C	Mn	Cu	Si	Al	Ti	Others
46	15	0.7	3.75	28.5	0.12	0.1	0.05	0.3	3	2.2	Rest

2.3 Applications

Inconel alloys are typically used in high temperature applications. Air craft engine, Marine chemical parts, Heat exchangers, Condensors and Evaportater tubing are generally made of inconel 700.

III. OPTIMIZATION

3.1 Process Parameters & Levels

S.No	Pulse on	Pulse off Time(T)	Gap Current
1	5	7	12
2	6	8	14
3	7	9	16

3.2 Design of Orthogonal Array

Orthogonal array is designed using minitab-17 software.

Trial No.	DESIGNATION	Pulse on time in us	Pulse off Time in us	Gap Current in amps
1	$A_1B_1C_1$	5	7	12
2	$A_1B_2C_2$	5	8	14
3	$A_1B_3C_3$	5	9	16
4	$A_2B_1C_2$	6	7	14
5	$A_2B_2C_3$	6	8	16
6	$A_2B_3C_1$	6	9	12
7	$A_3B_1C_3$	7	7	16
8	$A_3B_2C_1$	7	8	12
9	$A_3B_3C_2$	7	9	14

3.3 Experimental Data

Trial No.	Designation	Pulse on time in µs	Pulse off Time in µs	Gap Current in amps	RA Micron	MT Min	MRR m/min
1	$A_1B_1C_1$	5	7	12	1.612	28	0.027
2	$A_1B_2C_2$	5	8	14	1.893	23	0.045
3	$A_1B_3C_3$	5	9	16	2.469	18	0.043
4	$A_2B_1C_2$	6	7	14	2.212	19	0.042
5	$A_2B_2C_3$	6	8	16	2.186	15	0.058
6	$A_2B_3C_1$	6	9	12	2.420	20	0.045
7	$A_3B_1C_3$	7	7	16	2.168	13	0.067
8	$A_3B_2C_1$	7	8	12	2.898	16	0.055
9	$A_3B_3C_2$	7	9	14	3.142	18	0.051

3.4 Surface Roughness (Analysis of Result)

3.4.1 Surface Roughness and S/N Ratios Values for the Experiments

Trial No.	Designation	Pulse on time in µs	Pulse off Time in µs	Gap Current in amps	RA Micron	S/N Ratio Value db
1	$A_1B_1C_1$	5	7	12	1.612	-
2	$A_1B_2C_2$	5	8	14	1.893	-
3	$A_1B_3C_3$	5	9	16	2.469	-
4	$A_2B_1C_2$	6	7	14	2.212	-
5	$A_2B_2C_3$	6	8	16	2.186	-
6	$A_2B_3C_1$	6	9	12	2.420	-
7	$A_3B_1C_3$	7	7	16	2.168	-
8	$A_3B_2C_1$	7	8	12	2.898	-
9	$A_3B_3C_2$	7	9	14	3.142	-

3.4.2 Response Table for Signal to Noise Ratios

Smaller is better

Level	TON	TOFF	AMPS
1	-5.847	-5.921	-7.022
2	-7.122	-7.193	-7.461
3	-8.636	-8.490	-7.122
Delta	2.789	2.569	0.439
Rank	1	2	3

3.4.3 Response Table for Means

Smaller is better

Level	TON	TOFF	AMPS
1	1.991	1.997	2.310
2	2.273	2.326	2.416
3	2.736	2.677	2.274
Delta	0.745	0.680	0.141
Rank	1	2	3

3.4.4 Analysis of Variance

Source	DF	Seq SS	Adj SS	F	P	% of Contribution

T on	2	0.8483	0.4241	4.18	0.193	47
T off	2	0.6931	0.3465	3.15	0.226	40
Amps	2	0.0324	0.0162	0.16	0.862	2
Error	2	0.2027	0.1013			11
Total	8	1.7766				100

3.5 Machining Time (Analysis of Result)

3.5.1 Machining Time and S/N Ratios Values for the Experiments

Trial No.	Designation	Pulse on time in µs	Pulse off Time in µs	Gap Current in amps	MT Min	S/N Ratio Value db
1	$A_1B_1C_1$	5	7	12	28	-28.9432
2	$A_1B_2C_2$	5	8	14	23	-27.2346
3	$A_1B_3C_3$	5	9	16	18	-25.1055
4	$A_2B_1C_2$	6	7	14	19	-25.5751
5	$A_2B_2C_3$	6	8	16	15	-23.5218
6	$A_2B_3C_1$	6	9	12	20	-26.0206
7	$A_3B_1C_3$	7	7	16	13	-22.2789
8	$A_3B_2C_1$	7	8	12	16	-24.0824
9	$A_3B_3C_2$	7	9	14	18	-25.1055

3.5.2 Response Table for Signal to Noise Ratios

Smaller is better

Level	TON	TOFF	AMPS
1	-27.09	-25.60	-26.35
2	-25.04	-24.95	-25.97
3	-23.82	-25.41	-23.64
Delta	3.27	0.65	2.71
Rank	1	3	2

3.5.3 Response Table for Means

Smaller is better

Level	TON	TOFF	AMPS
1	23.00	20.00	21.33
2	18.00	18.00	20.00
3	15.67	18.67	15.33
Delta	7.33	2.00	6.00
Rank	1	3	2

3.5.4 Analysis of Variance

Source	DF	Seq SS	Adj SS	F	P	% of Contribution
T on	2	84.222	42.111	7.73	0.114	52
T off	2	6.222	3.111	0.5	0.636	3
Amps	2	59.556	29.778	5.47	0.155	38
Error	2	10.889	5.444			7
Total	8	160.889				100

3.6 MRR and S/N Ratios Values for the Experiments

3.6.1 MRR and S/N Ratios Values for the Experiments

Trial No.	Designation	Pulse on time in µs	Pulse off Time in µs	Gap Current in amps	MRR m/min	S/N Ratio Value db
1	$A_1B_1C_1$	5	7	12	0.027	-
2	$A_1B_2C_2$	5	8	14	0.045	-
3	$A_1B_3C_3$	5	9	16	0.043	-
4	$A_2B_1C_2$	6	7	14	0.042	-
5	$A_2B_2C_3$	6	8	16	0.058	-
6	$A_2B_3C_1$	6	9	12	0.045	-
7	$A_3B_1C_3$	7	7	16	0.067	-
8	$A_3B_2C_1$	7	8	12	0.055	-
9	$A_3B_3C_2$	7	9	14	0.051	-

3.6.2 Response Table for Signal to Noise Ratios

Smaller is better

Level	TON	TOFF	AMPS
1	-28.55	-27.46	-27.83
2	-26.40	-25.62	-26.77
3	-24.84	-26.70	-25.18
Delta	3.71	1.84	2.65
Rank	1	3	2

3.6.3 Response Table for Means

Smaller is better

Level	TON	TOFF	AMPS
1	0.03833	0.04533	0.04233
2	0.04833	0.05267	0.04600
3	0.05767	0.04633	0.05600
Delta	0.01933	0.00733	0.01367
Rank	1	3	2

3.6.4 Analysis of Variance

Source	DF	Seq SS	Adj SS	F	P	% of Contribution
T on	2	0.00056	0.00028	6.77	0.129	54

T of f	2	0.00009	0.00004	1.14	0.466	9
A m ps	2	0.00030	0.00015	3.62	0.216	28
Er ro r	2	0.00008	0.00004			9
T ot al	8	0.00103				100

IV. RESULT & CONCLUSION

In this study the Taguchi technique and ANOVA were used to obtain optimal machining parameters in the electrical discharge machining conditions. The experimental results were evaluated using Taguchi technique. The following conclusion can be drawn.

4.1 Optimal Control Factor

1. Surface Roughness- A_1 (Pulse on time -5µs), B_2 (Pulse off time -8 µs) & C_3 (Amps-16).
2. Machining Timing- A_1 (Pulse on time -5µs), B_3 (Pulse off time -9 µs), C_2 (Amps-14).
3. Material Removal Rate-A_1 (Pulse on time -5µs), B_3 (Pulse off time -9 µs) & C_2 (Amps-14).

4.2 Percentage Contribution of Process parameters

1. Surface Roughness- Pulse on time 47%
2. Machining Timing -Pulse on time 52%
3. Material Removal – Pulse on time 54%

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