Experimental optimisation of process parameters on micro hole machining by Die sinker EDM

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ABSTRACT

The present work deals with micro hole machining of diameter 0.7mm (700µm) on SS316 materials using Die sinker EDM. The design of experiment plan was done by Taguchi L9 Orthogonal Array where the process parameters are current, Time-On, Time-OFF. The output performance are material removal rate, tool wear rate were examined.

Keywords: Micro hole 0.7mm, Die Sinker EDM, Taguchi, MRR, TWR.

Introduction

Many new materials are manufacture by the industrial sectors depending upon the design of materials application, such as steel alloys and super Alloys which have high strength, heat resistance and hardness are very difficult in machining complex shapes of the by conventional methods. So these manufacturing problems are overcome by non-traditional machining processes in which Die Sinker electrical discharge machining applications are more in use. The working principle of EDM the following component

- Power supply - the machining is mainly done by the direct current by supply which results as spark between the Tool electrode and work piece
- Dielectric fluid used to tool and work piece
- Workpiece holder, Tool holder and table
- Servo control– Used to provide a constant gap between tool and workpiece.

EXPERIMENT METHODOLOGY

- Work piece and tool required.

Table 1 SS316 stainless steel has been used as work piece material with electrolytic copper with diameter 0.7mm (700µm) was used as tool electrode. The machining process was carried on Acro EDM Machine with process parameters namely Current, T-on, T-off were investigated in this study.

Table 1. Chemical composition of SS316

<table>
<thead>
<tr>
<th>Element</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.08</td>
</tr>
<tr>
<td>Ni</td>
<td>12</td>
</tr>
<tr>
<td>S</td>
<td>0.03</td>
</tr>
<tr>
<td>P</td>
<td>0.045</td>
</tr>
<tr>
<td>Cr</td>
<td>17</td>
</tr>
<tr>
<td>Fe</td>
<td>Balanced</td>
</tr>
</tbody>
</table>
• **Design of Experiment for Machining conditions for micro holes**

The experiment is plan on taguchi L9- orthogonal array where numbers of parameter were taken as 3 i.e. Current, T-on & T-off with number of levels are 3 are table 3, and experiment according L9 orthogonal Array are table in 4.

Table 2. Process parameters and their level for micro hole machining

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Current</th>
<th>T-ON</th>
<th>T-OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbols</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>1</td>
<td>0.2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>0.8</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3: Combination of Control parameters based on Experimental L9 OA

<table>
<thead>
<tr>
<th>Trail of Experiments</th>
<th>Current</th>
<th>Ton</th>
<th>Toff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>0.4</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>0.8</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>0.8</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>0.8</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

From the design of experiments the final output is Material Removal rate, Tool wear of micro hole machining.

**RESULTS & DISCUSSIONS**

The experimental results, in terms of Material Removal rate, Tool wear were obtained after conducting the micro holes machining on Die sinker EDM by copper electrode with diameter 0.7 mm (700µm) for all nine specimens and the application of three parameters are summarized in Table (). In the latter, the results were analysed by employing main effects, and the signal-to-noise ratio (S/N) analyses. Finally, a confirmation test was carried out to compare the experimental results with the estimated results.

Table 4. Experiments results of micro hole machined surface of SS316

<table>
<thead>
<tr>
<th>Trail of Expt</th>
<th>I</th>
<th>Ton</th>
<th>Toff</th>
<th>MRR mg/min</th>
<th>TWR mg/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>6</td>
<td>4</td>
<td>1.88667</td>
<td>0.021671</td>
</tr>
<tr>
<td>2</td>
<td>0.2</td>
<td>8</td>
<td>6</td>
<td>0.89056</td>
<td>0.022412</td>
</tr>
<tr>
<td>3</td>
<td>0.2</td>
<td>10</td>
<td>8</td>
<td>1.10733</td>
<td>0.016220</td>
</tr>
<tr>
<td>4</td>
<td>0.4</td>
<td>6</td>
<td>6</td>
<td>1.32352</td>
<td>0.007733</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>8</td>
<td>8</td>
<td>1.00440</td>
<td>0.016925</td>
</tr>
<tr>
<td>6</td>
<td>0.4</td>
<td>10</td>
<td>4</td>
<td>0.99254</td>
<td>0.009761</td>
</tr>
<tr>
<td>7</td>
<td>0.8</td>
<td>6</td>
<td>8</td>
<td>4.01551</td>
<td>0.012495</td>
</tr>
<tr>
<td>8</td>
<td>0.8</td>
<td>8</td>
<td>4</td>
<td>0.48211</td>
<td>0.018447</td>
</tr>
<tr>
<td>9</td>
<td>0.8</td>
<td>10</td>
<td>6</td>
<td>2.72357</td>
<td>0.013816</td>
</tr>
</tbody>
</table>

• **Effects of MRR**

![Main effects plot for SN ratios](image-url)
From the fig.2 show the combination of microhole machining parameters ie A3B1C3
(A3-current 0.8, B1-T.ON 6, C3-T.OFF 8)

Table 5. for Signal to Noise Ratios for MRR

<table>
<thead>
<tr>
<th>Level</th>
<th>Current</th>
<th>Ton</th>
<th>Toff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7976</td>
<td>6.6745</td>
<td>0.2961</td>
</tr>
<tr>
<td>2</td>
<td>0.8026</td>
<td>2.4352</td>
<td>3.3769</td>
</tr>
<tr>
<td>3</td>
<td>4.8135</td>
<td>3.1744</td>
<td>4.3328</td>
</tr>
<tr>
<td>Delta</td>
<td>4.0109</td>
<td>9.1096</td>
<td>4.6289</td>
</tr>
<tr>
<td>Rank</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

From table 5 shows the Signal to noise ratio of material removal rate of micro hole machining and it is The characteristics of S/N ratio for the experimental results were taken as Larger the better and smaller the better and expressed as

- $S/N = -10 \log (\Sigma (1/Y^2)/n)$
- $S/N = -10 \log (\Sigma (Y^2)/n))$

- Effects of TWR

Fig.3. Main effects of S/N ratio for TWR

From the fig.3 show the combination of microhole machining parameters ie A2B1C2
(A2-current 0.4, B1-T.ON 6, C2-T.OFF 6)
Table 8: ANOVA of TWR

<table>
<thead>
<tr>
<th>Source</th>
<th>D</th>
<th>F</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F - Value</th>
<th>% Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>2</td>
<td>0.0001 13</td>
<td>0.0000 57</td>
<td>6.16</td>
<td>56.219</td>
<td></td>
</tr>
<tr>
<td>T-ON</td>
<td>2</td>
<td>0.0000 64</td>
<td>0.0000 32</td>
<td>3.51</td>
<td>31.841</td>
<td></td>
</tr>
<tr>
<td>T-OFF</td>
<td>2</td>
<td>0.0000 06</td>
<td>0.0000 03</td>
<td>0.34</td>
<td>2.985</td>
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<tr>
<td>Error</td>
<td>2</td>
<td>0.0000 18</td>
<td>0.0000 09</td>
<td>8.955</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>0.0002 01</td>
<td></td>
<td>100.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

From the Experimental analysis of micro hole machining of ss-316 with dia. 0.7mm (700µm) the following results are made:

- For Material removal rate the optimum combination is A3B1C3 (Current 0.8, T.ON 6, T.OFF 8)
- For Tool wear rate the optimum combination is A2B1C2 (Current 0.4, T.ON 6, T.OFF 6)
- Percentage contribution for MRR is 39.27% where T-ON and for TWR 56.21%

Reference


