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# Experimental Investigation of process parameters influence on machining Inconel 800 in the Electrical Spark Eroding Machine

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**Abstract.** The Electrical Spark Eroding Machining is an entrenched sophisticated machining process for producing complex geometry with close tolerances in hard materials like super alloy which are extremely difficult-to-machine by using conventional machining processes. It is sometimes offered as a better alternative or sometimes as an only alternative for generating accurate 3D complex shapes of macro, micro and nano-features in such difficult-to-machine materials among other advanced machining processes. The accomplishment of such challenging task by use of Electrical Spark Eroding Machining or Electrical Discharge Machining (EDM) is depending upon selection of apt process parameters. This paper is about analyzing the influencing of parameter in electrical eroding machining for Inconel 800 with electrolytic copper as a tool. The experimental runs were performed with various input conditions to process Inconel 800 nickel based super alloy for analyzing the response of material removal rate, surface roughness and tool wear rate. These are the measures of performance of individual experimental value of parameters such as pulse on time, Pulse off time, peak current. Taguchi full factorial Design by using Minitab release 14 software was employed to meet the manufacture requirements of preparing process parameter selection card for Inconel 800 jobs. The individual parameter's contribution towards surface roughness was observed from 13.68% to 64.66%.

## 1. Introduction

Electrical discharge machining is an unconventional Spark eroding machine, which removes metal from a specimen by means of Electrical sparks (heat energy). Electrically conductive materials are only machined in electrical discharge machining. Comparing to conventional method of machining, it can machine the high hardened material. But the material removal rate (MRR) is very low and good surface finish (less surface roughness). Tzeng and Lee<sup>[1]</sup>, highlighted that the handling of process parameters in EDM is helping to get optimum value of MRR, TWR and SR. It is clearly stated that the effect of increasing the current will increase MRR. And MRR depends on pulse on & pulse off time also. Initially, increasing pulse on time reason for decreasing MRR. TWR is based on current. The peak current increases in directly proportional to the TWR. The surface roughness is increasing with increasing peak current and pulse on time. Jothimurugan et al.<sup>[2]</sup> studied that by varying the pulse off time, discharge current, voltage had significant of MRR. By giving the pulse on time of 400 $\mu$ s, pulse of time of 1600 $\mu$ s, current of 15A and voltage 40v was given to get a maximum MRR using response



surface methodology (RSM) in EDM process. Ay et al.<sup>[3]</sup> varied tools configuration like hexagonal and square profile copper electrode for machining of Inconel 718 to investigate TWR, MRR and SR in micro EDM. Assarzadeh and Ghoreishi<sup>[4]</sup> investigated based on desirability value is 1.0 as the value is completely dependent on how closely the lower and upper limits are set relative to the actual optimum in EDM with alumina power mix in dielectric fluid. Gopalakannan and Senthilvelan<sup>[5]</sup> investigations were on machining of Al-SiC nano-composites, Kumar et al.<sup>[6]</sup> concentrated Electrical Discharge Machining of Al (6351)-5% SiC-10% B4CnHybrid Composite in their studies and Goyal and Choudhary<sup>[7]</sup> considered inconel 800 machining in WEDM Machining. But here inconel 800 material is preferred for investigation due to its wide application in high temperature and high pressure applications. Dhanabalan et al.<sup>[8]</sup> used dielectric fluid as clean kerosene in EDM of Al Alloy (Grade HE9). In this research the kerosene dielectric is enriched with servotherm EDM oil. In this research Taguchi full factorial design is used. The experimentations were completely done to design the parameter setting card to the manufacture.

## 2. Method and Experimental Setup

These experimental runs were conducted with three factors of three levels to investigate process parameters' influence in machining in die sinking EDM machine. The tool was electrolytic copper. The work piece was Inconel 800 with servotherm EDM oil enriched kerosene as dielectric medium. Herein, the influences of machining parameters (Current, pulse on time and pulse off time) on machining performances are discussed. Material removal rate (MRR) and Tool Wear Rate were observed through the weight loss method for both work piece and tool for finding MRR and TWR. In this experiment, the work piece with size of  $\phi 22 \times 20$ mm Inconel 800. Additionally, the tool material

**Table 1** Parameter Description

Working parameter	Description
Work piece	Inconel 800
Tool	Electrolytic copper
Dielectric medium	kerosene enriched with Servotherm EDM oil
Peak Current	5,10 & 15 (A)
Pulse on time	6,7 & 8 ( $\mu$ s)
Pulse off time	3,4 & 5 ( $\mu$ s)
Pulse off time	5 ( $\mu$ s)
Supply voltage	240 (V)
Polarity	Straight

( $\phi 25 \times 23$ mm) was electrolytic copper The experiments have been performed on Electronica Machine Tools make Xpert1 model die sinking type CNC EDM machine. The Taylor Hobson makes, Surtronic3+ branded contact type profile-meter was employed in surface roughness measurement with 0.8mm cut length and sampling number is three. The laboratory balance of semi micro with an accuracy of 0.00001g, was employed in measuring weight loss tool and work material in before and after every run to compute MRR and TWR. Here pulse on time, Pulse off time and peak current value has been varied, to analyze the responses of MRR, SR and TWR with electrolytic copper as tool for machining 5 minutes.

## 3. Experimentation

At this experimental setup, Pulse on value has been maintained at 6  $\mu$ s, Pulse off time 3  $\mu$ s and Peak current value is varied 5A, 10A and 15A. The MRR, SR and TWR have been observed after machining 5 minutes. Then similarly the experimentations were carried out for Pulse off time 4  $\mu$ s and for 5  $\mu$ s for peak current 5A, 10A and 15A at 6  $\mu$ s. The observations recorded for pulse on time 6  $\mu$ s in Table 2, for 7  $\mu$ s in Table 3 and for 8  $\mu$ s in Table 4.

**Table 2** Observation for the Experimental Set 1

<b>RUN</b>	<b>Current (A)</b>	<b>Pulse On (<math>\mu</math>s)</b>	<b>Pulse Off (<math>\mu</math>s)</b>	<b>MRR (g/min)</b>	<b>TWR (g/min)</b>	<b>SR (<math>\mu</math>m)</b>
<b>1</b>	5	6	3	0.07219	0.00037	1.21
<b>2</b>	10	6	3	0.12975	0.00057	1.30
<b>3</b>	15	6	3	0.18745	0.00117	1.43
<b>4</b>	5	6	4	0.08240	0.00042	1.39
<b>5</b>	10	6	4	0.15471	0.00066	1.49
<b>6</b>	15	6	4	0.23205	0.00130	1.57
<b>7</b>	5	6	5	0.08968	0.00055	1.63
<b>8</b>	10	6	5	0.16180	0.00076	1.76
<b>9</b>	15	6	5	0.25684	0.00147	1.86

**Table 3** Observation for the Experimental Set 2

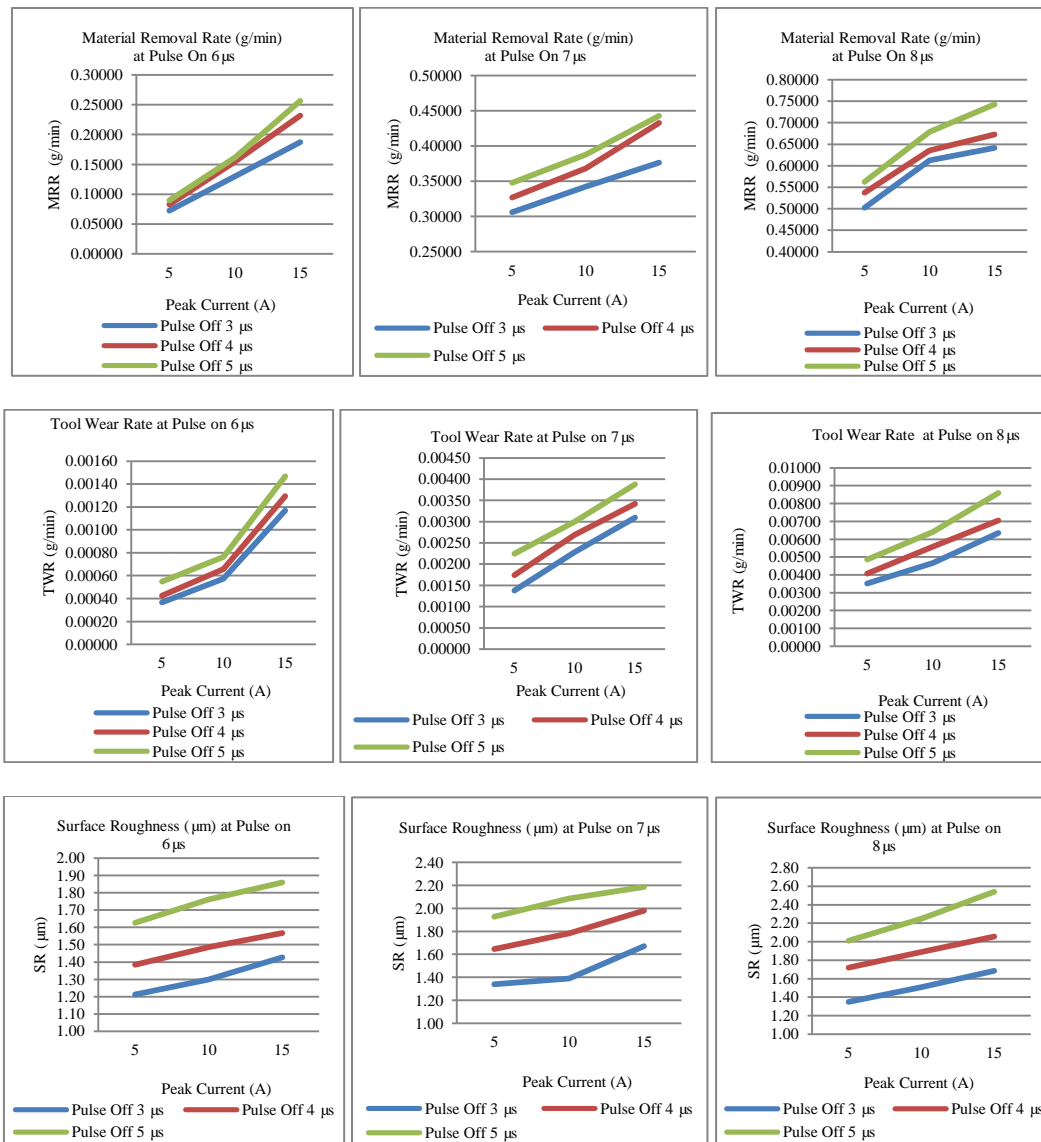
<b>RUN</b>	<b>Current (A)</b>	<b>Pulse On (<math>\mu</math>s)</b>	<b>Pulse Off (<math>\mu</math>s)</b>	<b>MRR (g/min)</b>	<b>TWR (g/min)</b>	<b>SR (<math>\mu</math>m)</b>
<b>10</b>	5	7	3	0.30573	0.00138	1.34
<b>11</b>	10	7	3	0.34230	0.00228	1.39
<b>12</b>	15	7	3	0.37632	0.00310	1.67
<b>13</b>	5	7	4	0.32676	0.00174	1.65
<b>14</b>	10	7	4	0.36833	0.00269	1.78
<b>15</b>	15	7	4	0.43249	0.00342	1.98
<b>16</b>	5	7	5	0.34753	0.00225	1.93
<b>17</b>	10	7	5	0.38756	0.00300	2.09
<b>18</b>	15	7	5	0.44281	0.00388	2.19

**Table 4** Observation for the Experimental Set 3

<b>RUN</b>	<b>Current (A)</b>	<b>Pulse On (<math>\mu</math>s)</b>	<b>Pulse Off (<math>\mu</math>s)</b>	<b>MRR (g/min)</b>	<b>TWR (g/min)</b>	<b>SR (<math>\mu</math>m)</b>
<b>19</b>	5	8	3	0.50210	0.00352	1.35
<b>20</b>	10	8	3	0.61234	0.00467	1.51
<b>21</b>	15	8	3	0.64130	0.00635	1.68
<b>22</b>	5	8	4	0.53725	0.00407	1.72
<b>23</b>	10	8	4	0.63530	0.00557	1.89
<b>24</b>	15	8	4	0.67268	0.00705	2.05
<b>25</b>	5	8	5	0.56255	0.00486	2.01
<b>26</b>	10	8	5	0.67892	0.00641	2.25
<b>27</b>	15	8	5	0.74297	0.00859	2.54

#### 4. Result and Discussion

The parameters influence investigation was carried out in three aspects such as the influence of input parameters with respect to the performance of MRR, TWR and SR. The first row reveals the MRR with respect to Pulse on Time in the order of 6 $\mu$ s, 7 $\mu$ s and 8 $\mu$ s. It is observed that if the peak current increases the MRR increase linearly as well as the increase of pulse on time. But the MRR response with respect to pulse off time minimal compared to peak current. If the pulse on time increases the MRR increase steeply. Similarly second row the MRR for Pulse on Time 6 $\mu$ s, 7 $\mu$ s and



**Figure 1** Influence of Input Parameters

8 μs. The TWR increases with increase of peak current, as well as pulse on time. The increase, if pulse off time. the increases of TWR less than MRR. The TWR is also increases with increase of pulse on time as well as peak current and some extent to increase of pulse off time. The third row is for SR, in which the pulse off time also influence in the SR and it is directly proportional to SR. The increase of pulse on time steeply increases the surface roughness. The significant differences were observed with increases of peak current. The influence of pulse off time is increase of pulse off time increases the SR.

## 5. Conclusion

The experimental study of influence of input parameters like pulse on time, pulse off time and peak current in EDM on inonel 800 was discussed. The pulse on time and peak current contribution is more than pulse off time. The influences of various parameters were analyzed in detail in results and discussion. The observation table can be used as a parameter selection card to obtain the suitable roughness. The contribution is the ratio of individual experimentation set rage of surface roughness variation to total surface roughness range of variation. Hence the lowest variation was obtained at pulse on time 6 μs, Pulse Off time 4 μs at 13.68%.

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