

Training Objectives

After watching the video and reviewing this printed material, the viewer will gain knowledge and understanding of electrical discharge machining, or EDM, principles and capabilities.

- both the ram and wire-type of EDM are detailed
- the subsystems of both types are explained
- hole drilling EDM's are shown
- computer numerically controlled, or CNC, EDM applications and safety issues are addressed

Electrical Discharge Machining

EDM is the thermal erosion process in which metal is removed by a series of recurring electrical discharges between a cutting tool acting as an electrode and a conductive workpiece, in the presence of a dielectric fluid. This discharge occurs in a voltage gap between the electrode and workpiece. Heat from the discharge vaporizes minute particles of workpiece material, which are then washed from the gap by the continuously flushing dielectric fluid.

There are two main types of EDMs; the ram and the wire-cut. Each are used to produce very small and accurate parts as well as large items like automotive stamping dies and aircraft body components. The largest single use of EDM is in die making. Materials worked with EDM include hardened and heat-treated steels, carbide, polycrystalline diamond, titanium, hot and cold rolled steels, copper, brass, and high temperature alloys. However, any material to be machined with the EDM process must be conductive.

The benefits of EDM include:

- EDM is a non-contact process that generates no cutting forces, permitting the production of small and fragile pieces
- Burr-free edges are produced
- intricate details and superior finishes are possible
- EDM machines with built-in process knowledge allow the production of intricate parts with minimum operator intervention

The limitations of EDM include:

- low metal removal rates compared to chip machining
- lead time is needed to produce specific, consumable electrode shapes

In ram EDM, the electrode/tool is attached to the ram which is connected to one pole, usually the positive pole, of a pulsed power supply. The workpiece is connected to the negative pole. The work is then positioned so that there is a gap between it and the electrode. The gap is then flooded with the dielectric fluid. Once the power supply is turned on, thousands of direct current, or DC, impulses per second cross the gap, beginning the erosion process. The spark temperatures generated can range from 14,000° to 21,000° Fahrenheit. As the erosion continues, the electrode advances into the work while maintaining a constant gap dimension.

The finished EDM'd workpiece can exhibit several distinct layers. The surface layer will have small globules of removed workpiece metal and electrode particles adhering to it, which are easily removed. The second layer is called the "white" or "recast" layer where EDM has altered the metallurgical structure of the workpiece. The third layer is the heat-affected zone or "annealed" layer. This layer has been heated but not melted.

All of these surface conditions are affected by:

- the EDM cycles of on- and off-time
- the duty cycle, which is the ratio of on-time relative to total cycle time
- the gap distance between the workpiece and the electrode

The electrode is fabricated with the reverse or negative image of the finished workpiece cavity. When EDM'd, this workpiece cavity is measurably larger than the electrode. This dimensional difference is called the overcut or kerf. This kerf dimension is critical during the fabrication of the electrode.

Ram EDM machines are also known as diesinkers or vertical EDMs. They range in size from tabletop models to large CNC units. Ram EDMs have four sub-systems:

- a DC power supply to provide the electrical discharges, with controls for voltage, current, duration, duty cycle, frequency, and polarity
- a dielectric system to introduce fluid into the voltage area/discharge zone and flush away work and electrode debris, this fluid is usually a hydrocarbon or silicone based oil
- a consumable electrode, usually of copper or graphite
- a servo system to control infeed of the electrode and provide gap maintenance

CNC ram EDM machines have automatic tool change capability allowing long unattended running times, use of multiple electrodes for rough and fine metal removal, orbiting controls for cavity enlargement, and contouring capability.

The wire EDM process uses a consumable, electrically charged wire to effect very fine and intricate cuts. The process is particularly useful in cutting fine details in pre-hardened stamping and blanking dies. A wire drive system constantly presents fresh wire to the work so electrode wear is not a problem. Typical wire diameters range from .002 to .013 inches. These wires will produce a kerf slightly larger than their own diameter. A .012 wire will leave a .015 kerf, just .003 inches larger. Wire EDM's can run for long periods without operator attention. The four basic wire EDM subsystems include:

- the DC power supply
- the dielectric system
- the wire feeding system
- the work positioning system

The wire system principle of operation is the same as the ram type, using a series of DC discharges between the wire and workpiece.

As with ram EDMs, flushing with dielectric fluid is critically important. In some cases, both wire and work are completely submerged. However, this may cause electrolytic corrosion on some workpiece materials. Since the wire electrode is

very thin, power used is limited and removal rates are slow. The actual removal rate is calculated in square inches per hour.

A two-axis wire EDM can only make cuts at right-angles to the work table, while a CNC positioning system with a two-axis table can perform a wide variety of angled cuts. Independent four-axis machines can cut tapered angles and make cuts that result in different top and bottom profiles. This capability is needed in making extrusion dies and flow valves. The wire never touches the work during cuts. The wire-control servo system is able to maintain a wire-to-work distance of approximately .001 inch. The wire cuts along a programmed path starting at either an edge or in a drilled hole. Parts to be cut can be stacked for production quantities.

A third type of EDM is designed for drilling small, but very deep holes. These holes may have a depth-to-diameter ratio of 30 to 1 or higher. Tubular electrodes up to a foot long are rotated at speeds of about 100 RPM while drilling. As the electrical discharges occur, this rotation aids in flushing and provides for uniform electrode wear.

Some of the hazards in EDM machining include the chance of flash fire in the dielectric fluid if the level falls too low. Smoke can be irritating to the eyes and lungs and but can be controlled with exhaust and smoke-eating devices. The dielectric fluid can be irritating to the skin as well.

Review Questions

1. In EDM, the cutting tool is actually:
 - a. contacting the work
 - b. an electrode
 - c. non-consumable
 - d. hardened to provide long tool life

2. The EDM workpiece must be:
 - a. small in size
 - b. pre-heated
 - c. conductive
 - d. kept cool

3. The largest single use of EDM is for:
 - a. automotive parts
 - b. aircraft components
 - c. small parts production
 - d. die making

4. The power supply used in EDM is usually:
 - a. pulsed alternating current, or AC power
 - b. pulsed direct current, or DC power
 - c. constant voltage
 - d. governed by the duty cycle

5. EDM electrodes are made of:
 - a. high temperature alloys
 - b. carbon steel
 - c. copper or graphite
 - d. titanium alloys

6. The main disadvantage of wire EDM is:
 - a. slower metal removal rates
 - b. the wire electrode is consumable
 - c. more operator intervention
 - d. long setup times

7. In wire EDM, the wire to work distance is approximately:
 - a. .010 of an inch
 - b. .005 of an inch
 - c. .003 of an inch
 - d. .001 of an inch

8. Holemaking EDMs are able to drill holes with depth-to-diameter ratios of:
 - a. 5 to 1
 - b. 10 to 1
 - c. 20 to 1
 - d. 30 to 1 or higher

Answer Key

1. b
2. c
3. d
4. b
5. c
6. a
7. d
8. d