UNIT-1

Introduction:-

→ The main work of an engineer and scientist is the development of newer methods.

→ The main ideas behind such work are

- Economic considerations
- Replacement of old manufacturing methods by faster ones and more efficient ones
- To get high accuracy and high surface finish
- use low cost material instead of costlier ones
- Developing new methods of machining to m/c hard materials which cannot be machined by conventional or normal methods like tungustan, Uranium, stainless steel etc

→ The use of such costly and hard to machine materials is common in tool design industries, aircraft industries, space research equipments, Powerplants etc.

→ To meet the requirements of these industries newer methods are developed by the engineers & Scientists

→ These machining methods are called as non conventional or unconventional or Nontraditional or modern methods of machining.

→ Machining depends primarily on electric motors, hydraulics, gravity and hard tool materials to perform machining, where as non traditional machining gets its source from electrochemical reactions, high temperature plasma, high velocity abrasive jets, high frequency sound, coherent light etc

→ The hardness of the material being machined is of no significant importance.

Need for Unconventional Machining process:-

→ Rapid technological developments in the field of new materials & alloys with ever increasing strength, hardness, toughness, heat resistance and wear resistance. have imposed many problems and difficulties during the machining of these materials by conventional machining process.

→ Machining of intricate and complicated shapes, thin and fragile components and accurate and economical forming of very hard, high strength materials which are being used in aerospace and nuclear industries

→ Thus all forced the scientists and engineers and technologists to search for new techniques of machining which can rapidly provide an effective solution to the problems.

→ As a result of research and development for the last forty years or so, several new methods of machining have emerged which can be grouped under the name of Unconventional machining methods or NTMM or MMM.

Manufacturing process can be broadly divided into two groups.

Manufacturing process

- Primary Manufacturing process
- Secondary Manufacturing process
  - Conventional Machining process
  - Unconventional Machining process

Primary Manufacturing process :-

It provides basic shape & size

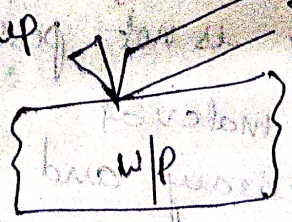
Ex:- Casting, forming & powder metallurgy

Secondary Manufacturing process :-

It provides final shape & size with tighter tol of dimensions, surface finish characteristics.

Conventional Machining process :-

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.



Ex of CMP are drilling, Grinding, milling, shaping etc.

Unconventional Machining process:

It is defined as a group of process that removes excess material by various techniques involving mechanical, thermal, electric 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 process.

→ They are used for machining of hard & brittle materials

→ In this there is no direct physical contact b/w the tool & w/p but material is removed in the form of small chips, & also tool material is not harder than w/p material.

Ex:- AJM, WJM, USM etc.

Limitations of conventional Machining process:-

1) CMP are difficult to machine the harder or newly developed materials like carbides, ceramics, alloys etc
2) The surface finish level is not quite high.
3) High tolerance or close tolerance cannot be achieved.
4) Difficult to obtain complex shapes
5) Mass production at high production rate with high accuracy is not possible.
6) High wastage of material
7) The degree of accuracy and precision are not in best position.
8) A large no. of holes in a single w/p with better quality is quite difficult

7) UCMP not so effective on soft materials like aluminium because accuracy cannot be maintained due to more material removal rate

Classification of Unconventional machining processes

They are classified according to the major energy sources employed in machining

1) Thermal Energy Methods :-

→ In these methods, the thermal energy is employed to melt and vaporize tiny particles of work material by concentrating the heat energy on a small area of the work piece

→ The required shape is obtained by the continued repetition of this process

→ The methods include are • Electrical discharge machining (EDM)
- Laser beam machining (LBM)
- plasma arc Machining (PAM)
- Electro beam Machining (EBM)
- Ion Beam Machining (IBM)

2) Electro chemical energy methods :-

→ These methods involve electrolytic (anodic) dissolution of the workpiece material in contact with a chemical solution
- work - anode
- tool - cathode

→ These methods include
- Electro chemical Machining (ECM)
- Electro chemical grinding (ECG)
- Electro Chemical Honing (ECH)
- Electro chemical deburring (ECD)

3) Chemical Energy Methods :-

→ These methods involve controlled etching of the w/p material in contact with a chemical solution.

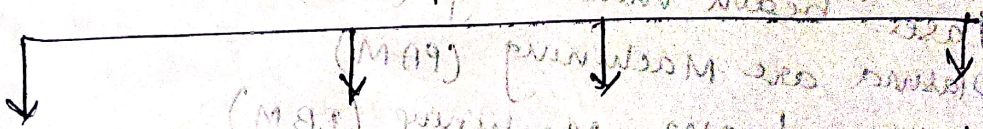
Ex:- chemical Machining methods (CHM).

4) Mechanical Energy Methods :-

→ In these methods, the material is principally removed by mechanical erosion of the w/p material. These methods include

- Ultra sonic Machining (USM)
- Abrasive jet machining (AJM)
- Water jet Machining (WJM)

Classification of UCMP



Thermal Energy Methods	Electro chemical	Chemical	Mechanical
• EDM	• ECM	• CHM	• USM
• LBM	• ECG		• AJM
• PAM	• ECH		• WJM
• EBM	• ECD		
• IBM			

Features of Unconventional Machining Processes:-

Characteristic features of UCMP:-

The following are the Characteristic features of Non traditional Machining process, when compared with traditional or conventional Machining process.

1) Material is removed from the w/p without mechanical contact (with the w/p)
2) In many processes material removal rate is independent of the hardness of w/p
3) Cutting forces are independent of the hardness of the work material
4) The tool material need not be harder than the work material (In many cases softer material is used as the tool material)
5) Almost any work material, irrespective of its hardness and Strength, can be machined.
6) Generally tool wear is negligible, hence tool wear is not a problem
7) No burr is left on the w/p
8) No residual stresses are left on the surface machined
9) In most of the cases, entire contour or desired shape can be obtained in one stage or in one setting. This is possible since material removal takes place uniformly over the entire area simultaneously.
10) In majority of the cases, "Surface integrity" of the surfaces produced by modern machining methods is superior.

11) Intricately shaped contours and fine machining of precision holes are possible.

12) Modern machining methods can be integrated easily with microprocessors and numerical controls for better control of the process and for improving the versatility and productivity of the machine.

Principle of Un Conventional Machining process :-

Basic principle of UCMP :-

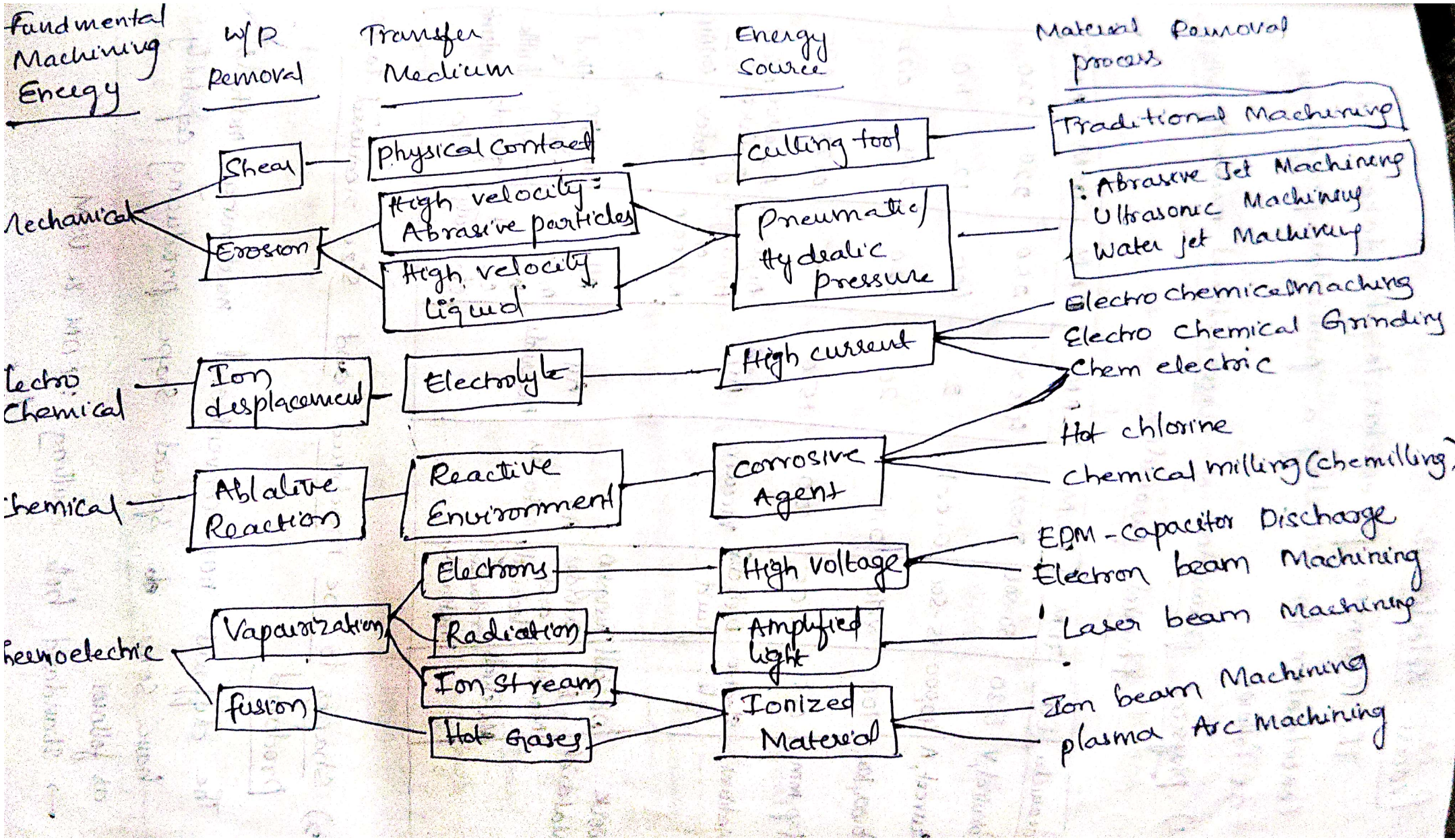
The basic principle of machining by these new methods is to apply some form of energy to the w/p directly without almost any physical contact b/w the tool and the w/p and have the desired shape or contour by material removal from the w/p.

Different forms of energy applied to the w/p are

1) Mechanical energy
2) Electrical (or electrochemical energy)
3) Thermal Energy (or Thermoelectric energy)
4) Chemical Energy.

classification based on all modes :-

Type of energy used, mode of mechanism of metal removal, medium used for the transfer of energy for different material removal processes, are shown below in a diagram.



Process selection :-

The common parameters to be taken into consideration for selecting a particular process are as follows.

1) Physical parameters of Unconventional machining methods

Physical parameters

Parameter	ECM	EDM	EBM	LBM	PAM	USM	AJM
Potential, V	5-30	50-500	200×10^3	4.5×10^3	250	220	220
Current, A	40,000	15-500	0.001	2	600	12	1.0
Power, kw	100	2.70	0.15	20	220	2.4	0.22
Gap, mm	0.5	0.05	100	150	7.5	0.25	0.25
Medium	Electro lyte	Dielectric fluid	vaccum	Air	Argon or Hydrogen or Nitrogen	Abrasive grains & water	N_2 (or) CO_2 (or) Air
Work Material	Difficult to Machine Materials	Tungsten carbides and electrically conductive materials	All materials	All materials	All materials which conduct electricity	Tungsten carbide, glass, quartz etc,	Hard & brittle materials

2) Shapes to be machined and size required to be produced

The different non conventional machining methods have some special shape producing capability as follows

→ Standard hole drilling : EDM & USM

→ fine hole drilling & contour machining : ECM
→ clean, rapid cuts and profiles : PAM
→ Micro machining & drilling : LBM & EBM

5) process capability :-

→ Out of all the non conventional machining methods, EDM has the lowest specific power requirement & it can achieve sufficient accuracy whereas ECM has the highest MRR (Metal Removal Rate)

→ USM and AJM have low MRR and combined with tool wear whereas LBM and EBM have high penetration rates with low MRR.

4) process economy :-

The process economy of various non conventional machining methods is given in the following table

Process	Capital cost	power requirement	Efficiency
EDM	Medium	Low	High
EBM	High	low	very high
PAM	very low	very low	very low
LBM	Medium	very low	very high
USM	Low	Low	High
AJM	very low	low	High
ECM	very high	Medium	Low
Conventional Method	Low	Low	very low

5) physical properties of work piece material to be u
6) Type of operation to be performed

If it is given for long answer

Classification

a) Based on the type of energy required to shape the material
   1) Thermal energy methods
   2) Electrical energy methods
   3) Electro chemical energy methods
   4) Chemical energy methods
   5) Mechanical energy methods

b) Based on the mechanism involved in the process
   1) Erosion
   2) Ionic dissolution
   3) Vaporisation

c) Source of energy required for material removal
   1) Hydrostatic pressure
   2) High current density
   3) High voltage
   4) Ionised material

d) Medium of Transfer of energies
   1) High voltage particles
   2) Electrolyte

Selection of Material for Machining methods :-

Material	Method of Machining
1) Non metals like Ceramics, plastics & glass	USM, AJM, EBM, LBM
2) Refractories	USM, AJM, EDM, EBM, EDM
3) Titanium	AJM, ECM, EDM, PAM
4) Super alloys	ECM, CHM, EDM, PAM
5) Steel	

Advantages :-

1) Material removed without mechanical contact with the workpiece
(ECM, EDM, LBM, CHM)

2) Material removed rate is independent of workpiece hardness
(ECM, LBM, EDM)

3) cutting forces are independent of workpiece hardness
(ECM, LBM, EDM, CHM)

4) Tool material need not be harder than the workpiece material
(ECM, LBM, EDM, CHM, USM)

5) Tool wear is not a problem
(ECM, LBM, CHM)

6) Ability to Machine any material
(LBM)

7) Burr free Machining
(ECM, EDM, CHM)

8) Stress free machining
(ECM, ECG, CHM)

9) Uniform material removal over the entire area simultaneously
(ECM, CHM)

10) Superior surface integrity possible
(ECM, CHM, ECG)

11) Intricately shaped, very hard and fragile material can be machined (USM)

12) finely focussed micro-machining possible
(EDM, LBM, EBM)

13) Micro hole drilling at shallow entrace angles possible
(EDM, ECM, LBM, EBM)

14) Easy compatibility with numerical control & mini-computer controls
(ECM, EDM, LBM, EBM)

Dicadvantages :-

1) work piece and tool must be electrically conductive
(eg EDM, ECM)

2) the depth of cut is limited (eg. LBM)

3) recast (or) heat affected zones (or) surface produced may be troublesome.

eg:- EDM, LBM, EBM

4) There may be taper in the side walls of holes or cavities (eg. EDM, LBM)

Applications :-

1) AJM (Abrasive jet machining) is suitable for machining super alloys and refractory material such as ceramics & glass. AJM can also be used for machining plastics

2) USM (Ultrasonic machining) has good machining performance for refractory type materials such as ceramics & glass. USM can also be used for machining plastics

3) ECM (Electrochemical machining) is used for machining steel and super alloys, ECM cannot be used for machining non conducting materials like ceramics, plastics & glass

4) EDM (Electrical discharge machining) is used for machining steel, super alloys, titanium and refractory materials, EDM cannot be used for machining non conducting materials, such as ceramics, plastics and glass.

5) EBM (Electron beam machining) is most suitable for machining refractory materials & has a medium performance on glass and plastics

6) LBM (Laser beam machining) can machine any substance and is suitable for refractory materials such as ceramics and has a medium performance on glass & plastics

7) PAM (plasma arc machining) is suitable for machining aluminium, steel and super alloys. PAM is not suitable for machining ceramics and glass.

Comparison b/w Convention and Non conventional Machining process

Conventional	Non conventional
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	1) There is no physical contact b/w the tool and work piece, In some nontraditional process tool wear exists.
2) Material removal rate is limited by mechanical properties of work material.	2) It can machine difficult to cut and hard to cut materials like titanium, ceramics, Composites, semiconducting materials
3) Relative motion b/w the tool and work is typically rotary or reciprocating thus the shape of work is limited to circular or flat shape. Inspite of CNC system, production of 3D surfaces is still a difficult task.	3) Many NTM are capable of producing complex 3D shapes and cavities

4) Machining of small cavities, slits, blind holes of through holes are difficult

5) Use relative simple and inexpensive machinery and readily available cutting tools

6) Capital cost and maintenance cost is low

7) Conventional process mostly uses mechanical energy

8) Surface finish tolerance are limited by machining inaccuracies

9) High metal removal rate

10) cutting tool is always harder than w/p

11) Generally macroscopic chip formation takes place

4) Machining of small cavities, slits and production of non-circular, micro sized, large holes are easy

5) Non traditional processes requires expensive tools and equipment as well as skilled workers, which increases the production cost significantly

6) Capital cost and maintenance cost is high.

7) Most NTM uses energy in direct form (ex: laser, electron beam) resp.,

8) High surface finish (up to 0.1 micron) and tolerances (25 Microns) can be achived

9) Low Material removal rate

10) Tool may not be harder than w/p

11) MRR occurs with or without chip formation