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EMT 2540: PRACTICAL REPORT I

ELECTRODISCHARGE MACHINING

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1 Introduction

1.1 Electrodischarge Machining

The principle of electrical-discharge machining (EDM) (also called electrodischarge or spark-erosion machining) is based on the erosion of metals by spark discharges [1]. When two current-conducting wires are allowed to touch each other, an arc is produced. A closer look at where the two wires meet, we can see that a small amount of the metal has been worn away, forming a tiny crater.

Despite the fact that this phenomenon has been well known since the invention of electricity, a machining method based on that idea wasn't established until the 1940s. The EDM process has become one of the most important and widely used production technologies in manufacturing[2]. EDM is used in applications that require a high degree of accuracy[2].

1.2 Objectives

1. To create a program to manufacture a part using Electro-discharge Machining.

2. To create and examine a part made from the Electro-discharge Machining process.

2 Literature Review

2.1 Non-traditional Machining

Non-traditional machining refers to a group of subtractive machining processes that remove the unwanted material from a workpiece using a number of techniques involving mechanical, thermal, electrical or chemical energy, or a combination of the aforementioned energies, but do not use a sharp cutting tool to remove material by plastic deformation or shearing[1].

2.2 Electro-discharge Machining

Electrodischarge Machining (EDM) is a non-traditional machining process where the removal of material is based on the electrodischarge erosion (EDE) effect of electric sparks occurring between two electrodes that are separated by a dielectric fluid. Metal removal occurs as a result of generation of extremely high heat generated by the high-energy sparks which melt and evaporate the two electrodes.

2.2.1 The EDM Machining System

The main components of the EDM system are shown in Fig. 2.1. These components include:

1. The tool feed servo-controlled unit - This maintains a constant machining gap between the two electrodes, in order to ensure the occurrence of active discharges between them.

2. Power supply - responsible for supplying pulses at a certain voltage, current and duty cycle.

3. Dielectric circulation unit - flushes the dielectric fluid to the inter-electrode gap after the machining debris has been filtered out. The dielectric fluid carries out a number of functions which are:

    - Acts as a flushing medium and carries away the debris in the machining gap.
    - Provides insulation between the electrode and the workpiece until the potential is sufficiently high.
    - Cools down the sections heated by the electrodischarge effect.

4. Tool holder - holds the tool/wire being used to machine the workpiece.

5. Filter - removes the machining debris from the dielectric fluid as it is being circulated in the system.

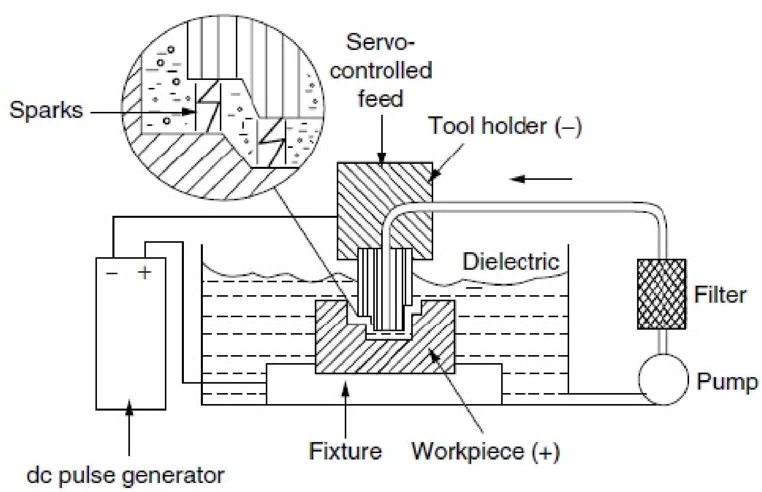


Figure 2.1: EDM Machining System Schematic[1]

2.2.2 Wire EDM

This is a special form of EDM, which uses a continuous wire which is constantly moving, called a wire electrode. It is used in the machining of superhard materials such as polycrystalline diamond(PCD) and Cubic Boron Nitride(CBN), and other matrix composites such as Tungsten carbide.

2.2.3 EDM Process Parameters

The EDM process can be used on any material that is an electrical conductor. The melting point and the latent heat of melting are important physical properties that determine the volume of metal removed per discharge. The performace of EDM is determined by a number of properties[2]:

1. Material Removal Rate (MRR)
2. Surface Quality
3. Accuracy

These are determined by the process parameters such as:

- Pulse characteristics
- Workpiece thermal properties - melting and boiling points, conductivity
- Dielectric properties
- Tool electrode - material, movement, wear

2.2.4 Applications

EDM has now become a vital process in modern manufacturing. It can manufacture intricate shapes with great precision from hard-to-machine materials like carbides, superalloys, and heat-resistant alloys. EDM can be incorporated within a computer-integrated manufacturing system to greatly cut down on the time a unit can operate without stopping for maintenance. Typically, EDM can be employed in:

1. Micro-EDM: Micromachining of holes, slots and dies.
2. EDM drilling - creation of cooling channels in turbines made of hard alloys.
3. Electrodischarge sawing where billets and bars are created.
4. Machining spheres, dies and molds.
5. EDM of ceramics used in insulation.
6. Texturing - texturing is applied to the steel sheets during the final stages of cold rolling.

2.3 Other Non-Traditional Machining Processes

1. Ultrasonic Machining - removal of hard and brittle materials using an axially oscillating tool at ultrasonic frequencies, with an abrasive slurry fed continuously into the machining zone between a soft tool and the workpiece.
2. Abrasive Jet Machining - using a focused stream of abrasive grains such as Al_2O_3 or SiC, carried by a high-pressure gas or air at a high velocity to impinge on the surface of a workpiece via a nozzle.
3. Chemical Machining - controlled chemical dissolution by contact with reagents or etchants, such as acids and alkaline solutions. Special coatings called maskants protect areas from which the material is not to be removed.
4. Electrochemical Machining - workpiece atoms are removed by Electrochemical Dissolution (ECD) in accordance with Faraday's principles. Particles from the anodic material (workpiece), to the cathodic material (machining tool). It can be considered to be the opposite of electroplating.
5. Laser-beam Machining - the source of energy is a laser (an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation), which focuses optical energy

on the surface of the workpiece. The highly focused, high-density energy source melts and evaporates portions of the workpiece in a controlled manner.

6. Abrasive Water Jet Machining - Water carried through a nozzle at high speed is used as the abrasive. A fine, high-pressure, high-velocity stream of water is directed at the work surface to cause cutting of the work.

7. Ice-Jet Machining - machining method that utilizes ice particles made from water instead of a mineral abrasive.

2.4 Design Considerations for EDM

Some general design guidelines for EDM are as follows:

1. Parts should be designed so that the required electrodes can be shaped properly and economically

2. Deep slots and narrow openings should be avoided

3. For economic production, the surface finish specified should not be too fine

4. In order to achieve a high production rate, the bulk of material removal should be done by conventional processes (roughing out).

3 Methodology

The equipment needed and procedures undertaken to carry out Electrodischarge Machining are described in the following sections. The experiment was done at ENW-04 (Machine Shop) at the JKUAT Workshops.

3.1 Equipment

1. EDM Machine (Joemars AWT 6S Wire Erosion Machine)
2. Workpiece design as specified by the manual
3. EDM Machine controller
4. Workpiece - 1mm mild steel sheet

3.2 Procedure

Prior to beginning the machining operation, the machine is checked for any defects such as a broken wire electrode. The dielectric tank is also drained to allow access to the work table for placement and orientation of the workpiece.

The shape to be created was analysed and the dimensions obtained. A toolpath was created using G codes to control the EDM Machine. The codes were programmed into the EDM Machine.

Once the program was loaded in the machine, the wire electrode was carefully placed at a small distance from the edge of the workpiece. The pump was then turned on and the dielectric fluid, in this case water, was used to fill the dielectric tank. Once the water level reached the trigger floaters, the machine was ready to begin the machining process, thus was turned on and the machining process done.

Once the machining process was completed, the tank was once again drained and the workpiece retrieved for examination.

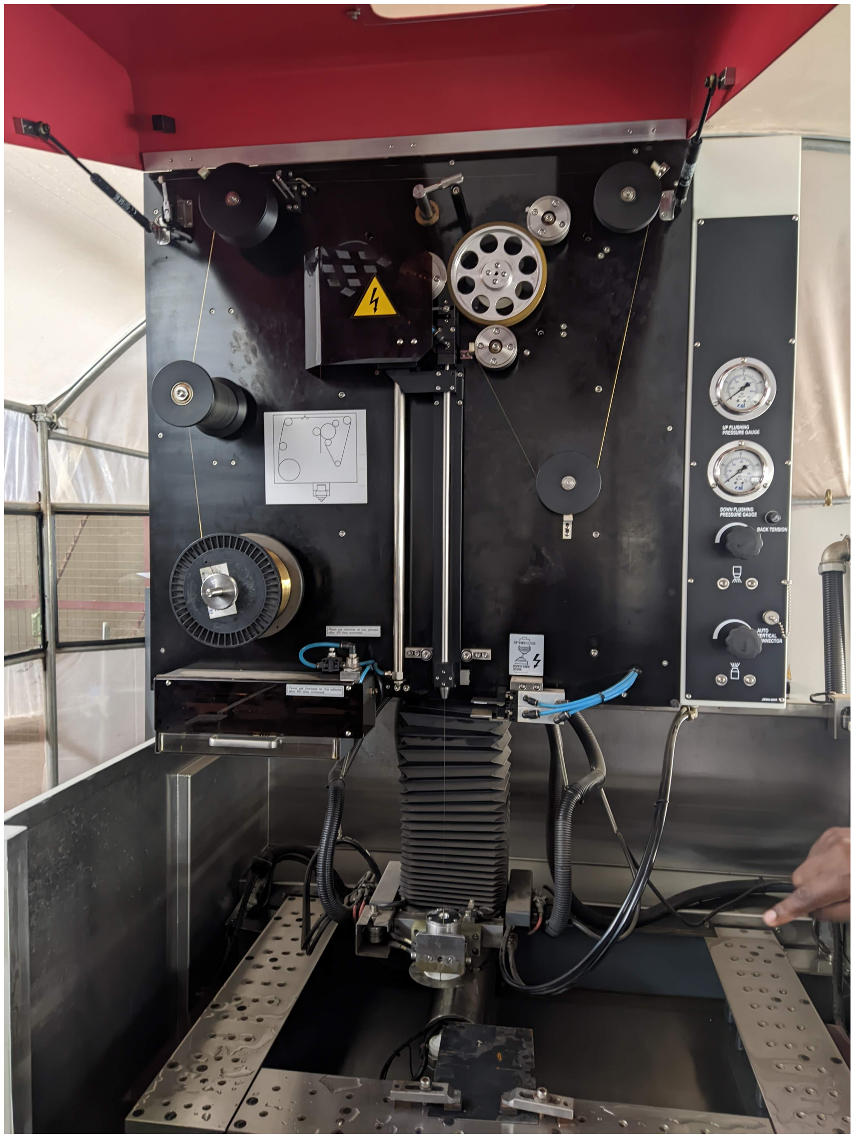


Figure 3.1: Electrodischarge Machine

3.3 EDM Machining Program

The program used to machine the workpiece was handwritten and then transferred to the EDM Machine Controller. The program is as follows:

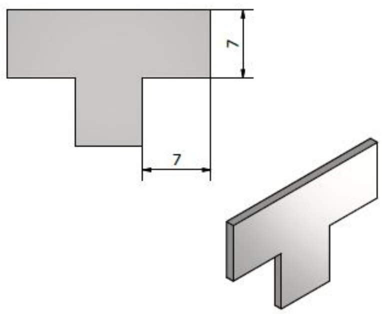
```
G21

G92 X0.0 Y0.0

S1D1
```

Figure 3.2: Electrodischarge Machining Process Underway

```
G01 X7.0 Y0.0
G01 X0.0 Y-7.0
G01 X-7.0 Y0.0
G00 X0.0 Y0.0
M02
```

4 Results

The final part was as shown in Fig. 2.1



(a) Detailed CAD View

(b) Final Part

Figure 4.1: Part cut using Wire EDM

5 Discussion

5.1 EDM Machining

The machining operation was successfully carried out and the workpiece retrieved, a T-shaped part cut out of 1mm mild steel sheet. The cut edge is sharp and clean without any burrs. The corners are also quite sharp, without a radius, as is the case with traditional machine tools which have a radius at the nose.

References

[1] M. Andanje, “EMT 2540: Advanced Production Technology,” *JKUAT Mechatronic Engineering*, vol. 1, no. 3, pp. 40–53, 2022.

[2] H. Youssef and H. El-Hofy, *Non-Traditional and Advanced Machining Technologies*. CRC Press, 2020.

6 Appendices

.1 G- and M-codes

Table .1: G-codes

G-code	Definition
G00	Rapid Transverse
G01	Linear Interpolation
G02	Circular Interpolation, CW
G03	Circular Interpolation, CCW
G21	Input in mm
G28	Return to reference point
G40	Cutter diameter compensation cancel
G42	Cutter compensation, right
G49	Tool length compensation cancel
G80	Canned Cycle cancel
G81	Basic Drilling Cycle
G90	Absolute Programming Mode

Table .2: M-codes

G-code	Definition
M00	Program Stop
M02	End of Program
M03	Spindle ON, CW
M05	Spindle OFF
M05	Automatic Tool Change
M07	Flood Coolant ON
M09	Coolant OFF
M30	Program Reset and Rewind