ABRASIVE JET MACHINING (AJM)

• Principle

– A high speed stream of abrasive particles mixed with high pressure air or gas are injected through a nozzle on the workpiece to be machined

Definition:

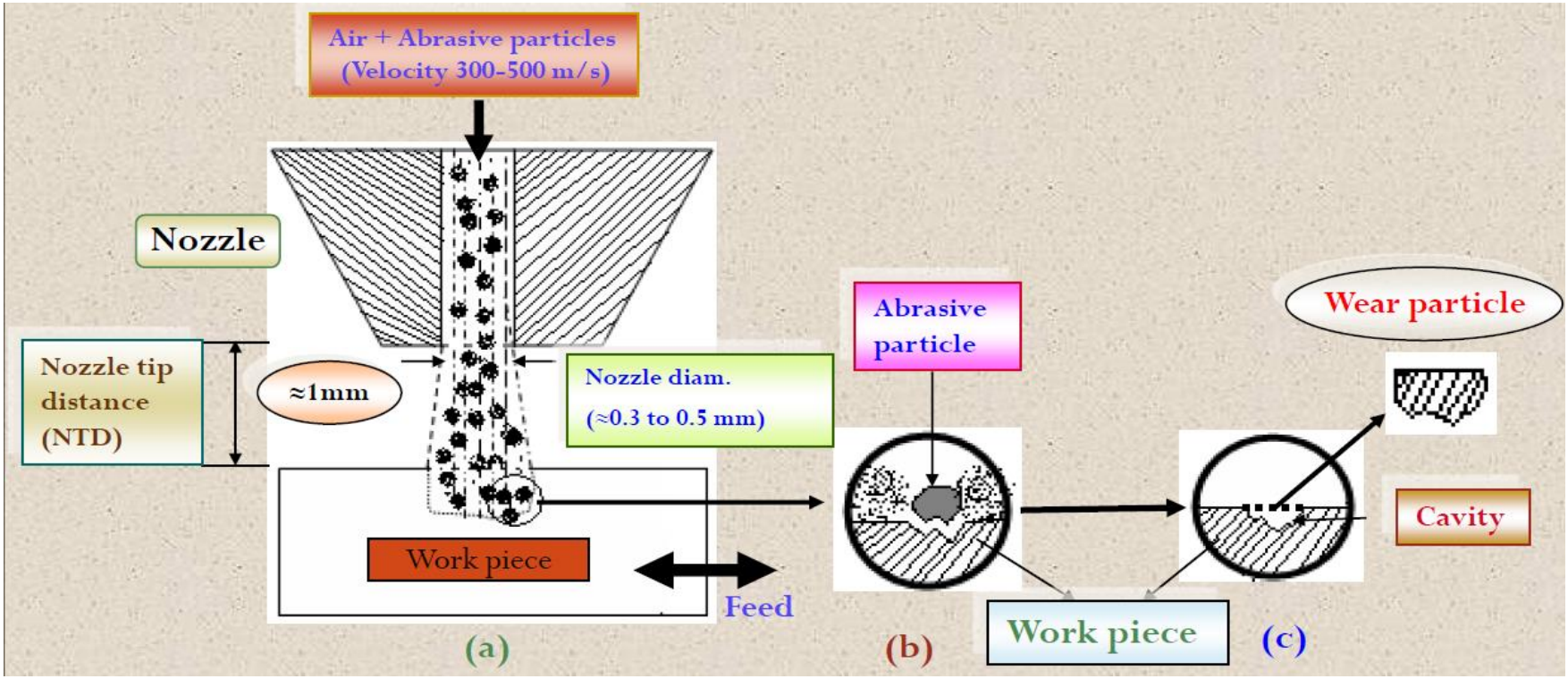
In abrasive jet machining, a focused stream of abrasive particles, carried by high pressure air or gas is made to impinge on the work surface through a nozzle and the work material is made to impinge on the work surface through a nozzle and work material is removed by erosion by high velocity abrasive particles.

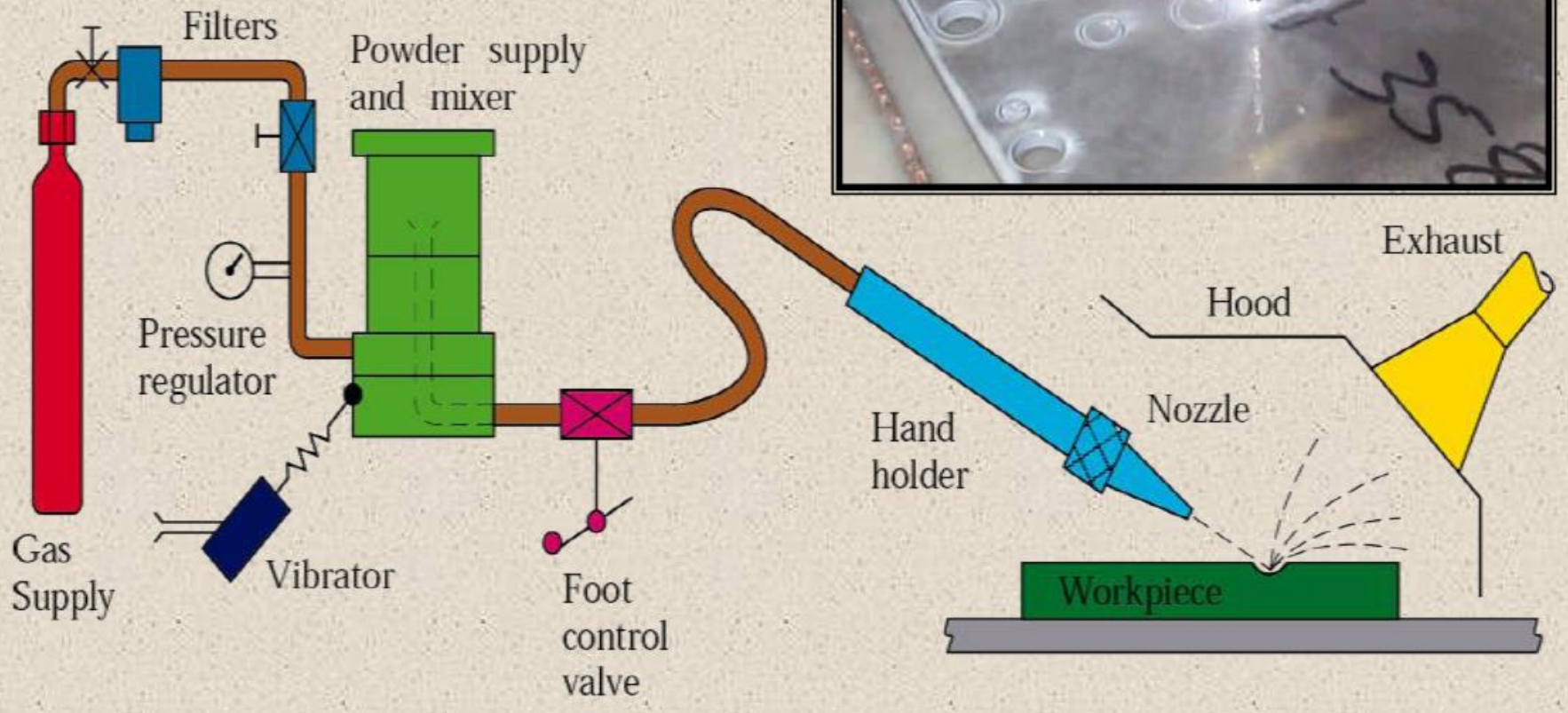
Process:

In Abrasive jet machining abrasive particles are made to impinge on work material at high velocity. Jet of abrasive particles is carried by carrier gas or air. The high velocity stream of abrasives is generated by converting pressure energy of carrier gas or air to its Kinetic energy and hence high velocity jet. Nozzles directs abrasive jet in a controlled manner onto work material. The high velocity abrasive particles remove the material by micro-cutting action as well as brittle fracture of the work material

This is a process of removal of material by impact erosion through the action of concentrated high velocity stream of grit abrasives entrained in high velocity gas stream. AJM is different from shot or sand blasting, as in AJM, finer abrasive grits are used and parameters can be controlled more effectively providing better control over product quality.

In AJM, generally, the abrasive particles of around 50 microns grit size would impinge on the work material at velocity of 200 m/s from a nozzle of ID 0.5mm with a stand off distance of around 2mm. The kinetic energy of the abrasive particles would sufficient to provide material removal due to brittle fracture of the work piece or even micro cutting by the abrasives.




Filters
Powder supply and mixer
Pressure regulator
Gas Supply
Vibrator
Foot control valve
Hand holder
Nozzle
Hood
Exhaust
Workpiece

Process parameters
– Mass Flow rate
– Abrasive grain size
– Gas pressure
– Velocity of abrasive particles
– Mixing ratio
– Nozzle tip clearance

Characteristics

Work material	Hard and brittle materials
Abrasive	Al_2O_3, SiC, glass powder
Size of abrasive	Around 25 microns
Flow rate	2 to 20 g/min
Medium	N_2 , CO_2 or air
Velocity	125 to 300m/s
Pressure	2 to 8 kg/centimetre square
Nozzle material	Tungsten carbide or synthetic sapphire
Life of nozzle	WC – 12 to 12 hrs Sapphire – 300 hrs
Nozzle tip clearance	0.25mm to 15mm
Tolerance	±0.05 mm
Machining operation	Drilling, deburring, cleaning

Advantages

– Process is suitable to cut all materials
– Even diamond can be machined using diamond abrasives
– No direct contact between tool and workpiece
– Low initial investment
– Good surface finish
– Used to cut intricate hole shapes

Disadvantages

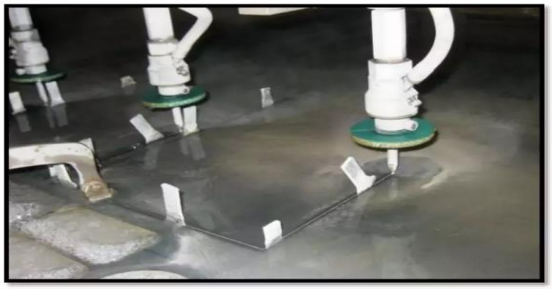
– MRR is slow
– Soft material cannot be machined
– Machining accuracy is poor
– Nozzle wear rate is high
– Abrasive powder once used can never be used again
– Requires some kind of dust collection system
– Cleaning is essential after the operation

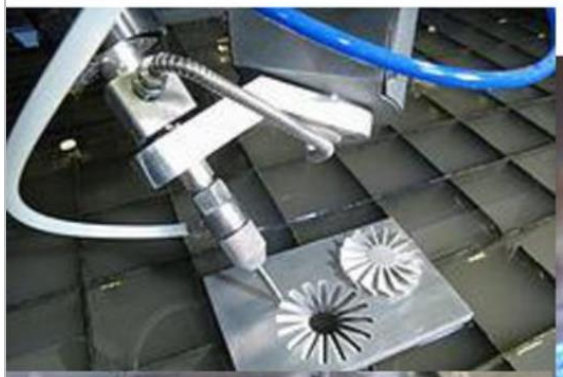
WATER JET MACHINING (WJM)

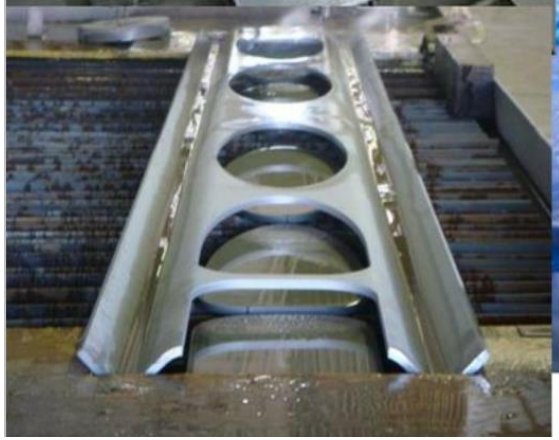
- ***Principle***

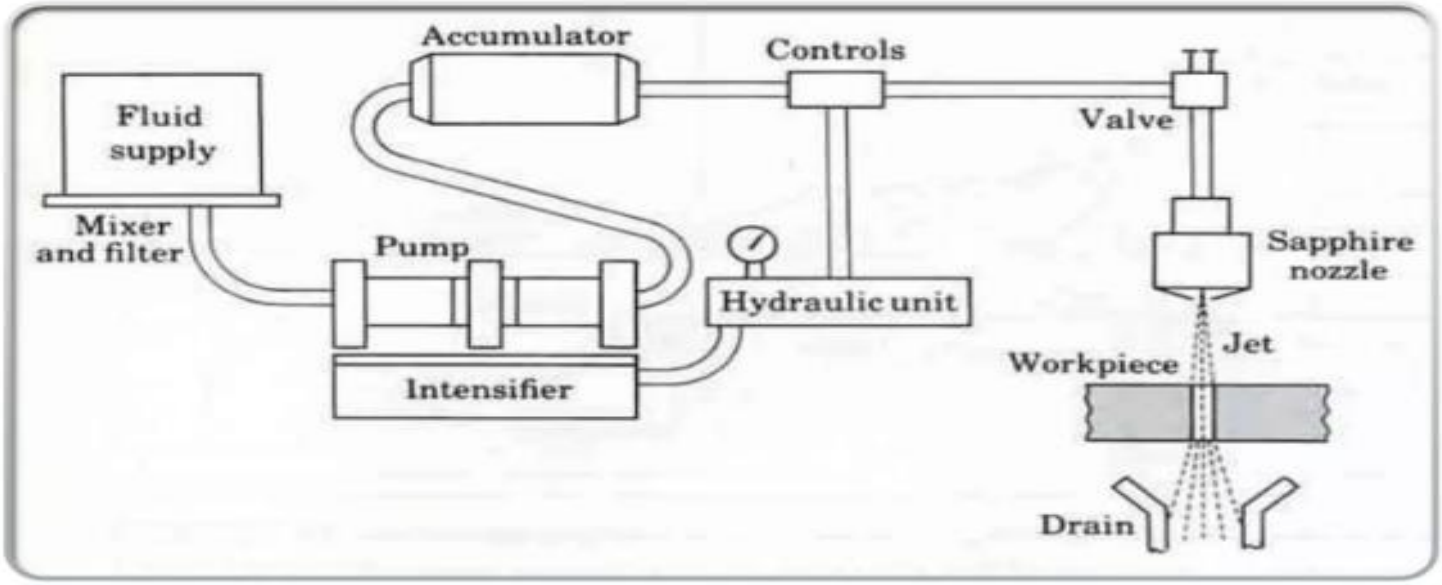
– When high velocity of water jet comes out of the nozzle and strikes the material, its kinetic energy gets converted into pressure energy inducing a high stress in the work material. When this stress exceeds the ultimate shear stress of the material, small chips of the material got loosened and fresh surface is exposed

– Used to cut paper boards, plastics, wood, fibre glass,
leather









SCHEMATIC LAYOUT OF WJM

Intensifier : The intensifier converts the energy from the low-pressure hydraulic fluid into ultrahigh-pressure water.

Accumulator:

Maintains the continuous flow of the high-pressure water and eliminates pressure fluctuations.

It relies on the compressibility of water (12 percent at 3800 bar) in order to maintain a uniform discharge pressure and water jet velocity, when the intensifier piston changes its direction.

Process parameters

– Material removal rate
– Geometry and surface finish of work material
– Wear rate of nozzle

Advantages

– Water is used as energy medium and hence it is cheap, non-toxic and easy to dispose
– Low operating cost
– Low maintenance cost
– Work area remains clean and dust free
– Easily automated
– No thermal damage to work

Disadvantages

– Initial cost is high
– Noisy operation
– Difficult to machine hard material

Characteristics

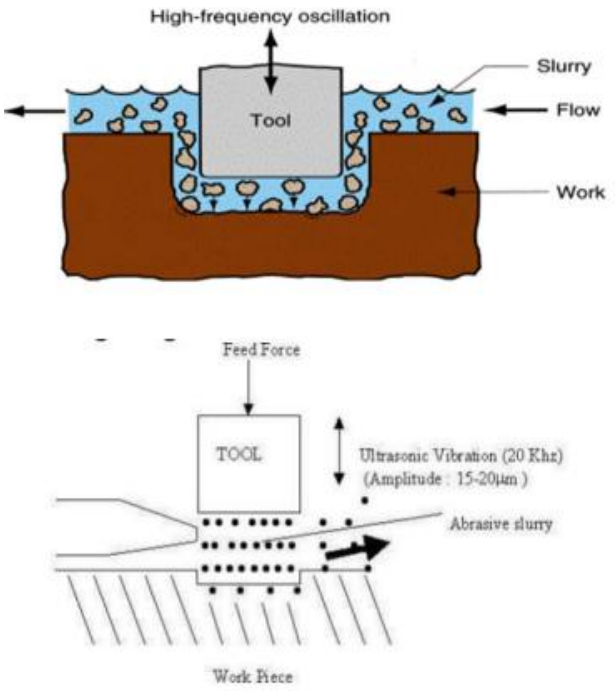
Work material	Soft and non-metallic materials
Tool	Water or water with additives
Additives	Glycerin, polyethylene oxide
Pressure of water	100 to 1000 Mpa
Mass flow rate	8 lit/min
Power	45 KW
MRR	0.6 Cu.m/S
Feed rate	1 to 4 mm/s
Nozzle material	Tungsten Carbide, synthetic sapphire
Stand off distance	2 to 50 mm

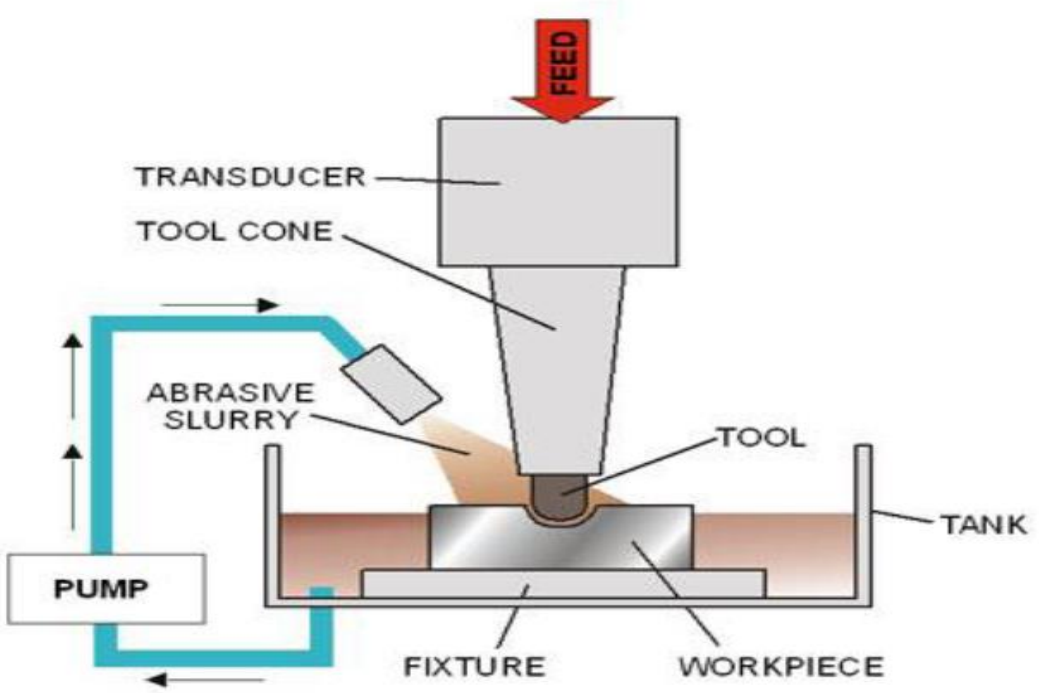
ULTRASONIC MACHINING (USM)

• Principle

– A slurry of small abrasive particles are forced against the work piece by means of a vibrating tool and it causes the removal of metal from the work piece in the form of extremely small chips – Also known as ultrasonic grinding or impact grinding

– Ultrasonic refers to high frequency – above 20khz



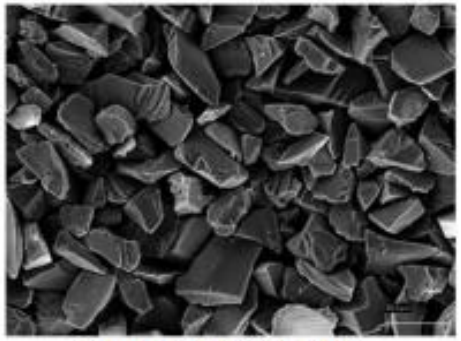


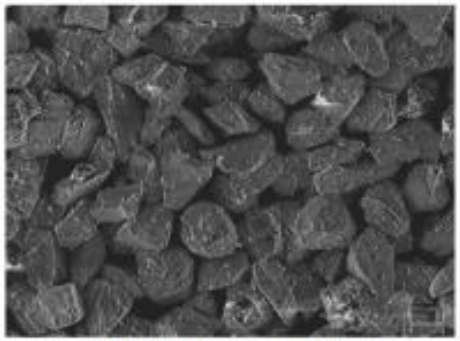
Components:

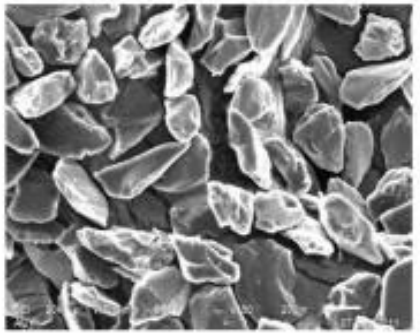
Ultrasonic Oscillator or Generator: - Converts electrical energy from low frequency to high frequency

Transducer: - Convert electrical energy to mechanical energy
- High frequency and low amplitude vibration –

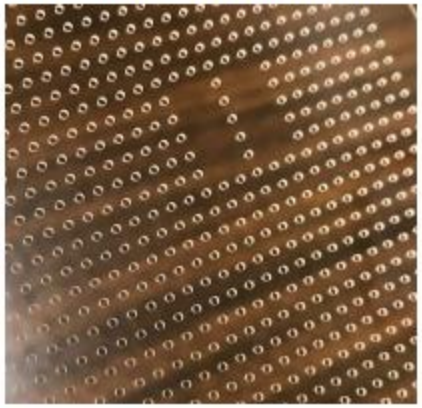
Abrasive Slurry
A mixture of fine abrasive grains and water. The abrasive slurry is circulated between the oscillating tool and workpiece.
• Abrasive grains: boron carbide (B4C), aluminum oxide (Al2O3), silicon carbide (SiC) • Abrasive Particles have random sharp edges


Silicon Carbide

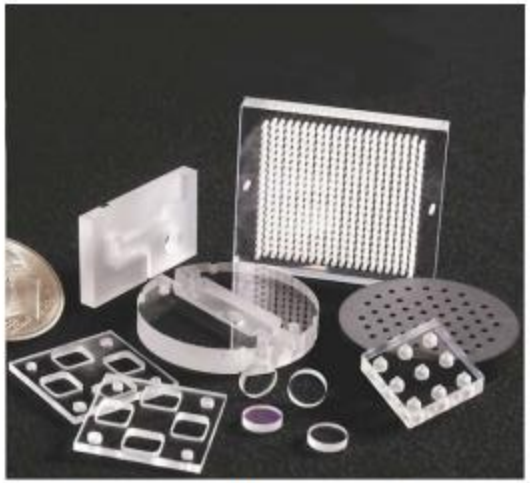

Aluminum Oxide


Boron Carbide

Ceramic holes (mmsonline.com)



Holes in Glass (swiftglass.com)



Ceramics (bullentech.com)

Graphite material

Process parameters

– MRR
– Tool material
– Work material
– Surface finish
– Tool wear rate
– Abrasive material & abrasive slurry

Advantages

– Extremely hard and brittle materials can be machined easily
– Noiseless operation
– Cost of metal removal is low
– No heat generation on this process
– Equipments are safe to operate
– No conductive materials can easily be machine

Disadvantages

– MRR is slow
– Softer materials are difficult to machine
– Wear rate of tool is high
– Initial setup cost is high
– High power consumption
– Tool cost is high
– Abrasive should be replaced periodically

Characteristics

Abrasive	Boron carbide, silicon carbide, diamond, aluminum oxide
Abrasive slurry	Abrasive grains + water(20 – 30 %)
Vibration frequency	20 to 30 KHz
Amplitude	25 to 100 microns
Wear ratio	1.5:1 for tungsten carbide 100:1 for glass 50:1 for quartz 75:1 for ceramics 1:1 for steel
Tool material	Low carbon steel, stainless steel
Work material	WC, Germanium, glass, quartz
Surface finish	0.2 to 0.7 micron