UNIT –I

INTRODUCTION

PART - A (2 MARKS)

1. **Compare conventional and unconventional machining processes.**

In conventional machining process, metal is removed by using some sort of the tool which is harder than the work piece and is subjected to wear.

In UMP do not employ a conventional or traditional tool for metal removal, instead, they directly utilize some of energy for metal machining process.

2. **State the need for unconventional machining.**

The following are the need for UMP,

- It increases productivity
- It reduces number of rejected components
- Close tolerance is possible
- The machined surfaces do not have any residual stresses.

3. **List out the limitations of non-traditional machining processes.**

The following are the limitations of UMP,

- UMP are more expensive
- MRR is slow
- AJM, CHM, PAM are not commercially economical processes.

4. **Write the importance of surface finishing in machining operations.**

The following are the importance of surface finishing operations.

- Metal removal rate is obtained
- Tolerance is maintained
- Surface finish is obtained
- Depth of surface damage

5. **Why do we require unconventional machining processes ahead of conventional processes?**

The following are the importance of UMP,

- To reduce the large cutting forces
- To reduce the operating temperature
- To reduce the wastages

6. **How to classify UCM processes with respect to the type of energy employed to remove materials?**

The following are the classification of UMP based on type of energy used,

- Thermal energy methods
- Electron energy methods
- Electro chemical energy methods
- Chemical energy methods
- Mechanical energy methods

7. **What are the characteristics of Unconventional Machining Process?**

The following are the characteristics of UMP,

- The tool material need not be harder than the work piece material
- The machined surface do not have any residual stresses.

8. **List the unconventional machining process, which uses mechanical energy.**

The following are the mechanical energy based unconventional machining processes,

- Ultrasonic Machining. (USM)
- Abrasive Jet Machining (AJM)
- Water Jet Machining (WJM)

9. What is necessity for unconventional machining process?

A harder and difficult to machine materials such as carbides, stainless steel, nitro alloy, hast alloy and many other high strength temperature resistant alloys find wide application in aerospace and nuclear engineering industries.

10. How non-traditional machining processes are classified?

The following are the classification of UMP,

- Based on the type of energy required to shape the material
- Based on the mechanism involved in the process
- Source of energy required for material removal
- Medium of transfer of energies

11. What types of energy are employed in non-traditional machining processes?

The following are the type of energy employed in UMP,

- Thermal energy methods
- Electrical energy methods
- Electro chemical energy methods
- Chemical energy methods
- Mechanical energy methods

12. Why conventional mechanical machining process is not so effective on soft metals like Aluminium?

In unconventional machining processes is not so effective on soft metals (ductile materials) like Aluminium because accuracy cannot be maintained due to more metal removal rate.

13. What are the industrial needs for unconventional machining process?

The following are the industrial need for UMP,

- To increases the productivity
- To maintain / minimize the tolerance
- To reduce the rejection rate of components.

14. Write down the energy transfer media, energy source and mechanism of metal removal for the following process.

a. Water Jet Machining.
   - High velocity particles
   - Pneumatic/Hydraulic Pressure
   - Erosion

b. Electrochemical Grinding.
   - Electrolyte
   - High current
   - Ion displacement

15. Name the importance factors that should be considered during the selection of an unconventional machining process for a given job.

The following factors to be considered for selection of UMP for a given job,

- Physical parameters.
- Shapes to be machined.
- Process capability or Machining characteristics
- Economic consideration

PART –B (16 MARKS)

1. **Narrate the various aspects involved in the selection of an unconventional machining process for a specific application.**

A comparative analysis of the various unconventional manufacturing processes should be made so that a guide-line may be drawn to find the suitability of application of different processes.

A particular manufacturing process found suitable under the given conditions may not be equally efficient under other conditions. Therefore, a careful selection of the process for a given manufacturing problem is essential. The analysis has been made from the point of view of:

(i) Physical parameters involved in the processes;

(ii) Capability of machining different shapes of work material;

(iii) Applicability of different processes to various types of material, e.g. metals, alloys and non-metals;

(iv) Operational characteristics of manufacturing and

(v) Economics involved in the various processes.

Physical parameters

The physical parameters of non-conventional machining processes have a direct impact on the metal removal as well as on the energy consumed in different processes. (Table 1)

Parameters	*USM*	*AJM*	*ECM*	*CHM*	*EDM*	*EBM*	*LBM*	*PAM*
Potential (V)	220	220	10	—	45	150000	4500	100
Current (Amp)	12 (A.C.)	1.0	10000 (D.C.)	—	50 (Pulsed D.C.)	0.001 (Pulsed D.C.)	2 (Average 200 Peak)	500 (D.C.)
Power (W)	2400	220	100000	—	2700	150	—	50000
Gap (m.m.)	0.25	0.75	0.20	—	0.025	100	150	7.5
Medium	Abrasive in water	Abrasive in gas	Electrolyte	Liquid chemical	Liquid dielectric	Vaccum	Air	Argon or hydrogen

Capability to shape

The capability of different processes can be analysed on the basis of various machining operation point of view such as micro-drilling, drilling, cavity sinking, pocketing (shallow and deep), contouring a surface, through cutting (shallow and deep) etc.

For micro-drilling operation, the only process which has good capability to micro drill is laser beam machining while for drilling shapes having slenderness ratio, l D < 20, the process USM, ECM and EDM will be most suitable. EDM and ECM processes have good capability to make pocketing operation (shallow or deep). For surface contouring operation, ECM process is most suitable but other processes except EDM have no application for contouring operation.

Applicability to materials

Materials applications of the various machining methods are summarized in the following tables. For the machining of electrically non-conducting materials, both ECM and EDM are unsuitable, whereas the mechanical methods can achieve the desired results.

Metals Alloys					
Process	*Aluminium*	*Steel*	*Super alloy*	*Titanium*	*Refractory material*
USM	Poor	Fair	Poor	Fair	Good
AJM	Fair	Fair	Good	Fair	Good
ECM	Fair	Good	Good	Fair	Fair
CHM	Good	Good	Fair	Fair	Poor
EDM	Fair	Good	Good	Good	Good
EBM	Fair	Fair	Fair	Fair	Good
LBM	Fair	Fair	Fair	Fair	Poor
PAM	Good	Good	Good	Fair	Poor

USM is suitable for machining of refractory type of material while AJM are for super alloys and refractory materials.

	Non-Metals		
Process	*Ceramics*	*Plastic*	*Glass*
USM	Good	Fair	Good
AJM	Good	Fair	Good
ECM	—	—	—
CHM	Poor	Poor	Fair
EDM	—	—	—
EBM	Good	Fair	Fair
LBM	Good	Fair	Fair
PAM	—	Poor	—

Machining characteristics

The machining characteristics of different non-conventional processes can be analysed with respect to:

(i) Metal removal rate
(ii) Tolerance maintained
(iii) Surface finish obtained
(iv) Depth of surface damage
(v) Power required for machining

The process capabilities of non-conventional manufacturing processes have been compared in table.

The metal removal rates by ECM and PAM are respectively one-fourth and 1.25 times that of conventional whereas others are only a small fractions of it. Power requirement of ECM and PAM is also very high when compared with other non-conventional machining processes. This involves higher capital cost for those processes. ECM has very low tool wear rate but it has certain fairly serious problems regarding the contamination of the electrolyte used and the corrosion of machine parts. The surface finish and tolerance obtained by various processes except PAM is satisfactory.

Economics of the processes

The economics of the various processes are analysed on the basis of following

(i) Capital cost
(ii) Tooling cost
(iii) Consumed power cost
(iv) Metal removal rate efficiency
(v) Tool wear.

The capital cost of ECM is very high when compared with traditional mechanical contour grinding and other non-conventional machining processes whereas capital costs for AJM and PAM are comparatively low. EDM has got higher tooling cost than other machining processes.

Power consumption is very low for PAM and LBM processes whereas it is greater in case of ECM. The metal removal efficiency is very high for EBM and LBM than for other processes. In conclusion, the suitability of application of any of the processes is dependent upon various factors and must be considered all or some of them before applying nonconventional processes.

Process	*Capital cost*	*Tooling cost*	*Power consumption cost*	*Material removal rate efficiency*	*Tool wear*
USM	L	L	L	H	M
AJM	VL	L	L	H	L
ECM	VH	M	M	L	VL
CHM	M	L	H*	M	VL
EDM	M	H	L	H	H
EBM	H	L	L	VH	VL
LBM	L	L	VL	VH	VL
PAM	VL	L	VL	VL	VL
MCG	L	L	L	VL	L

*VL-VERY LOW, *L-LOW, *M-MEDIUM, *H-HIGH, *VH-VERY HIGH

2. Enumerate the classification of unconventional machining processes.

CLASSIFICATION OF UCM PROCESSES:

1. Mechanical Processes
   - Abrasive Jet Machining (AJM)
   - Abrasive Water Jet Machining (AWJM)
   - Water Jet Machining (WJM)
   - Ultrasonic Machining (USM)
2. Electrochemical Processes
   - Electrochemical Machining (ECM)
   - Electro Chemical Grinding (ECG)
   - Electro Jet Drilling (EJD)
3. Electro-Thermal Processes
   - Electro-discharge machining (EDM)
   - Laser Jet Machining (LJM)
   - Electron Beam Machining (EBM)
4. Chemical Processes
   - Chemical Milling (CHM)
   - Photochemical Milling (PCM)

1. ULTRA SONIC MACHINING

USM is a mechanical material removal process in which the material is removed by repetitive impact of abrasive particles carried in liquid medium on to the work surface, by a shaped tool, vibrating at ultrasonic frequency.

2. ABRASIVE JET MACHINING

It is the material removal process where the material is removed or machined by the impact erosion of the high velocity stream of air or gas and abrasive mixture, which is focused on to the work piece.

3. LASER BEAM MACHINING

Laser-beam machining is a thermal material-removal process that utilizes a high- Energy, Coherent light beam to melt and vaporize particles on the surface of metallic and non- Metallic work pieces. Lasers can be used to cut, drill, weld and mark. LBM is particularly suitable for making accurately placed holes.

4. ELECTRON EAM MACHINING

It is the thermo-electrical material removal process on which the material is removed by the high velocity electron beam emitted from the tungsten filament made to impinge on the work

surface, where kinetic energy of the beam is transferred to the work piece material, producing intense heat, which makes the material to melt or vaporize it locally.

5. ELECTRO CHEMICAL MACHINING

It is the controlled removal of metals by the anodic dissolution in an electrolytic medium, where the work piece (anode) and the tool (cathode) are connected to the electrolytic circuit, which is kept, immersed in the electrolytic medium

6. ELECTO CHEMICAL GRINDING

ECG is the material removal process in which the material is removed by the combination of Electro- Chemical decomposition as in ECM process and abrasive due to grinding.

7. PLASMA ARC MACHINING

Plasma is defined as the gas, which has been heated to a sufficiently high temperature to become ionized.

8. WATER JET MACHINING

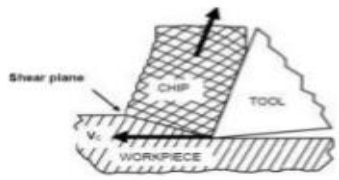
Water jet cutting can reduce the costs and speed up the processes by eliminating or reducing expensive secondary machining process. Since no heat is applied on the materials, cut edges are clean with minimal burr. Problems such as cracked edge defects, crystallization, hardening, reduced weldability and machinability are reduced in this process.

9. ELECTRICAL DISCHARGE MACHINING

EDM is the controlled erosion of electrically conductive materials by the

Initiation of rapid and repetitive spark discharge between the electrode tool to the cathode and work to anode separated by a small gap kept in the path of dielectric medium. This Process also called spark erosion.

3. Differentiate between conventional and unconventional machining processes. Discuss the reasons for the development of unconventional machining methods.

Conventional Manufacturing Processes	Non-Conventional Manufacturing Processes
1. Generally macroscopic chip formation by shear deformation. 	1. Material removal may occur with chip formation or even no chip formation may take place. For example in AJM, chips are of microscopic size and in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level
2. There may be a physical tool present. for example a cutting tool in a Lathe Machine,	2. There may not be a physical tool present. For example in laser jet machining, machining is carried out by laser beam. However in Electrochemical Machining there is a physical tool that is very much required for machining.
3. Cutting tool is harder than work piece at room temperature as well as under machining conditions	3. There may not be a physical tool present. For example in laser jet machining, machining is carried out by laser beam. However in Electrochemical Machining there is a physical tool that is very much required for machining.
4. Material removal takes place due to application of cutting forces – energy domain can be classified as mechanical	4. Mostly NTM processes do not necessarily use mechanical energy to provide material removal. They use different energy domains to provide machining. For example, in USM,

	AJM, WJM mechanical energy is used to machine material, whereas in ECM electrochemical dissolution constitutes material removal.
5. Conventional machining involves the direct contact of tool and work –piece	5. Whereas unconventional machining does not require the direct contact of tool and work piece.
6. Lower accuracy and surface finish.	6. Higher accuracy and surface finish.
7. Suitable for every type of material economically	7. Not Suitable for every type of material economically
8. Tool life is lessdue to high surface contact and wear.	8. Tool life is more
9. Higher waste of material due to high wear.	9. Lower waste of material due to low or no wear.
10. Noisy operation mostly cause sound pollutions	10. Quieter operation mostly no sound pollutions are produced.
11. Lower capital cost	11. Higher capital cost
12. Easy set-up of equipment.	12. Complex set-upequipment.
13. Skilled or un-skilled operator may required	13. Skilled operator required.
14. Generally they are manual to operate.	14. Generally they are fully automated process.
15. They cannot be used to produce prototype parts very efficiently and economically.	15. Can be used to produce prototype parts very efficientlyAnd economically.

4. What are the basic limitations of conventional manufacturing process? Justify the need of unconventional manufacturing process in today's industries.

Conventional Machining Processes mostly remove material in the form of chips by applying forces on the work material with a wedge shaped cutting tool that is harder than the work material under machining condition.

The major characteristics of conventional machining are:

• Generally macroscopic chip formation by shear deformation

• Material removal takes place due to application of cutting forces – energy domain can be classified as mechanical

• Cutting tool is harder than work piece at room temperature as well as under machining conditions.

Non-conventional manufacturing processes is defined as a group of processes that remove excess material by various techniques involving mechanical, thermal, electrical or chemical energy or combinations of these energies but do not use a sharp cutting tools as it needs to be used for traditional manufacturing processes.

Material removal may occur with chip formation or even no chip formation may take place. For example in AJM, chips are of microscopic size and in case of Electrochemical machining material removal occurs due to electrochemical dissolution at atomic level.

In conventional machining processes, metal is removed by using some sort of the tool which is harder than the work piece and is subjected to wear. In this process, tool and work piece being in direct contact with each other.

The Unconventional machining processes do not employ a conventional or traditional tool for metal removal, instead, they directly utilize some form of energy for metal machining. In this process, there is no direct physical contact between the tool and the work piece.

5. **Compare, and contrast various UCM processes with respect to process principle, process capability, advantages and disadvantages.**

Refer Question No.1

6. **i) What do you understand by chipless machining and what harmful effect may such machining have? Explain.**

Traditionally machining is classified as chip forming and chipless machining. Among the chipless machining, electro discharge machining is widely practiced. Development in electrode discharge machining in the micro and Nano-scale mostly concentrated with wire erosion technique.

Ultrasonic machining is a 'non-traditional' machining technique and is a part of a family of relatively modern material finishing and shaping processes described as 'chipless machining'. These processes don't use cutting tools and do not create residual stresses in the work piece. Ultrasonic machining is often used in the combination with other chipless machining techniques, such as electro discharge machining, in the manufacturing of precision components.

ii) Make a comparison among various non-traditional machining processes in terms of the following.

i) Cavity-sinking(through) operation
ii) Pocketing operation
iii) Through cutting operation

	Holes				*Trough cavities*		*Surfacing*		*Trough cutting*	
Process	*Precision small holes*		*Standard*		*Precision*	*standard*	*Double contouring*	*Surface of revolution*	*Shallow*	*deep*
	Dia < .025 mm	*Dia > .025 mm*	*Length < 20 mm*	*Length > 20 mm*						
USM	—	—	good	poor	good	good	poor	—	poor	—
AJM	—	—	fair	poor	poor	fair	—	—	good	—
ECM	—	—	good	good	fair	good	good	fair	good	good
CHM	fair	fair	—	—	poor	fair	—	—	good	—
EDM	—	—	good	fair	good	good	fair	—	poor	—
LBM	good	good	fair	poor	poor	poor	—	—	good	fair
PAM	—	—	fair	—	poor	poor	—	poor	good	good

7. **Compare the mechanical and electrical energy processes in terms of physical, shape capabilities, Process capability, and Process economy.**

Refer Question No.1

8. **For different non-conventional processes, present in the form of a table, various process parameters recommended.**

Refer Question No.1

9. **Discuss in detail the various factors affecting the selection of suitable non-traditional machining technique for any specific application.**

Refer Question No.1