



Abrasive Flow Machining (AFM)

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Goals

- Getting basic knowledge about AFM
- Clasification of AFM
 - One-way AFM
 - Two-way AFM
 - Orbital AFM
- Application areas of AFM
- Research areas of AFM

Outline

- What is AFM ?
- Why a smooth surface?
- Classification of AFM machine
- Key Components of AFM Process
- Process input Parameters
- Operating Range
- Properties of AFM
- One-way AFM (advantages)
- Two-way AFM (advantages)
- Orbital AFM (advantages)
- Monitoring of AFM Process
- Research Areas of AFM
- Applications of AFM
- Summary
- References

What is AFM ?

- Developed method in 1960s, by Extrude Hone Corporation
 - AFM can
 - Polish and deburr parts internally
 - Through holes
 - Intersecting holes
 - Calibrate fuel injection nozzles to a specific flow rate
- A method to radius difficult to reach surfaces like intricate geometries
- Produce surface finish (Ra) as good as 0,05 μm deburr holes as small as 0,2 mm radius edges from 0,025 mm to 1,5 mm
- Widely used finishing process to finish complicated shapes and profiles

Why a Smooth Surface?

Reduction in Friction

- Aerospace



Torque and Fuel Economy

- Engine



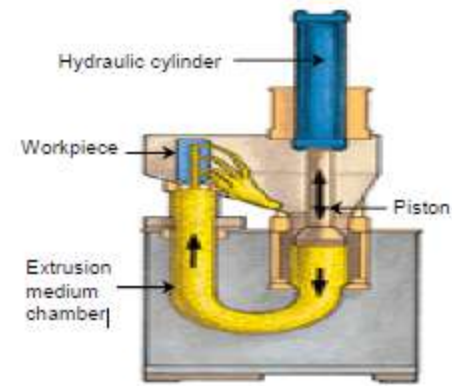
Eliminate imperfection

- Medicine

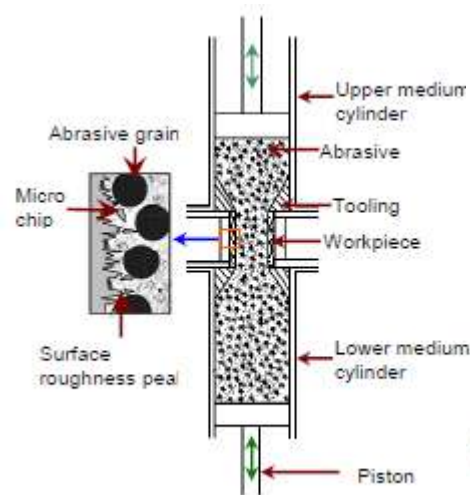


Classification of AFM Machine

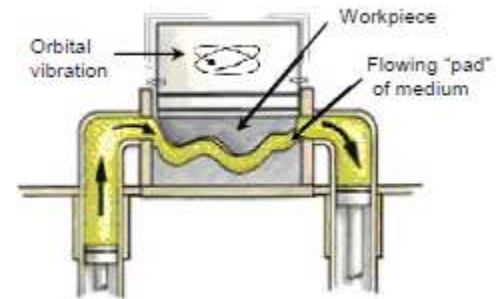
One-way AFM



***Two-way
AFM***



Orbital AFM



Key Components of AFM Process

- **Machine** :One –way AFM, Two-way AFM, Orbital AFM
- **Tooling**: Workpiece - Drill bit - Fixture plate - Fixture - Piston - Cylinder
- **Abrasive medium**:The medium that is needed to be polished, deburred or finished.

Process Input Parameters of AFM

- Extrusion Pressure
- Number of cycles
- Grit composition and Type
- Tooling
- Fixture design

Operating range of AFM

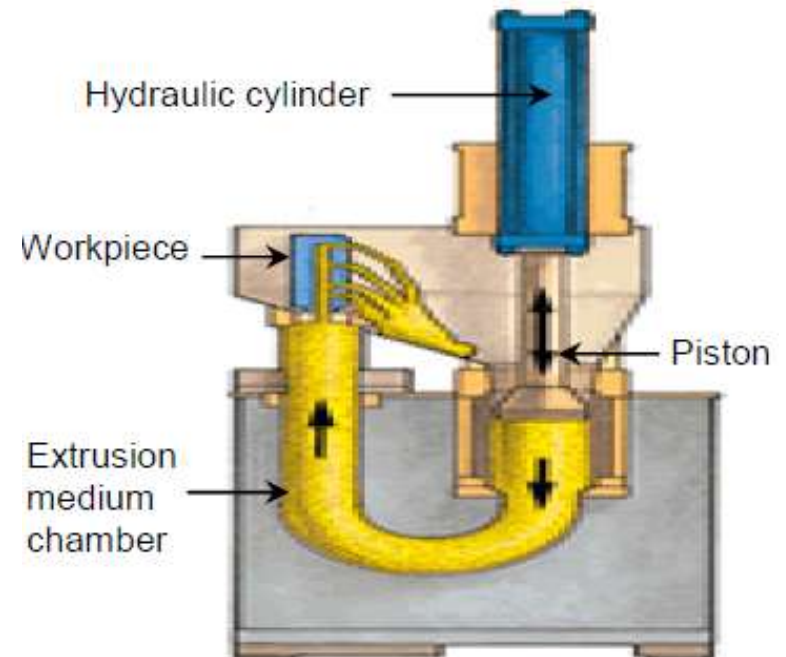
- Easy flowability
- Better self deformability
- Fine abrading capability
- Layer thickness of material removed is, order of about $1\ \mu\text{m}$ to $10\ \mu\text{m}$
- Best surface finish that has been achieved as 50nm and tolerances $\pm 0,5\ \mu\text{m}$

Properties of AFM

- Deburring , radiusing, and polishing are performed simultaneously in a single operation
- AFM can produce true round radii even on complex edges
- Reduces surface roughness by 75 to 90 % on cast and machined surfaces
- AFM can process dozens of holes or multiple passages parts simultaneously with uniform results

One-Way AFM

- One-way flow AFM processing pushes abrasive media through the work piece in only one direction, allowing the media to exit freely from the part.

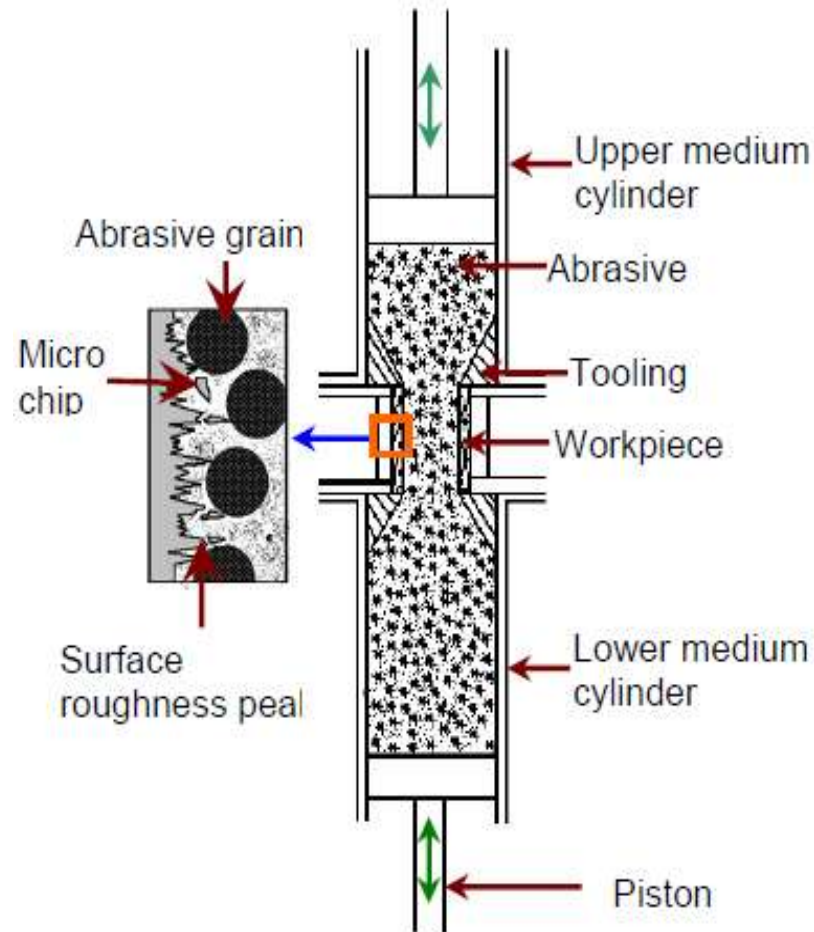


The advantages of One Way AFM

- Faster cycle processing
- Easy clean-up
- Media temperature control generally not required
- Able to process larger parts
- Simpler tooling and part change-over
- Accurately replicates air or liquids natural flow
- Does not encapsulate workpart in media

Two-Way AFM

The typical two-way flow AFM process uses two vertically opposed cylinders to extrude an abrasive media back and forth through or around passages formed by the workpiece and tooling. Abrasive action occurs wherever the media enters and passes through the most restrictive passages



Advantages of Two-Way AFM

- Excellent process control
- Can finish both ID and OD of component
- Good control of radius generation
- Fully automated system capabilities
- Faster setup & quick-change tooling
- Faster change-over of media

Orbital AFM

- Surface and edge finishing are achieved by rapid, low-amplitude, oscillations of the work piece relative to a self-forming elastic plastic abrasive polishing tool.
- The tool is a pad or layer of abrasive-laden elastic plastic medium (similar to that used in two way abrasive flow finishing), but typically higher in viscosity and more in elastic.

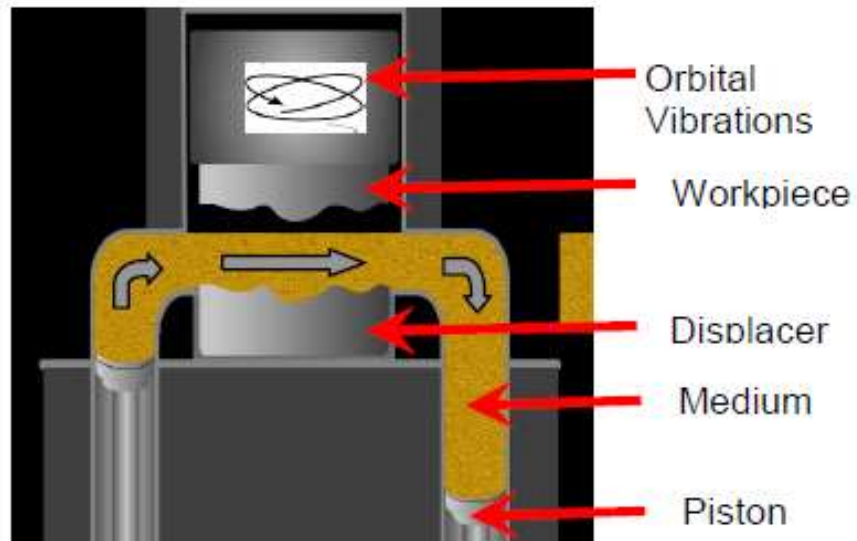


Figure: Before start of finishing

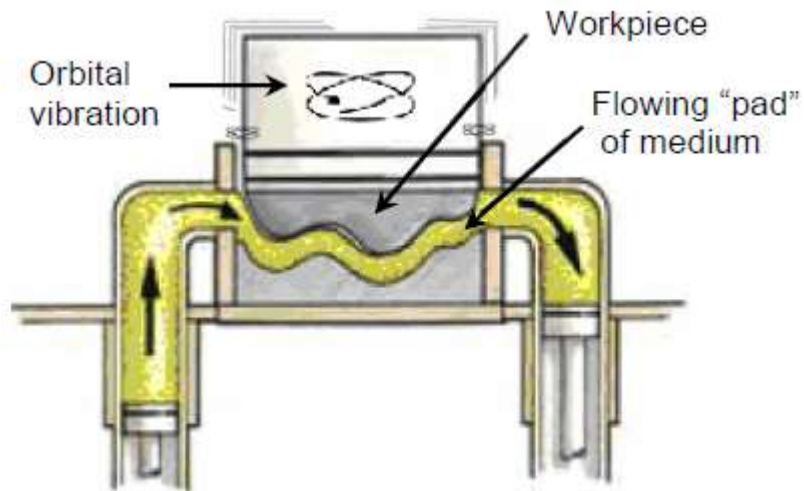
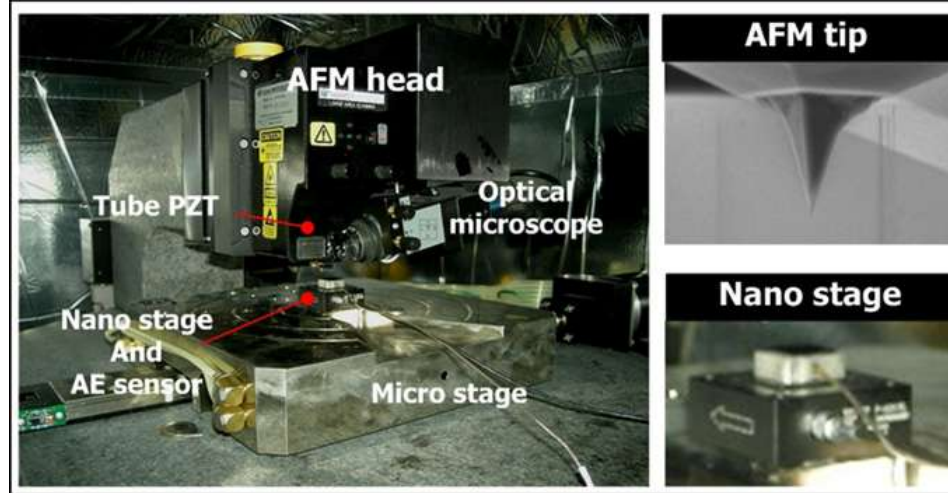


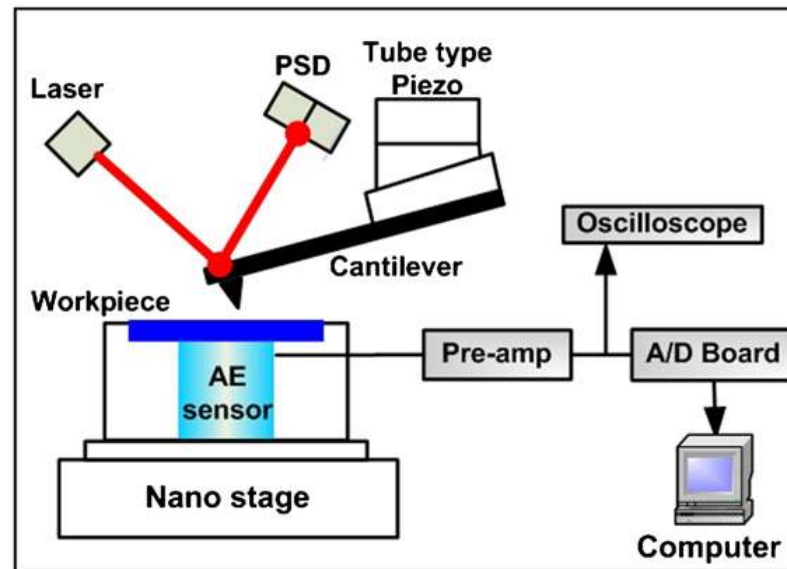
Figure: While finishing

Monitoring of AFM process

- For online monitoring of material removal and surface roughness in AFM process, Williams and Rajurkar applied *acoustic emission technique*.
- They developed a stochastic model of AFM generated surfaces by using Data Dependent Systems (DDS) methodology.
- It was established in their research that AFM finished surface profiles possess two distinct wavelengths, a large wavelength that corresponds to the main path of abrasive while the small wavelength is associated with the cutting edges.



(a)



(b)

AFM machining and monitoring system

(a) AFM machining and monitoring setup;

(b) schematic of the process monitoring system.

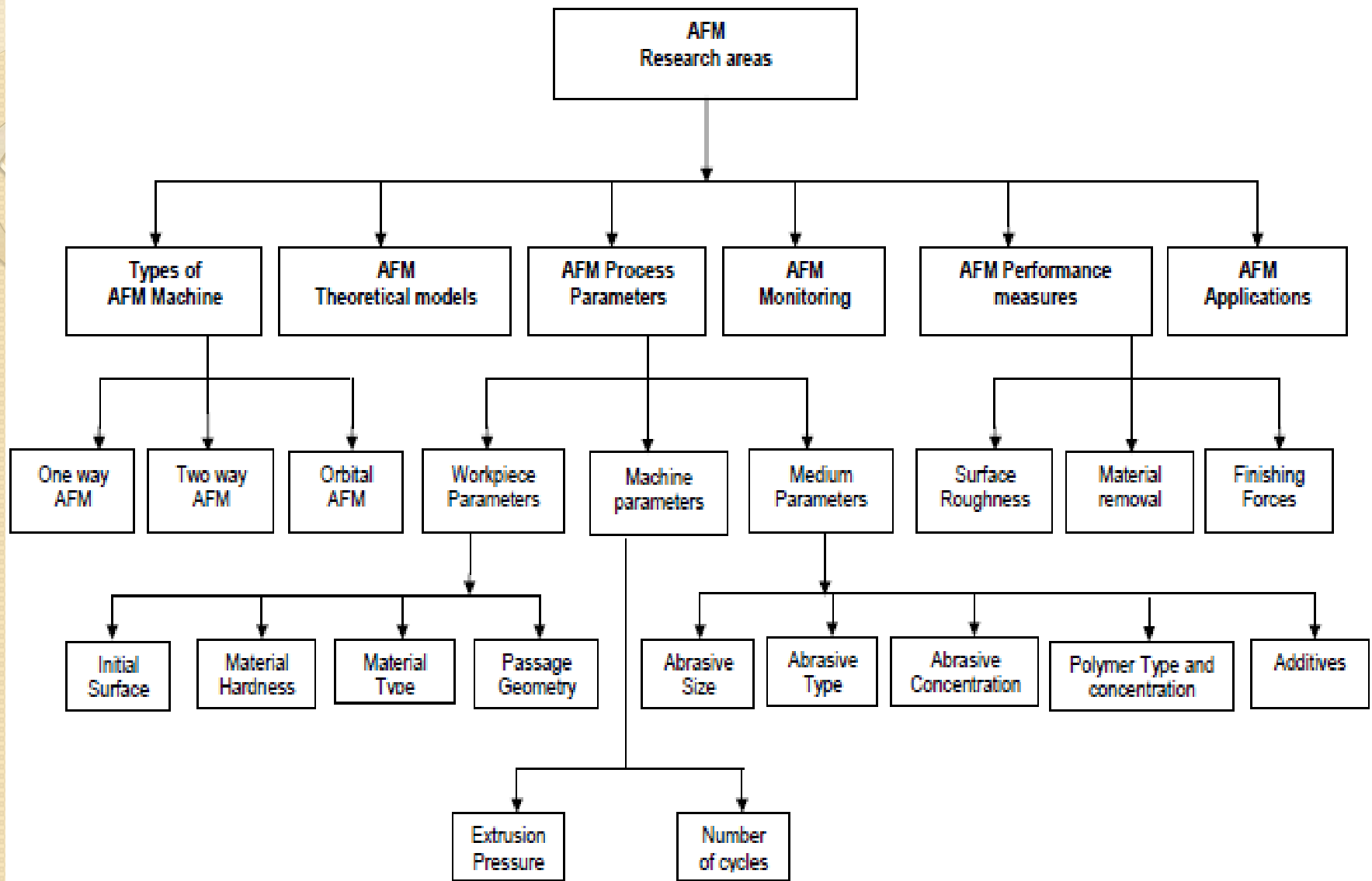
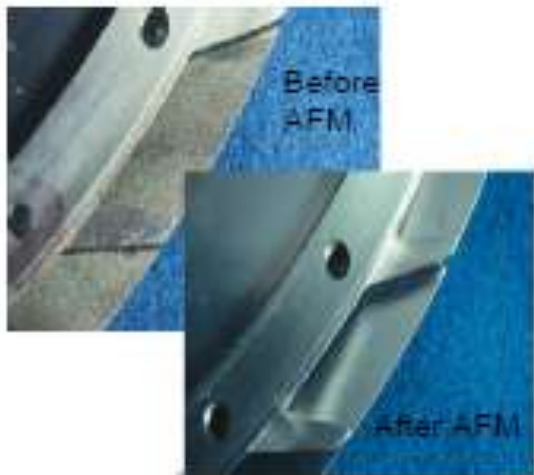


Figure: Classification of major AFM research areas

Application of AFM

- Automotive
- Aerospace
- Medicine
- Dies and Moulds

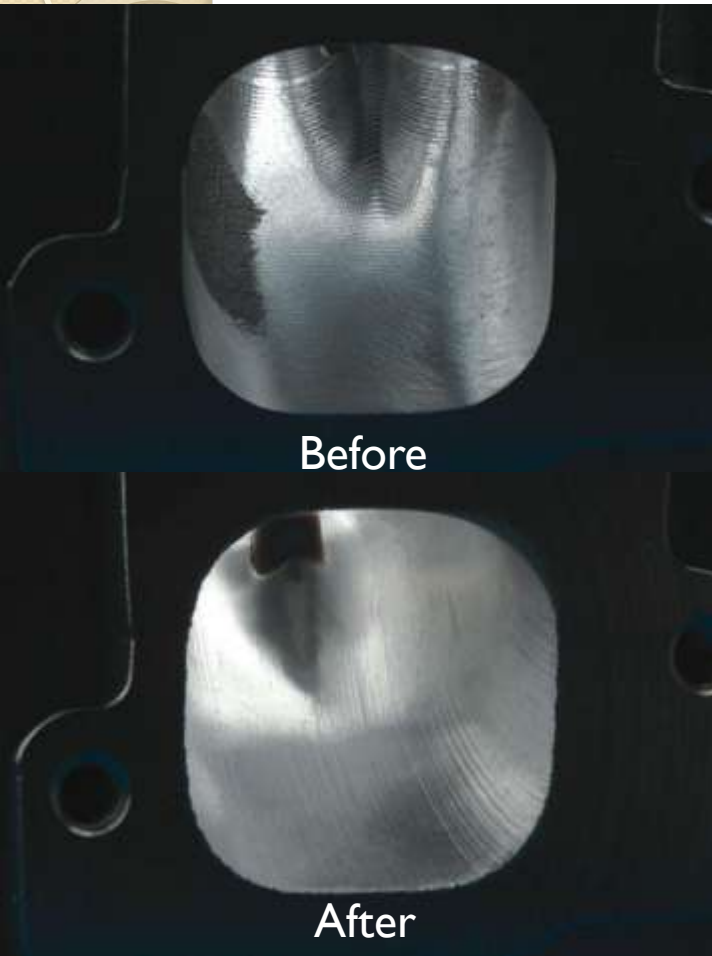


AFM in Aerospace Industry

- Improved surface quality
- Enhanced high cycle fatigue strength
- Optimized combustion and hydraulics
- Increased airflow
- Extended component life



AFM in Automotive Industry



- Enhanced uniformity and surface quality of finished components
- Increased engine performance
- Increased flow velocity and volume
- Improved fuel economy and reduced emissions
- Extended work piece life by reducing wear and stress surfaces

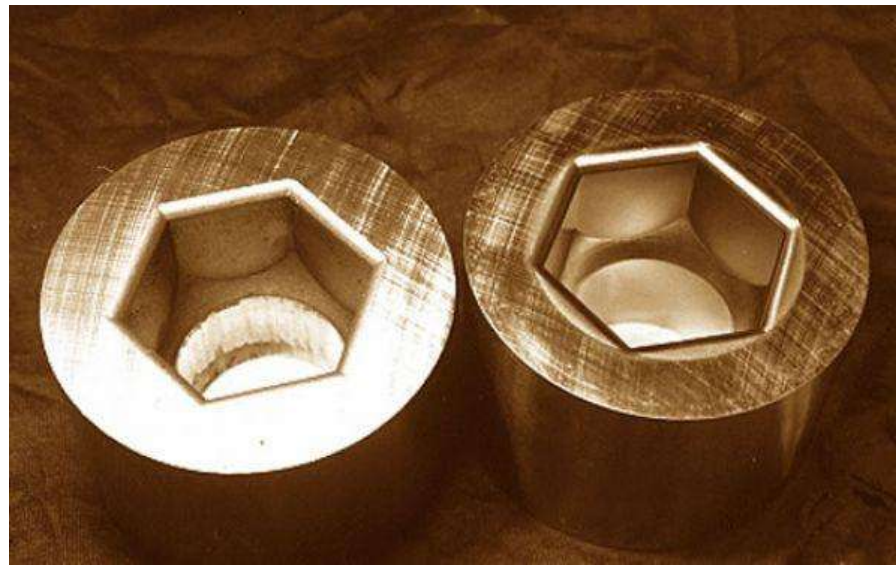
Figure : Grains in the same direction to increase flow rates.



Figure :Polishing and blending the internal surfaces

AFM in Dies and mold Industry

- Reduced production costs
- Increased production throughput
- Enhanced surface uniformity, finish and cleanliness
- Improved die performance and extend life of dies and molds



AFM in Medical Industry

- Eliminate the surface imperfections where dangerous contaminants can reside
- Improved functionality, durability and reliability of medical components
- Enhanced uniformity and cleanliness of surfaces,
- Extended component life



Figure: Medical implant

Summary

- Possible to control and select the intensity and location of abrasion
- Produces uniform, repeatable and predictable results on an impressive range of finishing operations.
- Maintain flexibility and jobs which require hours of highly skilled hand polishing can be processed in a few minutes
- Process used in **aerospace**, **medical** and **automobile** industries
- Better surface roughness values and tight tolerances.
- Disadvantage of this process is low finishing rate
- Better performance is achieved if the process is monitored online.
- Improve surface quality
- Reduction in Friction
- Eliminate imperfection

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Thank You...