Characterization of Wire Electric Discharge Machining of AISI 1040 Steel

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Abstract

Wire electrical discharge machining (WEDM) is an important non-traditional machining process, widely used in aerospace, nuclear, electronics, medical and automotive industries. AISI 1040 material used in automotive for manufacture of forged arm rod. In this work WEDM process is used to machine AISI 1040 steel. Pulse on time, pulse off time, wire feed and current were taken as input parameter. The effect of these input parameters on material removal rate (MRR), machining speed and machining time is analyzed. MRR increases with increase in pulse on time, wire feed and current whereas MRR decreases with increase in pulse off time.

Keywords: WEDM, AISI 1040 Steel

I. INTRODUCTION

Wire electro discharge machining has been defined as the process of material removal of electrically conductive materials using the thermo electric source of energy. The material removal is by controlled erosion through a series of repetitive spark between electrodes (Kuriakose et al, 2005). The material removal rate in EDM decreases with discharge interval is too long (Kunieda et al). Liao et al (1997) were determined various process parameters are affecting the machining performance on metal removal rate using wire EDM. Amandeep singh et al (2015) were investigated the effect of deep cryogenic treatment on tool wear rate and material removal rate at different current level setting with EN-31 as work piece material and Copper, Brass and Graphite as electrodes with and without deep cryogenic treatment. Houriyeh marashi et al (2015) were investigated a negligible amount of Ti deposited over AISI steel surface will not change the property of steel intermittent pulse time and peak current shows better MRR. Sreenivasa rao et al (2014) were investigated the effect of WEDM process parameters such as pulse on time, pulse off time, peak current and servo voltage in machining of Nimonic-263 alloy. Gangaram mandaloi et al (2016) investigated for finding the material removal rate of tool steel material depends upon three variable input process parameters. I. P. Rajurkar et al (1993) investigated the influence of machine parameters on the machining performances such as material removal rate (MRR) and surface roughness. A thermal model for the WEDM process has been developed and a large number of experiments has been carried out to determine the effect of thermal load on the wire rupture frequency.

From literature it is observed, researchers have analyzed the effect of WEDM process parameters on machining of difficult to machine materials. Not much work is been carried out in machining of AISI 1040 steel during WEDM process. In this work the effect of pulse on time, pulse off time, wire feed and current on MRR of AISI 1040 steel is analyzed. The details of the work are presented in the following sections.

II. EXPERIMENTAL SET UP

Experiments were conducted on ELECTRONICA Maxi cut Wire EDM machine with 5 controllable axes. Zinc coated brass wire of 0.25 mm diameter is used as electrode material. The experimental setup used for conducting experiment is given in Figure 1. Among the various WEDM process parameters pulse on time, pulse off time, wire feed and gap current were taken as the input parameters. The effect of these input parameters on MRR, machining speed and machining time which are taken as output parameters were analyzed. The input parameters are varied at three levels viz. pulse on time 5, 7.9 µs; pulse off time 6, 4.2 µs; wire feed 3, 4.5 m/min and gap current 1, 1.5, 2 A. The machine setting parameters is given in Table 1. The parameters such as wire tension, gap voltage and machining length were maintained constant at 6 kg, 7 V, 63 mm respectively. The dielectric flushing pressure is maintained constant by keeping the valve fully opened. Three specimen of AISI 1040 steel of dimension 10 x 12 x 63 mm each is used for conduct of experiment. The effect of these input parameters on MRR, machining speed and machining time is analyzed and presented in in this paper.
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III. RESULT AND DISCUSSION

Machining of AISI 1040 steel is carried out by varying the WEDM process parameters such as pulse on time, pulse off time, wire feed and gap current at three levels is given in Table 1. The effect of these input parameters on MRR, machining speed and machining time is discussed below.

A. Influence of Process Parameter on Material Removal Rate

It is observed from Table 1, MRR shows an increasing trend by increasing the pulse on time from 5 to 9 µs, wire feed from 3 to 5 m/min, gap current from 1 to 2 A and decreasing the pulse off time from 6 to 2 µs. As the pulse on time increases, the amount of energy dissipated in machining zone increases that removes more amount of material from the workpiece. As the wire feed increases, more number of spark occur in the machining zone. Increase in number of spark for a given time, removes more amount of material from workpiece that resulted in increased MRR. Increasing the current magnitude from 1 to 2A, the amount of energy dissipated per spark increases that lead to increased MRR. Decreasing the pulse off time from 6 to 2 µs, the amount of energy available per spark increases that resulted in increased MRR as shown in Figure 2. The effect of process parameters on machining speed and machining time is given in Figure 3.

![Fig. 1: Experimental setup used for conducting experiments](image)

![Fig. 2: Effect of process parameters on MRR](image)

Table - 1

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Pulse on time (µs)</th>
<th>Pulse off time (µs)</th>
<th>Wire feed (m/min)</th>
<th>Gap current (A)</th>
<th>MRR (mm³/min)</th>
<th>MS (mm/min)</th>
<th>MT (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>1.0</td>
<td>13.63</td>
<td>1.5</td>
<td>42.09</td>
</tr>
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<td>2</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>1.5</td>
<td>18.20</td>
<td>1.7</td>
<td>37.33</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>2</td>
<td>5</td>
<td>2.0</td>
<td>22.75</td>
<td>2.0</td>
<td>31.40</td>
</tr>
</tbody>
</table>

MS – Machining speed, MT – Machining time
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**IV. CONCLUSIONS**

In this work wire electrical discharge machining of AISI 1040 steel is carried out. The input process parameters such as pulse on time, pulse off time, wire feed and gap current on material removal rate, machining speed and machining time is analyzed. It is observed, MRR increases with increase in pulse on time, wire feed, gap current and by reducing pulse off time. Increasing the pulse on time and reducing the pulse off time, the amount of discharge energy available in the gap increases that resulted in increased MRR. As the wire feed increases, the increased spark frequency in the gap resulted in increased MRR. Increasing the current magnitudes, the energy discharged per spark increases that lead to increased MRR.

**REFERENCES**


