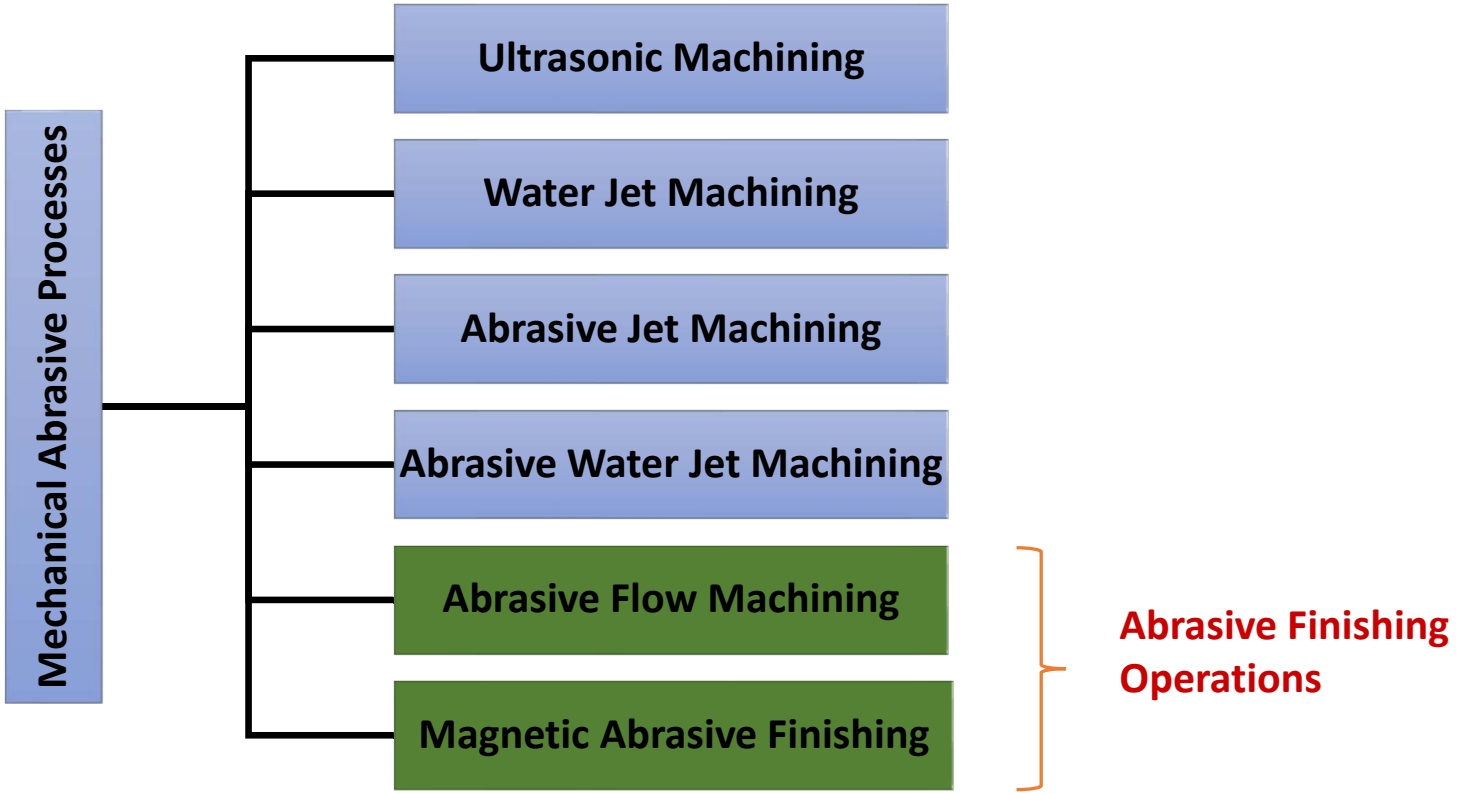
Abrasive Finishing Operations

ME688: Advanced Machining Processes
Instructor: R K Mittal

Classification of Mechanical Abrasive Processes



Why Finishing Operations??

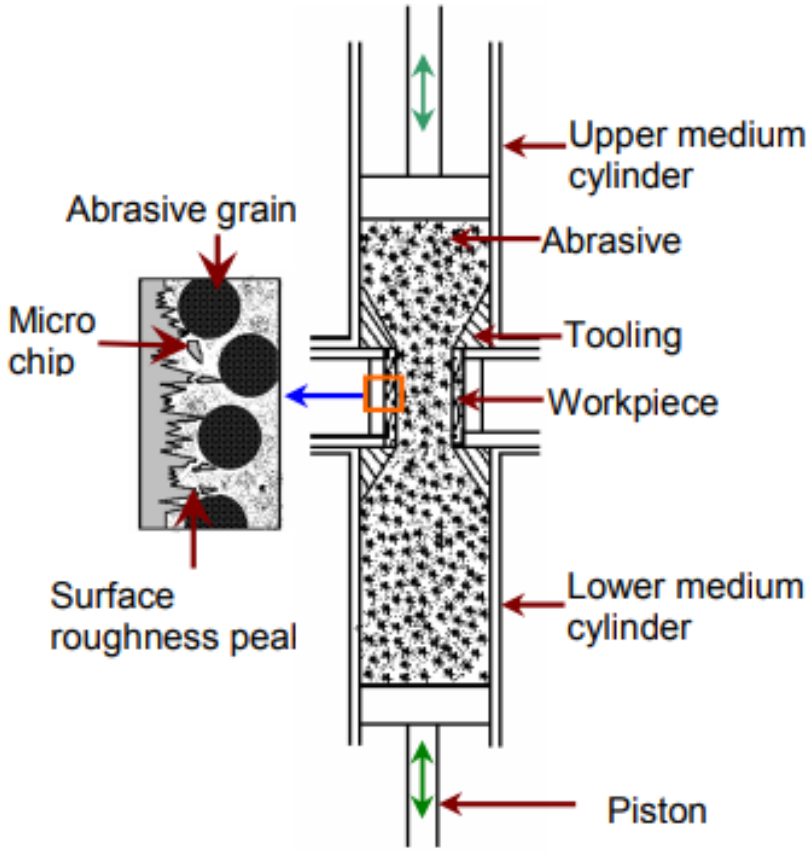
- The need for high accuracy and high efficiency machining of difficult-to-machine materials
- The requirement of high-quality finish on the parts to improve performance and life of the component
- The most important, labor intensive and uncontrollable area in the manufacture of precision parts involves final machining operations
- The increase cost of surface finish with roughness value of less than one micron
- Abrasive finishing processes can be used for effective removal of material with chip sizes smaller than those obtained during machining using cutting tools with defined edges.
- Abrasive finishing processes provide better surface finish, closer tolerances, generation of more intricate surface features, and machining of harder materials

Abrasive Flow Machining (AFM)

- Abrasive flow machining (AFM) was developed by Extrude Hone Corporation, USA in 1960
- A purely mechanical abrasive machining process that finishes surfaces and edges.
- Abrasive flow machining removes a small quantity of material by flowing a semisolid abrasive laden putty over the surface to be finished
- Use of a viscous abrasive media flowing, under pressure, through or across a workpiece
- Widely used finishing process to finish complicated shapes and profiles

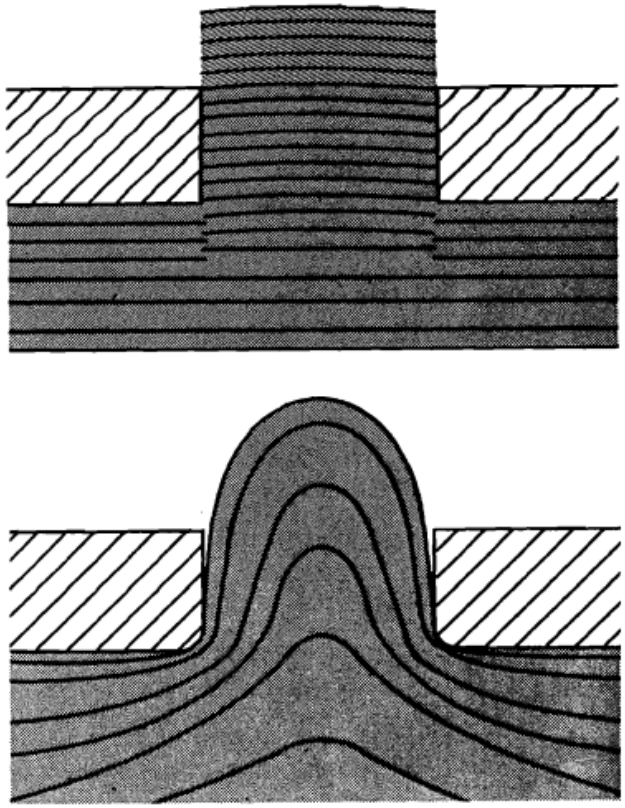
Material Removal Mechanism

- A hydraulic ram forces the abrasive medium through the workpiece
- As the abrasive medium flows through the part, its velocity will change with the different cross-sectional areas of the passageways
- The passageways with the greatest restriction will produce the largest forces and the highest velocity medium
- The result is a multipoint-cutting action against the passageway walls from the medium's many small abrasive particles

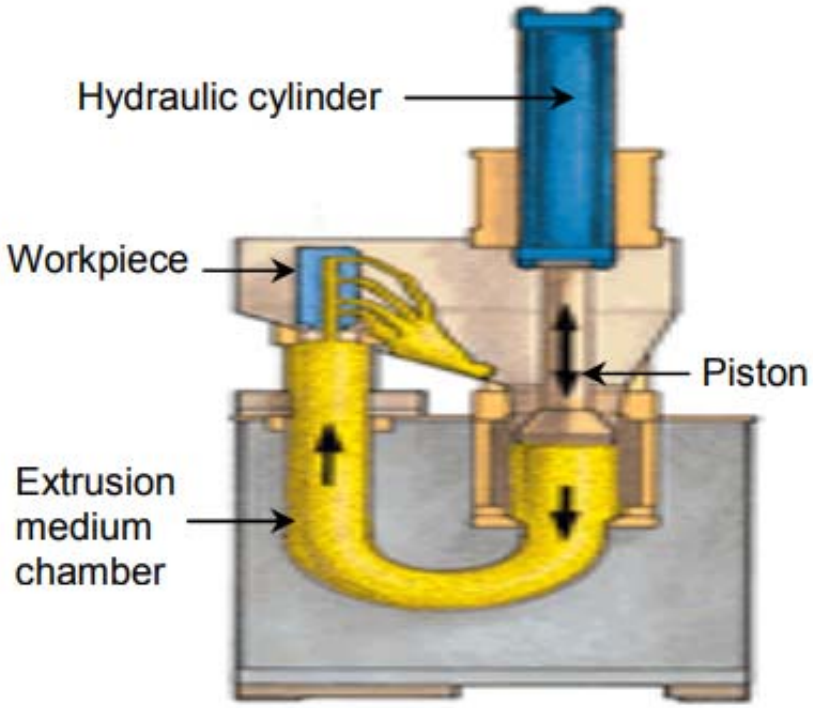


Abrasive Media

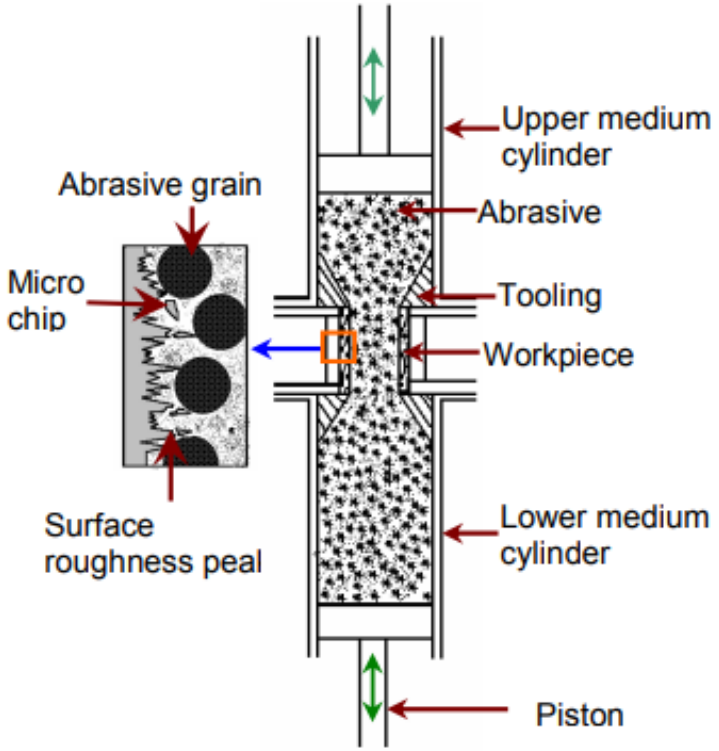
- AFM medium is a pliable material that is resilient enough to act as a self-forming grinding stone when forced through a passageway
- The medium comprises a base and abrasive particles
- The base consists of an organic polymer and special hydrocarbon gels; the specific composition of the base determines the degree of stiffness exhibited by the medium.
- The stiffest medium is used for abrading the largest holes
- For abrasion of small holes or long passages use softer medium is used
- Abrasive used: aluminum oxide, silicon carbide, boron carbide, and diamond.



Classification of AFM machine

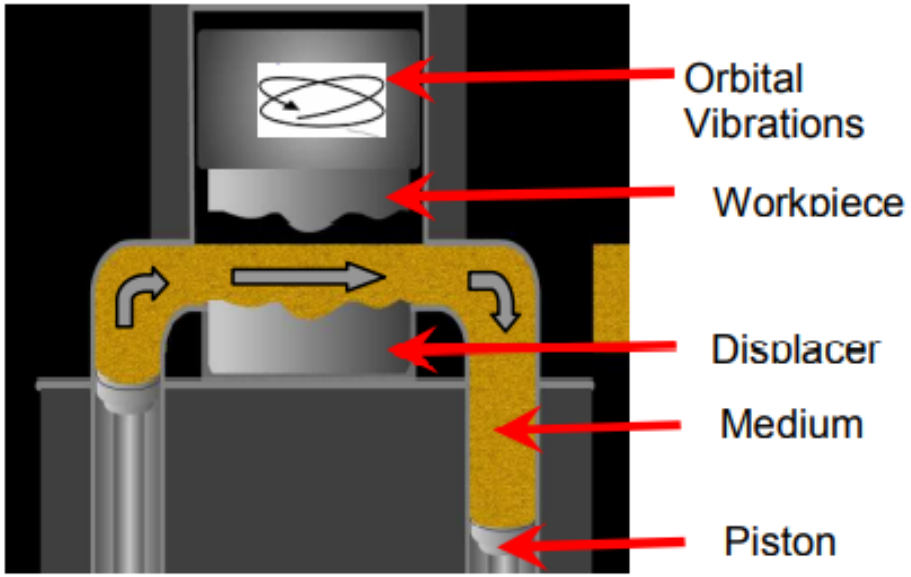


Unidirectional AFM process

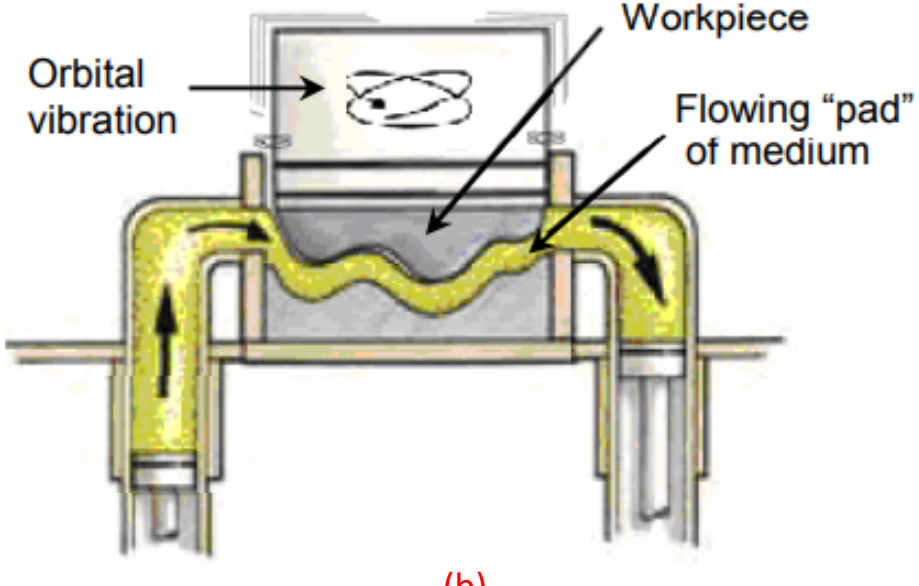


Two Way AFM

Classification of AFM machine



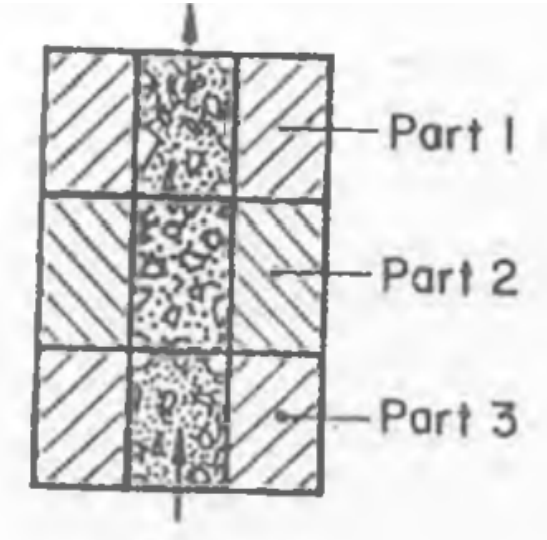
(a)



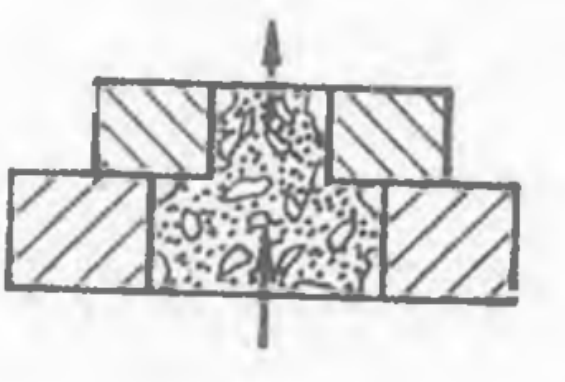
(b)

Orbital AFM (a) before start of finishing, (b) while finishing

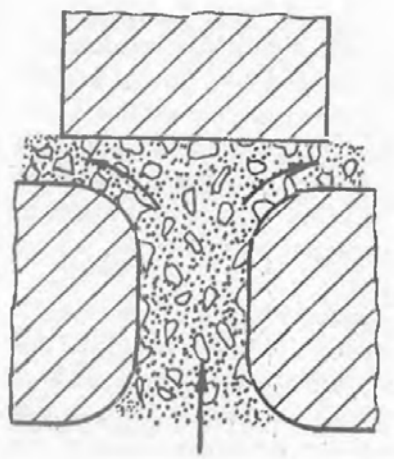
Finishing of Different Features of Part



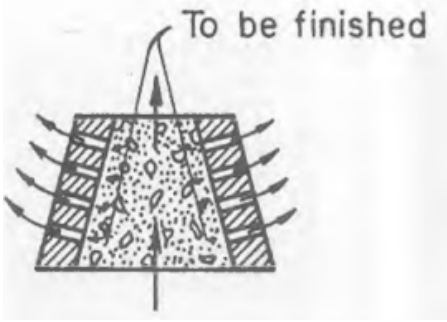
Finishing of two parts with same configurations.



Finishing of two parts but with different configurations



Finishing and radiusing of an internal hole



Deburring/finishing of inaccessible holes

Process Parameters

- The polishing media parameters:
  - Viscosity
  - Abrasive material
  - Abrasive mesh
  - Abrasive concentration
  - Temperature
- The AFM process parameters:
  - Pressure
  - Volume flow
  - Number of cycles
  - Machining time
- The workpiece parameters:
  - Material hardness
  - Roughness
  - Pre-machining process
  - Texture orientation
  - Workpiece shape

Process Parameters

- Slurry base: organic polymer and special hydrocarbon gels
- Abrasive: aluminum oxide, silicon carbide, boron carbide, and diamond
- Abrasive Size: 20 – 1000 microns
- Flow rate: 7-350 L/min
- Cycles: 3 to several hundred
- Pressure: 6-200 bar
- Surface finish: upto 50 nm

Advantages and Disadvantages

- Advantages
  - Debur, polish, and radius in one operation
  - More repeatable than manual method
  - Finish inaccessible area
  - Batch production
  - Faster than manual
- Disadvantages
  - Fixtures can be expensive
  - High capital investment
  - Can not process blind holes

Applications

Internal passages within turbine engine diffuser

Medical implants

Complex automotive engine parts

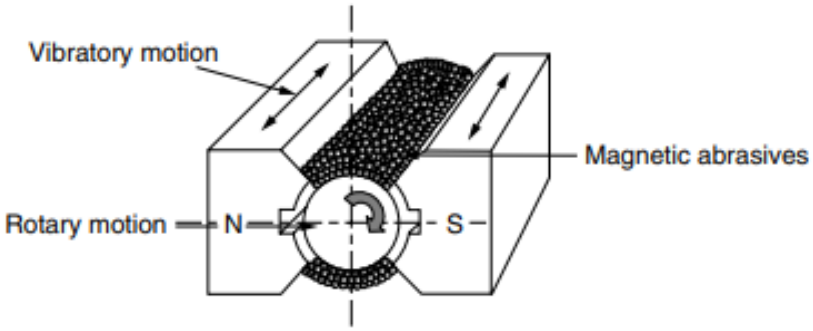
Video1: https://www.youtube.com/watch?v=2QBc59YZYxA
Video2: https://www.youtube.com/watch?v=pnnpGR7mE44

Magnetic Abrasive Finishing (MAF)

- Magnetic field–assisted polishing is a nonconventional process in which the machining forces are controlled by a magnetic field.
- Granular magnetic abrasive composed of ferromagnetic material and abrasive grains
- The necessary finishing pressure is applied by electro-magnetically generated field.
- Magnetic abrasive finishing (MAF), uses a brush of magnetic abrasives for finish machining

Machining System

- A cylindrical workpiece is clamped into the chuck of the spindle that provides the rotating motion
- The workpiece can be a magnetic or a nonmagnetic (ceramic) material
- Axial vibratory motion is provided by the oscillating motion of the magnetic poles relative to the workpiece
- A mixture of fine abrasives held in a ferromagnetic material (magnetic abrasive conglomerate) is used



Process Parameters

- Workpiece circumferential speed
- Axial vibration amplitude and frequency
- Magnetic flux density
- Working clearance
- Workpiece material
- Size of magnetic abrasive conglomerates
- Type of abrasives used
- Grain size
- Volume fraction in the conglomerate

Applications

- Polishing of balls and rollers
- Finishing of inner tube surface
- Polishing of fine components such as printed circuit boards
- The removal of oxide layers and protective coatings
- Chamfering and deburring of gears and cams
- Automatic polishing of complicated shapes
- Polishing of flat surfaces

References

- V. K. Jain, Advanced Machining Processes, Allied Publishers, 2009
- Hassan El-Hofy, Advanced Machining Processes, McGraw-Hill Prof Med/Tech, 2005
- Helmi Youssef, Non-Traditional and Advanced Machining Technologies, CRC Press, 2020
- V. K. Jain et al., Abrasive flow machining (AFM): An Overview, 2008