SNS COLLEGE OF ENGINEERING

(An autonomous institution)

Department of Mechanical Engineering

Unit – I

Abrasive Jet Machining

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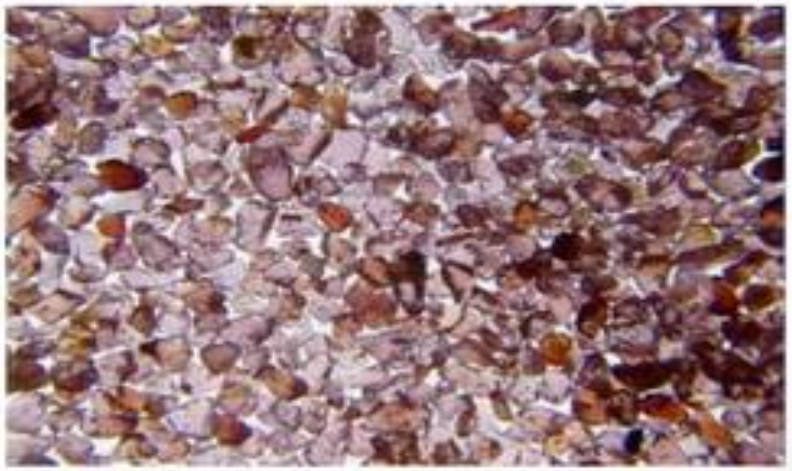
DEFINITION

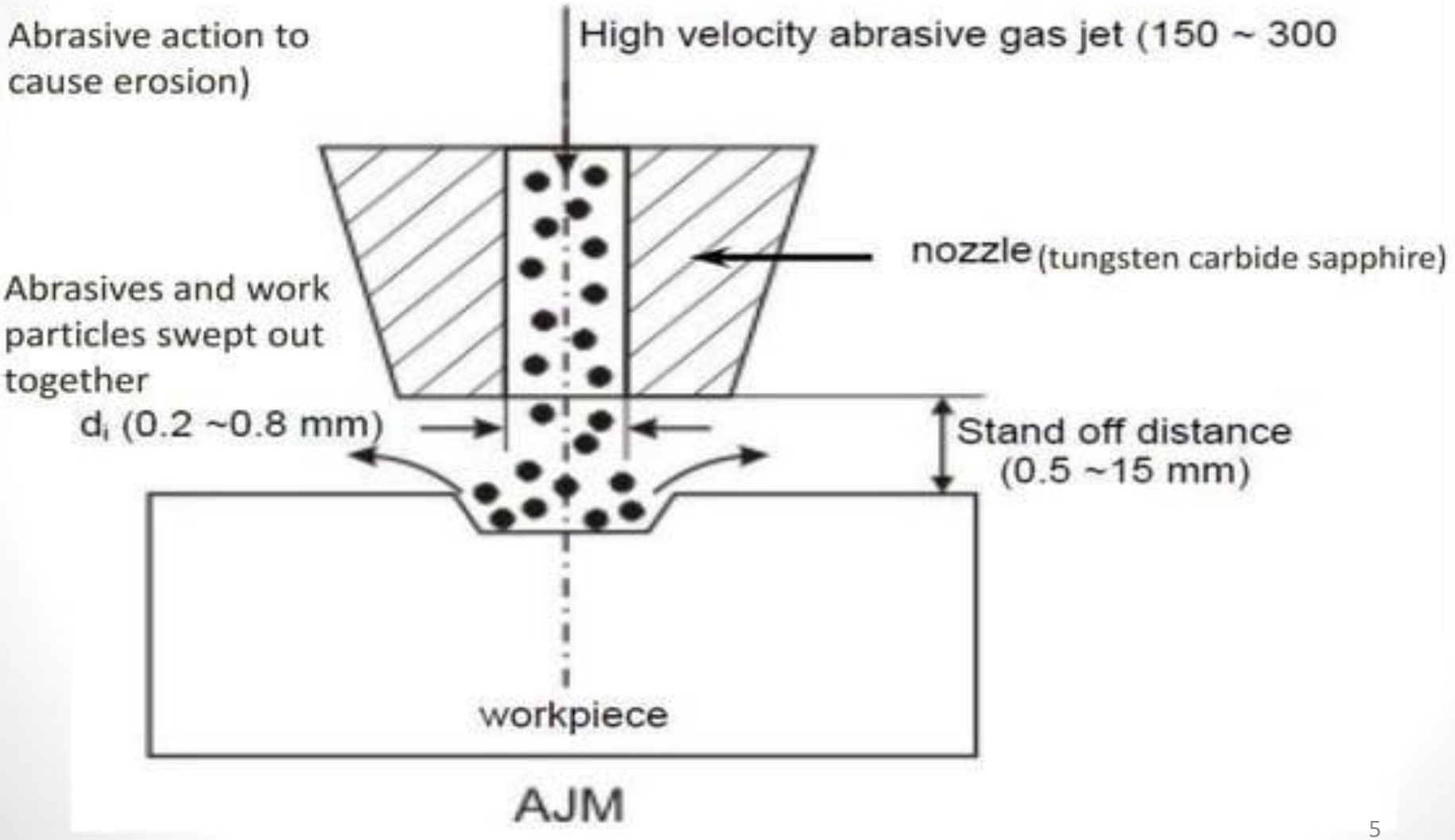
- It is the material removal process where the material is removed by high velocity stream of air/gas or water and abrasive mixture
- A focused stream of the abrasive particles, carried by high pressure air or gas is made to impinge on the work surface through a nozzle and work material is removed by erosion by high velocity abrasive particles.



PROCESS PRINCIPLE

- Abrasive particles are made to impinge on work material at high velocity.
- Abrasive particles is carried out by carrier gas/air.
- High velocity stream of the abrasives is generated by converting pressure energy of carrier gas or air to its kinetic energy and hence high velocity jet.
- Nozzles directs the abrasive jet in a controlled manner onto workpiece.
- **Metal cutting action by micro-cutting as well as the brittle fracture of the work material.**
- Different from conventional sand blasting/shot blasting, finer abrasive grits are used and process or machining parameters are easily controllable.

PROCESS PRINCIPLE (contd.)

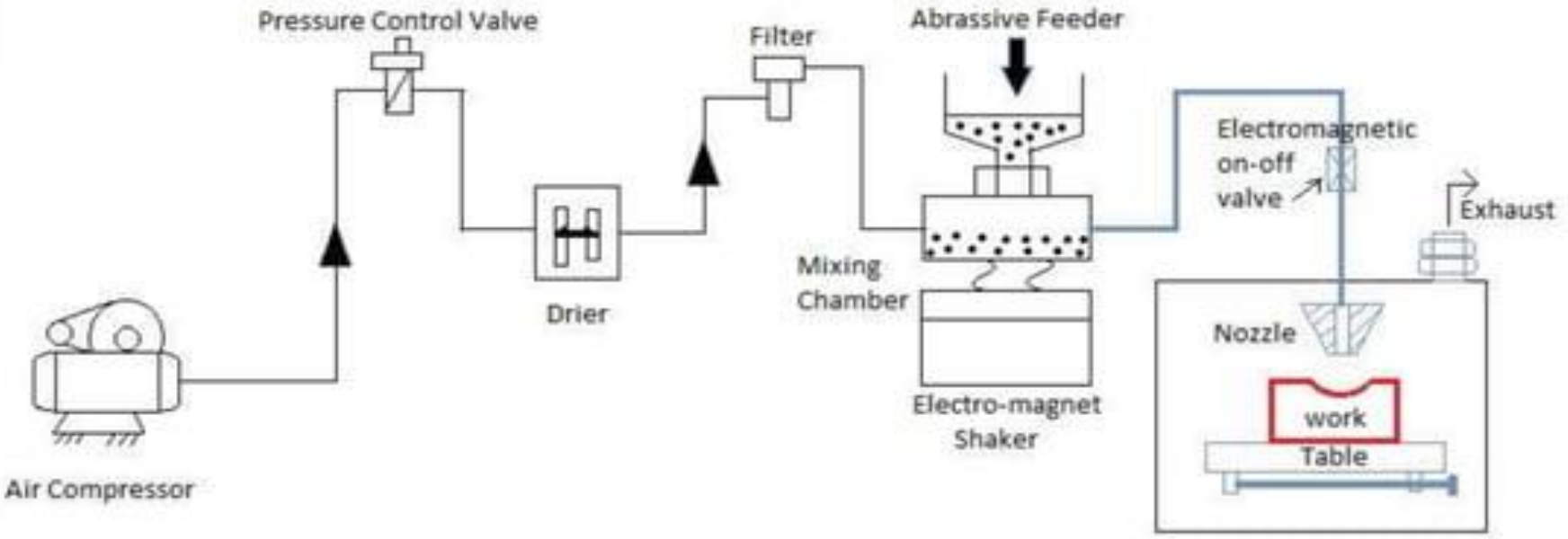


Mechanism

1. Fine particles (0.025mm) are accelerated in a gas stream.
2. The particles are directed towards the focus of machining.
3. As the particles impact the surface, it causes a micro fracture, and gas carries fractured particles away.

- Abrasives used:
  1. Aluminium oxide
  2. Silicon carbide
  3. Sodium bicarbonate
  4. Dolomite
  5. Glass beads

Equipment



1. Gas propulsion system
2. Abrasive feeder
3. Machining chamber
4. AJM nozzle
5. Abrasives

Machining system

1. Gas propulsion system
    1. Air, Nitrogen & Carbon dioxide
    2. Oxygen in pure form is not used because of its violent chemical action with workpiece chips or abrasive particles.
    3. Supplied at 2 – 8 kg/cm^2
2. Abrasive feeder
    1. Abrasive particles are fed through a sieve vibrating at 50-60 Hz.
    2. Mixing ratio is controlled by the amplitude of vibration of sieve.
    3. Particles are propelled by the carrier gas to the mixing chamber and then to the nozzle.
3. Machining chamber
    1. Equipped with vacuum dust collector.

Machining system(Contd.)

4. Pump

- Crankshaft & intensifier pump are mainly use in the abrasive jet machine .
- The intensifier pump was the only pump capable of reliably creating pressures high .
- Crankshaft pumps are more efficient than intensifier pumps because they do not require a power robbing hydraulic system ultra high pressure & more stroke per minute.

5. AJM Nozzle

- Tungsten carbide(20-30) or sapphire(300) – resistance to wear.
- Circular(0.2 to 1mm) or rectangular(0.075x0.5/0.15x2.5) cross-section.
- Head- straight or at right angle.
- Loss of pressure due to the bends, friction is minimum possible.

Machining system(Contd.)

6. Abrasives

ABRASIVES	GRAIN SIZE	APPLICATION
Aluminium oxide	12/20/50 microns	Cleaning, cutting and deburring (for brass and aluminium)
Silicon carbide	25,40 micron	For hard material (for SS and ceramics)
Glass beads	0.635 to 1.27mm	Light polishing and fine deburring
Dolomite	200 mesh/ 66 microns	Etching and polishing
Sodium Carbonate	27 microns	Light finish below 50'C (for nylon and tylon)

Process Parameters

- Process criteria:
  - Material removal rate
  - Geometry and surface finish of workpiece.
  - Wear rate of nozzle

- Process criteria are influenced by process parameters:
  - Abrasives
  - Carrier Gas
  - Abrasive jet
  - Nozzle

Process Parameters

Abrasives

a) Material – Al_2O_3; SiC; glass beads.

b) Shape – irregular/regular

c) Size – 10 to 50 microns

d) Mass flow – 2-20 gm/min

Carrier Gas

a) Composition – Air, CO_2, N_2

b) Density – 1.3 kg/m_3

c) Velocity - 500 to 700 m/s

d) Pressure - 2 to 10 bar

e) Flow rate - 5 to 30 microns

Abrasive Jet

a) Velocity - 100 to 300 m/s

b) Stand off distance (SOD)– 0.5 to 15mm.

c) Impingement angle – 60 to 90 deg.

Nozzle

a) Material – WC/Sapphire

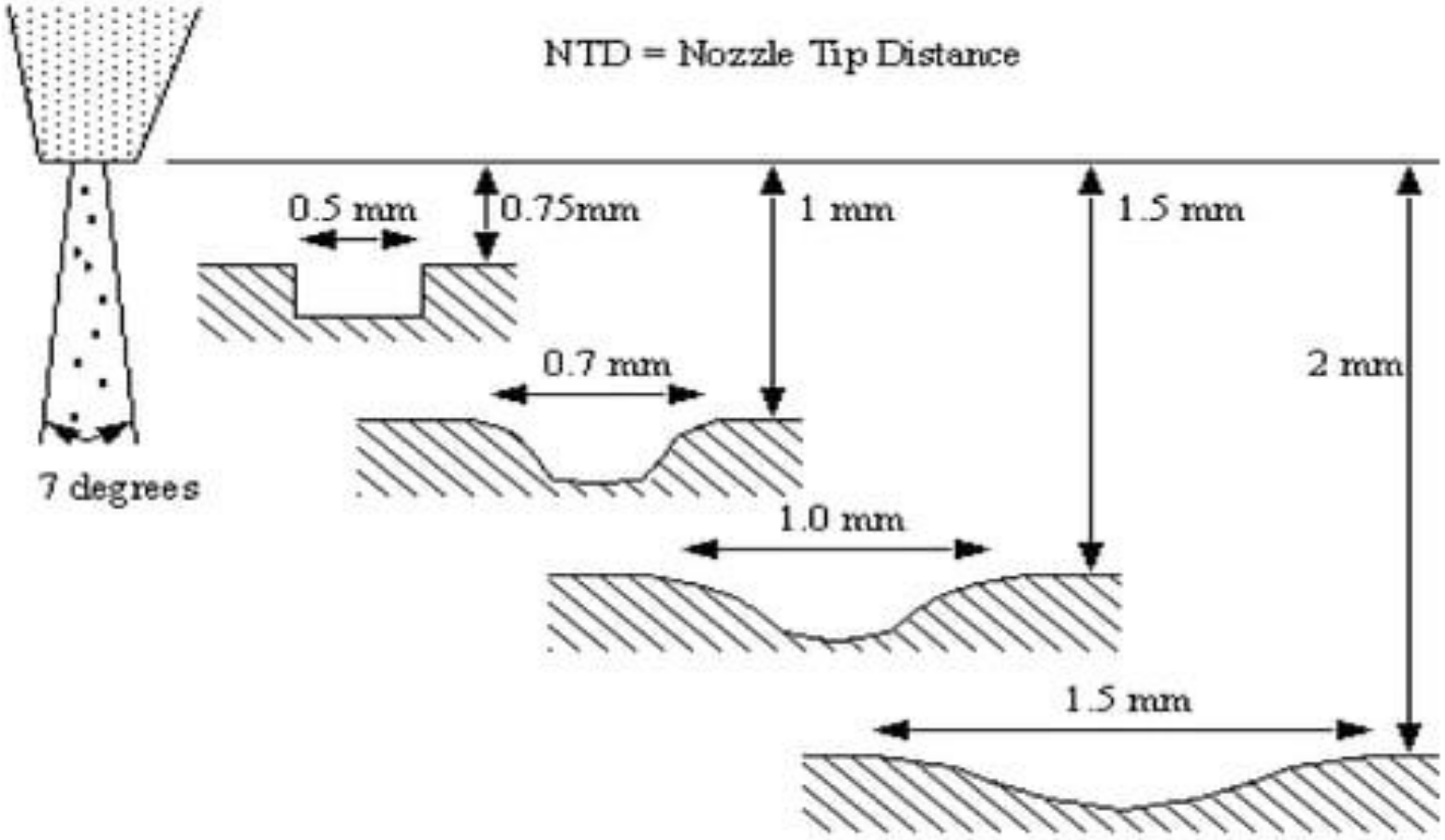
b) Diameter – 0.2 to 0.8 mm

c) Life – 300 hours for sapphire, 20 to 30 hours for WC

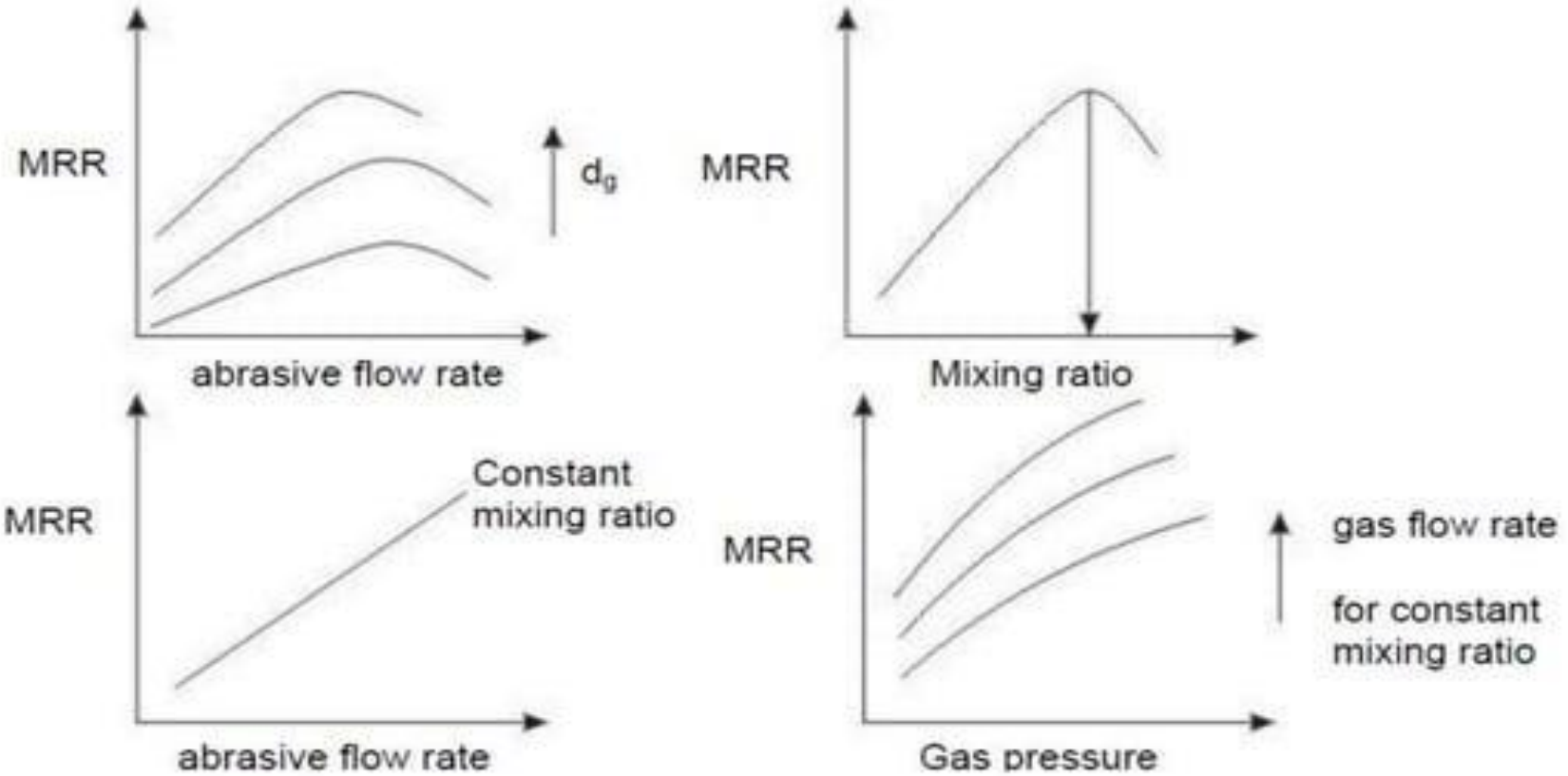
Process Capability

- Material removal rate – 0.015 cm^3/min
- Narrow slots – 0.12 to 0.25mm ± 0.12mm
- Surface finish -0.25 micron to 1.25 micron
- Sharp radius up to 0.2mm is possible
- Steel up to 1.5mm ,Glass up to 6.3mm is possible to cut
- Machining of thin sectioned hard and brittle materials is possible.

Stand off distance (NTD)

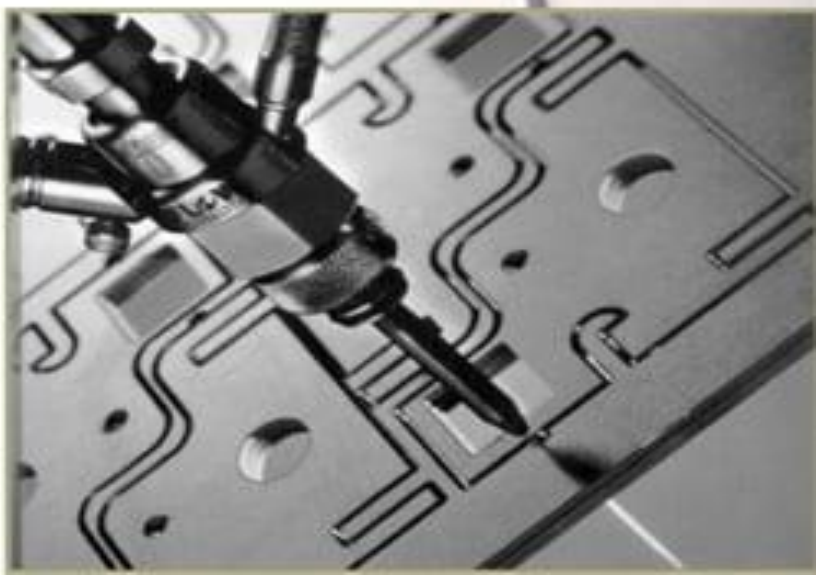


Effect of process parameters on MRR



Applications

- Abrading/frosting of glass
- Cleaning of metallic smears on ceramics, oxides on metals , resistive coating etc.
- Manufacture of electronic device, drilling of glass wafers, deburring of plastics, making of nylon and teflon parts, permanent marking on rubber utensils etc.
- Engraving registration numbers on toughened glass used for car windows.
- For cutting thin fragile components- Germanium/silicon etc.
- For drilling, cutting, deburring, etching and polishing of hard and brittle materials.



Advantages

1. High surface finish can be obtained depending upon the grain sizes.
2. Depth of damage is low (around 2.5 microns).
3. It provides cool cutting action, so it can machine delicate and heat sensitive material.
4. Process is free from chatter and vibration as there is no contact between the tool and work piece
5. Capital cost is low and it is easy to operate and maintain AJM.
6. It has the capability of cutting holes of intricate shape in hard materials.

Disadvantages

1. Abrasives may get embedded in the work surface, especially while machining soft material like elastomers or soft plastics.
2. The accuracy of cutting is hampered by tapering of hole due to unavoidable flaring of abrasive jet.
3. Stray cutting is difficult to avoid.
4. Nozzle life is limited (300 hours).
5. Abrasive powders cannot be reused as the sharp edges are worn and smaller particles can clog the nozzle.

Abrasive Jet Machining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