- Non-conventional Machining Processes

Machining

- The process of precise removing metal to form or finish a part, either with traditional methods like turning, drilling, milling, and grinding, or with non-traditional methods that use electricity, heat, or chemical reaction.

Defination of Nontraditional Processes

- A group of processes that remove excess material by various techniques involving mechanical, thermal, electrical, or chemical energy (or combinations of these energies) but do not use a sharp cutting tool in the conventional sense.
- The word un-conventional machining means that the part/ component can not be machined by conventional machining methods such as turning, milling, grinding etc.
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Why Nontraditional Processes are needed

- In the field of space reserch,missiles and nuclear inductry, newly metals and non-metals with special properties have been developed with unusual machining requirements that make them difficult or impossible to machine by conventional methods
- The part geometry is so that the machining cannot easily be accomplished by conventional machining
- To machine hard and brittle part which can be machined by conventional methods such as glass, ceramics, heat-treated alloys
- To avoid surface damage that often accompanies conventional machining
- Workpiece too slender and flexible, hard to clamp
- Part shape complex, long and small hole
- Special surface and dimensional tolerance requirements

Non-traditional Machining Processes

- Mechanical Energy Processes
- Electrochemical Machining Processes
- Thermal Energy Processes
- Chemical Machining

Classification of Nontraditional Processes by Type of Energy Used

- 1. Mechanical -

  Erosion of work material by a high velocity stream of abrasives or fluid (or both) is the typical form of mechanical action
- 2. Electrical -
- Electrochemical energy to remove material (reverse of electroplating)
- 3. Thermal –
- Thermal energy usually applied to small portion of work surface, causing that portion to be removed by fusion and/or vaporization
- 4. Chemical –
- Chemical etchants selectively remove material from portions of workpart, while other portions are protected by a mask

Non-traditional Machining Process

- Chemical machining(CM)
- Electro-chemical machining (ECM)
- Electrical discharge machining (EDM)
- Wire cut machining (WCM)
- Electro-beam machinig (EBM)
- Plasma arc machining(PAM)
- Laser Beam machining (LBM)
- Water jet machining (WJM)
- Abrasive jet machining (AJM)
- Ultra sonic machining (USM)
- Elecrto chemial grinding (ECG)
- High velocity forming (HVF)
- High energy rate forming (HER)
- Hot Machining (HM)
- Electro hydraulic forming (EHF)
- Magnetic Pulse Forming (MPF)
- Ion Beam Machining (IBM) etc

Non-traditional Machining Processes to be disussed

- Electrochemical Machining
- Electrical Discharge Machining
- Wire EDM

- Electro-chemical Machining Processes

Electro-chemical Machining Processes

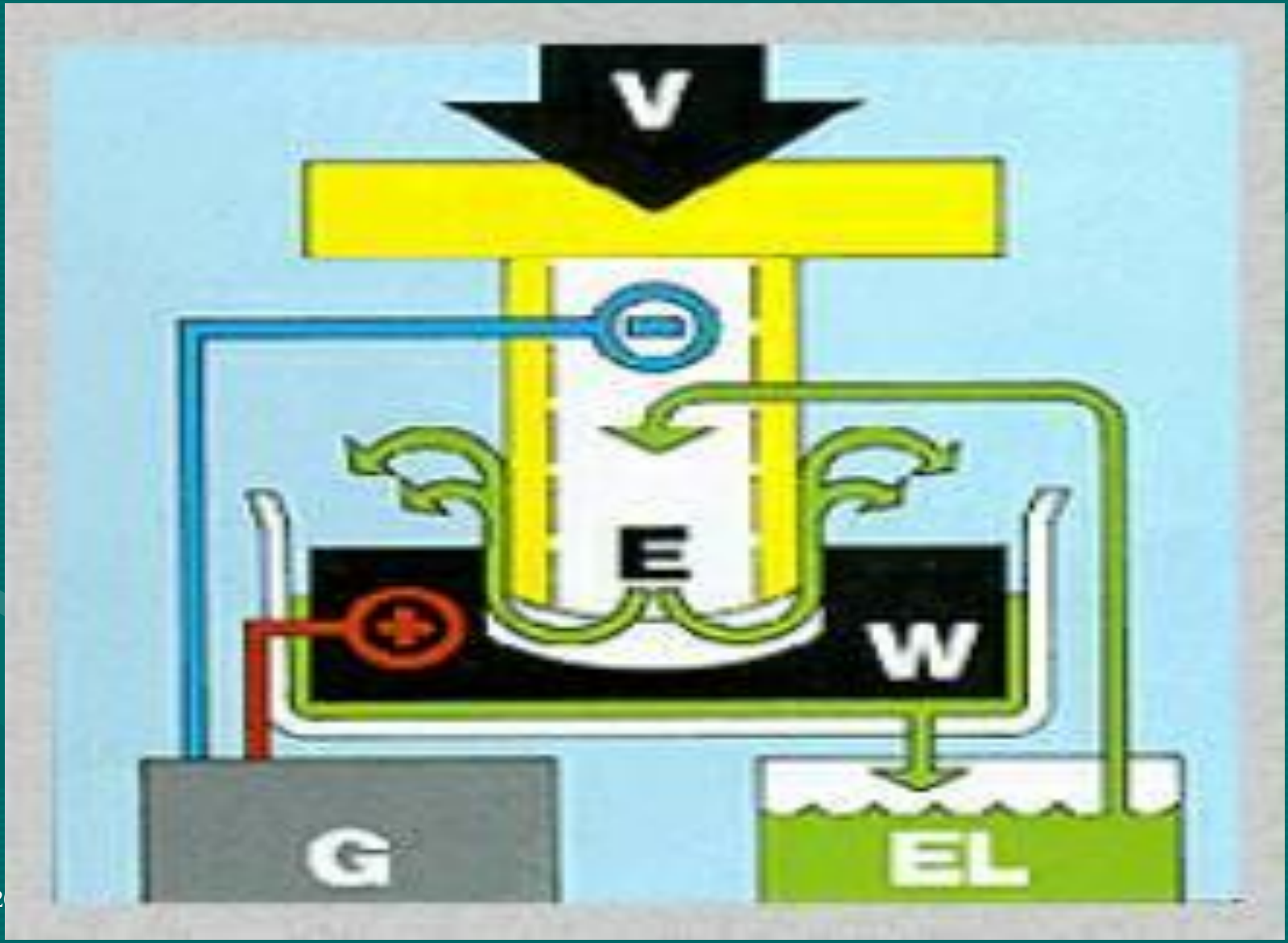
- Uses an electrolyte and electrical current to ionize and remove metal atoms
- Reverse of electroplating
- Work material must be a conductor
- Electrochemical Processes include the following:
  - Electrochemical machining (ECM)
  - Electrochemical deburring (ECD)
  - Electrochemical grinding (ECG)

ECM Operation

- In Electro-chemical machining process the removal of metal takes place by dissolution of metal from the job in an electrolytic medium.
- In this process the workpiece acts as anode and the tool as cathode.
- The two electrodes are placed with agap of about 0.5 mm and immersed in an electrolyte generally a solution of sodium chloride.
- In this process the tool does not come in contact with the work piece thus wear and tear of the tool is negligible.
- When a potential difference (5 to 15 V) is maintained between the electrods, the ions existing in the electrolyte migrate towards them.
- As tool approaches the workpiece it erodes the negative shape of it.
- Positively charged ions are attracted towards the cathods and negatively charged towards the anodes.
- Material is deplated from workpiece (positive pole) and transported to a tool (negative pole) in an electrolyte bath.

- Electrolyte must be injected in the gap at high pressure (15 kg/sq.cm) between the two poles to carry off deplated material, so it does not plate onto tool.
- The gap between the tool and the work piece must be low for higher accuracy, thus the voltage must be low to avoid a short circuit. The metal removal rate is high.
- Electrode materials: Cu, brass, or stainless steel
- No spark is produced in the process.
- Tool has inverse shape of part.
- Tool size and shape must allow for the gap.
- The electrolyte system must include a fairly strong pump.
- System also includes a filter, sludge removal system, and treatment units.

Operating Principle



Main Subsystems

- The power supply.
- The electrolyte circulation system.
- The control system.
- The machine.

Advantages of ECM

- Wear and tear of tool is negligible so it can be used repeatedly with a high degree of accuracy.
- Machining is done at low voltage.
- Close tolerance, upto 0.05mm, can be easily controlled.
- Any metal which is good conductor of electricity can be given any complicated profile by changing the shape of the tool.
- The chemical composition, hardness, structure, strength etc, of the metal remain the same.
- The brittleness of a material has no effect on the machining process.
- No thermal damage take place in the workpiece structure due to low temperature developed at the time of normal machining.
- There is no cutting forces therefore clamping is not required except for controlled motion of the work piece.
- There is no heat affected zone, very accurate, relatively fast and can machine harder metals than the tool.

Dis-advantages of ECM

- Consumption of electrical energy is high.
- Process is comparatively slow.
- Work material should be a good conductor of electricity.
- More expensive than conventional machining.
- Need more area for installation.
- Electrolytes (brine solution) may destroy the equipment.
- Not environmentally friendly (sludge and other waste)

ECM Applications

- ECM process is extensively used for facing and turning three dimensional surfaces.
- It is commonly used on thin walled, easily deformable and brittle material because they would probably develop cracks with conventional machining.
- Die sinking, irregular shapes and contours for forging dies, plastic molds, and other tools
- Multiple hole drilling - many holes can be drilled simultaneously with ECM
- Holes that are not round, since rotating drill is not used in ECM

Economics

- The process is economical when a large number of complex identical products need to be made (at least 50 units)
- Several tools could be connected to a cassette to make many cavities simultaneously. (i.e. cylinder cavities in engines)
- Large cavities are more economical on ECM and can be processed in 1/10 the time of EDM.

Products

- The two most common products of ECM are turbine/compressor blades and rifle barrels. Each of those parts require machining of extremely hard metals with certain mechanical specifications that would be really difficult to perform on conventional machines.
- Some of these mechanical characteristics achieved by ECM are:
  - Stress free grooves.
  - Any groove geometry.
  - Any conductive metal can be machined.
  - Repeatable accuracy of 0.0005”.
  - High surface finish.
  - Fast cycle time.

Safety Considerations

- Several sensors are used to control short circuit, turbulence, passivation, contact and overcurrent sensors. In case of contact, immense heat would be generated melting the tool, evaporating the electrolyte and cause a fire.
- The worker must be insulated to prevent electrocution.
- The tool and the work piece must be grounded before any handling is performed.
- Hydrogen gas emitted is very flammable, so it should be disposed of properly and fire precautions should be taken.
- The waste material (metal sludge) is very dangerous and environmentally unfriendly so it must be recycled or disposed of properly.
- Electrolyte is highly pressurized and worker must check for minor cracks in piping before operating.

Electric Discharge Machining (EDM)

Electric Discharge Processes

- Electrical Discharge Machining (EDM) also known as Spark erosion process is one of the most widely used non-traditional processes
- It removes metal through erosion of metal by use of an electric current.
- A formed tool of reverse shape is used in the process.
- Requires dielectric fluid, which creates a path for each discharge as fluid
- becomes ionized in the gap
- Both the tool and workpiece are immersed in a dielectric fluid, usually kerosene or tranformer oil.
- The tool is made as cathode and the workpiece as anode.
- The voltage is increased gradully till the di-electric fluid becomes ionised and sparks occur across a small gap between tool and work to carry out the metal removal operation.
- The metal is removed by a series of repetitive short-lived electric sparks (10,000 sparks per second) between the tool and the workpiece, causing localized temperatures high enough to melt or vaporize the metal
- The electrical current is varied from 0.5 to 400 A and the voltage between 40 to 300 volts.

- Temperature in the range of 10,000 to 50,000 C is developed in the spark zone.
- Heat transfer results in local melting , vapourisation and ionisationin a thin surface layer on both the tool and the workpiece.
- The tool materials are electrolytic copper,tellurium,copper tungsten, brass tungsten, graphite, copper graphite, tungsten carbide and aluminium.
- Hardness and strength of the work material have no influence
- Material removal rate is related to melting point of work material.
- Can be used only on electrically conducting work materials.

Electric Discharge Machining (EDM)

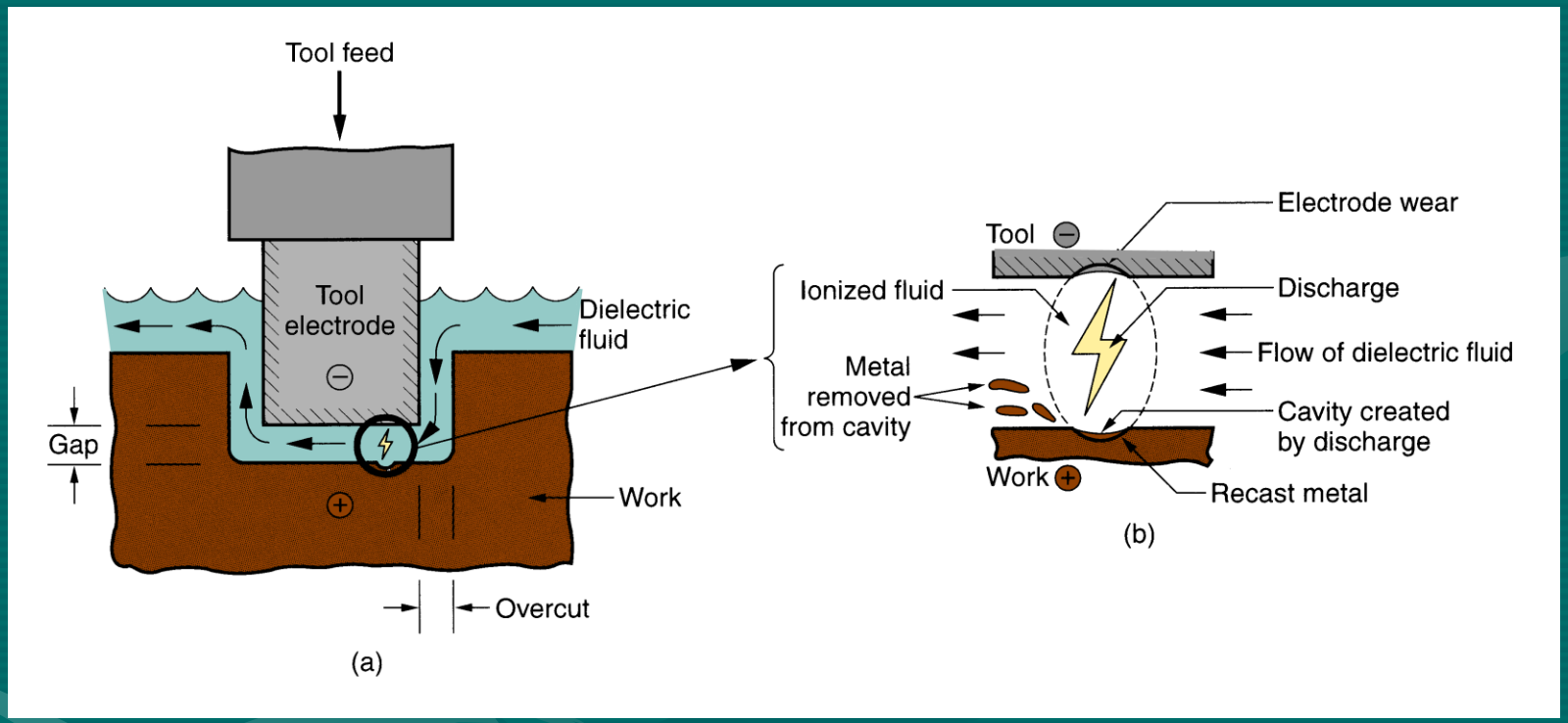


Figure 26.8 - Electric discharge machining (EDM): (a) overall setup, and (b) close-up view of gap, showing discharge and metal removal

Advantages & Dis-advantages of EDM

- **Advantages**
- It can be used on various materials such as tungsten carbide, ceramics
- and other hard materials which can not be machined on conventional
- machines.
- It gives good surface finish.
- As no cutting forces act on the job error due to ellastic deformation is eliminated.
- Very thin sections can also be machined.
- Tool material need not be harder than the work material.
- It is suitable for the complicated components.
- **Dis-advantages**
- It can not be applied to electrically non-conducting materials.
- It is normally applicable to small sized components.
- In many cases the surface machined has been found to have micro cracks.

EDM Applications

- Tooling for many mechanical processes such as molds for plastic injection molding, extrusion dies, wire drawing dies, forging and heading dies, press tools and sheetmetal stamping dies
- Production of intricate,irregular shaped and delicate parts not rigid enough to withstand conventional cutting forces, hole drilling where hole axis is at an acute angle to surface, and machining of hard and exotic metals.
- Drilling of micro holes and thread cutting in jobs.
- Helical rpofile drilling
- Curved hole drilling

- Wire EDM

Wire EDM Operation

- Wire EDM is a special form of EDM that uses a thin single-strand metal wire (usually brass) of dia 0.01 which is fed through the workpiece,submerged in a tank of dielectric fluid or typically deionized water and acts as electrode to cut a narrow kerf in work.
- The wire, is constantly fed from a spool, and is held between upper and lower diamond guides. The wire is generally used once.
- While cutting, wire is continuously advanced between supply spool and take-up spool to maintain a constant diameter
- Work is fed slowly past wire along desired cutting path, like a bandsaw operation
- Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.
- Wire-cutting is commonly used when low residual stresses are desired

Wire EDM

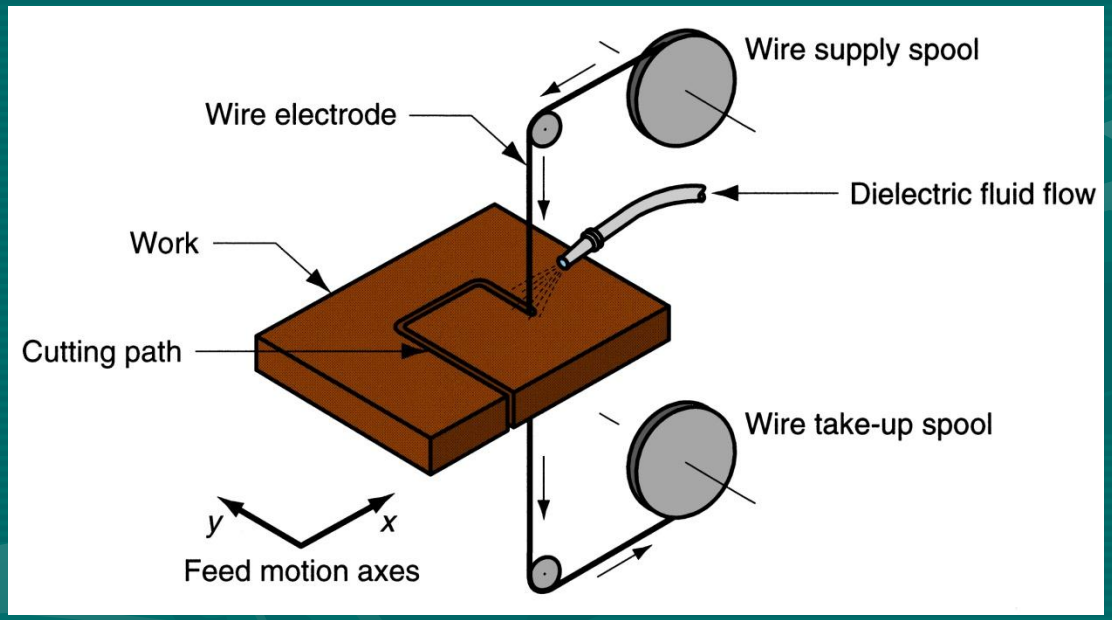


Figure 26.10 -

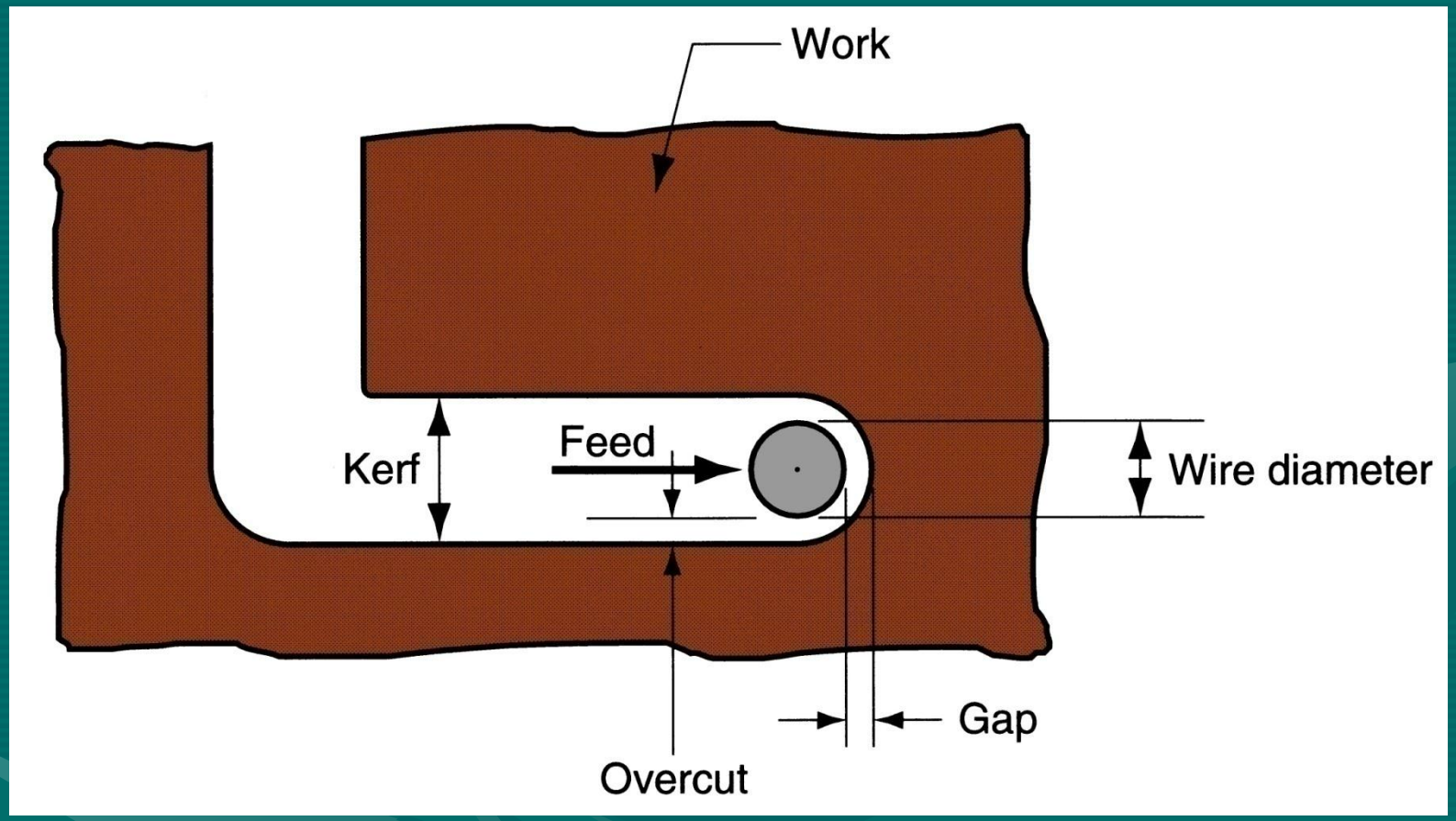


Figure 26.11 - Definition of kerf and overcut in electric discharge wire cutting

Wire EDM Applications

- Ideal for stamping die components
  - Since kerf is so narrow, it is often possible to fabricate punch and die in a single cut
- Other tools and parts with intricate outline shapes, such as lathe form tools, extrusion dies, and flat templates