Review on Process Parameter of EDM & micro EDM
Nikhil Jain1, Bhuvnesh Bhardwaj2 Akhil Vijay3, Gourav Jain4
1Jaipur Engineering College and Research Centre, Jaipur, 2Jaipur Engineering College and Research Centre, Jaipur, 3Jaipur Engineering College and Research Centre, 4Jaipur Engineering College and Research Centre

Abstract: Electric discharge machining is a non-conventional machining method and it is widely used in aerospace, automobile and pharmaceutical industries. In present research work a detailed review is given on different process parameter utilized in micro-EDM and their utility in different research application.

INTRODUCTION

Production of difficult material and hard material by traditional method is difficult by traditional method especially where miniaturization is required hence there is requirement of non-conventional method for the machining these type of material.

One such method is EDM & micro EDM. Electro Discharge Machining (EDM) is an electro-thermal non-traditional no physical cutting forces between the tool and the workpiece where material is removed using thermal energy by generating a spark between two opposite polarity to erode the work-piece. (Bhardwaj et al(2013a).

The material is removed by a a series of rapidly recurring spark discharges between the two electrodes under the presences of dielectric fluid which results in high temperature of order of 8,000 °C to 12,000 °C. With the advancement in material science which have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties, Edm has proved to be very effective process to machine metals irrespective of their hardness and different mechanical properties. Change in thermal properties has very little effect on the process. (Leera Raju et al(2016) μ-EDM capability to machine microstructures of varying complexity levels on difficult to cut metals and alloys. the term micro-machining defines the processes that machine dimensions in the range of 1 μm to 999 μm (Kanlayasiri et al 2007). μ- EDM has gained importance because of its ability to produce stress free micro sized cavities of desires shapes on conducting and semi conducting materials.

Even the principle of EDM and μ- EDM are same but there are differences due to scaling effect Table 1 shows the major differences between the conventional EDM and μ-EDM.(Leera Raju et al 2016).
Major differences between conventional EDM and μ-EDM

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional EDM</th>
<th>μ-EDM</th>
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<tbody>
<tr>
<td>Size of tool</td>
<td>Greater than 999 μm</td>
<td>Lesser than 999 μm</td>
</tr>
<tr>
<td>Inter-electrode gap</td>
<td>10 to 500 μm</td>
<td>Less than 3 μm</td>
</tr>
<tr>
<td>Open Circuit voltage</td>
<td>4-400 V</td>
<td>10-120 V</td>
</tr>
<tr>
<td>Peak Current</td>
<td>Greater than 3A</td>
<td>Less than 3A</td>
</tr>
<tr>
<td>Pulse-on time</td>
<td>0.5 to 8μs</td>
<td>50 μs to 100 μs</td>
</tr>
<tr>
<td>Specific Energy</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Basic principle
The basic principal followed is the conversion of electrical energy into thermal energy through a series of recurring spark discharges between the two electrodes (Tsai et al). During this process two electrode are kept at a certain distance and ignition voltage of 200V is given and breakdown of dielectric medium occurs which results in electric spark and increases the temperature, the increased temperature creates thermal erosion and hence material is removed.

Components of EDM
1. Work-piece-almost all the conductive material can be worked by EDM.
2. Tool Electrode-depended on shape of cavity.
3. Dielectric fluid- Electrode & wokpiece submersed into the dielectric fluid.
4. Servo system-The servo system is commanded by signals from gap voltage sensor system in the power supply and control the feed of electrode & work-piece to precisely match the rate of material removal.
5. Power supply-The power supply is an important part of any EDM system. It transform the alternating current from the main utility supply into the pulse direct current (DC) required to produce the spark discharge at the machining gap.
6. DC pulse generator- The DC pulse generator is responsible for supplying pulses at a certain voltage and current for specific amount of time.
The detailed explanations of these components are elaborated below:


4. **Pulse generators**: The commonly used pulse generators in μ-EDM are RC type, transistor-type and transistor-type iso-pulse generators. In RC type of generators, the capacitor stores the energy and this energy is discharged during the machining process. Whereas in transistor type pulse generators, the capacitor is replaced by a transistor which switches the pulses to generate rectangular pulses between 0V and 60 V, supply voltage. RC type generators are preferred to transistor type because of high discharge frequency and low discharge energy (Leera R et al (2016). In most cases, transistor-type generator has been used to supply the discharge energy which is good for conventional EDM (Han F et al (2004). Jahan (Hyun-Seok TAK et al(2009). studied, RC-type circuit could be more suitable for fabricating microstructures in tungsten carbide, where accuracy and surface finish are of prime importance.

5. **Tool feed mechanisms**: For interrupted machining the gap between the tool electrode and the workpiece electrode should be maintained constant. The function of tool feed mechanism is to raise or lower the tool by sensing the voltage fluctuations in the inter electrode gap, so that a constant inter electrode gap is maintained. Servo feed control mechanism is used in most of the setups (Han F et al(2004). Whereas some researchers used different technology based micro actuators to impart the tool movements and these have proved to be more efficient compared to the conventional servo controlled tool feed mechanisms. (Han et al, (2007) proposed a new servo control tool feed mechanism that senses the average gap voltage and uses it as the feedback signal to control the feed, so that the electrode gap is maintained constant. Mahendran S et al. (Mahendran S et al (2011) developed a μ-EDM system with directly mounted APA 400MML Actuator as the tool feed mechanism. (Li et al(2002)) have proposed an inchworm type micro feeding mechanism and direct drive method (Mahendran S et al(2011) based on piezoelectric actuation were also proposed and elaborated.( Leera et al(2014) developed a μ-EDM system with a piezo-actuated tool feed mechanism to maintain a constant gap between the electrodes.

Effect of machining voltage on machining performance To investigate the effect of machining voltage in micro-ECM finishing process on the machining performance, it was set at 8 V, 9 V and 10 V respectively. The initial bottom machining gap between
Table 1
Basic machining condition in micro-EDM.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
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<tbody>
<tr>
<td>Open voltage</td>
<td>250 V</td>
</tr>
<tr>
<td>Servo reference voltage</td>
<td>180 V</td>
</tr>
<tr>
<td>Discharge current</td>
<td>0.21 A</td>
</tr>
<tr>
<td>Discharge duration</td>
<td>5 µs</td>
</tr>
<tr>
<td>Pulse interval time</td>
<td>10 µs</td>
</tr>
<tr>
<td>Capacitance</td>
<td>(1000 pF) 71</td>
</tr>
<tr>
<td>Polarity</td>
<td>Positive</td>
</tr>
<tr>
<td>Diameter of electrode</td>
<td>Ø 0.11 mm</td>
</tr>
<tr>
<td>Rotation of electrode</td>
<td>2000 rpm</td>
</tr>
</tbody>
</table>

The diameter of electrode and workpiece is 10 µm, and the tool feed rate is 10 µm/s. The machining time of micro-EDM is 80 min. The depth of EDM finished square cavity is 0.185 mm. The length and width of cavity after micro-EDM roughing is 0.55 mm and 0.565 mm. And the objective width of the square cavity is 0.5 mm and 0.2 mm in depth. The diameter of the electrode is 0.11 mm. So the micro-EDM single side discharge gap is about 25 µm. (Z. Zeng et al (2012). Fig. 3 shows the SEM photos of micro-EDM.

Conclusion: The detailed review study on different process parameter used in micro-EDM shows its utility in micro-machining applications.

References:


Fig. 3 shows the SEM photos of micro-EDM.


