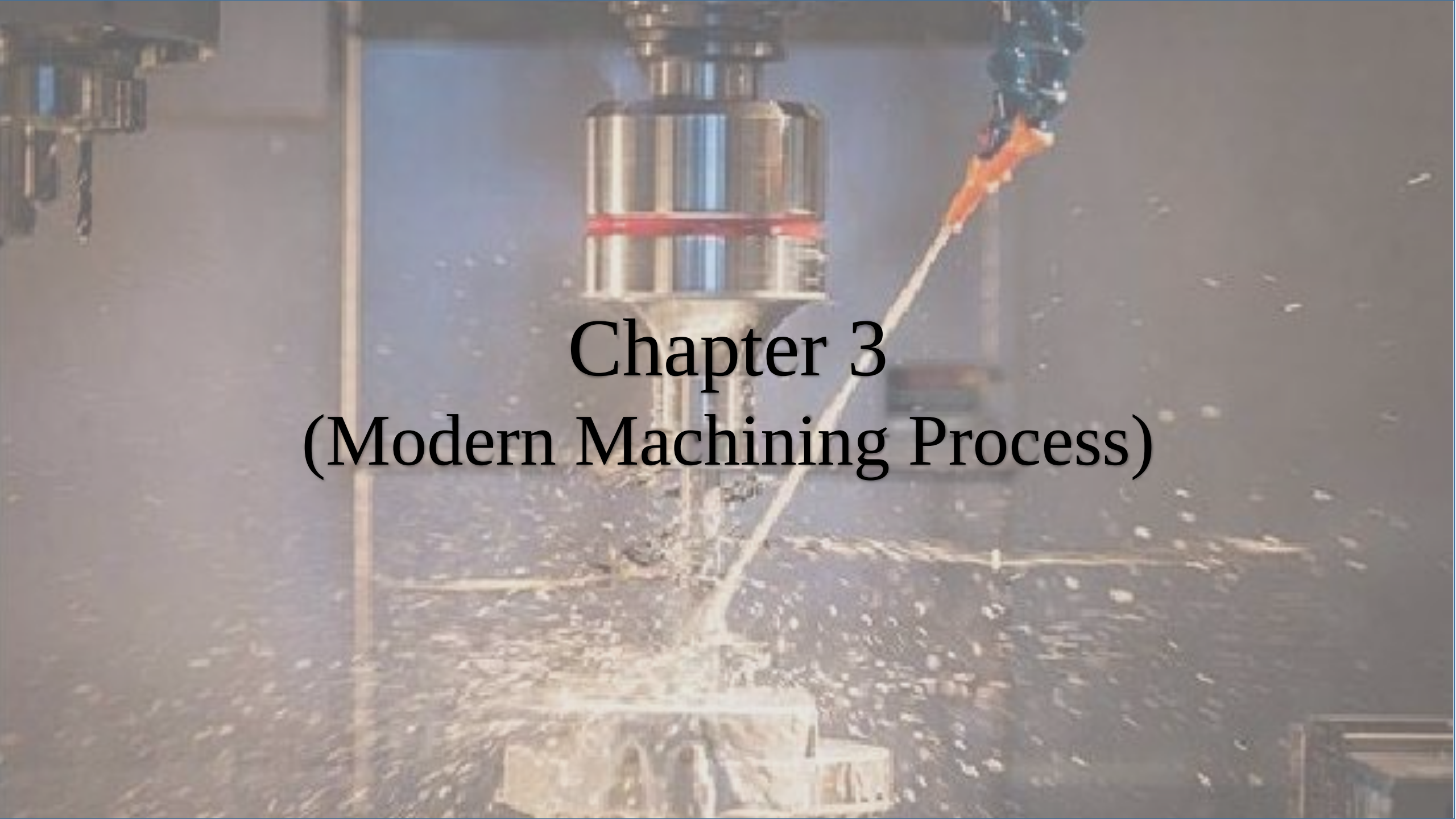
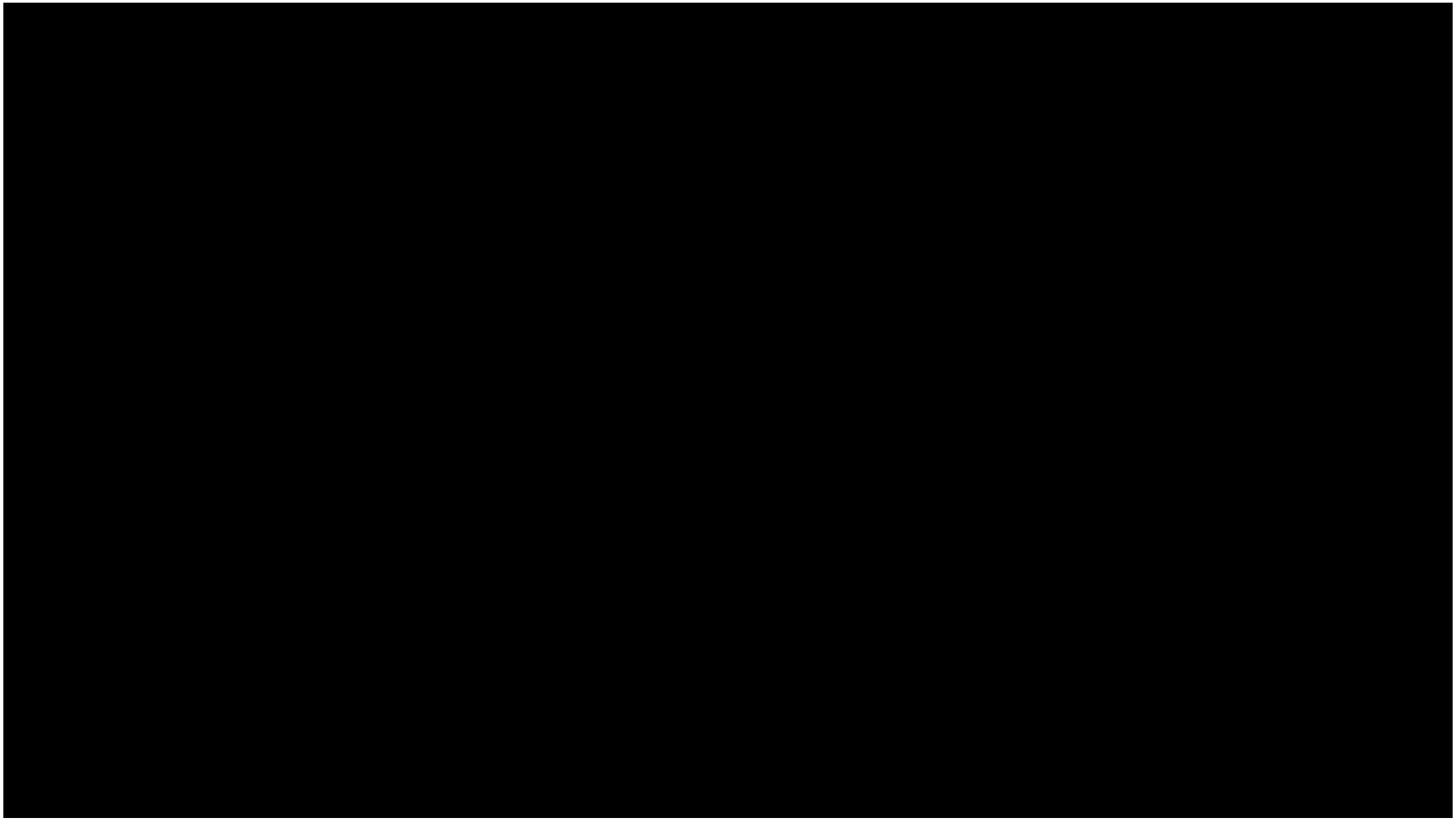


Chapter 3
(Modern Machining Process)



Introduction

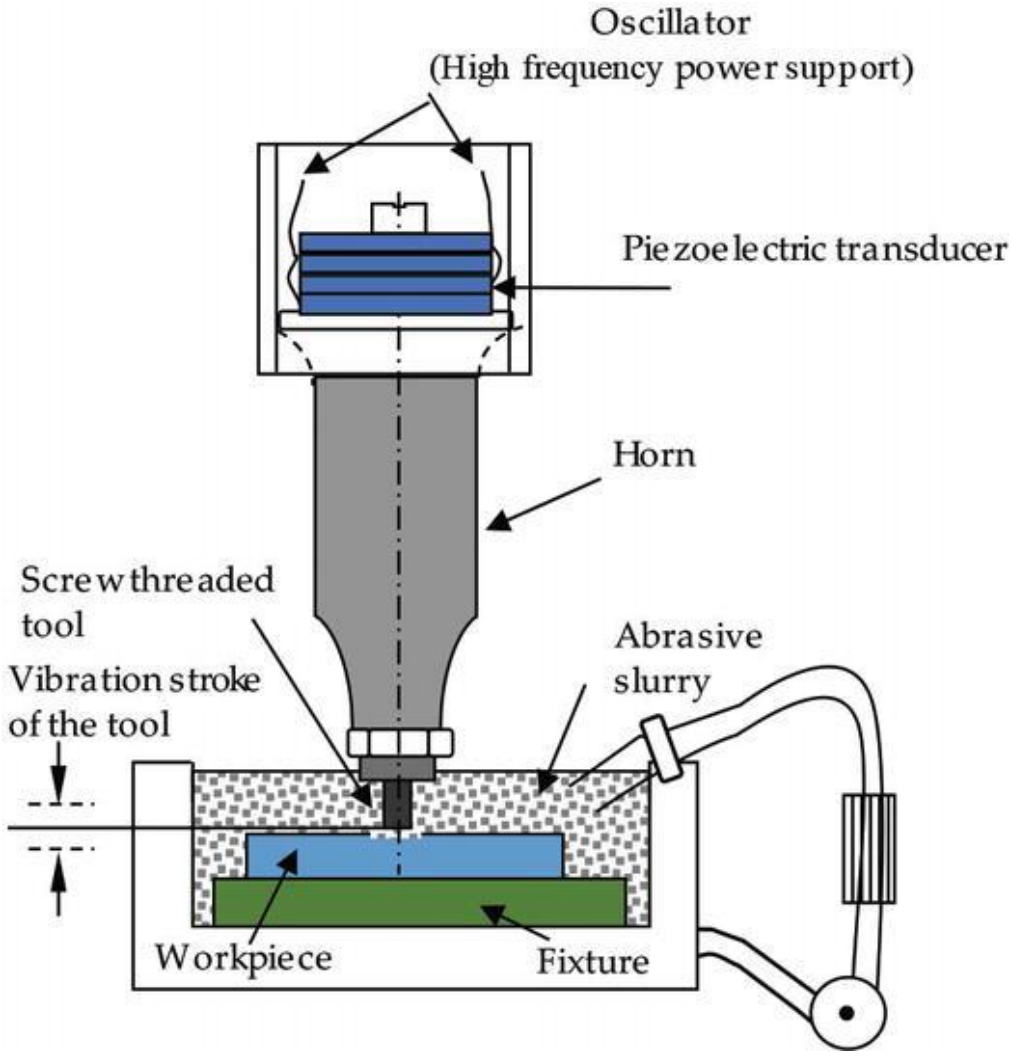
i) High Production rate and economy
ii) The desired dimensional accuracy and quality of surface finish.
iii) The desired shapes.
iv) Adaptability of cheaper materials.
v) Method to machine hard material such as tungsten, carbides and stainless steel used in aircraft industry, space research center, nuclear plants, missile technology.

Introduction

S. No.	Type of Energy	Basic mechanism of metal removal	Transfer media	Energy source	Process
1.	Mechanical	Erosion shear	High velocity particles, physical contact	Pneumatic or hydraulic, pressure, cutting tool	Abrasive Jet machining, ultrasonic machining
2.	Chemical	Chemical abrasion	Reactive environment	Corrosive agent	Chemical machining
3.	Electro-chemical	Ion Displacement	Electrolyte	High current	Electrochemical machining, grinding
4.	Thermoelectric	Fusion, Vaporization	Hot gases electron radiation	Ionized material, high voltage amplified light	IBM, plasma arc, EBM, EDM, LBM

Ultrasonic Machining

- The basic USM process involves a tool (made of a ductile and tough material) vibrating with a low amplitude and very high frequency and a continuous flow of an abrasive slurry in the small gap between the tool and the work piece.
- The tool is gradually fed with a uniform force.
- The impact of the hard abrasive grains fractures the hard and brittle work surface, resulting in the removal of the work material in the form of small wear particles.
- The tool material being tough and ductile wears out at a much slower rate.



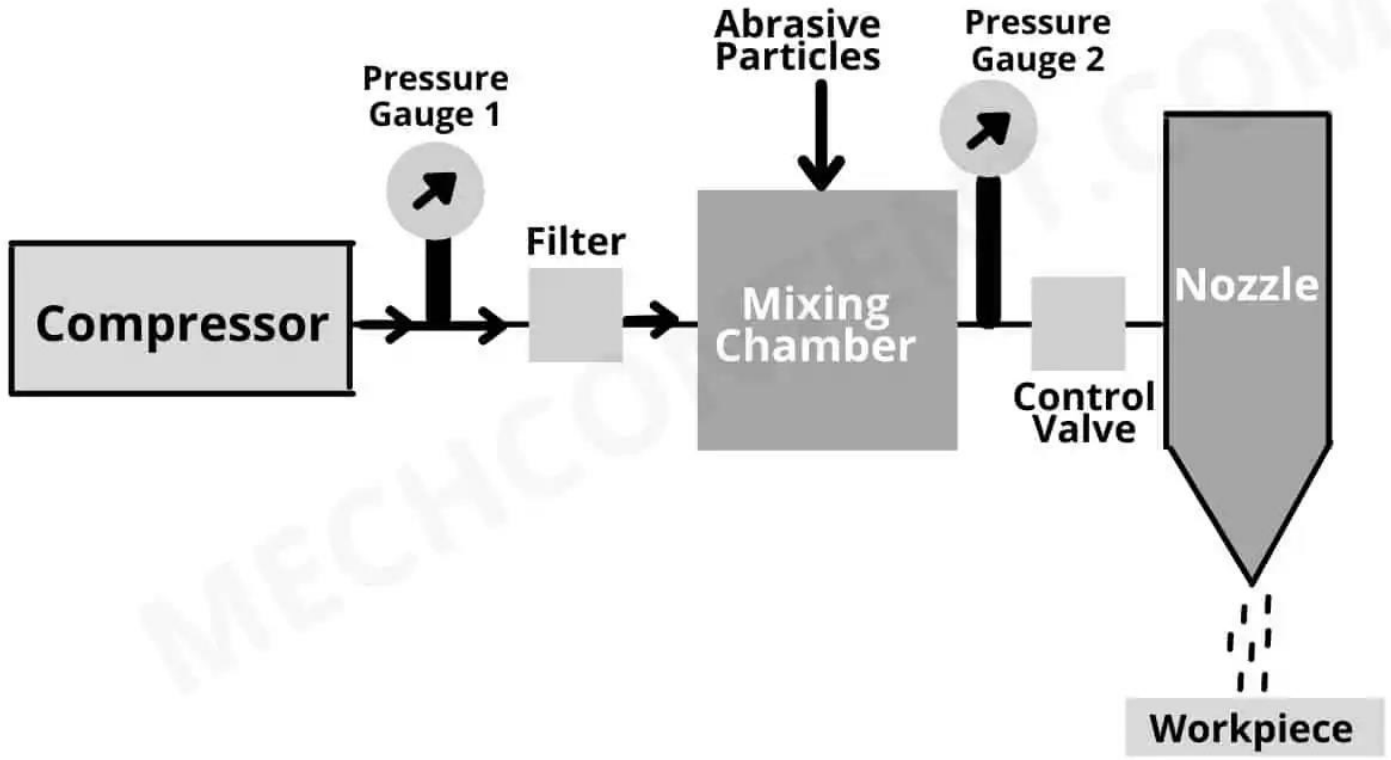
Ultrasonic Machining

Applications

- Machining very precise and intricately shaped articles.
- Drilling the round holes of any shape.
- Grinding the brittle materials.
- Profiling the holes.
- Engraving
- Trepanning and coining
- Threading

Abrasive Jet Machining

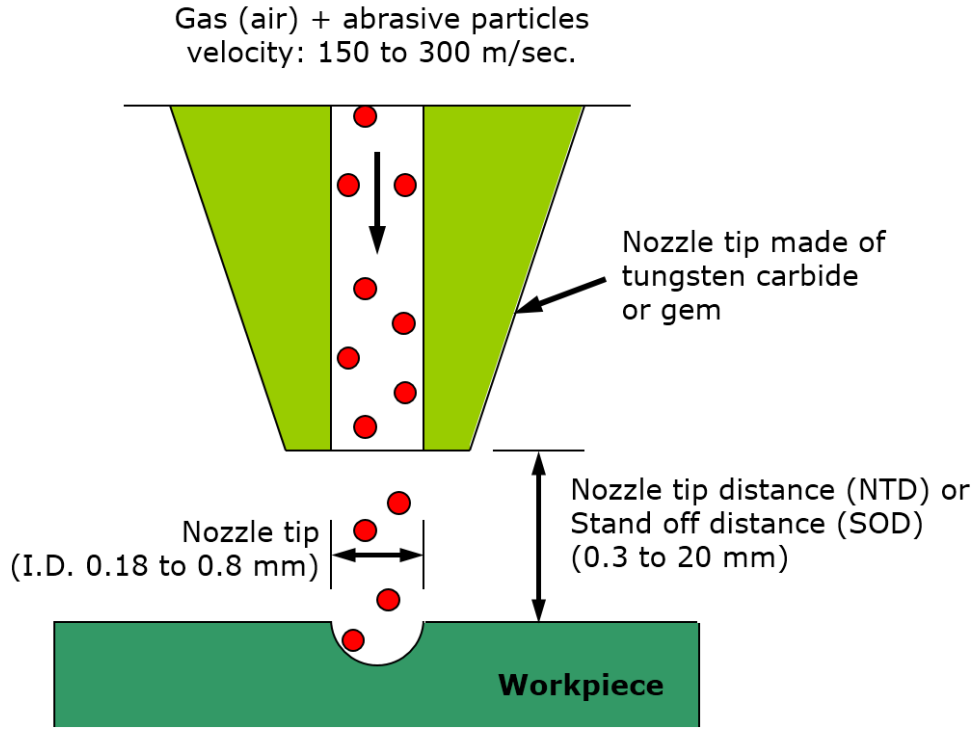
- In abrasive jet machining material is removed by the erosive action of the high velocity stream of fine abrasive particles imparting on the work surface.
- High pressure air or gas is supplied to the mixing chamber containing the fine abrasive particles.
- These high pressure mixture is passed through the small nozzle and the erosion caused by their impact at high speed removes the metal of workpiece



Abrasive Jet Machining

Abrasive Jet Machining Consists of the following parts

- **Gas Supply** – Compressed air instead of other gas is supplied
- **Filter** – It clean the air if there is any dust particles
- **Pressure Gauge** – To check whether the required amount of pressure is there or not
- **Regulator** - To control the flow of compressed air through the pipe
- **Mixing Chamber** – Abrasive particles are mixed with supplied amount of compressed air.
- **Nozzle** – Mixture is injected on the workpiece with the help of nozzle of diameter (0.18 to 0.8mm)



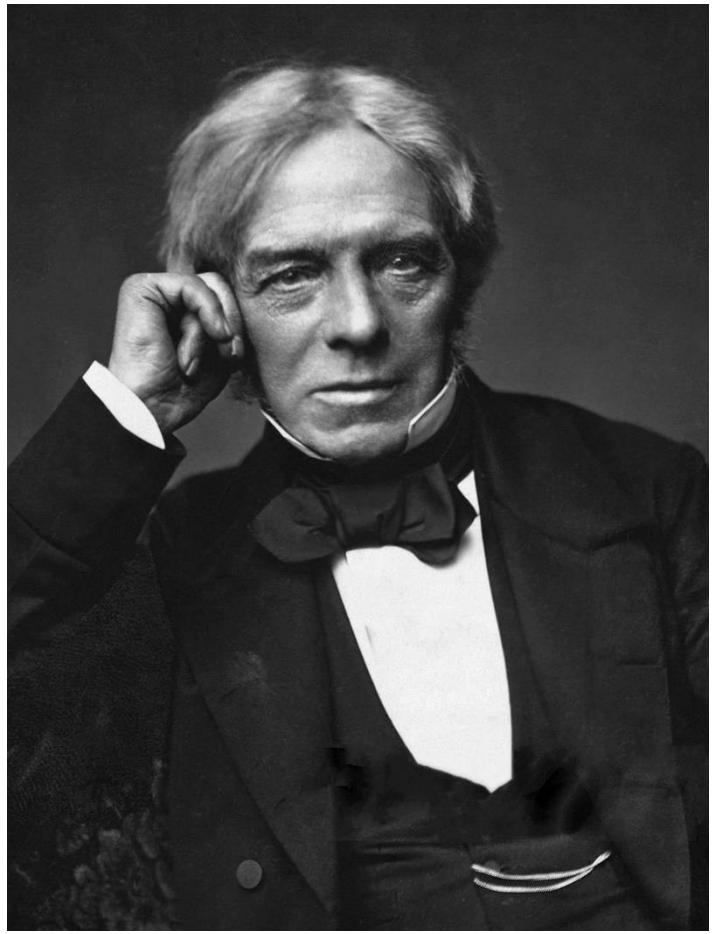
Abrasive Jet Machining

Applications

- **Cutting slots and thin sections**
- **Contouring and drilling operations**
- **Producing intricate hole shapes in a hard and brittle material**
- **Cleaning and polishing the plastic, nylon and Teflon component**

Electric Chemical Machining (ECM)

- **Electrical Chemical machining** is the process of removing metal with the help of the electrolysis process.
- It is also known as the reverse of the electroplating process because in electroplating, the metal is deposited on the surface of the workpiece, while in electrochemical machining the metal is removed from the workpiece.
- This process is used for the large-scale production of machined parts. This process is based on Faraday's law of electrolysis



Faraday's law of electrolysis states that when two electrodes, anode (+) and cathode (-) are placed in an electrolyte the mass of the metal deposited on the cathode coming from the anode is directly proportional to the potential difference applied across the electrodes.

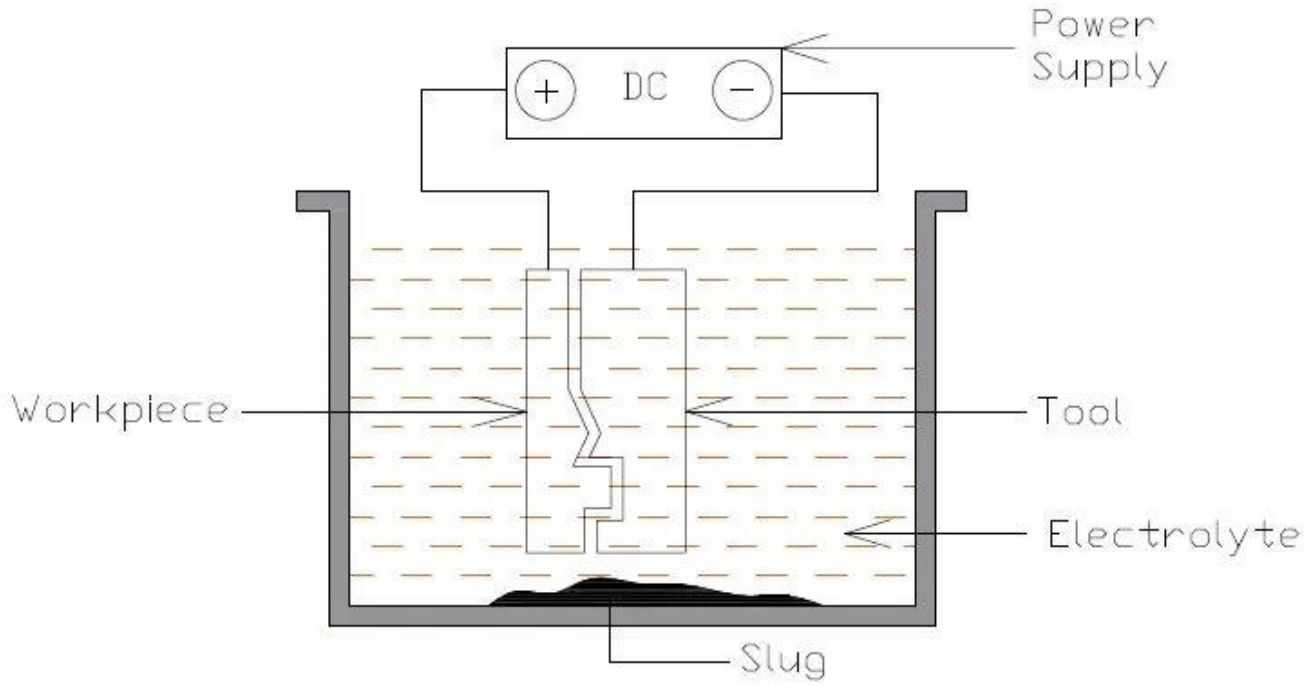
Electric Chemical Machining (ECM)

$$2H^+ + 2e^- = H_2 \qquad (eq1)$$

$$Fe = Fe^{2+} + 2e^- \qquad (eq2)$$

$$Na^+ + OH^- = NaOH \qquad (eq3)$$

$$Fe^{2+} + 2Cl^- = FeCl_2 \qquad (eq4)$$

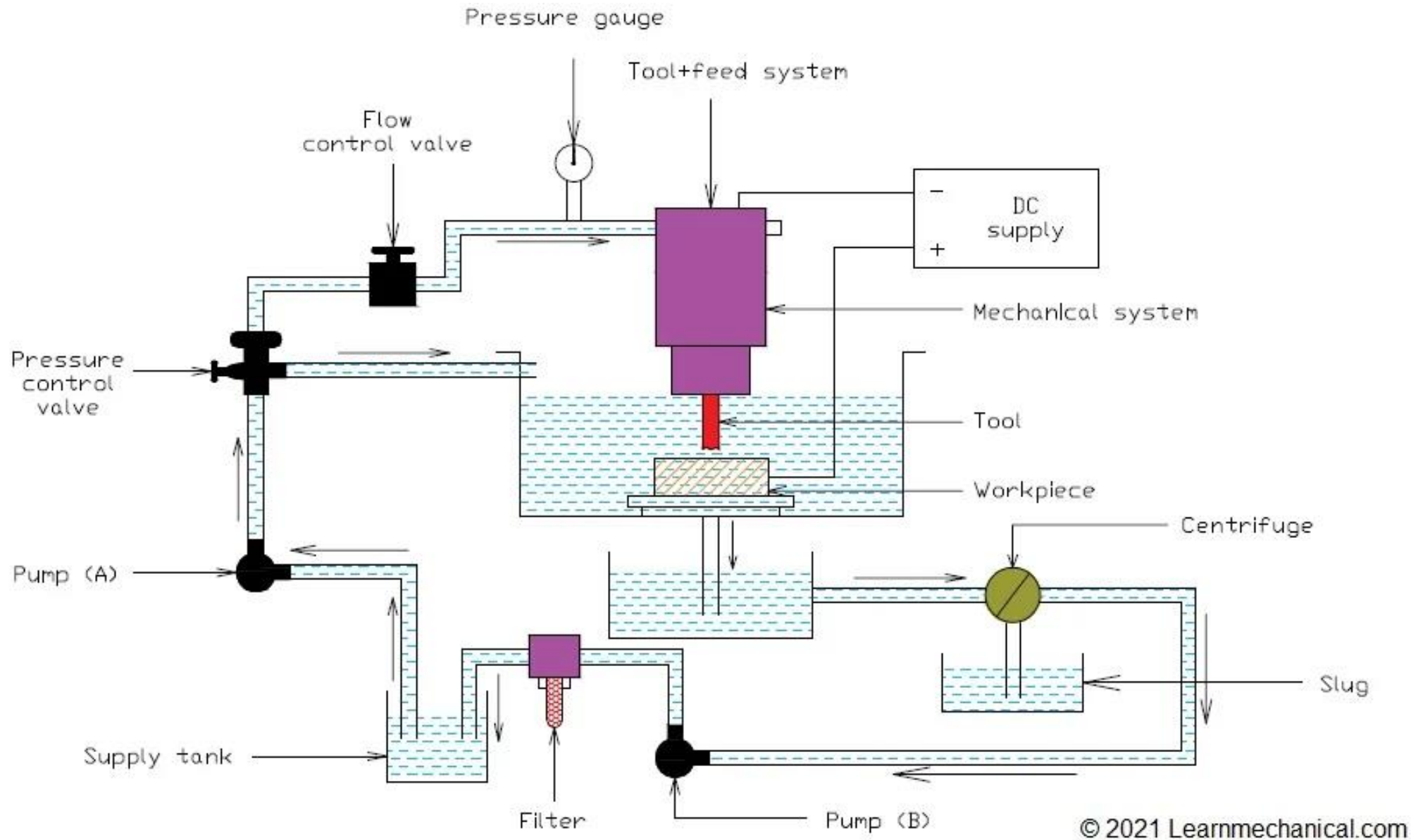


Electric Chemical Machining (ECM)

An Electro Chemical Machine consists of the following parts

- DC Power Supply – The power supply is DC battery consisting of a potential difference from 3 to 30V.
- Electrolyte – An **electrolyte** is a salt solution in which the workpiece and tool are kept during the process of machining. It acts as a current-carrying medium between the workpiece and the tool. Different electrolytes used in ECM are Sodium chloride (NaCl), Sodium nitrate ($NaNO_3$), hydrochloric acid (HCl), etc.
- Tool – The **tool** or cathode used in ECM is one of the electrodes. It is also the desired shape in which the workpiece is to be cut. The tool used in ECM should always have accurate dimensions.
- Mechanical system
- Tank
- Pressure gauge
- Flow control valve
- Reservoir tank
- Pump
- Filter and centrifuge
- Slug container

Electric Chemical Machining (ECM)

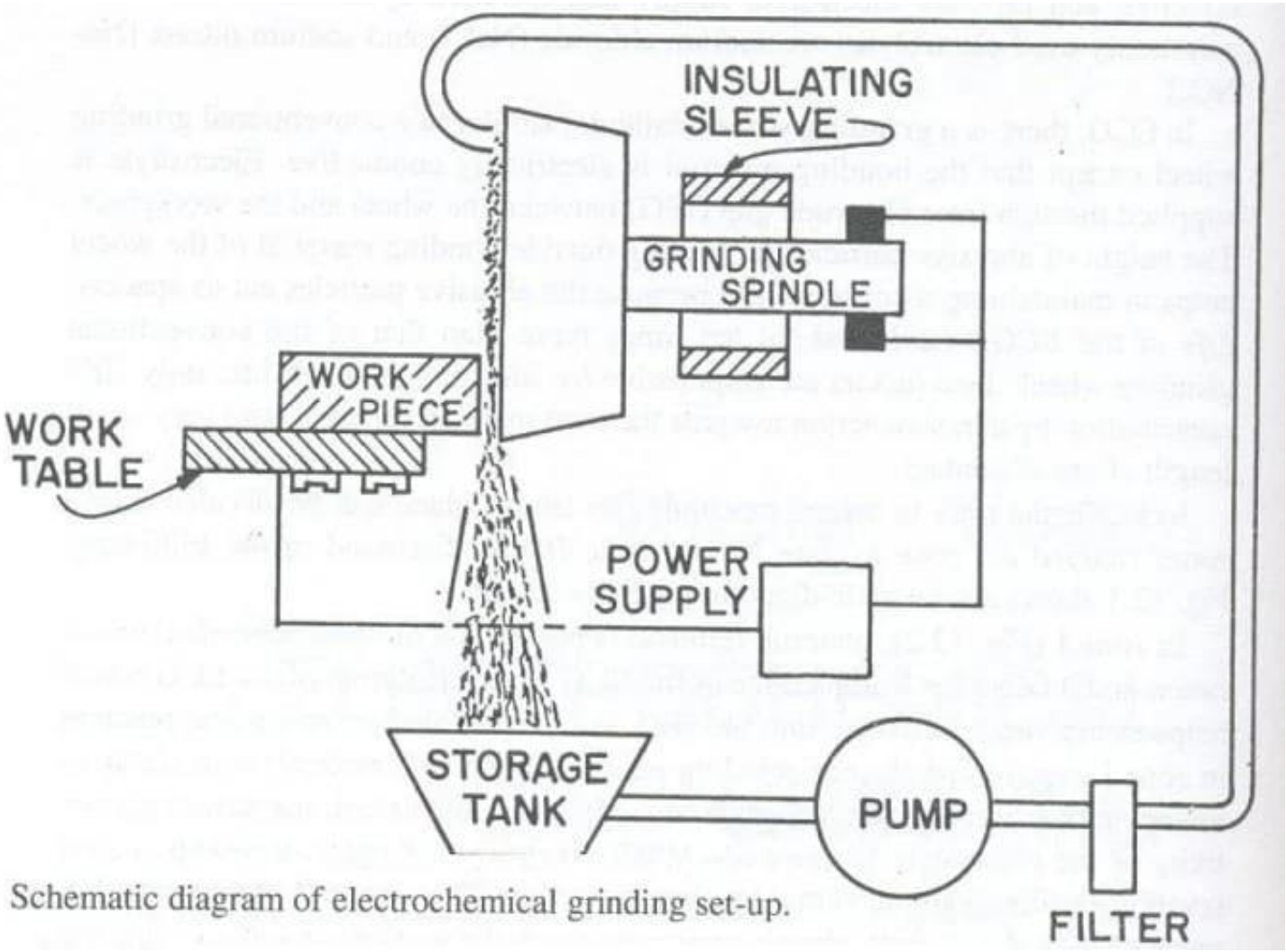


Electric Chemical Machining (ECM)

Applications of Electrochemical Machining

- As mentioned earlier in the article ECM is used for the heavy machining of hard materials which cannot be machined using conventional methods.
- Due to its high accuracy and surface finish, **ECM** is used for **micromachining**. As there is no contact between the tool and the workpiece the final product obtained is accurate at the atomic level.
- **ECM** is also used for the production of very small gear systems which cannot be machined using typical machining processes.
- **ECM** is used for machining turbine blades as it is difficult to machine due to its complex concave structure.
- **ECM** can also be used for drilling and milling operations.

Electric Chemical Grinding (ECG)



Schematic diagram of electrochemical grinding set-up.

Electric Chemical Machining (ECM)

Advantage

- The greatest advantages are that all work is completely free of burrs.
- No heat is formed so no heat cracks or distortions are developed.
- Very little pressure is exerted on the work, and no wheel wear is found.
- Higher metal removal rates are possible, particularly upon hard materials.

Disadvantage

- The major disadvantage is the cost of the ECG system.
- The metal removal rates are a low being of the order of 15 mm /s, and power consumption is high

Electric Chemical Grinding (ECG)

Applications of Electrochemical Grinding

- An electrically conductive material is ground by the electrolytic process.
- Cutting thin section of hard materials
- Sharpening of Carbide tips and tools.

Electric Discharge Machining (EDM)

Electrical Discharge machining is the process of metal removal from the work surface due to an erosion of metal caused by electric spark discharge between the two electrodes tool (cathode) and the work (Anode) submerged in a dielectric liquid. This process is used to manufacture parts that are impossible to machine. Since EDM does not use mechanical force to remove material, it is considered to be non-traditional.

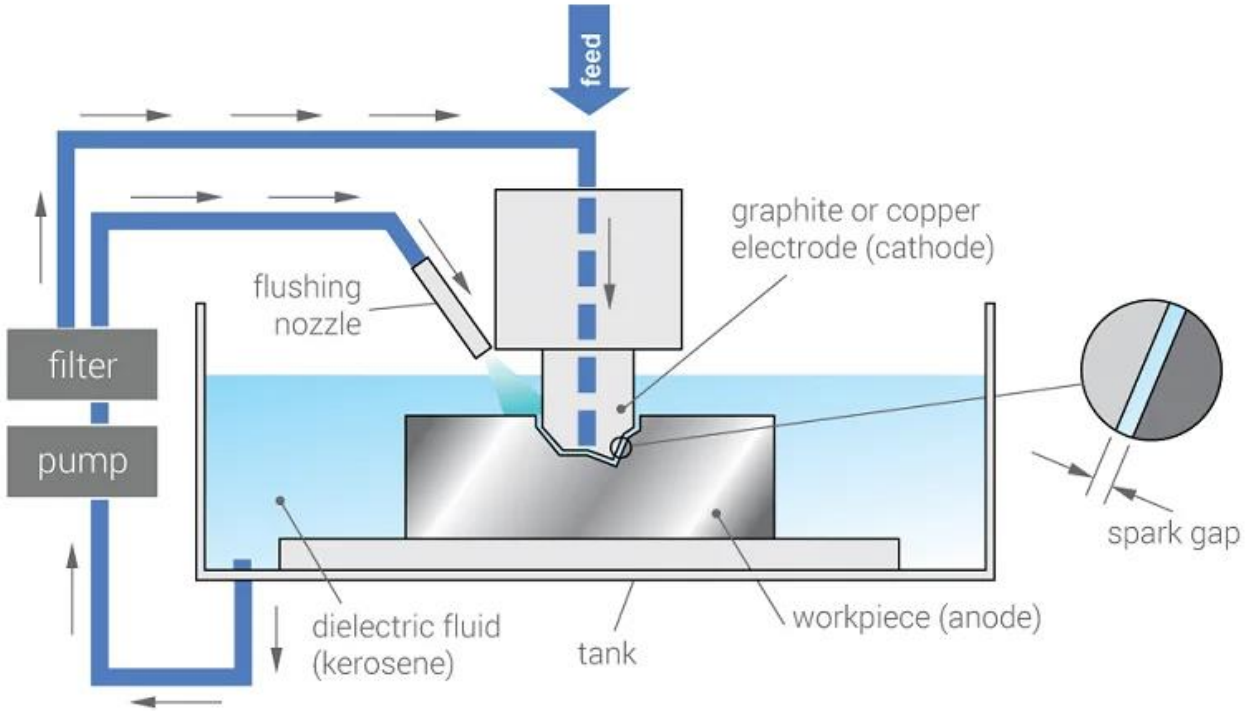
Electric Discharge Machining (EDM)

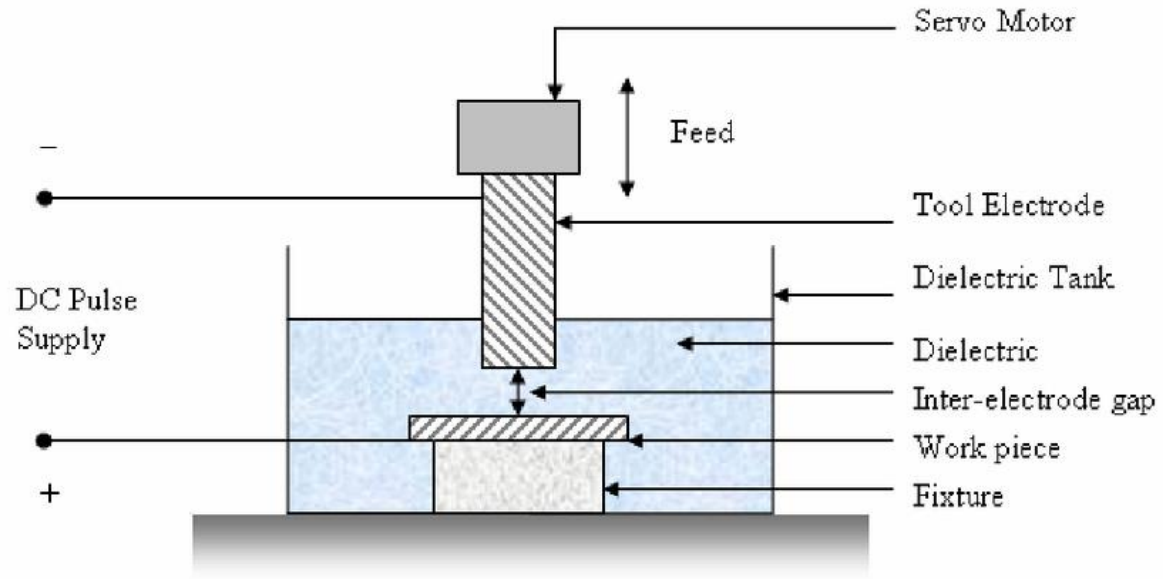
An Electro Discharge Machine consists of the following parts

- DC pulse Generator – This is a power source for the machining operation. DC power is supplied.
- Voltmeter – To measure the voltage
- Ammeter – To measure the current
- Tool – A tool is connected to negative terminal of power whereas the workpiece is connected to positive terminal
- Die electric fluid – It possesses the property of insulation which means no current flows from one point to another.
- Pump - It send the fluid to the filter
- Filter – It is used to filter the dust particles
- Servo Controlled Feed
- Fixtures
- Table

Electric Discharge Machining (EDM)

Working Principle



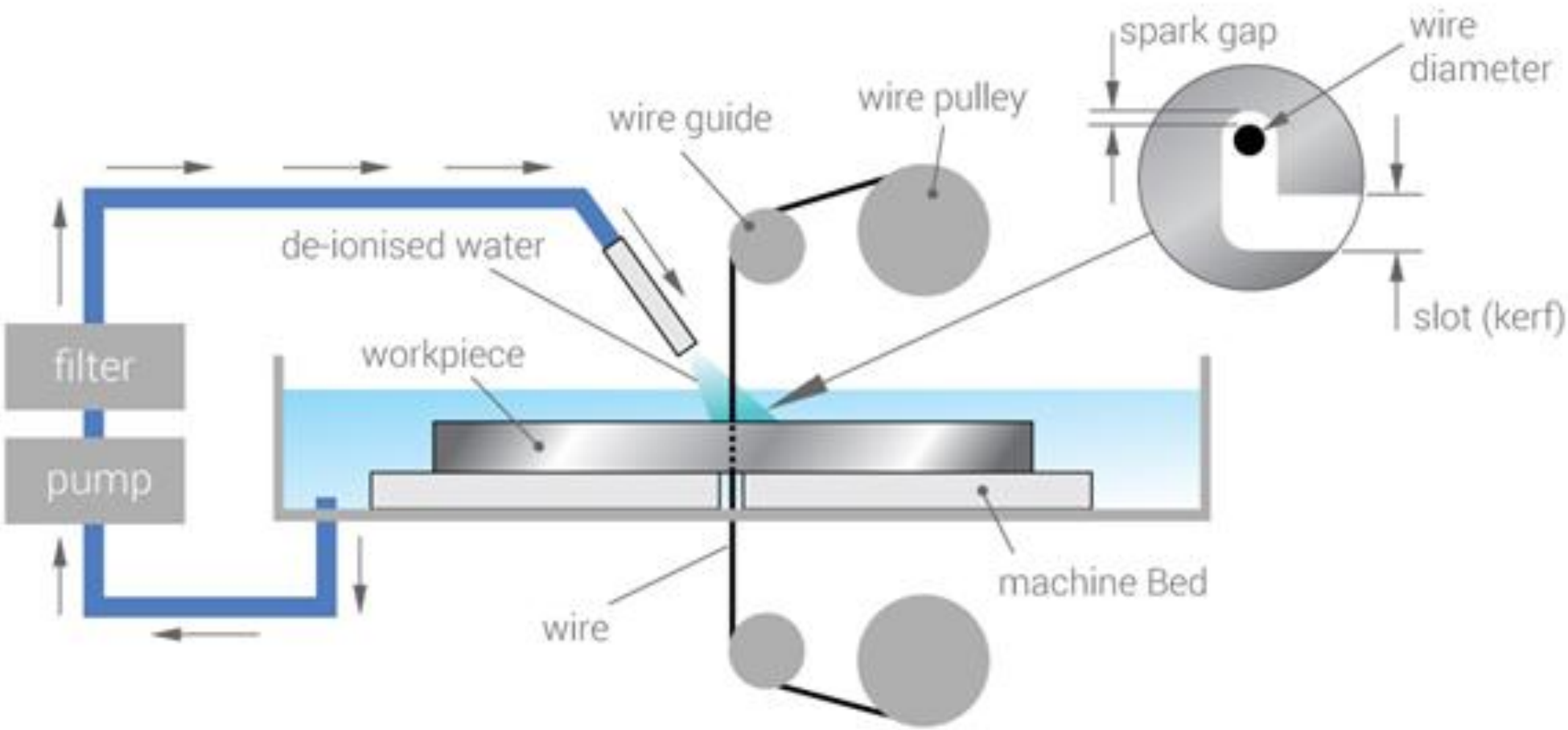


Electric Discharge Machining (EDM)

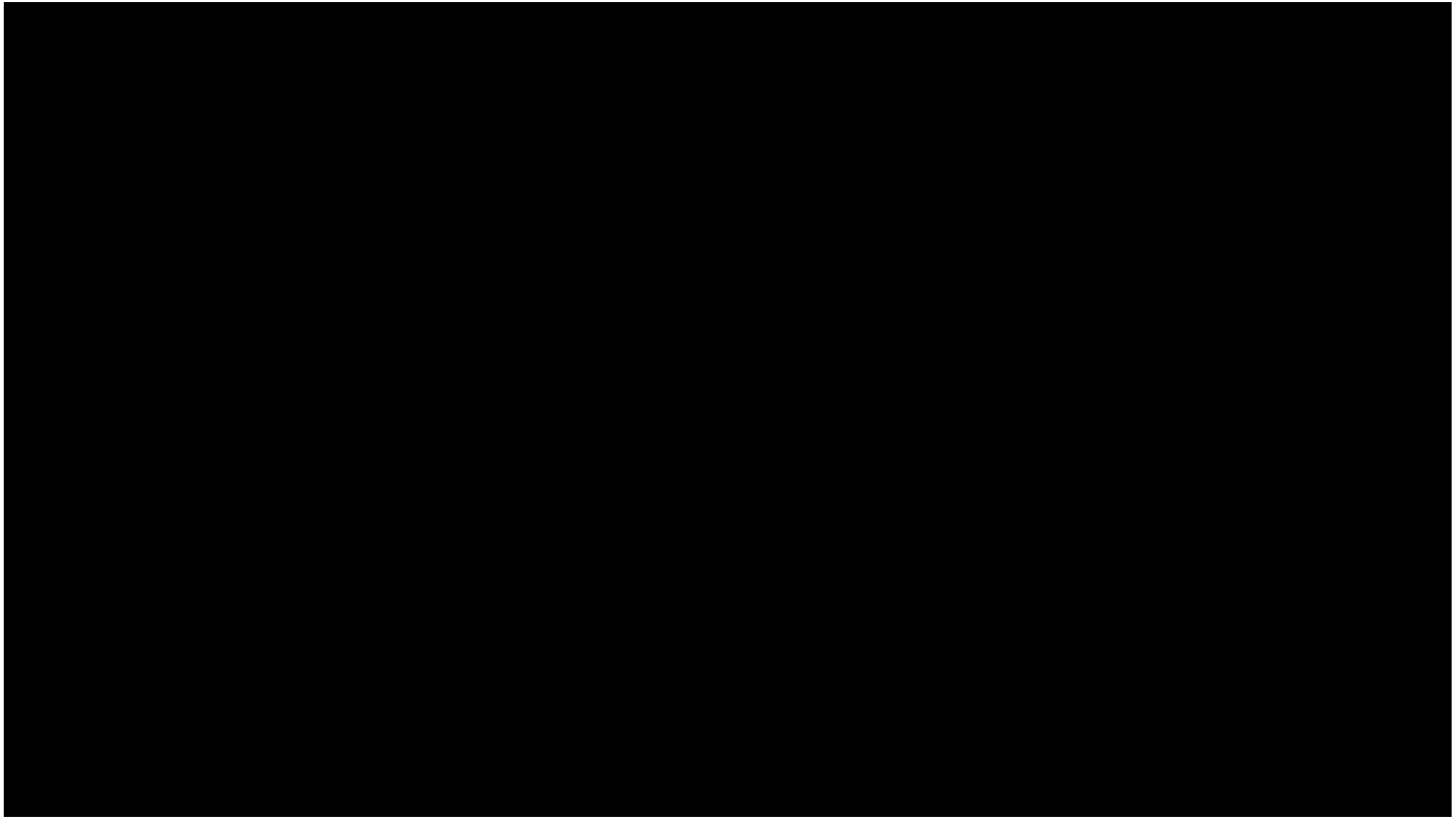
Applications

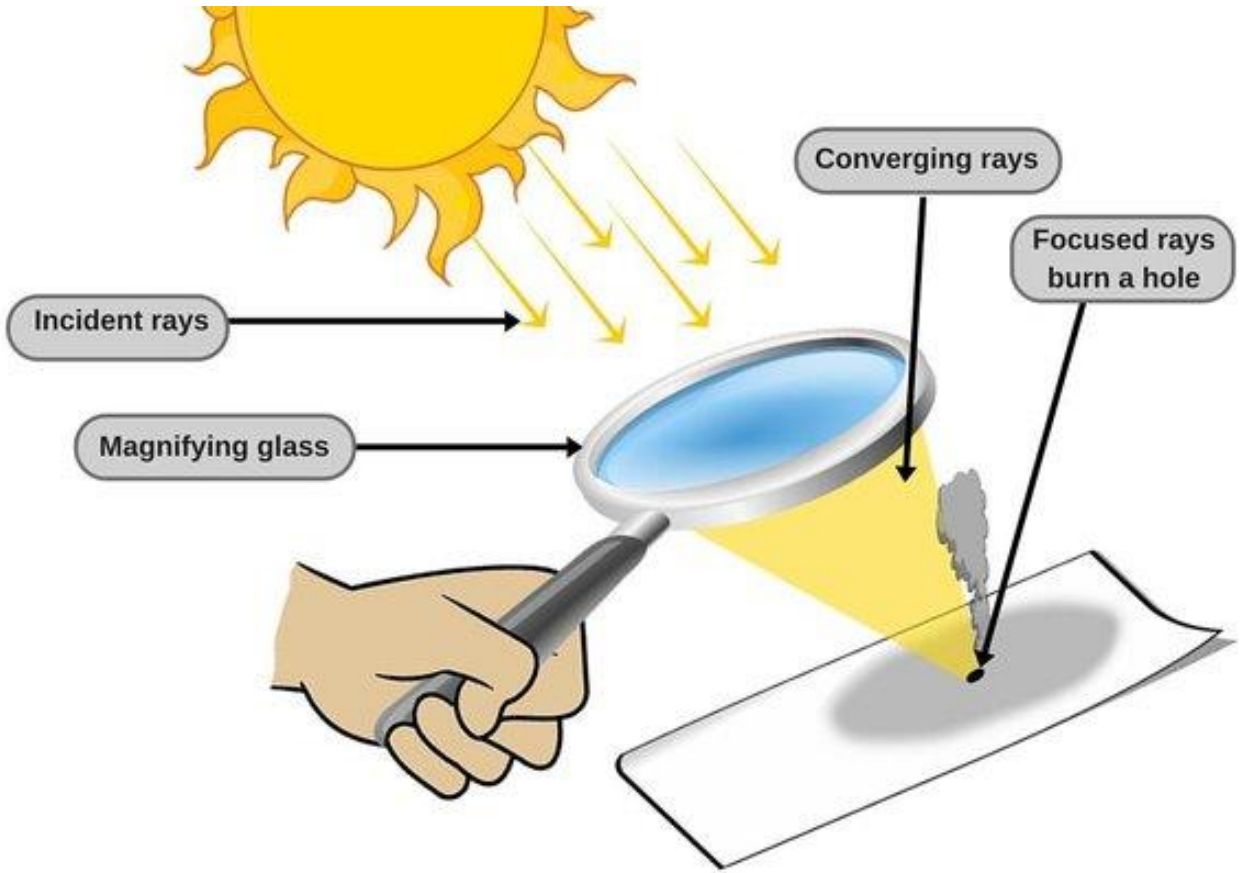
- Drilling for micro holes in the nozzle.
- Used in thread cutting.
- Used in wire cutting.
- Rotary form cutting.
- Helical profile milling.
- Curved hole drilling.
- Engraving operation on harder materials.
- Cutting off operation.
- The shaping of alloy steel and tungsten carbide dies.

Wire Electric Discharge Machining (EDM)



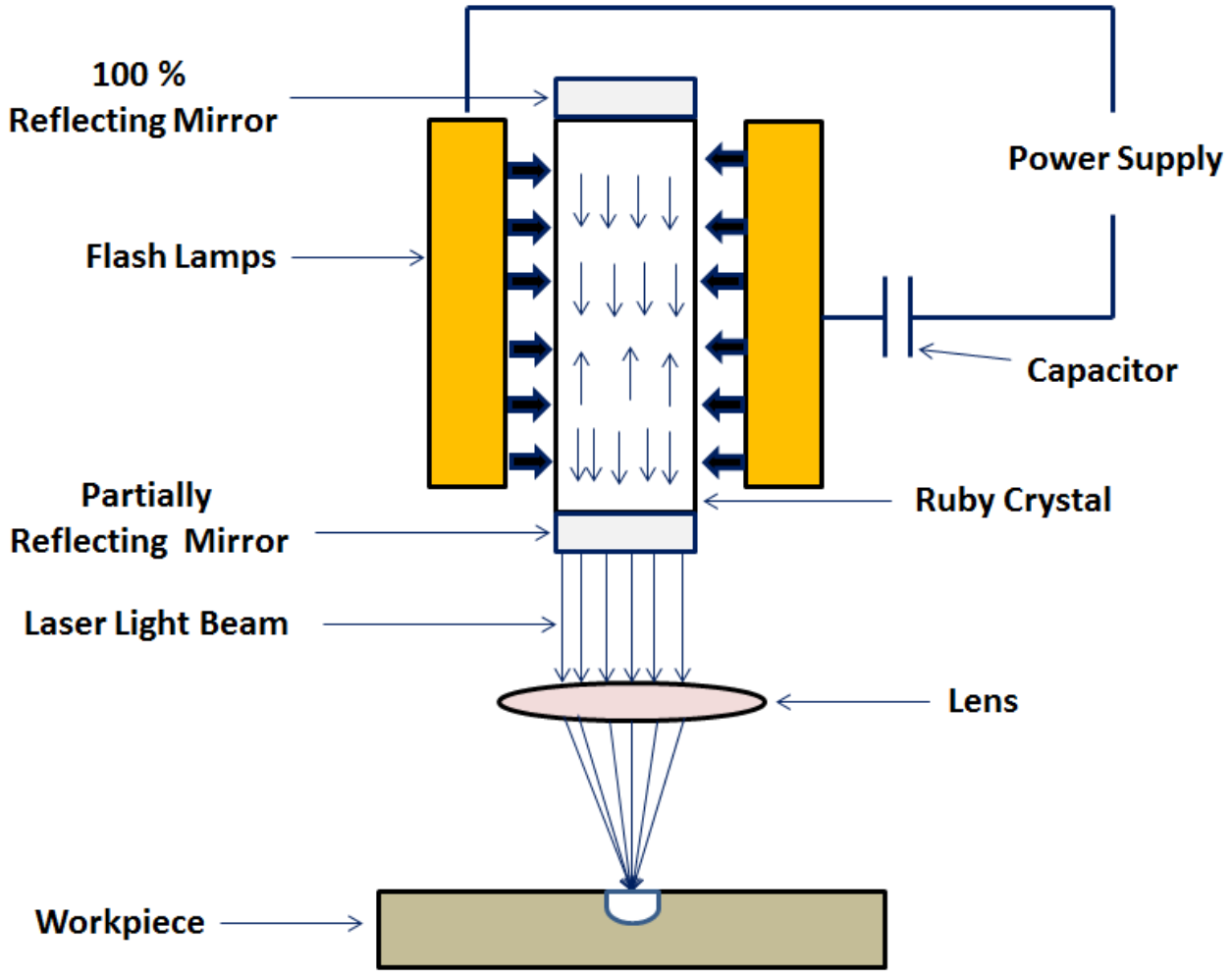
Wire Electric Discharge Machining (EDM)



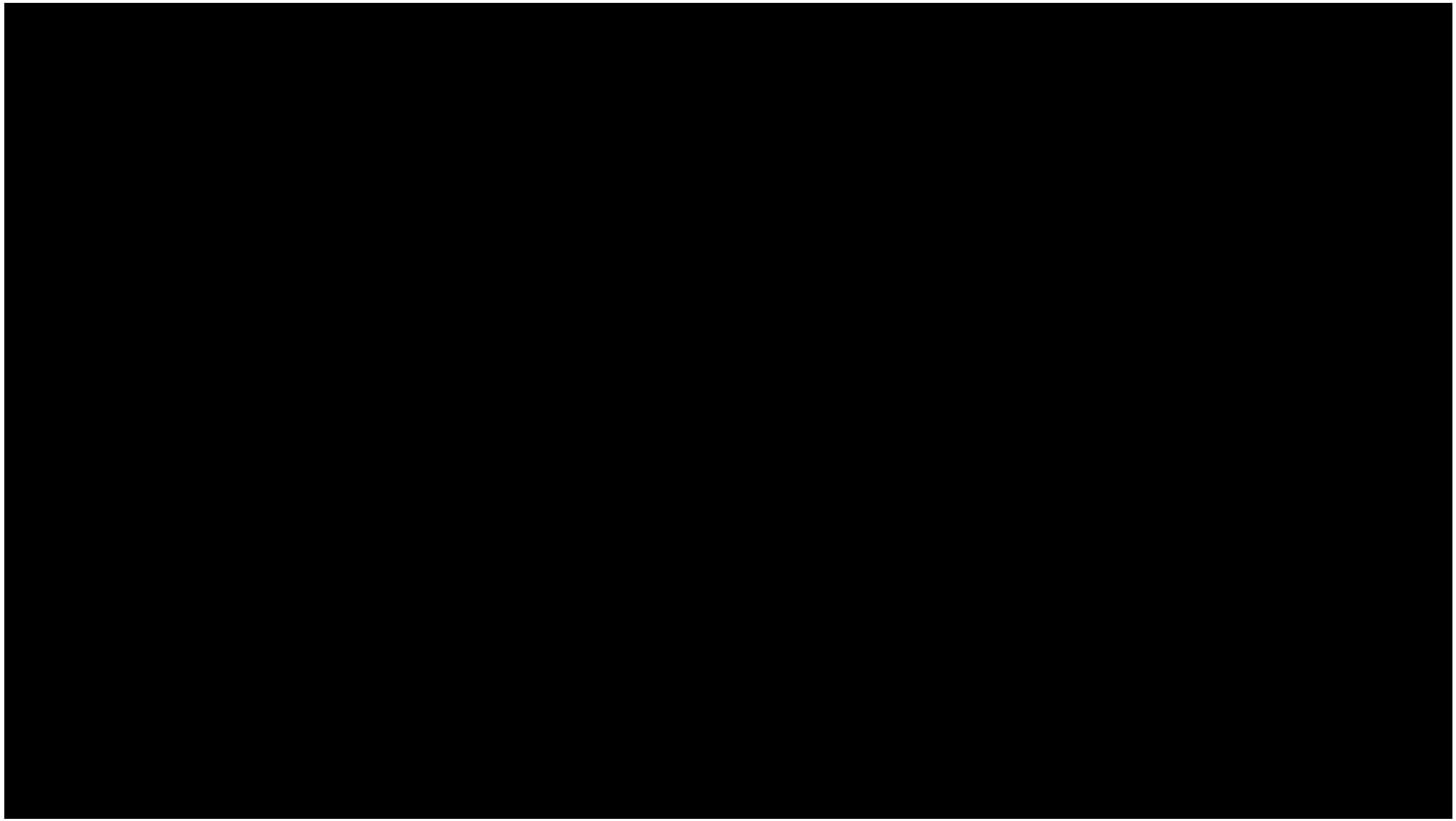

Converging rays
Focused rays burn a hole
Incident rays
Magnifying glass

Laser Beam Machining (LBM)

LBM is the process to remove material by using a focused mono frequency collimated light beam which heats, melts and vaporize work material at the focus point.



Laser Beam Machining (LBM)



Laser Beam Machining (LBM)

Advantages

- Easy to machine any materials
- Heat affected zone is small because of converged beam
- No tool wear.

Disadvantages

- High initial cost
- The process is limited to thin sheets.
- Highly skilled operator is needed.

Applications

- To trim carbon resistors, sheet metals and plastic parts
- To drill small holes in hard materials in tungsten and ceramics
- To cut complex profiles on hard materials