SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MATERIAL

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Unit-V

OTHER ADVANCED MACHINING PROCESS

UNIT –V

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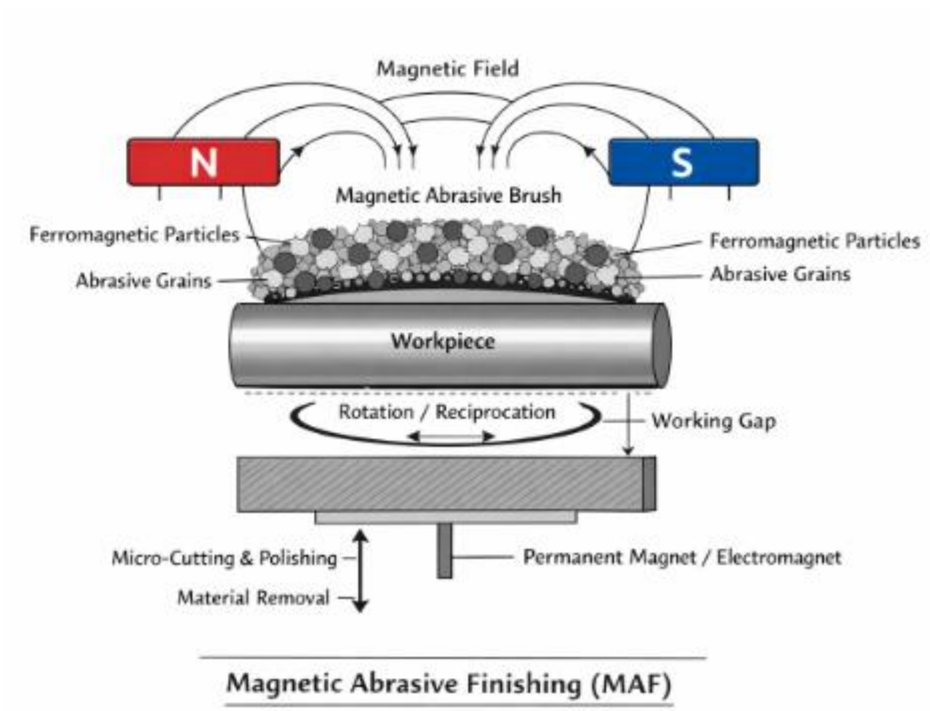
Magnetic Abrasive Finishing (MAF)

1. Introduction

Magnetic Abrasive Finishing (MAF) is an advanced non-traditional finishing process used to improve surface quality by using magnetic force to control abrasive particles. It is especially useful for precision components in aerospace, automotive, medical, and die industries.

2. Principle of Magnetic Abrasive Finishing



The working principle is based on **magnetic force acting on ferromagnetic abrasive particles**.

- A magnetic field is generated using permanent magnets or electromagnets.
- Magnetic abrasive particles (mixture of ferromagnetic particles + abrasive grains like Al_2O_3, SiC, and diamond) are attracted and form a flexible abrasive brush.
- This brush acts as a finishing tool.
- When relative motion is provided between the workpiece and the magnetic brush, micro-cutting and polishing occur.

The magnetic field controls the stiffness and pressure of the abrasive brush.

3. Working of MAF

1. Magnetic abrasive particles are placed between the magnet and work piece.
2. When the magnetic field is applied, particles align along magnetic lines of force.
3. A flexible magnetic abrasive brush (FMAB) is formed.
4. The work piece is rotated or reciprocated.
5. Abrasives remove surface irregularities through micro-cutting and ploughing.
6. Surface roughness gradually decreases.

Types of MAF operations:

- Internal finishing (tubes, pipes)
- External cylindrical finishing
- Plane surface finishing

4. Material Removal Mechanism

Material removal occurs mainly due to:

- **Micro-cutting action** of abrasive particles
- **Shearing of asperities (surface peaks)**
- **Plastic deformation and rubbing action**

Factors affecting material removal rate (MRR):

- Magnetic field strength
- Abrasive size and type
- Rotational speed
- Working gap

- Finishing time

MRR is low compared to conventional machining, but surface finish is very high.

5. Surface Finish

- Achieves very fine surface finish (up to 0.01–0.05 µm Ra).
- Removes burrs and improves dimensional accuracy.
- Produces mirror-like finishing.

Surface finish improves because:

- Only surface asperities are removed.
- Controlled magnetic force ensures uniform finishing.

6. Advantages

- High surface finish quality
- Suitable for hard materials
- No tool wear (brush is self-adjusting)
- Can finish complex shapes
- Burr removal capability

7. Limitations

- Low material removal rate
- High equipment cost
- Mainly suitable for finishing (not for heavy machining)

8. Applications

- Finishing of internal surfaces of tubes and pipes
- Dies and molds polishing
- Medical components (surgical instruments)

- Aerospace precision parts
- Automobile components
- Finishing of hard materials like stainless steel, ceramics, and superalloys

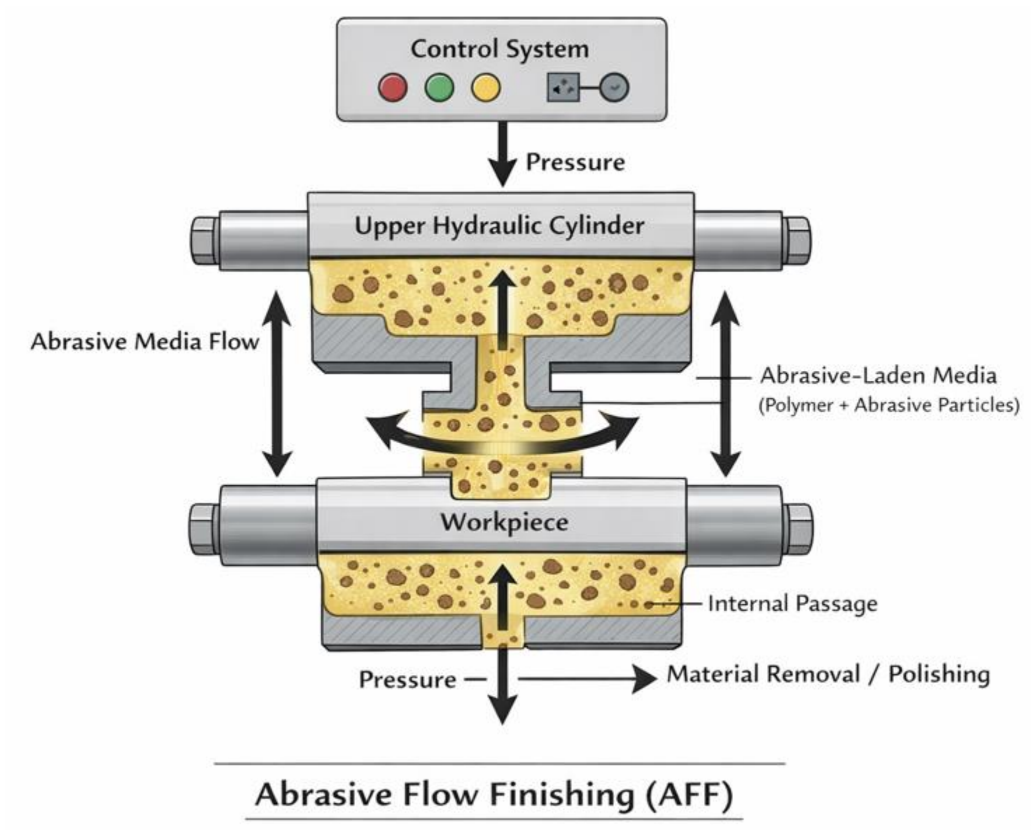
Abrasive Flow Finishing (AFF)

1. Introduction

Abrasive Flow Finishing (AFF) is a non-traditional finishing process used to improve surface finish, deburr, and polish complex internal passages by forcing a semi-solid abrasive media through or across a workpiece.

It is also called **Extrude Honing Process**.

2. Principle of Abrasive Flow Finishing



The principle is based on:

Material removal by the abrasion action of abrasive particles carried by a flowing visco-elastic media under pressure.

- A polymer-based media mixed with abrasive particles (SiC, Al_2O_3, diamond, etc.) is used.
- The media is hydraulically forced through restrictive passages.
- Abrasive particles perform micro-cutting and polishing.
- High shear stress at surface irregularities causes material removal.

3. Working of AFF

Step-by-step Process:

1. The workpiece is placed between two hydraulic cylinders.
2. Abrasive-laden media is filled into the cylinders.
3. Hydraulic pressure forces the media through the workpiece passage.
4. The media flows back and forth (reciprocating motion).
5. Abrasive particles remove burrs and surface asperities.
6. Required surface finish is achieved after multiple cycles.

Main Components:

- Hydraulic cylinders
- Abrasive media (polymer + abrasives)
- Workpiece fixture
- Control system

4. Process Performance

(A) Material Removal Rate (MRR)

- MRR is low compared to conventional machining.
- Controlled and uniform material removal.
- Mainly used for finishing and deburring.

Factors affecting MRR:

- Abrasive size and concentration
- Media viscosity
- Extrusion pressure
- Number of cycles
- Workpiece material

(B) Surface Finish

- Surface roughness can be improved from 3–5 µm to 0.1–0.2 µm Ra.
- Produces uniform and consistent finish.
- Suitable for internal and inaccessible surfaces.

(C) Accuracy

- Maintains dimensional accuracy.
- Does not significantly alter geometry.
- Good for complex 3D passages.

5. Advantages

- Finishes complex internal passages
- Simultaneous deburring and polishing
- Uniform surface finish
- Suitable for hard materials
- Good repeatability

6. Limitations

- Low material removal rate
- High equipment cost
- Media cost is high
- Not suitable for heavy stock removal

7. Applications

- Automotive engine components (cylinder heads, fuel injectors)
- Aerospace turbine blades
- Medical implants
- Die and mold finishing
- Internal passages of hydraulic components

Electro Stream Drilling (ESD)

1. Introduction

Electro Stream Drilling (ESD) is a non-traditional machining process used for producing small and deep holes in hard and difficult-to-machine materials using a high-velocity electrolyte jet and electrical energy.

It is a modified form of **Electrochemical Machining (ECM)**.

2. Principle of Electro Stream Drilling

The principle is based on:

Anodic dissolution of metal due to electrochemical reaction.

- Workpiece → Anode (+)
- Tool (hollow nozzle) → Cathode (–)
- Electrolyte ($NaCl$ or $NaNO_3$ solution) flows at high velocity.
- When DC power is applied, metal dissolves from the workpiece surface.
- No physical contact between tool and workpiece.

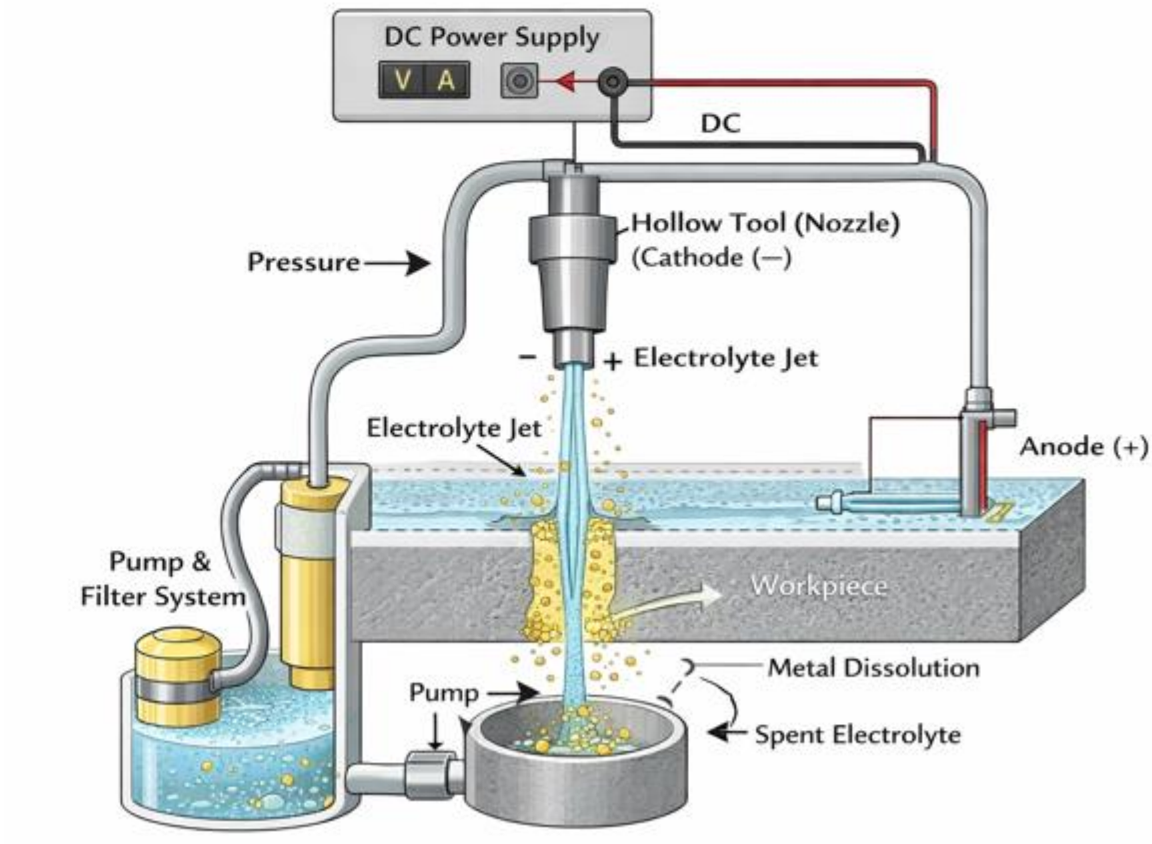
Material removal follows **Faraday's Law of Electrolysis**.

3. Working of ESD

Step-by-Step Process:

1. The workpiece is connected to the positive terminal (anode).
2. The hollow tool/nozzle is connected to the negative terminal (cathode).
3. Electrolyte is pumped at high pressure through the nozzle.
4. A high-velocity electrolyte jet strikes the workpiece.

5. DC current is applied.
6. Metal is removed by anodic dissolution.
7. The tool advances gradually to produce a deep hole.



Electro Stream Drilling (ESD)

Main Components:

- DC Power Supply
- Electrolyte Supply System
- Hollow Tool (Nozzle)
- Workpiece
- Pump and Filtration System

4. Process Performance

(A) Material Removal Rate (MRR)

- Higher than conventional ECM for small holes.
- Depends on:
  - Current density
  - Electrolyte flow rate
  - Applied voltage
  - Tool feed rate

According to Faraday's Law:

MRR∝IMRR \propto IMRR∝I

Where **I = Current supplied**

(B) Surface Finish

- Good surface finish (0.2 – 1.5 µm Ra)
- No tool marks
- No residual stresses
- No heat-affected zone (HAZ)

(C) Accuracy

- Suitable for deep holes (high L/D ratio up to 20:1 or more)
- Slight overcut due to stray current
- Good dimensional control with proper parameters

(D) Tool Wear

- No tool wear (since no contact)
- Tool life is high

5. Advantages

- Can drill very small holes (0.1–2 mm diameter)
- Suitable for superalloys and hard materials
- No burr formation
- No thermal damage
- High aspect ratio holes possible

6. Limitations

- Only for electrically conductive materials
- High equipment cost
- Electrolyte disposal issues
- Overcut and stray machining possible

7. Applications

- Cooling holes in turbine blades
- Fuel injector nozzles
- Aerospace components
- Medical needles
- Micro-drilling applications

Shaped Tube Electrolytic Machining (STEM)

1. Introduction

Shaped Tube Electrolytic Machining (STEM) is a specialized form of **Electrochemical Machining (ECM)** used to drill deep, small-diameter holes using a shaped tubular electrode and high-pressure electrolyte flow.

It is widely used for producing **cooling holes in turbine blades** and precision aerospace components.

2. Principle of STEM

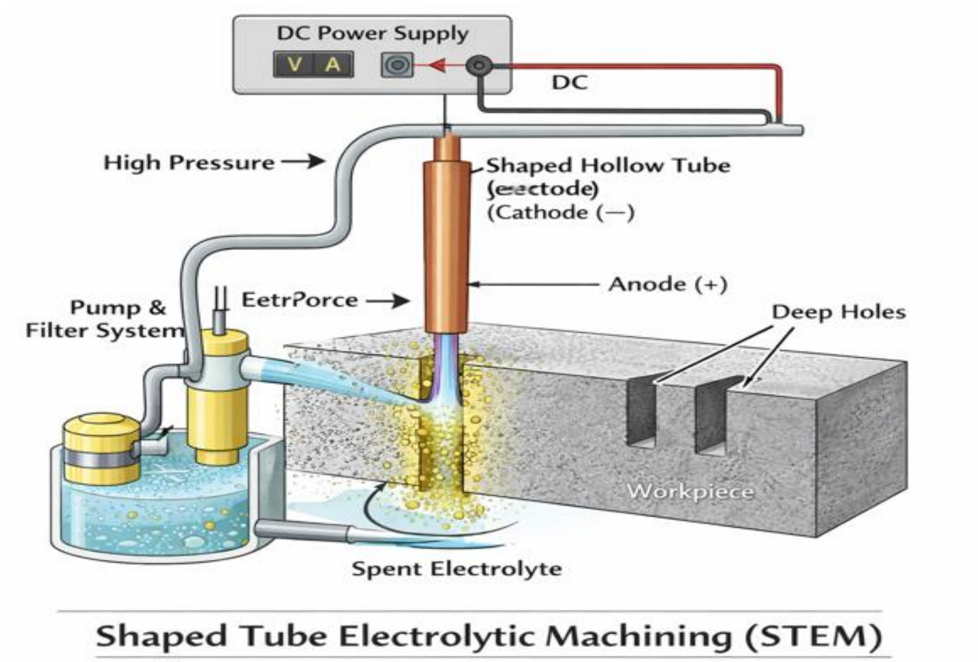
The principle is based on:

Electrochemical anodic dissolution of metal (Faraday's Law of Electrolysis).

- Workpiece → **Anode (+)**
- Tool (Shaped hollow tube) → **Cathode (–)**
- Electrolyte flows at high pressure through the tube.
- When DC current is applied, metal dissolves from the workpiece.
- No physical contact between tool and workpiece.

Material removal occurs only at the region where the electrolyte jet impinges.

3. Working of STEM



Step-by-Step Process:

1. A **shaped tubular electrode** (brass or copper) is used as the tool.
2. The tool is connected to the negative terminal (cathode).
3. The workpiece is connected to the positive terminal (anode).
4. Electrolyte (NaCl or $NaNO_3$ solution) is pumped at high pressure through the hollow tool.
5. DC power supply is switched ON.
6. Metal dissolves from the workpiece due to electrochemical reaction.
7. The tool is fed gradually into the workpiece.
8. Deep and precise holes are produced.

Important Features:

- High-pressure electrolyte flow
- Small inter-electrode gap
- Controlled tool feed rate
- No tool wear

4. Material Removal Mechanism

Material removal occurs due to:

- Anodic dissolution
- Electrochemical reaction
- According to Faraday's Law:

MRR∝IMRR \propto IMRR∝I

Where:
I = Current supplied

No thermal damage or mechanical cutting occurs.

5. Advantages

- Can machine hard and superalloy materials
- Produces deep holes (High L/D ratio 20:1 or more)
- No tool wear

- No burr formation
- No heat-affected zone
- Good surface finish

6. Limitations

- Only for electrically conductive materials
- Electrolyte handling and disposal required
- High initial equipment cost
- Overcut possible due to stray current

7. Applications

- Cooling holes in gas turbine blades
- Aerospace engine components
- Fuel injector nozzles
- Heat exchanger tubes
- Nuclear reactor components
- Medical precision components