Electrical Discharge Machining (EDM)

MAE 250L
Electrical Discharge Machining

• EDM is a method for producing holes and slots, or other shapes. It is also called spark erosion.
• EDM, is especially well-suited for cutting intricate contours or delicate cavities that would be difficult to produce with a grinder, an end mill or other cutting tools.
• EDM removes metal by producing a rapid series of repetitive electrical discharges.
EDM Generalities

• Electrical discharge machining is a machining method primarily used for hard metals or those that would be very difficult to machine with traditional techniques.

• EDM typically works with materials that are electrically conductive, although methods have also been proposed for using EDM to machine insulating ceramics.

• EDM can cut intricate contours or cavities in pre-hardened steel without the need for heat treatment to soften and re-harden them. This method can be used with any other metal or metal alloy such as titanium, hastelloy, kovar, and inconel.
Electrode Discharge Machining (EDM)

- Direct Competitor of ECM – much more common than ECM
- The tool acts as a cathode (typically graphite) is immersed in a Dielectric fluid with conductive workpiece
- DC voltage (~300V) is applied. As voltage builds up over gap between workpiece and tool, eventually you get dielectric breakdown (sparking at around 12,000 deg F)
- The sparking erodes the workpiece in the shape of the tool
- The tool is progressively lowered by CNC as the workpiece erodes
- Cycle is repeated at 200,000-500,000 Hz
- Dielectric:
  - Cools tool and workpiece
  - Flushes out debris from work area
Die Sinker vs. Wire EDM

- **Die Sinker EDM**
  - The die sinks into the part as it sparks away the workpiece
  - Most common Injection molding die process

- **Wire EDM**
  - The electrode is a wire that traverses through the part
  - Common for Extrusion Dies
How EDM works

• EDM removes metal by producing a rapid series of repetitive electrical discharges.

• These electrical discharges are passed between an electrode and the piece of metal being machined. The small amount of material that is removed from the work piece is flushed away with a continuously flowing fluid. The repetitive discharges create a set of successively deeper craters in the work piece until the final shape is produced.
Electrical Discharge Machining (EDM)

Types
1. Sinker EDM
2. Wire EDM
3. Fast hole drilling EDM

Applications
1. Prototype production
2. Coinage die making
3. Small hole drilling
4. Metal disintegration machining
5. Closed loop manufacturing. CNC + CAD/CAM
Die Sinking EDM

• In a typical Die Sinking EDM application, a graphite electrode is machined with traditional tools as a specially-shaped electrode
• Electrode is connected to the power source, attached to a ram, and slowly fed into the workpiece.
• The entire machining operation is usually performed while submerged in a fluid bath. The fluid serves the following three purposes:
  1. flushes material away
  2. serves as a coolant to minimize the heat affected zone of the workpiece
  3. acts as a conductor for the current to pass between the electrode and the workpiece.
Die Sinking (Sinker or “Ram”) EDM

Figure 1. (A) Schematic representation of the phases of an electric discharge in EDM and the definition of duty factor \( \tau \) and (B) the concept of EDM phenomenon.
Die Sinking (Sinker or “Ram”) EDM

Typical Parts

1 Injection Molds

2 Dies

3 Complex shapes
Wire EDM

• In wire EDM a very thin wire serves as the electrode. Special brass wires are typically used; the wire is slowly fed through the material and the electrical discharges actually cut the workpiece.

• Wire EDM is usually performed in a bath of water. The wire itself does not actually touch the metal to be cut; the electrical discharges actually remove small amounts of material and allows the wire to be moved through the workpiece.
Wire EDM

- 1 Wire.
- 2 Electrical discharge erosion (Electric arc).
- 3 Electrical potential.
- 4 Workpiece.
Motion or Wire & Workpiece: Wire EDM
4-axis motion possible
The Wire EDM Process

- Deionized water surrounds the wire electrodes as the power supply generates voltages and amps to produce the spark
- The generated spark precisely melts and vaporizes the material
- During the off cycle, the pressurized dielectric fluid immediately cools the material and flushes out the eroded particles
- New wire is constantly fed
Electrical-Discharge Wire Cutting

Example of a wire EDM machine
Courtesy of Edison Industrial Service Center
4-axis Motion

• With the 4-axis Wire EDM
• Different shapes can be produced on top and bottom of a workpiece
Electrical-Discharge Wire Cutting

Example of cores removed from a part using wire EDM to create the cavity in a high-pressure nozzle

Holes were drilled in the interiors so that the wire could be strung through
Wire EDM Precision & Depth

• To better understand the wire EDM process, visualize the wire EDM machine as a super precision band saw with accuracies capable up to
• +/-0.001” (0.0025mm), and under certain circumstances even closer.
• Machine is capable of cutting up to 15.75 in (400 mm) with independent angles up to 30-degrees
**Wire EDM MRR**

\[ MRR = V_f \cdot h \cdot b \]

MRR: mm\(^3\)/min  
h: workpiece height  
b: slot

\[ b = d_w + 2s \]

d\(_w\): wire diameter  
s: spark gap
Materials

• Materials must be electrically conductive. So, it does not work on materials such as glass or ceramic, or most plastics.

• EDM is primarily used for hard metals or those that would be impossible to machine with traditional techniques. Metals that can be machined with EDM include hastelloy, hardened tool-steel, titanium, carbide, inconel and Kovar
Advantages EDM include machining

- Complex shapes that would otherwise be difficult to produce with conventional cutting tools.
- Extremely hard material to very close tolerances.
- Very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure.
- There is no direct contact between tool and work piece. Therefore, delicate sections and weak materials can be machined without perceivable distortion.
- A good surface finish can be obtained; a very good surface may be obtained by redundant finishing paths.
- Very fine holes can be attained.
- Tapered holes may be produced.
- Pipe or container internal contours and internal corners down to R .001".
Disadvantages of EDM include

- Difficulty finding expert machinists.
- The slow rate of material removal.
- Potential fire hazard associated with use of combustible oil based dielectrics.
- The additional time and cost used for creating electrodes for ram/sinker EDM.
- Reproducing sharp corners on the workpiece is difficult due to electrode wear.
- Specific power consumption is very high.
- Power consumption is high.
- "Overcut" is formed.
- Excessive tool wear occurs during machining.
- Electrically non-conductive materials can be machined only with specific set-up of the process.[29]
End