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CMRIT — CMR INSTITUTE OF TECHNOLOGY, BENGALURU. ACCREDITED WITH A+ GRADE BY NAAC

Internal Assessment Test 1 – MAY. 2022

Sub:	Nontraditional machining					Sub Code:	18ME641	Branch:	ME	
Date:	06.05.22	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VI/A&B		OBE	

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1	Explain the factors influencing selection of NTM process and also briefly explain applications of NTM	[10]	CO1	L2
2	Explain briefly the basic factors upon which the Nontraditional machining process is classified?	[10]	CO1	L2
3	Distinguish between Conventional and Nontraditional machining process.	[10]	CO1	L2
4	Explain with neat sketch the working principle of Ultrasonic machining process and also mention its advantages and disadvantages.	[10]	CO2	L2
5	Explain with neat sketch the working principle of Abrasive jet machining process and also mention its advantages and disadvantages.	[10]	CO2	L2
6.	Explain how the following parameters influence the metal removal rate in Ultrasonic machining (1) Grain size of abrasive (2) Abrasive materials (3) Concentration of Abrasive slurry (4) Amplitude of vibration (5) Frequency of Vibration.	[10]	CO2	L2

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Scheme of Evaluation

Question number	Particulars	Marks distribution
1.	Factors Applications	6 marks 4 marks
2.	4 classifications	$2^1/_2$ marks each
3.	10 differences	1 mark each 1x10= 10 marks
4.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
5.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
6.	(1) Grain size of abrasive (2) Abrasive materials (3) Concentration of Abrasive slurry (4) Amplitude of vibration (5) Frequency of Vibration.	2 marks each

1. The correct selection of the non-traditional machining methods must be based on the following aspects.

i) Physical parameters of the process

ii) Shape to be machined

iii) Process capability

iv) Economics of the processes

Physical parameter of the process:

The physical parameters of the different NTM are given in the Table 1.0 which indicates that PAM and ECM require high power for fast machining. EBM and LBM require high voltages and require careful handling of equipment. EDM and USM require medium power. EBM can be used in vacuum and PAM uses oxygen and hydrogen gas.

Shapes cutting capability

The different shapes can be machined by NTM. EBM and LBM are used for micro drilling and cutting. USM and EDM are useful for cavity sinking and standard hole drilling. ECM is useful for fine hole drilling and contour machining. PAM can be used for cutting and AJM is useful for shallow pocketing

Process capability

The process capability of NTM is given in Table 2.0 EDM which achieves higher accuracy has the lowest specific power requirement. ECM can machine faster and has a low thermal surface damage depth. USM and AJM have very material removal rates combined with high tool wear and are used non metal cutting. LBM and EBM are, due to their high penetration depth can be used for micro drilling, sheet cutting and welding. CHM is used for manufacture of PCM and other shallow components.

2. Classification of NTM processes is carried out depending on the nature of energy used for material removal.

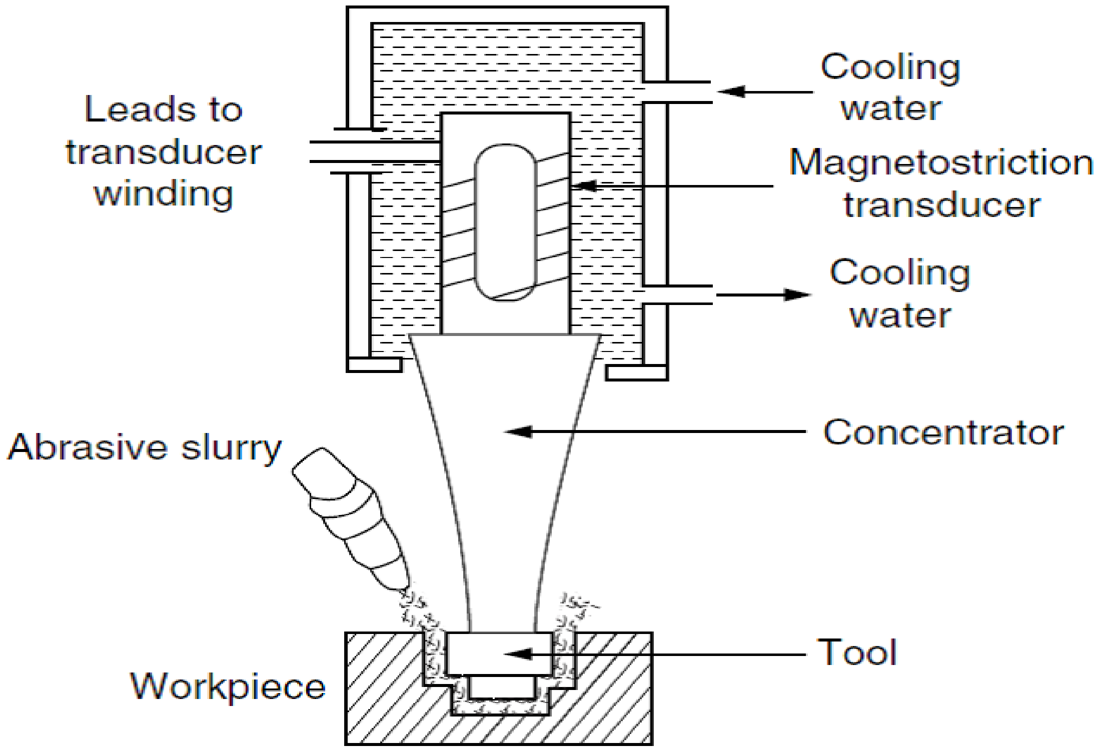
1. Mechanical Processes: In this case mechanism the material removal is by Erosion/Shear process, the high velocity particles are made to hit the work piece under the influence of pneumatic or hydraulic pressure.
    - Abrasive Jet Machining (AJM)
    - Ultrasonic Machining (USM)
    - Water Jet Machining (WJM)
    - Abrasive Water Jet Machining (AWJM)
2. Electrochemical Processes: In this case mechanism the material removal is by Ion displacement process with the help of electrolytes.
    - Electrochemical Machining (ECM)
    - Electro Chemical Grinding (ECG)
    - Electro Jet Drilling (EJD)
3. Electro-Thermal Processes: In this case mechanism the material removal is by fusion / vaporization process with the help of hot gases, radiation, ion stream etc.
    - Electro-discharge machining (EDM)
    - Laser Jet Machining (LJM)
    - Electron Beam Machining (EBM)
4. Chemical Processes: In this case mechanism the material removal is by ablative reaction process with the help of suitable chemicals like corrosive agents.
    - Chemical Milling (CHM)
    - Photochemical Milling (PCM)

3.

Sl. No	Conventional Machining	Non traditional Machining
1.	The cutting tool and work piece are always in physical contact with relative motion with each other, which results in friction and tool wear.	There is no physical contact between the tool and work piece, In some non traditional process tool wear exists.
2.	Material removal rate is limited by mechanical properties of work material.	NTM can machine difficult to cut and hard to cut materials like titanium, ceramics, SST, composites, semiconducting materials.
3.	Relative motion between the tool and work is typically rotary or reciprocating. Thus the shape of work is limited to circular or flat shapes. In spite of CNC systems, production of 3D surfaces is still a difficult task.	Many NTM are capable of producing complex 3D shapes and cavities.
4.	Machining of small cavities , slits , blind holes or through holes are difficult	Machining of small cavities, slits and Production of non-circular, micro sized, large aspect ratio, shall entry angle holes are easy using NTM
5.	Use relative simple and inexpensive machinery and readily available cutting tools	Non traditional processes requires expensive tools and equipment as well as skilled labour, which increase the production cost significantly

6.	Capital cost and maintenance cost is low	Capital cost and maintenance cost is high
7.	Traditional processes are well established and physics of process is well understood	Mechanics of Material removal of Some of NTM process are still under research
8.	Conventional process mostly uses mechanical energy	Most NTM uses energy in direct form For example: laser, Electron beam in its direct forms are used in LBM and EBM respectively.
9.	Surface finish and tolerances are limited by machining inaccuracies	High surface finish(up to 0.1 micron) and tolerances (25 Microns)can be achieved
10.	High metal removal rate.	Low material removal rate.

4. It works on the same principle of ultrasonic welding. This machining uses ultrasonic waves to produce high frequency force of low amplitude, which act as driving force of abrasive. Ultrasonic machine generates high frequency vibrating wave of frequency about 20000 to 30000 Hz and amplitude about 25-50 micron. This high frequency vibration transfer to abrasive particle contains in abrasive slurry. This leads indentation of abrasive particle to brittle work piece and removes metal from the contact surface.



In ultrasonic machining, tool of desired shape vibrates at ultrasonic frequency (19 to 25 kHz.) with an amplitude of 15-50 Microns over work piece. Generally tool is pressed down with a feed force F. Between the tool and work, machining zone is flooded with hard abrasive particles generally in the form of water based slurry. As the tool vibrates over the work piece, abrasive particles acts as indenter and indent both work and tool material . Abrasive particles , as they indent , the work material would remove the material from both tool and work piece. In Ultrasonic machining material removal is due to crack initiation, propagation and brittle fracture of material. USM is used for machining hard and brittle materials, which are poor conductors of electricity and thus cannot be processed by Electrochemical machining (ECM) or Electro discharge machining (EDM). The tool in USM is made to vibrate with high frequency on to the work surface in the midst of the flowing slurry. The main reason for using ultrasonic frequency is to provide better performance. Audible frequencies of required intensities would be heard as extremely loud sound and would cause fatigue and even permanent damage to the auditory apparatus.

Power Source:
As we know, this machining process requires high frequency ultrasonic wave. So a high frequency high voltage power supply require for this process. This unit converts low frequency electric voltage (60 Hz) into high frequency electric voltage (20k Hz).

Magnetostrictive transducer:
As we know, transducer is a device which converts electric single into mechanical vibration. In ultrasonic machining magnetostrictive type transducer is used to generate mechanical vibration. This transducer is made by nickel or nickel alloy.

Booster:
The mechanical vibration generated by transducer is passes through booster which amplify it and supply to the horn.

Tool:
The tool used in ultrasonic machining should be such that indentation by abrasive particle, does not leads to brittle fracture of it. Thus the tool is made by tough, strong and ductile materials like steel, stainless steel etc.

Tool holder or Horn:
As the name implies this unit connects the tool to the transducer. It transfers amplified vibration from booster to the tool. It should have high endurance limit.

Abrasive Slurry:
A water based slurry of abrasive particle used as abrasive slurry in ultrasonic machining. Silicon carbide, aluminum oxide, boron carbide are used as abrasive particle in this slurry. A slurry delivery and return mechanism is also used in USM.

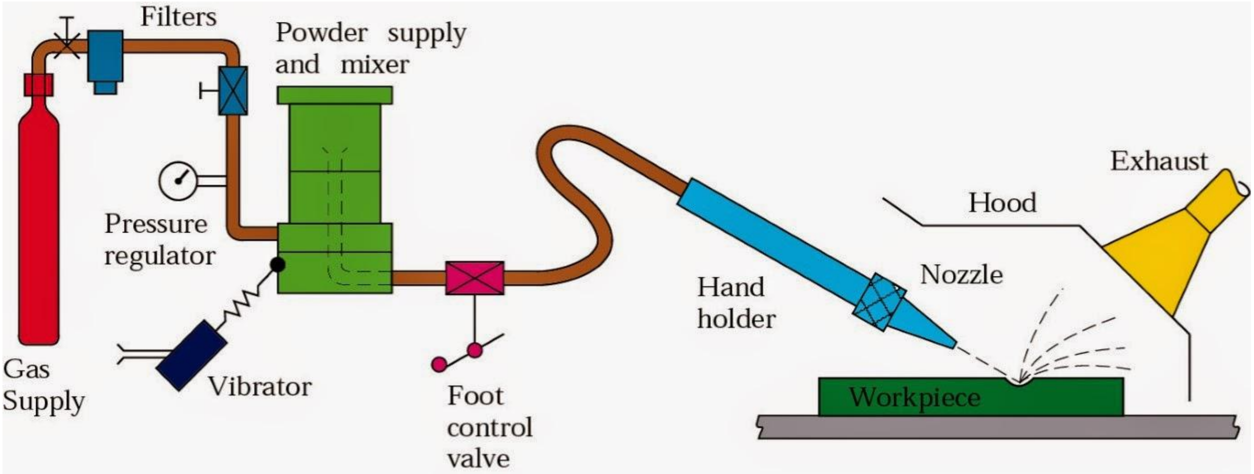
- First the low frequency electric current passes through electric supply. This low frequency current converts into high frequency current through some electrical equipment.
- This high frequency current passes through transducer. The transducer converts this high frequency electric single into high frequency mechanical vibration.
- This mechanical vibration passes through booster. The booster amplify this high frequency vibration and send to horn.
- Horn which is also known as tool holder, transfer this amplified vibration to tool which makes tool vibrate at ultrasonic frequency.
- As the tool vibrates, it makes abrasive particle to vibrate at this high frequency. This abrasive particle strikes to the work piece and remove metal form it.

Advantages:
- Hard material can be easily machined by this method.
- No heat generated in work so there is no problem of work hardening or change in structure of work piece.
- Non-conductive metals or non-metals, which cannot be machined by ECM of EDM can be machined by it.
- It does not form chips of significant size.

Disadvantages:

- It is quite slower than other mechanical process.
- Tool wear is high because abrasive particle affect both work-piece and tool.
- It can machine only hard material. Ductile metal cannot be machine by this method.
- It cannot used to drill deep hole.

5. The gap between nozzle tip and work surface has great influence on the diameter of cut, its shape and size and also rate of material removal. It is clear that the SOD or stand off distance, changes the spread of abrasive particles on the working surface and increases the diameter of the cut.
The process makes use of an abrasive jet with high velocity, to remove material and provide smooth surface finish to hard metallic work pieces. It is similar to Water Jet Machining (WJM).
A simple schematic diagram of Abrasive Jet Machining (AJM) is shown below:



Construction of Abrasive Jet Machining (AJM):
The constructional requirements of Abrasive Jet Machining (AJM) are listed and described below:

1. **Abrasive jet:** It is a mixture of a gas (or air) and abrasive particles. Gas used is carbon-di-oxide or nitrogen or compressed air. The selection of abrasive particles depends on the hardness and Metal Removal Rate (MRR) of the workpiece. Most commonly, aluminium oxide or silicon carbide particles are used.
2. **Mixing chamber:** It is used to mix the gas and abrasive particles.
3. **Filter:** It filters the gas before entering the compressor and mixing chamber.
4. **Compressor:** It pressurizes the gas.
5. **Hopper:** Hopper is used for feeding the abrasive powder.
6. **Pressure gauges and flow regulators:** They are used to control the pressure and regulate the flow rate of abrasive jet.
7. **Vibrator:** It is provided below the mixing chamber. It controls the abrasive powder feed rate in the mixing chamber.
8. **Nozzle:** It forces the abrasive jet over the workpiece. Nozzle is made of hard and resistant material like tungsten carbide.

Working:
Dry air or gas is filtered and compressed by passing it through the filter and compressor.
A pressure gauge and a flow regulator are used to control the pressure and regulate the flow rate of the compressed air.
Compressed air is then passed into the mixing chamber. In the mixing chamber, abrasive powder is fed. A vibrator is used to control the feed of the abrasive powder. The abrasive powder and the compressed air are thoroughly mixed in the chamber. The pressure of this mixture is regulated and sent to nozzle.

The nozzle increases the velocity of the mixture at the expense of its pressure. A fine abrasive jet is rendered by the nozzle. This jet is used to remove unwanted material from the workpiece.
For a good understanding of construction and working of AJM, refer the schematic diagram above.
Operations that can be performed using Abrasive Jet Machining (AJM):
The following are some of the operations that can be performed using Abrasive Jet Machining:

1. Drilling
2. Boring
3. Surface finishing
4. Cutting
5. Cleaning
6. Deburring
7. Etching
8. Trimming
9. Milling

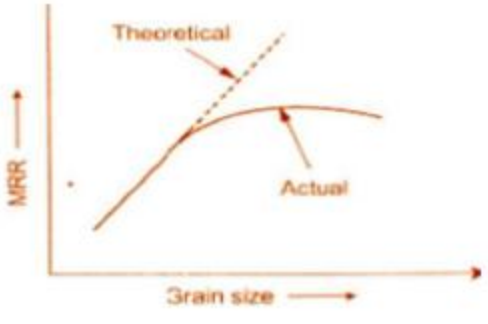
Advantages of Abrasive Jet Machining:

- Surface of the workpiece is cleaned automatically.
- Smooth surface finish can be obtained.
- Equipment cost is low.
- Hard materials and materials of high strength can be easily machined.
- A process quite suitable for machining brittle, heat resistant and fragile materials like, ceramic, glass, germanium, etc.
- It could be used to cut, drill, polish, debur, clean the materials.

Disadvantages of Abrasive Jet Machining:

- Metal removal rate is low
- In certain circumstances, abrasive particles might settle over the work piece.
- Nozzle life is less. Nozzle should be maintained periodically.
- Abrasive Jet Machining cannot be used to machine soft materials.
- The tapering of hole mainly when the depth of the hole is more, becomes inevitable.
- It need a dust collecting chamber to prevent air pollution.
- The abrasive particles might remain embedded into work surface.
- Abrasive particles are not reusable.

6. Grain size of the abrasive
   - MRR and surface finish are greatly influenced by the grain size of the abrasive
   - Maximum rate in machining is attained when the grain size of the abrasive is bigger.
   - For rough work operation grit size of 200-400 is used and for finishing operation the grit size of 800-1000 is used



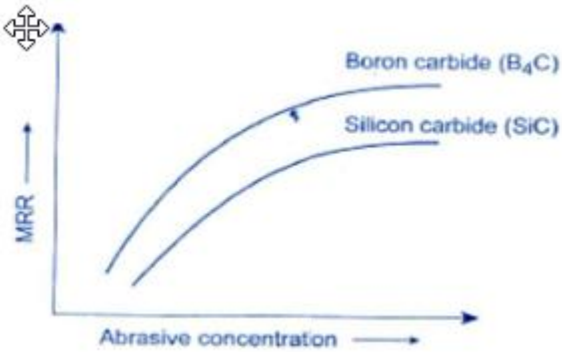
(b) Abrasive Materials

- The proper selection of the abrasive particles depends on the type of material to be machined, hardness of the material and metal removal rate and the surface finish required.

- The most commonly used abrasive materials are boron carbide and silicon carbide used for machining tungsten carbide and die steel.
- Aluminum oxide is the softest abrasive used for machining glass and ceramics

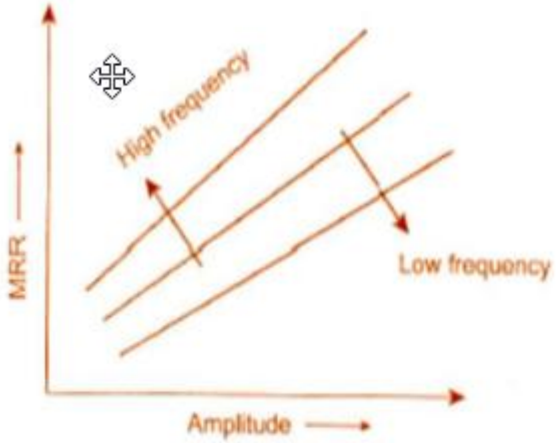
(c) Concentration of slurry:

- Abrasive slurry usually a mixture of abrasive grains and water of definite proportion 20-30% is made to flow flow under pressure.
- The fig shows how the metal removal rate varies with slurry concentration



d) Amplitude of Vibration

- Metal removal rate in ultrasonic machining process increases with increasing amplitude of vibration



e) Frequency

- Ultrasonic wave frequency is directly proportional to the metal removal rate as shown in the fig.