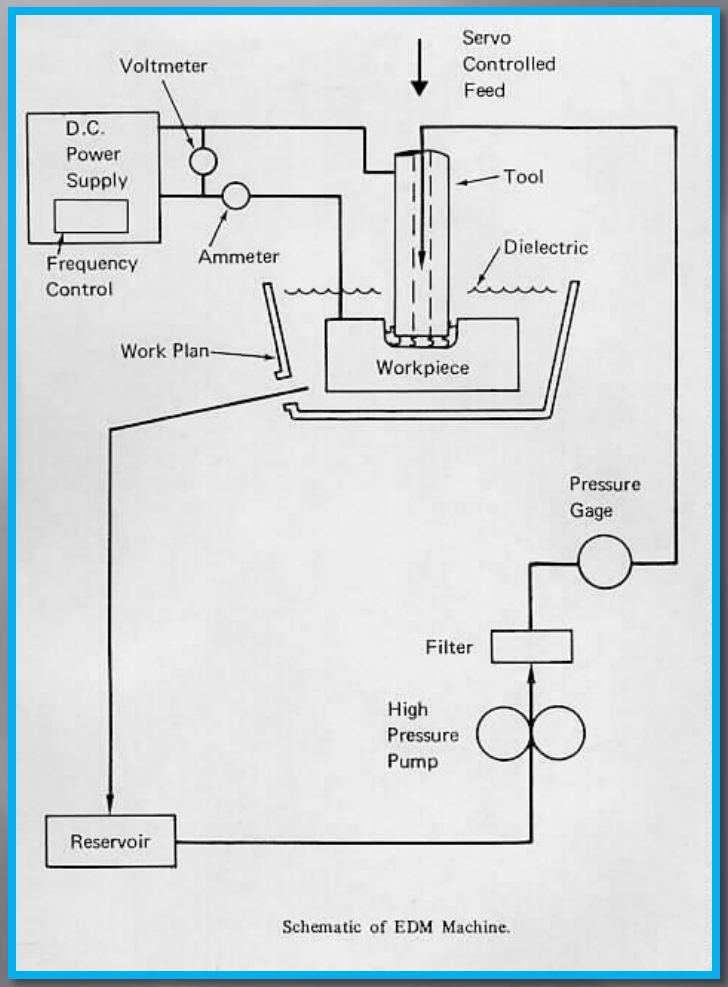
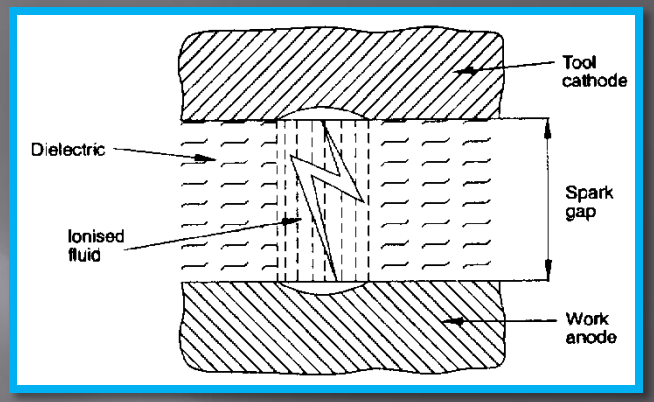
Chapter Ⅲ EDM

ELECTRIC DISCHARGE MACHINING

Principle Of EDM



Schematic of EDM Machine.



Principle Of EDM

- The tool (electrode) usually acts as a cathode and is immersed in a dielectric fluid.
- DC voltage (~300V) is applied in modulated pulses (200-500K Hz).
- The dielectric breaks down (sparking at around 12,000 deg F) when gap is small.
- The sparks erodes the workpiece in the shape of the tool.
- The tool is progressively lowered as the workpiece erodes.
- Material removal rate is typically 300 mm^3/min
- Tool wear ratio 3:1 with metallic electrodes, 3:1-100:1 with graphite electrodes

Principle Of EDM

Arrangement of EDM

- Pulsed power supply (Pulsed generator)
- Electrode (tool, workpiece) shape must match
- Electric discharge (spark)
- Dielectric
- Gap

Principle Of EDM

Physical Principle

1. Charge up an electrode
2. Bring the electrode near a metal workpiece (oppositely charged).
3. As the two conductors get close enough a spark will arc across a dielectric fluid. This spark will "burn" a small hole in the electrode and workpiece.
4. Continue steps 1-3 until a hole the shape of the electrode is formed.

Principle Of EDM

Introduce of EDM

- The removal of metal from the workpiece is obtained by means of energy released by repetitive spark discharges
- Take place between two conductors (tool, workpiece)

Principle Of EDM

Workpiece

- Electrical conductor
- To require to erode cavity or hole
- Connected to power supply

Principle Of EDM

Tool

- An electrically conductive electrode
- Shaped to match the dimensions of the desired cavity or hole
- Connected to the pole of the supply

Typical electrode materials

- copper
- tungsten
- graphite

Principle Of EDM

Dielectric and gap

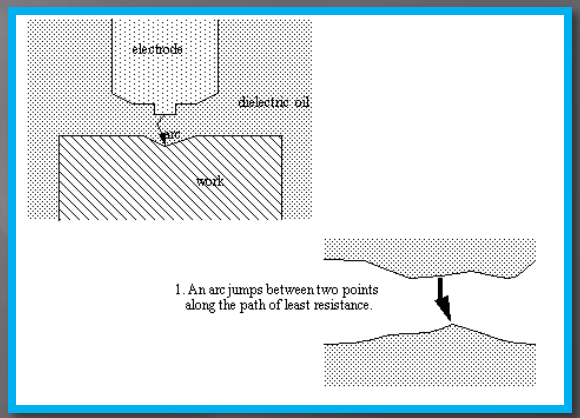
- Dielectric---insulating fluid
- Gap --- workpiece and tool are separated by a small gap flooded by dielectric to provide a controlled electrical resistant

Process Of EDM

Process --- step 1

- An increasing voltage is applied to the electrodes, resulting in an *increasing stress* on the fluid between them until it is ionized, and the gap becomes conductive, allowing current to flow from one electrode to the other in the form of a spark discharge .

Basic process 1

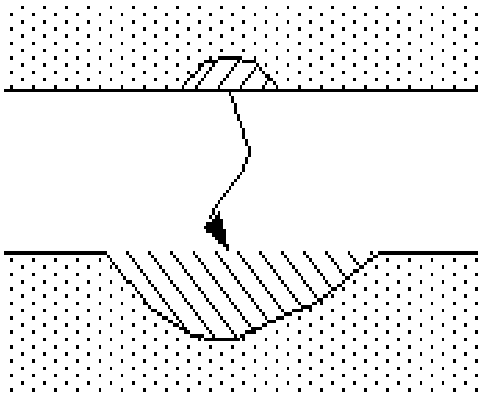


Process Of EDM

Process --- step 2

- The *spark channel* in the first few microseconds has a very *small cross-sectional* area resulting in a correspondingly high current density calculated to be on the order of $I0^4$~$I0^6$ A /cm^2.

Basic process 2



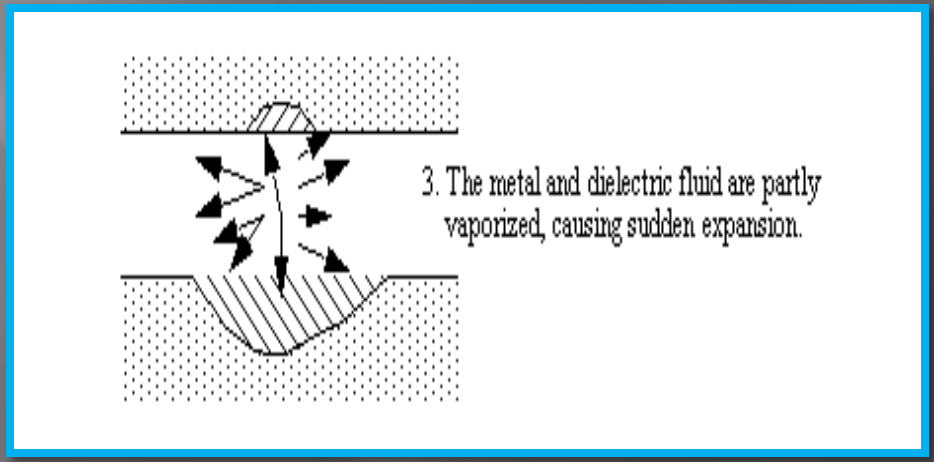
2. The energy of the arc is so concentrated that it causes the electrode, and the work to melt. But the electrode material is chosen so that it melts less.

Process Of EDM

Process --- step 3

- Because of these extreme densities, the temperature in the channel is very high, (5,000-l0,000°C), resulting in the *melting* and *vaporization* of a small amount of material from the surfaces of both the electrode and the workpiece at the points of spark contact, a rapidly expanding bubble is created in the dielectric fluid around the spark channel.

Basic process 3

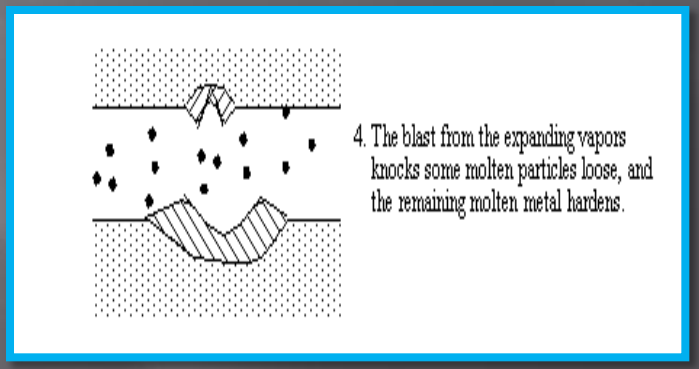


Process Of EDM

Process --- step 4

- When the electrical pulse is terminated, both the *spark channel* and the *vapor bubble* collapse.
- The violent inrush of cool dielectric fluid results in an explosive expulsion of molten metal from both the electrode and workpiece surfaces, resulting in the formation of a small crater in the surfaces of the two conductors, solidifying hollow balls of material, which are removed from the gap by the fluid.

Basic process 4



Process Of EDM

How to minimize the material removal of tool electrode

- Suitable choice of polarity
- Suitable choice of electrode material
- Suitable choice of the operating parameters

Equipment Of EDM

Cathode and anode

- In EDM, therefore, the cathode-electrode is made the workpiece
- The anode becomes the tool
- The erosion of metal from the cathode can be as high as *99.5%*
- The wear of the anode being kept as low as *0.5%*.

Equipment Of EDM

Cathode and anode

Parameters

- Electrode material
- Electrode polarity +/-
- pulse current I_f (A)
- pulse duration t_i (micro s)
- pulse off time t_o (micro s)
- average voltage U (V)
- average current I (A)
- working current density I_d (A/cm^2)
- open gap voltage V_o (V)
- Dielectric
- flushing mode

Equipment Of EDM

These in turn effect

- Metal removal rate V_w (mm^3/min)
- Relative electrode wear θ (% or a fraction)
- Surface finish R (peak to valley micro m)
- Thickness of recast layer
- Gap between electrode and workpiece
- Corner and edge radii

Equipment Of EDM

Fluid

- Fluid is used to act as a dielectric, and to help carry away debris.
- If the fluid is pumped through and out the end of the electrode, particles will push out, and mainly collect at the edges. They will lower the dielectric resistance, resulting in more arcs. As a result the holes will be conical.
- If fluid is vacuum pumped into the electrode tip, straight holes will result.

Equipment Of EDM

Fluid

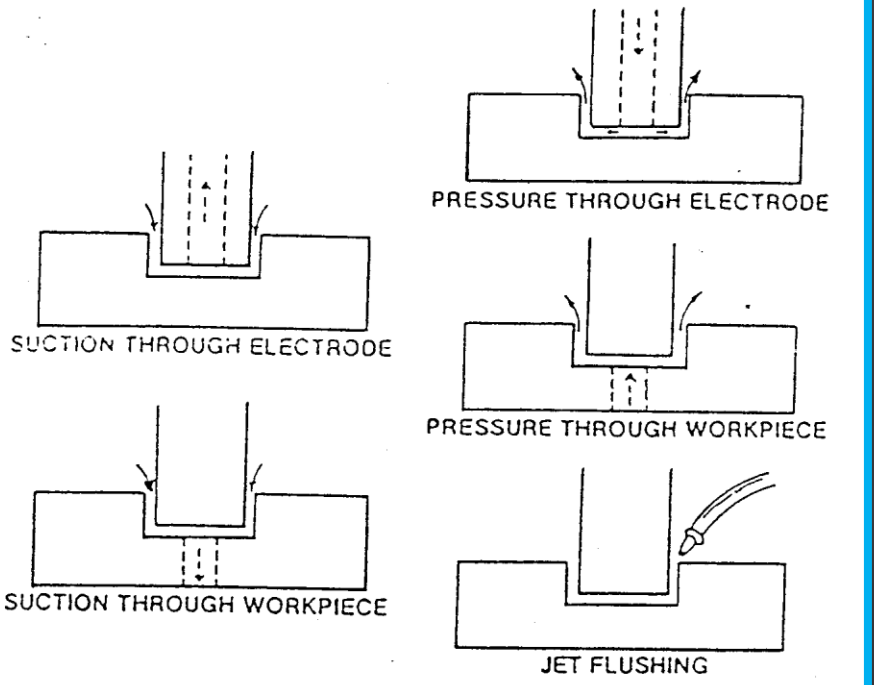


Figure 1.3 The EDM flushing techniques. (Courtesy, Hanstvedt EDM Division. Urbana, Illinois).

successfully used for EDM applications. Common requirements are that elec-

Various flushing techniques used in the EDM process

Equipment Of EDM

Dielectric type and recycle

- Quite often kerosene-based oil.
- Paraffin and light oils, (cheap, low viscosity, and a flash point high enough to make them safe to work
- The fluid must be cleaned, recycled, and returned to the cutting gap by means of pumps and filters.

Equipment Of EDM

Parameters

- The electrode workpiece gap is in the range of 10 micro m to <100 micro m.
- Uses a voltage discharge of 60 to 300 V to give a transient arc lasting from 0.1 micro s to 8 ms.
- Typical cycle time is 20 ms or less, up to millions of cycles may be required for completion of the part.

Equipment Of EDM

Electrode materials

- High temperature, but easy to machine, allowing easy manufacture of complex shapes.
- Low wear rate, be electrically conductive,provide good surface finishes on the workpiece, and be readily available.

Equipment Of EDM

When the energy density is higher (machining faster), the results are:

- Energy density (lower to higher)
- Amount machined (less to more)
- Machining speed (slower to faster)
- Clearance (less to more)
- Surface roughness (fine to rough)

Equipment Of EDM

Power

- Keep in mind the power is given by

$$P=V\ I\ t$$

Typical machine parameters are

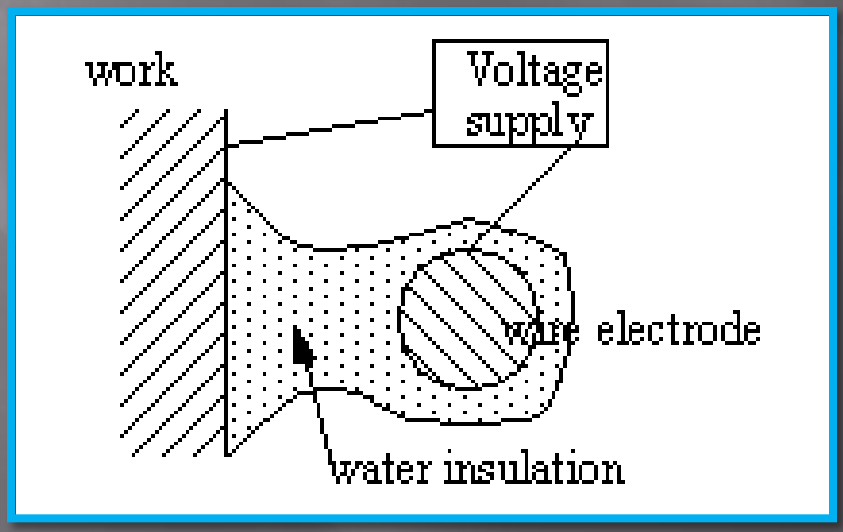
Parameter	Typical Value
Power(KW)	0.5-1.5
In.**3/hr	.18-1.1
Electrode wear(%)	1-10
Surface(micro in.RMS)	12

Wire EDM

Introduction

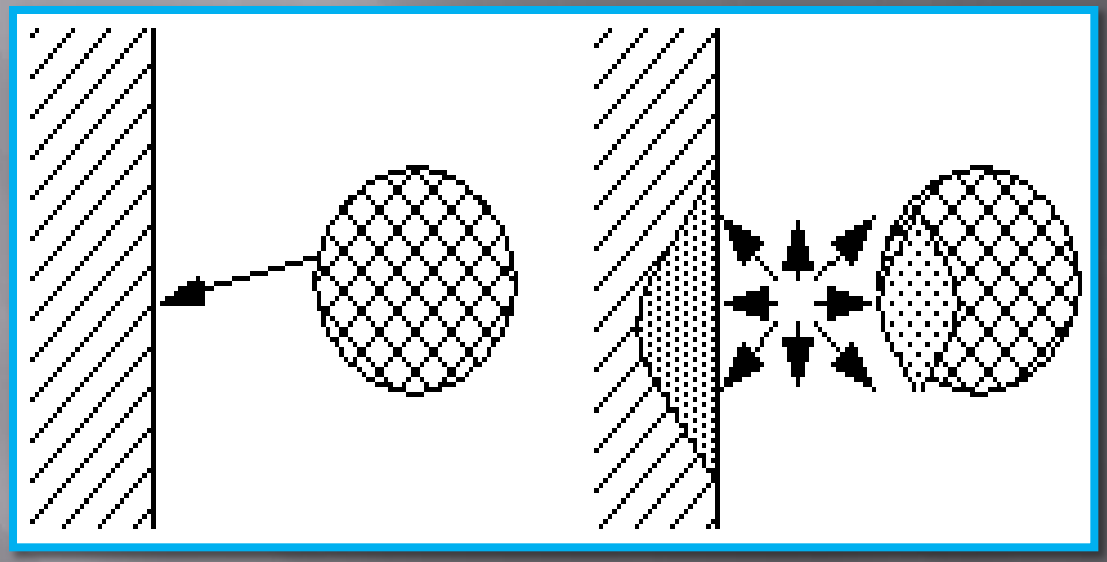
- A thin wire of brass, tungsten, or copper is used as an electrode.
- Deionized water is used as the dielectric.

The process is similar to standard EDM



Wire EDM

Introduction

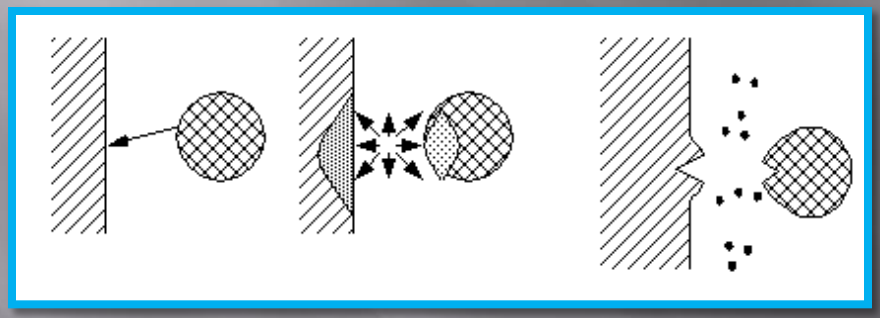


- Slowly cuts groove in shape of wire.
- Wire is consumed and is slowly fed.

Wire EDM

Characteristic of W-EDM

This process is much faster than electrode EDM.



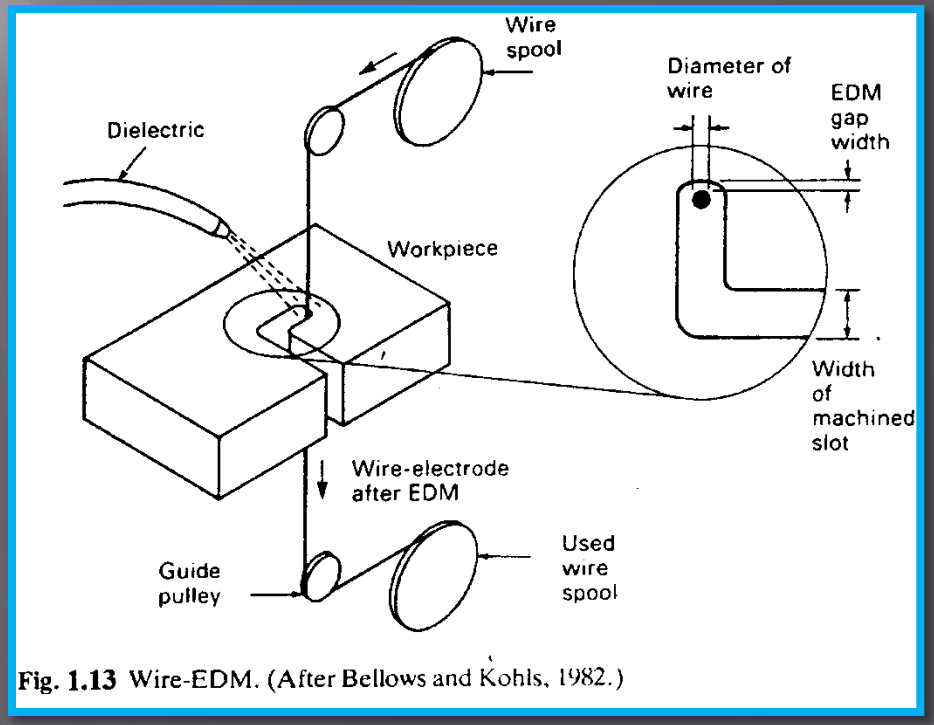
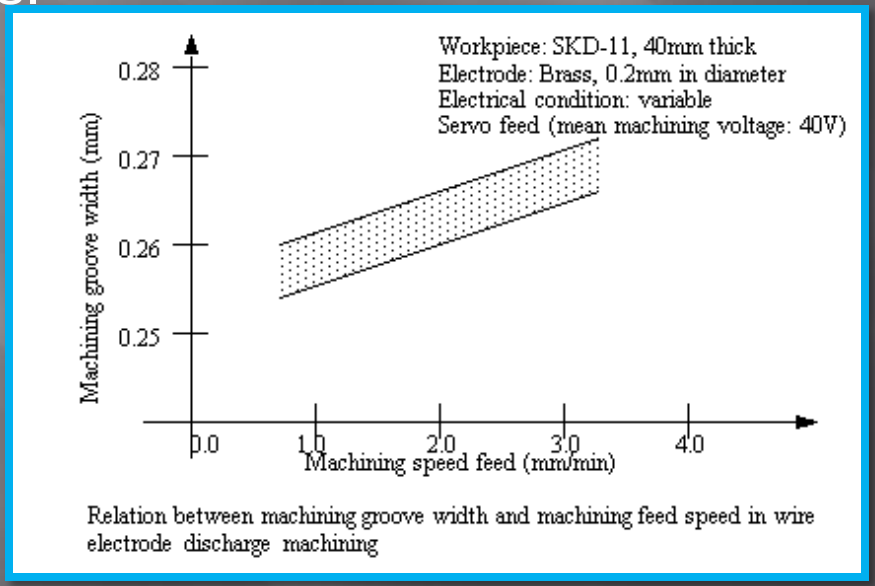


Fig. 1.13 Wire-EDM. (After Bellows and Kohls, 1982.)

Wire EDM

Machine speed

- Machine speed (mm^2/min)
  = machine speed feed (mm/min) * workpiece thickness (mm)
- Higher currents, and lower rest times increase the speed of this process.



Relation between machining groove width and machining feed speed in wire electrode discharge machining

Summary of EDM

- Mechanism of material removal - melting and evaporation aided by cavitation
- Medium - dielectric fluid
- Tool materials - Cu, Brass, Cu-W alloy, Ag-W alloy, graphite
- Material/tool wear = 0.1 to 10
- Gap = 10 to 125 micro m - maximum mrr = $5*10^3$ mm^3/min
- Specific power consumption 1.8 $W/mm^3/min$
- Critical parameters - voltage, capacitance, spark gap, dielectric circulation, melting temperature
- Materials application - all conducting metals and alloys
- Shape application - blind complex cavities, microholes for nozzles, through cutting of non-circular holes, narrow slots

Summary of EDM

Limitations

- High specific energy consumption (about 50 times that in conventional machining);
- When forced circulation of dielectric is not possible, removal rate is quite low;
- Surface tends to be rough for larger removal rates;
- Not applicable to nonconducting materials.

Practice Problems

1. We try an EDM process where the copper tool has a mass of 200g before beginning and 180g after. The iron workpiece drops from 3.125kg to 3.096kg, but has rounded corners.

   a) What is the tool wear factor?

   b) If the tool was cylindrical to begin with, draw sketches of the electrode before and after.

Practice Problems

2. What are the selection criteria for choosing between machining and EDM?

Answer : EDM is particularly useful when dealing with internal

cuts that are hard to get tools into. Machining tends to work best with external cuts. EDM is suitable for removal of smaller amounts of material at a much slower rate.