Influence of Process Parameters in n-PMEDM of Inconel 800 with Electrode and Coated Electrodes

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Abstract. By considering the unique performances, the Powder Mixed Electrical Discharge Machining (PMEDM) mostly encounter choice for machining the hard materials with job features like intricate shapes with grater accuracy and those materials are difficult to cut in conventional machining processes. This Research aimed to prepare parameter index chart for machining nickel based super alloy - Inconel 800 for various requirements. To achieve the aim, In this experimental study on machining of Inconel 800 in PMEDM with electrolyte copper electrode as well as silver coated electrolyte copper electrode is focused. Taguchi full factorial design derived from MINITAB release-16 software was used to design the experimentation. The factors like pulse off time, Current and Pulse on Time were considered. The responses like amount of Tool Wear, Quantity of material removal, surface finishes were noted against each case. In the same experimental conditions the coated electrode increased the MRR by 36.67% with minor increment of maximum surface roughness to 16.11%.

1 Introduction

The Inconel materials generally have high hardness, thermal strength and low thermal diffusivity and their applications are especially in high pressure and high temperature field such as gas turbine, Nuclear reactors, chemical vessels, electrical power plant equipments etc [1]. The EDM is choice for machining them to meet the definite shape and accuracy requirements because they form build-up-edge and have tendency to stick or weld with tool material and extremely difficult by using traditional processes [2]. The PMEDM extends the cutting efficiency and surface quality by sparking more rapidly and enhances the thermal conductivity surrounded by discharge take place causes the high rate of erosion from the work [3]. The Kuppan *et al*. [4] studied the influence of process parameters in in deep hole EDM drilling of Inconel 718 and developed mathematical model for the responses of depth averaged surface roughness and MRR to interpret process parameters. Rajyalakshmi and Venkata Ramaiah, [5] studied machining of Inconel 825 in Wire EDM. The MuthuKumar et al. [6] studies were on WEDM of Inconel 800 for optimimsing process parameters and later about radial overcut [7]. Mao-yong LIN et al. [8] investigation was parameter optimization in micro milling EDM of Inconel 718. In PMEDM, the Rathi and Mane [9] studied the Effect of Powders of Al_2O_3, SiC and graphite powder for machining of Inconel 718. Tzeng and Lee [10] reported that the density, particle size, Electrical and Thermal Condivity and power concentration in the mix are influencing significantly in Performance of PMEDM. The Syed et al. [11] recommended up to 2g/l of Al Powder mix in Kerosene for Machining of Aluminium-Silicon Carbide Composites. The Shriram et al. [12] used 4g/l of Al powder mix EDM for machining of Tungsten Carbide work. And many authors were recommended Al powder mix in kerosene dielectric. Here the Al powder mixed with kerosene and stirred continuously about 8 to 9 hours in the Magnetic stirrer for reducing the size of particles about to 5 Nm, before they mix in the actual dielectric. Hence this unique case of research may be referred as Nano Powder mixed EDM (n-PMEDM) of Inconel 800.

2 The Experimentation

This research is motivated by industrial requirements. The manufacturer deals various kinds of jobs of inconel 800. The practical issues like, statistical approximation and mathematical models to choose parameters often difficult to interpolate by industrialist. Sometimes the approximate solutions and manual mistakes of interpolating parameter values leads to losses.

Table 1. Factors and responses

Factors	Level 1	Level 2	Level 3
Peak Current (A)	5	10	15
Pulse on time (μs)	6	7	8
Pulse off time (μs)	4	5	6
Electrode	Plain	Coated	-
Responses	MRR, TWR and SR		

Table 2. Taguchi full factorial design of experiments

Expt. No	Current (A)	Pulse On Time (µs)	Pulse Off Time (µs)
1	5	6	3
2	5	6	4
3	5	6	5
4	10	6	3
5	10	6	4
6	10	6	5
7	15	6	3
8	15	6	4
9	15	6	5
10	5	7	3
11	5	7	4
12	5	7	5
13	10	7	3
14	10	7	4
15	10	7	5
16	15	7	3
17	15	7	4
18	15	7	5
19	5	8	3
20	5	8	4
21	5	8	5
22	10	8	3
23	10	8	4
24	10	8	5
25	15	8	3
26	15	8	4
27	15	8	5

Hence the manufacturer demanded that a parameter choice card to select and fix factors for desired requirements of their job for regular use. Hence the research is designed completely experimental. Taguchi general full factorial design was preferred for the experimental design. The MINITAB release 16 software was used for obtaining such design. The factors and their levels and responses were furnished in Table 1. The Experiments mainly classified as PMEDM with Electrolyte copper Electrode and PMEDM with Silver coated Electrolyte copper Electrode.

Table 3. Observations of PMEDM with plain electrode

Expt. No	MRR (g/min)	TWR (g/min)	SR (µm)
1	0.11438	0.00069	0.98
2	0.13967	0.00091	1.04
3	0.15019	0.00127	1.18
4	0.21576	0.00161	1.12
5	0.22548	0.00185	1.21
6	0.25345	0.00224	1.37
7	0.38793	0.00246	1.27
8	0.43584	0.00284	1.34
9	0.46086	0.00175	1.54
10	0.28472	0.00186	1.08
11	0.31560	0.00204	1.18
12	0.33025	0.00219	1.26
13	0.35302	0.00223	1.23
14	0.38582	0.00271	1.35
15	0.43447	0.00313	1.49
16	0.49270	0.00418	1.34
17	0.52210	0.00445	1.54
18	0.58815	0.00328	1.75
19	0.50203	0.00412	1.17
20	0.53702	0.00439	1.26
21	0.55829	0.00475	1.33
22	0.60079	0.00521	1.27
23	0.64298	0.00618	1.38
24	0.67097	0.00644	1.53
25	0.69663	0.00690	1.58
26	0.74722	0.00706	1.63
27	0.79346	0.00745	1.78

Table 3. Observations of PMEDM with coated electrode

Expt. No	MRR (g/min)	TWR (g/min)	SR (µm)
1	0.13086	0.00094	1.13
2	0.16983	0.00124	1.18
3	0.20524	0.00177	1.24
4	0.24762	0.00205	1.28
5	0.26186	0.00254	1.35
6	0.29222	0.00308	1.41
7	0.45716	0.00323	1.47
8	0.52833	0.00368	1.54
9	0.57562	0.00184	1.76
10	0.36433	0.00197	1.21
11	0.37210	0.00216	1.26
12	0.37984	0.00228	1.34
13	0.40252	0.00299	1.37
14	0.41140	0.00324	1.46
15	0.46888	0.00321	1.59
16	0.54627	0.00429	1.54
17	0.61643	0.00489	1.67
18	0.67616	0.00394	1.83
19	0.59742	0.00424	1.24
20	0.61350	0.00469	1.29
21	0.69590	0.00501	1.38
22	0.71494	0.00564	1.42
23	0.73120	0.00637	1.54

DOI: 10.1051/matecconf/20179502002

24	0.83280	0.00689	1.67
25	0.79329	0.00702	1.64
26	0.81330	0.00745	1.71
27	0.92407	0.00859	1.93

In each case there were 27 experiments. In each experiment, the net observations were three likr TWR, SR and MRR. The experimental design is shown in Table 2 with parameters setting values for each case. The Electronica Machine Tools make Xpert 1model die sinking type CNC EDM machine was employed in this research. Kerosene is dielectric fluid in this machine because of its property of very low viscosity and it gets flushed away easily. Based on the literature review the recommended aluminum nanopowder concentration is 2g/l to 4g/l and fixed for this research as average value of 3g/l. The machining time for each test was 5 minutes exactly. The Taylor Hobson make, Surtronic3+ branded contact type profile-meter was used to measure surface roughness with 0.8mm cut of length and took three sample readings to avoid observational error. The tool and work material weight losses were measured by using laboratory balance of semi micro with accuracy of 0.00001 gm. The observations of MRR, SR and TWR were carried out for each experimental setting as per Table 1. They were recorded and furnished for electrode and coated electrode in Table 3 and Table 4 respectively.

3. Result and Discussion

The Comparative performances of both electrode types in terms of Material Removal Rate, Surface Roughness produced and Tool wear rates were analyzed. In figures the Input current index A, B and C used for experiments with Plain Electrode and 1, 2 and 3 for Silver coated Electrode for 5A, 10A and 15A respectively. The graphs plotted for constant pulse on time 6, 7 and 8µs for MRR, SR and TWR.

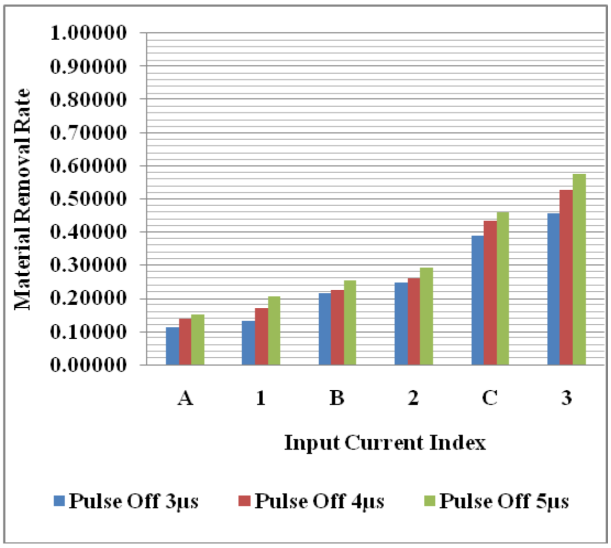

Figure 1. The MRR at Pulse on Time 6µs.

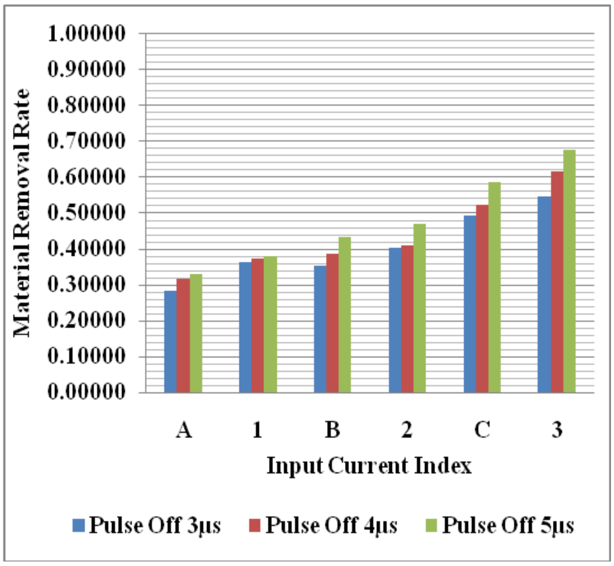

Figure 2. The MRR at Pulse on Time 7µs.

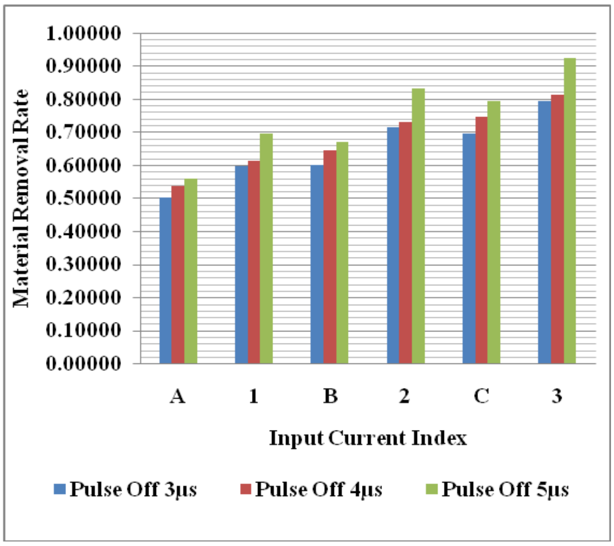

Figure 3. The MRR at Pulse on Time 8µs.

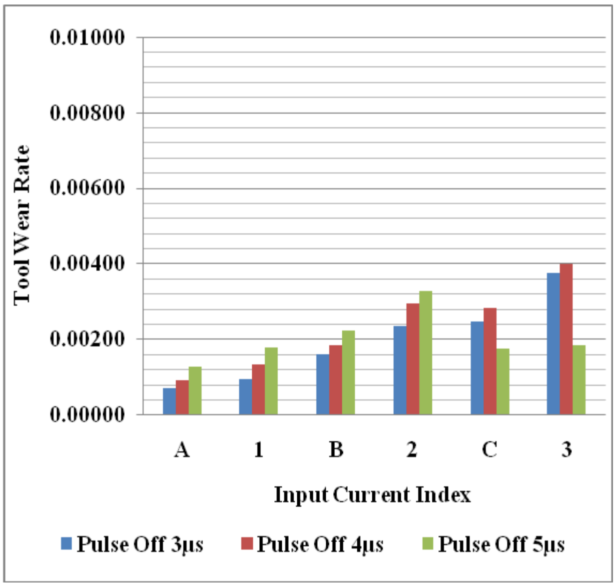

Figure 4. The TWR at Pulse on Time 6µs.

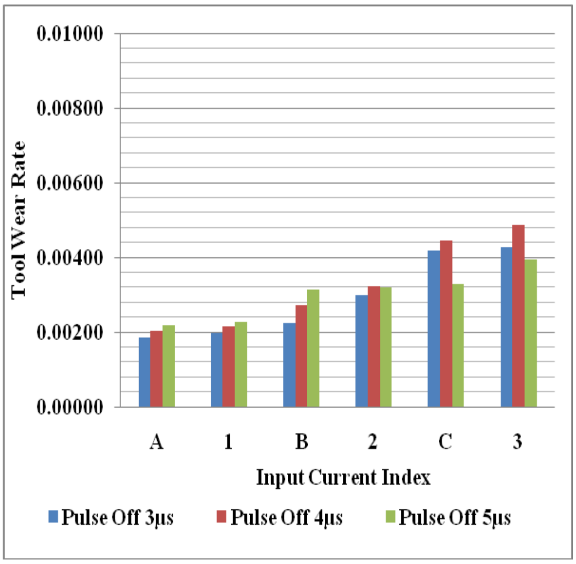

Figure 5. The TWR at Pulse on Time 7µs.

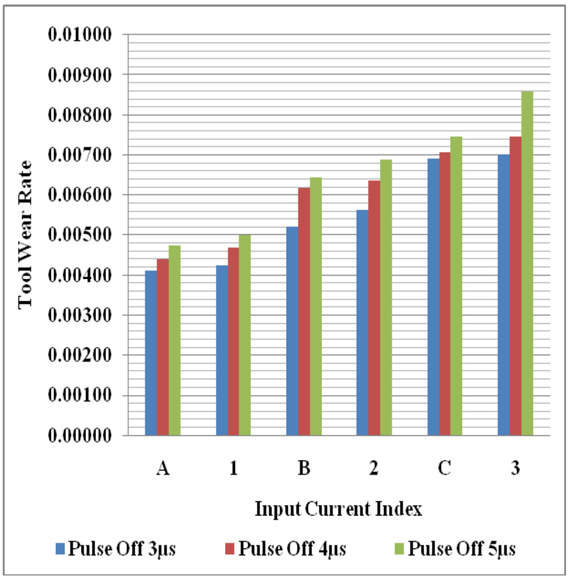

Figure 6. The TWR at Pulse on Time 8µs.

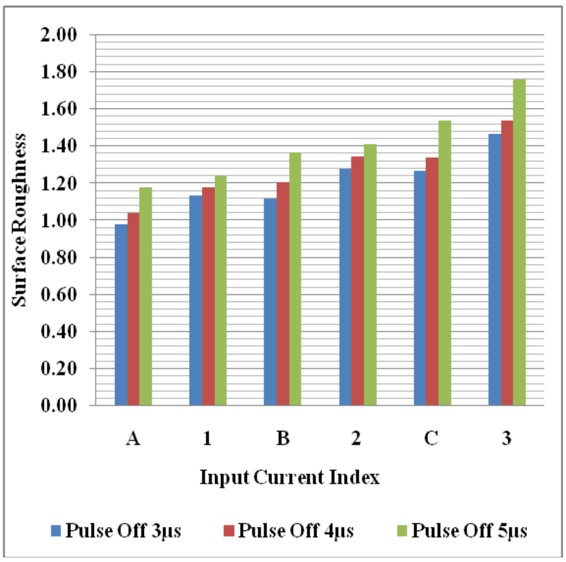

Figure 7. The SR at Pulse on Time 6µs.

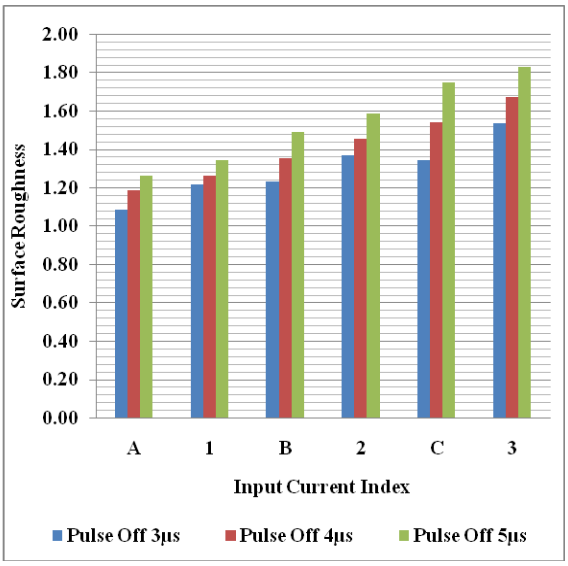

Figure 8. The SR at Pulse on Time 7µs.

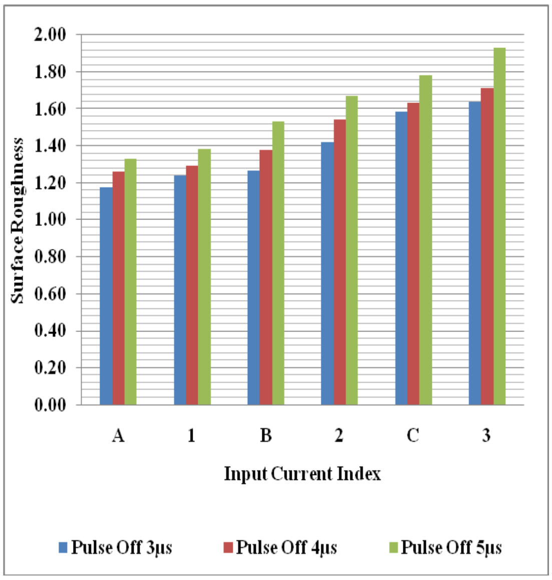

Figure 8. The SR at Pulse on Time 7µs.

The results reveals that the input current influenced more in increasing MRR as well as SR and TWR than Pulse on and pulse off times. But the factors Pulse on time and pulse off time influence are signifiant. The contribution of coated electrode is appréciable.

4. Conclusion

The Al Nano Powder Mixed EDM of Inconel 800 surface machining with plain Electrolyte Copper Electrode and Silver coated Electrolyte Copper Electrode were considered for this study. The reserach concluded that:

1. The maximum MRR can be achieved at higher values of the process parameters especially the input current.
2. The influence of pulse on time and pulse of time along with higher value of input current gives higher MRR.
3. The silver coating on Electrolyte Copper electrode significantly increases the MRR as

well as TWR. But lesser percentage of increments were observed in surface finish.

4. The MRR are directly proportional to TWR but inverse to the surface finish.
5. The manufacurer can be used the observation to understand the parameter influences in both cases as well as those table are healpful them to take appropriate decition to fix the parameters based on their requirements for the respective job type.

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