Unit-1

MODERN MACHINING PROCESSES

INTRODUCTION

Traditional Machining

→ Traditional machining Technology describes the fundamentals, basic elements, and operations of general-purpose metal cutting and abrasive machine tools used for the production and grinding of cylindrical and flat surfaces by turning, drilling, and reaming; shaping and planing; and milling processes.

Differences bet? traditional & non-traditional machining

Point of view	Traditional machining	Non-Traditional machining
Contact of tool with job	Direct contact.	Not in contact
Tool hardness	Should be harder than work material	Not necessary
Effect of cutting force on job.	Develops mechanical stress	Nil.
cost of operation	Comparatively less	More.
metal removal	very high	very less
power consumption	Low.	High
Limitations	very hard and brittle material and thin sheets cannot be machined	In some cases work material must be an electrical conductor.
Hardness of working metal	Limits metal forming	will not affect the machining
wearing of tool	More	Negligible
Surface finish	Burrs are left out on work piece	Smooth surface finish

Applications of non traditional maching process

- Traditional maching processes are not suitable for machining of parts of space crafts nuclear reactors, rockets jet engines etc.
- very hard and brittle material
- High strength heat resistant materials
- Thin metal sheets
- complex shaped parts
- Micro holes (Fuel injection nozzles)

Limitations & Advantages

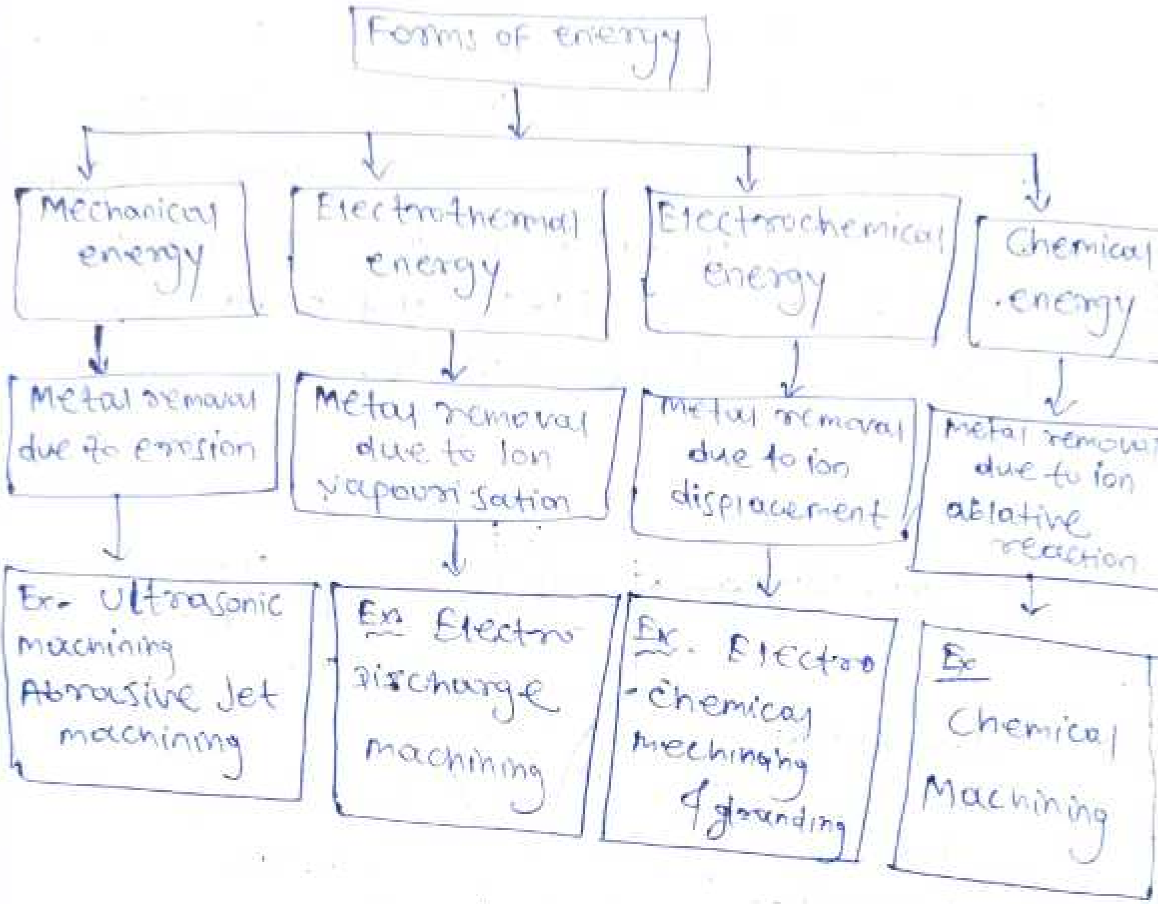
Limitation

- These methods are generally more expensive to set up.
- Slower rate of metal removal.
- considerable technical knowledge required.
- consumption of electrical energy is very high.

Advantages

- The tool material does not have to be harder than the work material.
- Tool forces do not increase as the work material gets harder.
- Economic metal removal rate does not decrease as the work material gets harder.

Classification of modern maching processes

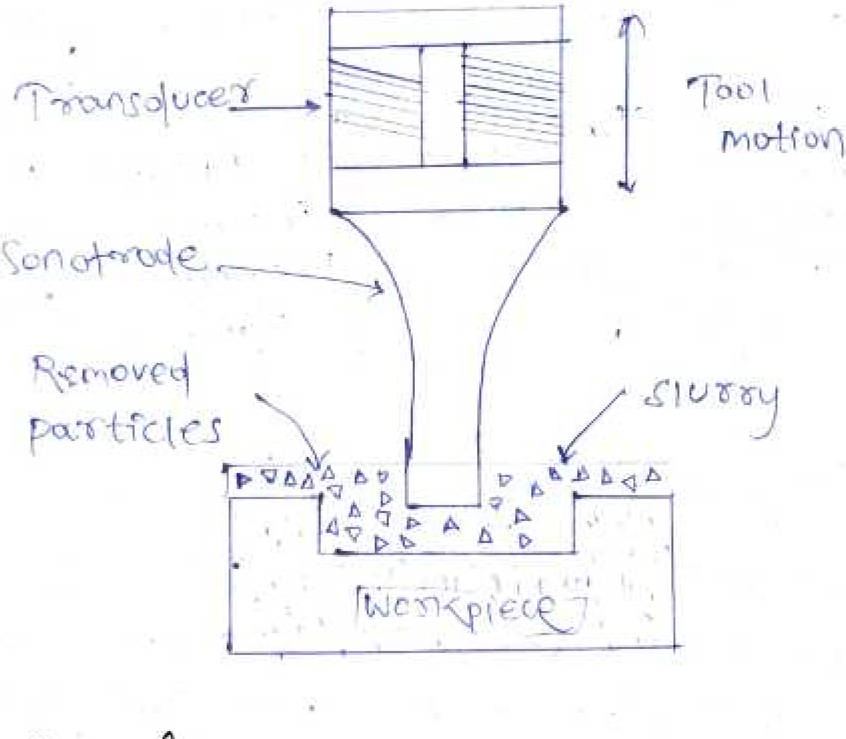


Ultrasonic machining

→ ultrasonic machining is a subtractive manufacturing process that removes material from the surface of a part through high frequency, low amplitude vibrations of a tool against the material surface in the presence of fine abrasive particles.

Principle : It works on the same principle ultrasonic welding This maching 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.



Equipment's

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 (20 k 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.

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 ~~and~~ delivery and return mechanism is also used in USM.

Application :

- This maching is used to machine hard and brittle material like carbide ceramic, glass etc.
- This is used in maching of die and tool of drill wire drawing machine etc.
- used in Fabrication of silicon nitrite turbine blade.
- It is used to cut diam ond in desire shape

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 or EDM can be machined by it.

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
- Low MRR
- Low depth of hole
- Rather high tool wear.

Electric Discharge Machining

Electric Discharge machining, also known as spark machining, spark eroding, die sinking, wire burning or wire erosion is a metal fabrication process whereby a desired shape is obtained by using electrical discharges. Material is removed from the work piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and and subject to an electric voltage. The process depends upon the tool and work piece not making physical contact.

Working principle of (EDM)

It consists of an electric power supply, the dielectric medium the tool, workpiece, and servo control. The workpiece is connected to the positive terminal and the tool is connected to a negative terminal of the DC power supply. An air gap of 0.005 to 0.05 mm is maintained between the tool and the work. The die electric fluid which is non-conductor of electricity is forced under pressure through the gap. The electric and magnetic fields on heated metal cause a compressive force which removes the metal from the work surface. The die electric fluid acts as a coolant carry the cooled metal from the work surface. A servomechanism is used to the tool continues to maintain a constant gap between two electrodes.

Description of Equipment

An Electric Discharge Machine consists of.

- DC pulse Generator
- Voltmeter
- Ammeter
- Die electric Fluid
- Tool
- pump
- Filter
- Servo controlled feed
- Fixtures
- Table (To hold the workpiece)

1. DC pulse Generator : This is a power source for the machining operation. DC power is supplied.

2. Voltmeter : we know that the voltmeter measure the voltage. Here in this device the same for use.

3. Ammeter : It measure or checks the flow of the current. If Ammeter is not connected we might not see or check current is flowing or not.

4. Tool : A tool is connected to negative sources of power whereas the workpiece is connected to positive sources. From the filter, the fluid comes to the tool for the operation.

When power supply will increase between tools workpiece the spark generates and then machining starts.

5. Die electric fluid : It has a property like insulation and we know what insulation means. Insulation means no current flows from one to another.

The Die electric Fluid will be ionized in the Form of ion which will help between the tool and workpiece again when power supply stops the Fluid comes to its initial position.

process parmeters

The EDM process parameters which drive this process are divided into two types, namely, electrical and non-electrical parameter.

→ The major electrical parmeters are discharge voltage, peak current, pulse duration and interval electrode gap, polarity, and pulse wave Form.

→ The discharge or machining voltage is the average voltage the spark gap during machining. The discharge voltage directly influence the regulation of the size spark gap and overcut.

→ In contrast, higher voltage is considered with materials of low conductivity. This parmeter has a direct effect on the meterial removal rate (MRR), tool wear rate (TWR), and maching accuracy.

→ Accordingly increasing the discharge energy by applying longer pulse-on time also increases the MRR.

→ Flushing improves the ionization condition and avoids the formation of an insulating layer; thus, proper selection of pulse-off time provides stable maching.

- Furthermore, a pulse wave has many forms such as rectangular and trapezoidal waves or even a composite geometric form.
- The polarity in EDM depends on many factors, including electrode and workpiece materials, current density and pulse length.
- Negative electrode polarity is recommended for high-precision machining when the MRR is high.
- The electrode and workpiece are located at a small predetermined distance called the "discharge gap" which is controlled by the discharge gap servo.
- The function of the dielectric fluid is to provide insulation against premature discharging, reduce the temperature during machining and clean away the debris from the machining area.

Output parameters

The two output parameters considered were: MRR (Ro

Material Removal Rate (MRR)

Equation (1) could be used for the determination of the MRR in the EDM process.

$$MRR = Wi - Wf / t$$

Where, Wi = Initial weight of the workpiece before machining, Wf = Final weight of the workpiece after machining, t = time period of trials.

- MRR is directly proportional on the amount of current passed and maching time Besides these critical factors the MRR is also dependent on the type of volage etc.

Average Roughness (Ra)

The deviation of a surface from its ideal level is defined in terms of surface roughness. The surface roughness is defind according to ISO 4287:1997 International Standard. The term average roughness is often referred to as roughness and determines the surface texture. The average roughness is calculated by the deviations i.e deviation of surface from a theoretical centre line. This is known as arithmetic mean surface roughness Ra.

Application of EDM

- Drilling for micro holes in the nozzle.
- This is used in thread cutting
- used in wire cutting.
- Rotary Form cutting
- Helical profile milling
- Engraving operation on harder materials.
- Cutting off operation.
- The shaping of alloy steel and tungsten carbide dies

Advantanges of EDM

- It can be used for any hard material and even in the heat treated condition.
- Any complicated shapes made on the tool can be reproduced.
- High accuracy of About 0.005 mm can be achived.

- Good surface finish can be achived economically up to 0.2 microns.
- Higher tool life due to proper lubrication and cooling.
- It can be applied to any electrically conductive materials.

Disadvantages of EDM

- Excessive tool were
- High power consumption
- The sharp corner cannot be reproduced
- High heat developing causing the change in metallurgical properties of materials.
- Surface cracking may take place in some materials.
- over-cut is formd. Difficult finding expert machinists.

WIRE CUT EDM

Principle : CNC wire cut EDM machine puts impulse voltage between electrode wire and workpiece through impulse source controlled by servo system to get a certain gap and realize impulse discharging in the working liquid between electrode wire and workpiece. Numerous tiny holes appears due to erosion of impulse discharging, and therefore get the needed shape workpiece.

Electrode wire is connecting to cathode of impulse power source and workpiece is connecting to anode to anode of impulse power source, when workpiece is approaching electrode wire in the insulating liquid and gap between them getting small to a certain value.

Description of equipment

In wire EDM. three elements are of particular importance wire electrode, dielectric bath and workpiece. Both the workpiece and the wire electrod are in the dielectric bath during the cutting process. This is produced with the aid of a non-conductive liquid, for which either deionized water or special erosion oil is used. wire electrodes with a diameter a diameter between 0.02mm and 0.33 mm are normally used. For wire EDM.

In this field, an acceleration of the electrically charged particles takes place which leads to the generation of a visible spark. This generates great heat which causes the dielectric to evaporate and the material of the electrode and workpiece melt. As a result, a gas bubble forms, which in turn fills with plasma. Depending on the machine the processes from ignition phase to pause phase are repeated up to 100,000 times per second. Temperatures of up to 40,000°c are generated in the process.

Controlling parameters of wire cut EDM

Four process control parameters, namely wire speed, gap voltage, flushing pressure and current are analyed for two response parameters viz surface roughness and material removal rate(MRR). It is found that MRR during WEDM have a predominant impact of current on it, while flushing pressure has the least impact on MRR. whereas, surface roughness is most effected by wire speed during WEDM and gap voltage has the least impact on surface roughness of steel workpiece during WEDM process.

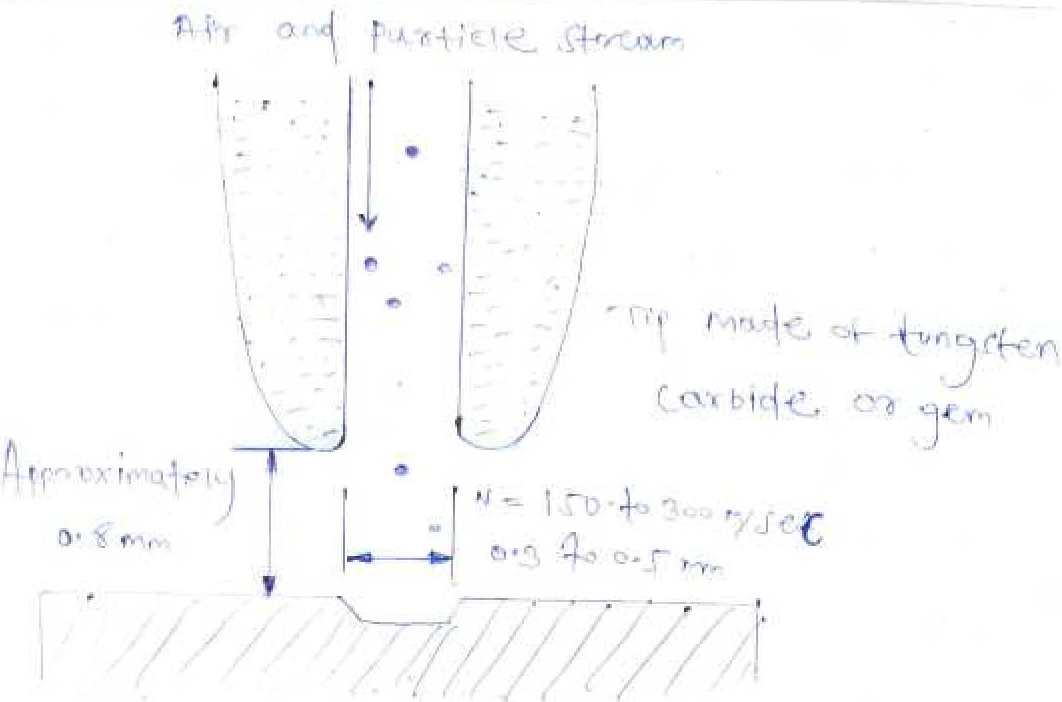
Applications of wire cut EDM

- prototype production
- Automotive parts
- Aerospace parts
- medical devices for implantations
- prototypes
- small hole drilling
- Blanking punches
- Extrusion dies
- miniature parts
- Titanium needles
- Turbine blades
- Internal gear

Abrasive Jet Machining (AJM)

Principle • In abrasive jet machining the metal removal is accomplished by the application of high speed stream of abrasive particles carried in a gaseous medium from a suitable nozzle.

- This process can be used to cut intricate shapes in hard and materials which are sensitive to heat.



description of equipment

- mixing chamber
- carrier gas
- Abrasives
- Nozzle

Mixing chamber

- Mixing chamber is partially filled with the abrasive particles.
- The high pressure gas at 2 to 8 kg f/cm2 enters the mixing chamber and mixes with the abrasive particles
- It is also used control the abrasive feed rate.

carrier gas

- The carrier gas can be air, nitrogen or carbon dioxide but never oxygen.
- The air must be filtered to remove water oil and other contaminants.
- The pressure of the carrier gas also affects the metal removal rate.

Abrasive • The abrasive generally used in AJM are aluminium oxide, silicon carbide, glass powder or specially prepared sodium bicarbonate.

• The cutting performance will depend on hardness, strength, particle size and particle shape of the abrasive.

• The maximum size of the particles is limited by the inside diameter of the nozzle.

Nozzle

• The nozzle are subjected to a great degree of abrasion and wear hence, they are made of hard materials such as tungsten carbide or synthetic sapphire to reduce wear rate.

Advantages AJM → Ability to cut intricate shapes in material of any hardness and brittleness.
→ Ability to cut fragile and heat sensitive material without damage. → Low capital cost.

Disadvantage → Material removal rate is slow and hence its application is limited.
→ Stray cutting can occur and hence accuracy is not good. → Embedding of the abrasive in the work piece surface may occur while machining softer materials.

Material removal rate → Knowledge of material removal rate (MRR) is beneficial for selecting process parameters and choosing feed rate of the nozzle. It also facilitates accurate estimation of productivity, delivery time as well as production cost. Since only kinetic energy of abrasive grits is utilized for erosion, the analytical

Formula for MRR can be established by equating available kinetic energy with the work done required for creating an indentation of certain cond length on a specific work material.

$$MRR_{Brittle} = 1.04 \frac{M_g V^{3/2}}{\rho_g^{1/4} H^{3/4}}, \quad MRR_{Ductile} = 0.5 \frac{M_g V^2}{H}$$

<u>Application of AJM</u> → Brittle and heat sensitive materials like glass, quartz, sapphire, semiconductor material, mica and ceramics can be machined. → Drilling holes, cutting slots, cleaning hard surface. cutting fine lines, deburring scribing grooving, splashing.

→ Delicate cleaning, such as removal of smudges from antique document.

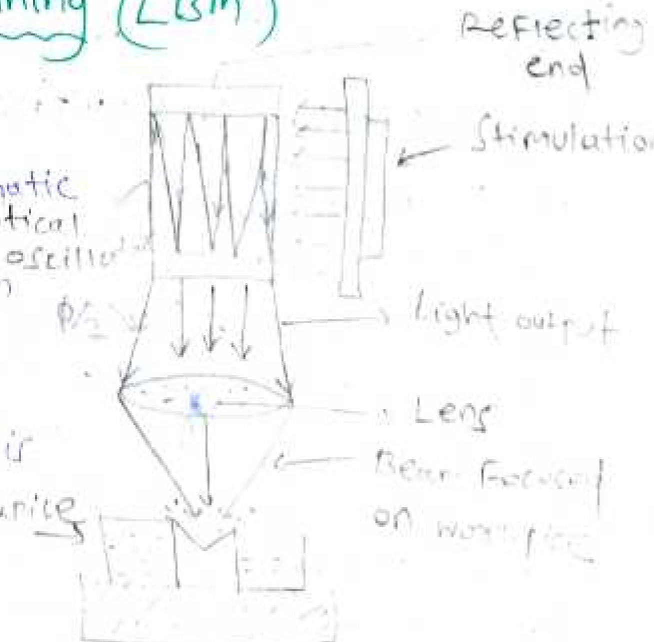
→ used for cleaning and polishing of plastics, nylon and teflon components.

Laser Beam Machining (LBM)

→ Laser is an electro-magnetic radiation

→ It produces monochromatic light which is in the form of collimated beam

→ Through has been introduced recently but is making much head way in Industry.



(LBM)

Principle → Electrons are arranged in different cells in an atom and each cell has a set number of electrons. As if any atom is excited we pump some amount of external energy, then the atomic cell will be in excited condition and some electrons will jump up to next energy level.

→ For production of laser beam we generally use Ruby rod in which aluminium is the main ingredient.

→ The Chromium plays very important role for laser beam production and is most desirable.

→ This emission is normal phenomena will not be instantaneous as the atoms are not at excited level.

→ For production of laser beam it is desirable that the energy be pumped in and pumped energy should come out instantaneously of course, it will be of great intensity. → It has further tendency to return to ground level unless bombarded by other photons. → In case of Chromium before jumping to ground level it rests at intermediate level.

Description of equipment

1. A pumping medum : A medium is needed that contains a large number of atoms. ~~the~~

2. Flash Tube / Flash Lamp : The Flash tube or Flash lamp is used ~~is~~ to provide the necessary energy to the atoms to excite their electrons.

3. Power Supply: A high voltage power source is used to produce light in flashlight tubes.

4. Capacitor: Capacitor is used to operate the laser beam machine at pulse mode.

5. Reflecting mirror: ~~To~~ Two types of mirrors are used First one is 100% reflecting and other is partially reflecting.

Material Removal Rate

If a lower amout of power supply is given to the Ruby rod, the intensity of the electromagnetic waves is reduced. Therefore the heat generated in the workpiece is sufficient to melt and join the blades called a laser beam welding operation.

-> In paracticle conditions, the wavelength of the laser beam is about 0.4 to 0.6 micrometers only.

Application

- No vacuum is required.
- Mainly used for producing holes in the diesel injection nozzle.
- Also used for producing blind holes Narrow slots in the workpieces.

Characterisitics of LBM

Material removal technique - Heating, melting

Tool - Laser beams in wavelength range of 0.4-0.6 μm

power denisity - As high as 10^7 W/mm2

output energy of laser and its pulse duration - 20 J

peak power - 20 kW

medium - normal atmosphere

material removal rate - 5 mm3/min

Specific power consumption - 1000 W/mm3/min

Efficiency - 0.3-0.5%.

ELECTRO CHEMICAL MACHINING (ECM)

Electrochemical machining is a process of removing metal with the help of the electrolysis process. The electrochemical process is also known as the reverse of the electroplating process because, in electroplating. the metal is deposited on the surface of the workpice. While in electro-chemical machining the metal is removed from the workpiece.

PRINCPLE → The Electrochemical machning process is based on Faraday's Law of electrolysis.

→ Faraday's Law of electrolysis states that when two electrodes, anode(+ve) and cathode(-ve) are placed in an electrolyte the mass of the metal deposit on the cathode coming from the anode is directly proportional to the potential difference applied across the electrodes. There is a very small gap between the workpiece and the tool for the removal of material. → The negative ions are attracted towards the workpiece which is placed at the +ve potential and positive ions are attracted towards the tool which is placed at the -ve potential.

$2H + 2e^- = H_2$

Hydrogen ions gain electrons and get conveted into hydrogen gas. $Fe = Fe^{++} + 2e^-$

→ The iron atom releases its 2 electrons and gets converted into Iron ions (anode).

$Na^+ + OH^- = NaOH$

$Fe^{2+} + 2Cl^- = FeCl_2$

DECRIPTION OF EQUIPMENT

Power Supply : The power supply is the source of energy that is provided to the setup. The power supply is generally a D.C. battery consisting of a potential difference from 3 to 30V depending.

Electrolyte : An electrolyte is a salt solution in which the workpiece and tool are kept during the process of machining. It acts as a current carrying medium between the workpiece and the tool.

Tool. Tool or cathode used in ECM is one of the electrod. It is also the desired shape in which the workpiece is to be cut. The tool used in ECM should always have accurate dimensions. Tank: The tank contains the electrolyte, tool, and workpiece. All the reaction take place here.

Mechanical System: One of the most important elements in ECM is the mechanical system. It is used for the advancement of a tool that is perpendicular to the workpiece and is at a constant velocity.

Pressure Gauge : A pressure gauge is used to measure the pressure of electrolytes which is supplied to the tool. Flow control valve : A flow control valve is used to control the flow of electrolyte which is applied to the tool.

Reservoir Tank. In case the pressure of electrolyte flow exceeds a certain limit, the pressure relief valve opens and it sends the electrolyte back to the tank. Pump - There are two pumps used namely A & B. Pump A is used to draw electrolytes from the reservoir tank and pump B is used to supply.

Slug container : A slug container is used to store the slug which is separated from the electrolyte.
~~This slug can be used for~~

Working ECM - The working of electrochemical machining starts with the advancement of the tool toward the workpice. The tool and the workpiece are kept in a suitable electrolyte with a very small gap between them.

- As soon as the potential difference is applied, the workpiece starts behaving as an anode and the tool starts behaving as a cathode.
- when the condition of electrolysis is fulfilled the removal of metal from the workpiece starts
- In the filtration process the electrolyte is passed through a centrifuge where the slug is removed. If there is an increase in the pressure of the electrolyte the pressure valve deviates the flow of the electrolyte directly to the tank.

Material removal rate

- $m \alpha Q$ $m \alpha ECE \alpha A/v$ $m \alpha QA/v \cdot \alpha ItA/v$
- $m = ItA/Fv$ F = Faraday's constant = 96500 Colomb

$MRR = m/tp = ItA/Fvtp = IA/F\rho v$

Application

- As mentioned earlier in the article ECM is used for heavy machining of hard materials which canot be machined using conventional methods.
- Due to its high accuracy surface finish, ECM is used for micromachining. As there is no contact between the tool and workpiece the final product obtained is accurate at the atomic level

- ECM is used for the production of very small gear systems which cannot be machined using typical machining process. → ECM can also be used for drilling and milling operations.

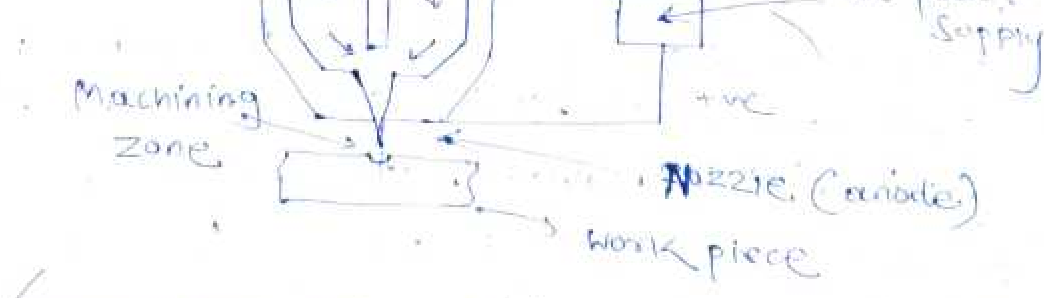
CHARACTERISTICS

Material removal mechanism – controlled removal of metal by anodic dissolution in an electrolytic medium.

Tool – Cu, brass or steel.
power supply – constant voltage DC supply
voltage and current – 5–30 V d.c, 50–40,000 Amp.
Material removal rate – 1600 mm/min.

PLASMA ARC MACHINING (PAM)

Plasma-arc maching (PAM) employs a high-velocity jet of high temp. gas to melt and displace material in its path. called PAM. this is a method of cutting metal with a plasma-arc, or tungsten inert-gas-arc torch. Temp. in the plasma zone range from 20,000°F to 50,000°F (11,000 to 28,000°C).



(working principle and process details of PAM)

DESCRIPTION OF EQUIPMENTS

- Plasma gun : Gases are used to create plasma like , nitrogen, argon, hydrogen , or a mixture of these gases. The plasma gun consists of a tungsten electrode fitted in the chamber. The electrode is given negative polarity and the nozzle of the gun is given positive polarity.

- Power Supply and Terminals - power supply is used to develop two terminals in the plasma gun. A tungsten electrode is inserted to the gun and made cathode and nozzle of the gun is made anode. • Cooling mechanism : As we know that hot gases continuously come out of nozzle so there are chances of its overheating. A water jacket is used to surround the nozzle to avoid its overheating. Tooling - There is no direct visible tool used in PAM. Focused spray of hot plasma state gases works as a cutting tool.

Workpiece : The workpiece of different materials can be processed by the PAM process. These materials are aluminum, magnesium, stainless steel, and carbon and alloy steels.

Material removal rate → The value of the material removal in plasma beam machining will be nearly 150 cm^3/min.

PROCESS PARAMETER

parameters that govern the performance of PAM can be divided into three categories.

1. Those associated with the design and operation of the torch - electrical power delievered, the gases used to form the plasma, the flow rate of the gases through the torch, the orifice, diameter through the nozzle duct.

2. Those associated with the physical configuration of the set up - torch standoff, angle to the work, depth of cut, feed into the work and speed of the work toward the torch.

3. Environment in which the work is performed - cooling that is done on the bar, any protective type of atmosphere used to reduce oxidation of the exposed high temperature machined surface and any means that might be utilized to spread out or deflect the arc and plasma impingment area.

CHARACTERISTICS OF PAM

Technique of machining	Heating of workpiece by high temp. ionised gas & causing quick
Tool	Plasma jet
velocity of plasma jet	500 m/sec
material removal rate	150 cm^3/min
Specific energy	1000 W/cm^3-min
power range	2 to 200 kW

Voltage	:	30-250 V
Current	:	upto 600 amp.
Cutting speed	:	0.1 – 7.5 m/min
Limitation	:	Low accuracy

APPLICATIONS

1. It is used for cutting alloy steels, stainless steel, cast iron, copper, nickel, titanium, aluminium, and alloy of copper and nickel etc.
2. It is used for profile cutting.
3. It is successfully used for turning and milling of hard to machine materials.
4. It is can be used for stack cutting, shape cutting, piercing and underwater cutting.
5. Uniform thin film spraying of refractory materials on different metals, plastics, ceramics are also done by plasma arcs.

ELECTRON BEAM MACHINING (EBM)

EBM is a thermal machining process in which high-velocity electrons concentrated into a narrow beam are used for instantly heating, melting, or vaporizing the material. This process is used in many application, including drilling, cutting, annealing and welding.

PRINCIPLE → In an electron beam machining, the electrons strike the workpiece with a high velocity. As the electron strikes the workpiece, the kinetic energy of the electron changes into heat energy. The heat energy so produced is used to melt and vaporize the materials from the w/p. The whole process takes place in vacuum. Vacuum environment is used to prevent the contamination and avoid collision of electrons with air molecules. If the electrons collide with the air molecules, it will lost its kinetic energy.

DESCRIPTION OF EQUIPMENTS

① Cathode. The cathode is negatively charged and it is used to produce electrons.

② Annular Bias Grid. It is present next to the cathode. Annular bias grid is a circular shaped bias grid and prevents the diversion of electrons produced by the cathode.

③ Anode – It is placed after the annular bias grid. It is positively charged. Annular anode attracts the beam of electron towards.

④ Magnetic lenses – The magnetic lenses reduce the divergence of electron beam and shape them. It allows only convergent electrons to pass & captures low energy divergent electrons from fringers. ⑤ Deflector coils – The deflector coil carefully guides the high velocity electron beam to a desired location on the workpiece and improves shape of the holes.

Material removal rate

The values of the material removal in the process of electron beam machining are abo 10 mm3/min.

process parmeters

→ Beam current It is related to the emission of electrons by the cathode in the beam whose value is as low as 1MA.

→ Duration of pules : It can be varied from 50 Ms to 15 ms.

→ Accelerating voltage (V_a) is 100 KV

→ Energy per pulse is 100 J/pulse.

Characteristics of EBM

Material Removal Technique	High speed electrons impinge on surface.
Voltage	150 KV
Electron velocity	6.5 500 billion W/mm²
operations performed	Annealing, welding, or metal removal by cutting narrow slots
Materials of workpiece	All material
Specific power consumption	500 W/mm min

Limitations – Not suitable for large workpieces. Small craters produced on beam incident side of work. A little taper produced on holes. very high specific energy consumption, high cost of machine.

Advantages There is no effect local heat on workpiece as the temp. of surrounding material (25-50) μm away from the machining spot) is not raised.

Application of EBM

- Mainly used for producing holes in the diesel Injection nozzles.
- Also used for producing blind holes, narrow slots, etc. in the workpiece.
- In electron beam machining, if the voltage given to the electron gun is about 60 to 70000 volts. the velocity of electrons produced is reducing heat generation at the workpiece is reducing.
- Therefore the heat generated is sufficient to melt and join the workpiece called an electron beam welding operation.

Unit-3 # PLASTIC PROCESSING

Plastic - It is a synthetic organic material which is moulded any desire shape by heating under pressure.

Plastic processing

→ It is a process of converting the plastic raw materials into semifinished product.
→ Semi finished because finishing is done after plastic processing. Ex. Buckets, Automobile parts, tanks.
→ Due to sufficient plasticity / formability plastics can be changed to required parts.
→ processing method of plastic are:
(i) Forming - (Extrusion, compression etc)
(ii) casting (iii) maching (iv) joining
→ Raw materials are commonly used pallets, powder
→ Liquid plastics used to mainforced plastic parts
→ Due to high plasticity / formability plastic require less energy to be processed.
→ plastics melts and cures at relatively very low temp.
→ After processing little past processing is need called surface finished.

Uses of plastic

→ Automobile or Automotive industry
→ Electrical appliance
→ communication centre
→ Safety glasses

Types of plastics

- Polymeric materials
  - Plastics
    - Thermoplastic
      - Commodity plastics: Polyethylene, polypropylene, Polystyrene, PVC
      - Engg. Plastics: Polyethylene, Acetals, Cellulosics, Polycarbonate, others
    - Thermosetting
      - Commodity plastics: Phenolics, unsaturated Polyesters, ureas
      - Engg. plastics: Silicones, urethanes, Melamines, others
  - Elastomers

Thermoplastics

Nylons (polyamides)

- Semi-crystalline
- very tough
- Have good thermal and chemical resistance

polyvinylchloride (pvc)

- can be clear or colored
- can be rigid or Flexible

Ethylene vinyl acetate

- Flexible
- Transparent
- Good chemical resistance
- High friction co-efficient

Acrylonitrile Butadiene Styrene (ABS)

- Rigide
- opaque
- Tough
- Easily electroplated

Polyactals → • Rigid • Translucent • Tough

- spring like qualities.

Thermosetting plastics

Vinyl esters • Rigid • Translucent
• Good corrosion resistance • Low viscosity

Polythene • Hard • Brittle • opaque
• Resistance to deformation under load.

Epoxies • Rigied • Clear • very tough • chemical resistance

Phenolics
• Hard • Brittle • Good heat resistance

Melamine • Hard • opaque • Scratch resistance

Acrylics • Hard. • Transparent • Abrasion resistance

Alkyds • Rigid • Tough • Heat resistance
• Good long term dimension stability

MOULDING PROCESS

→ using the peculiar characteristics of plastics it can be moulded in different distinct methods.
→ comparing metals plastics have different moulding techniques due to their low glass transition temp. → The liquid plastic is called as resin.
→ In liquid stage different plastics have verying property in viscosity and surface tension

Injection moulding

• Injection moulding is one of the most common processing methods for thermostting plastics.
• It incudes three steps
→ melting of the polymer → Ejection
→ Injection of polymer into a closed mould.

• The above steps can be achieved by two type of injection moulding machines
  → Screw machine → plunger machine

Compression moulding

→ The moulding process can be carried out with either thermosets or thermoplastics
→ compression moulding was specifically developed for replacement of metal components with composite parts. → In this process a pre-measured quantity of plastic in the form of charge or briquettes is placed into bottom half of a heated mould. → Hydraulic pressure are usually employed to provided the pressure for compressing the plastic compound. → The upper half mould is moved to increases the pressure, charge flows towards mold shape which also forces out the air.
→ The mould halves are opened to remove the part from the die cavity.
→ The process is an effective forming technique form the liquid state, the materials is held in the mould until the curing stage is over and polymerization is complete.

Advantages :

• curing time is Low. • High volume production can be achived • High quality Finishing

disadvantages

• High initial capital investment • Labor intensive
• Maintenance cost is high
• Secondary operations are sometimes required.

Types

→ These ~~mod~~ moulds range from relatively simple one cavity form to large multiple cavity dies

- Flash type
- positive type
- Landed positive type
- Semi positive type

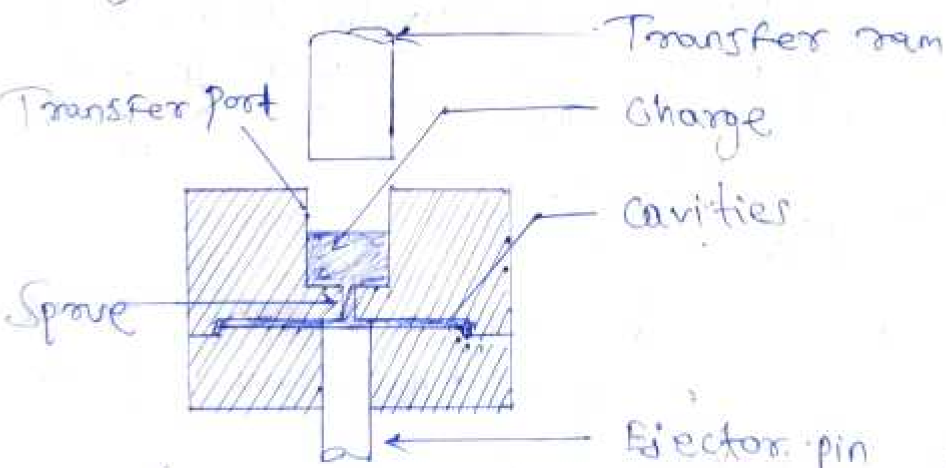
Transfer moulding

- Transfer moulding is a modification of compression moulding. → Thermosetting charge is loaded into a transfer pot gets heated.

→ This charge is allowed to flow into an orifice mould by applying pressure where curing takes place.

→ This action is done by a punch at the mould closes.

→ The material to be moulded is often pre-heated by radio-frequency methods and where it is desired to improve toughness and strength, reinforcing fillers may be used.



(TRANSFER MOULDING)

→ Transfer produced during the operation in the base of transfer arm called cull.

→ Transfer moulding is capable of moulding part shapes that are more intricate than compression moulding.

Disadvantage → wastage of material

→ production rate lower than injection molding

→ Air can be traped in the mold.

Extrusion of plastic

- Extrusion is the base of all shaping process
- It is widely used for thermoplastic and elastomers.
- This process is similar to injection moulding
- Extrusion process is a continuous operation in which powdered polymer or monomer is fed by a screw along a cylindrical chamber.

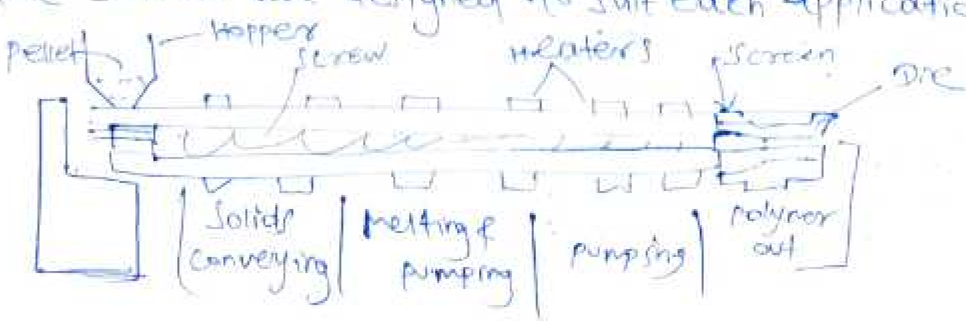
→ The molten plastic is forced through a die opening of the desired shape.

→ The material in granular form together with necessary additives is placed into a feed hopper which feeds the cylinder of the extruding machine.

→ The hopper portion is kept cool by circulating water in order to avoid pre-mature softening of the feed and a blockage in the supply system.

→ A rotating screw is used for carrying and mixing material through cylinder and forcing through a die of required shape.

→ The screws are designed to suit each application.



Calendaring - An important method of making film and sheet is known as calendaring.

- In this process the plastic compound is passed between a series of heated rollers as illustrated
→ It comes out from the roller squeezed into film or sheet.
→ Thickness is controlled by a combination of squeezing and altering the speed of the finishing rollers.
→ vinyl floor tile cellulose acetate sheeting and films are some of the application.

Casting process

- Casting involves introducing a liquefied plastic into a mold and allowing it to solidify.
→ In contrast to molding and extrusion casting relies on atmospheric pressure to fill the mold rather than using significant force to push the plastic into the mold cavity.
→ Some polymers have a viscocity similar to bread dough even when they are at elevated temperature so they are not candidates for the casting process. → Ex. polymers like pom, PC, PP
→ Casting includes a number of processes that take a monomer, powder or solvent solution and pour them into a mold.
→ They transition from liquid to solid by either evaporation, chemical action, cooling or external heat. → The final product can be removed from the mold once it solidifies.

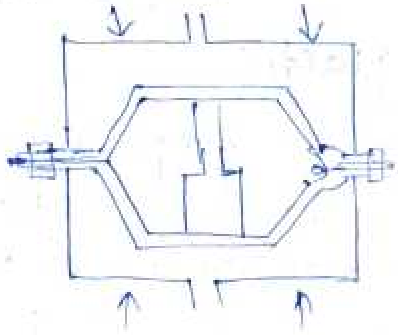
FABRICATION METHOD

Sheet Forming – A number of techniques have been made available for the production of hollow products by thermoforming. → Typical is the concept of dual sheet thermoforming.

→ Two rolls plastic sheet are automatically fed, one above the other with a predetermined space in between through the heating stations and into the forming station.

→ High pressure air then is introduced between the two sheets from the blow pin and a vacum is applied to each of the two mold halves.

→ The hollow object then indexes forward and the next two segments of sheet move into place for forming. → in one variation of the process urethane foam instead of air pressure is introduced between the two sheets.



(Sheet Forming)

Blow moulding

- Blow moulding and rotational moulding are used to make hollow seamless parts out of thermoplastic polymers. → Rotational moulding can also be used for thermosets. → From small plastic bottles to large storage drums.

→ Blow moulding are used to makes small parts of bulk production and rotational moulding favours large hollow shape.

→ There are Two methods
→ Direct method and
→ Indirect method.

Direct method

→ A thermoplastic resin is heated to a molten state it is than extruded through a die head to form a hollow tube called a parison.
→ The parison is dropped between two mold halves which close around it.
→ The parison is inflated by pressrized air.
→ The mould opens and the finished component is removed

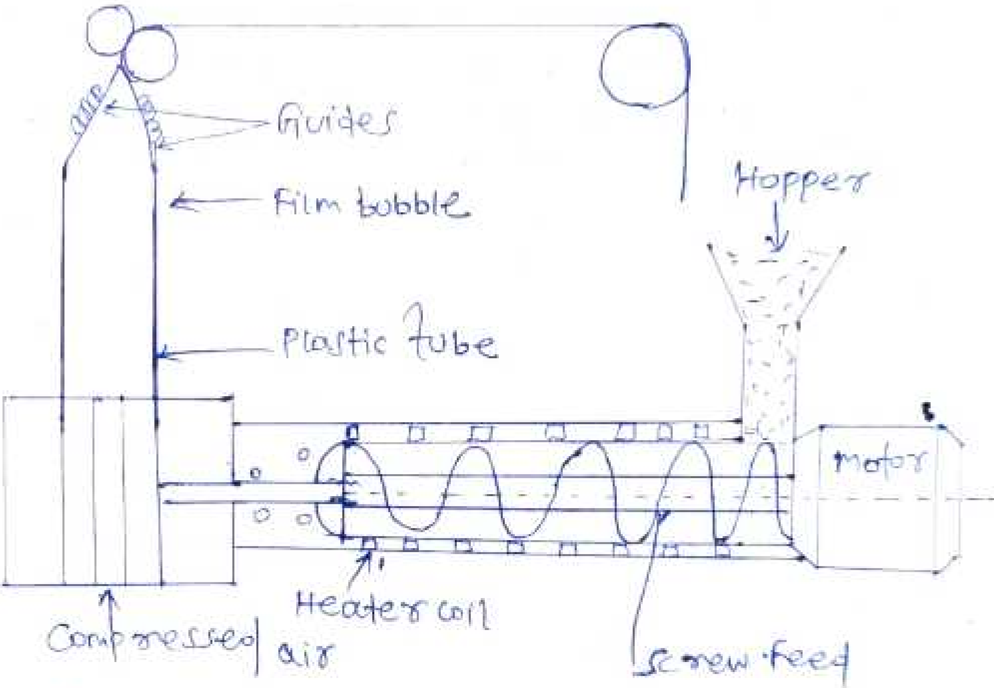
In direct method

→ in - indirect blow moulding process a flat plastic sheet whose ends are clamped at the edge between the die and a cover is uniformaly heated and softend
→ The desired shape is then obtained by blowing the air between the sheet and the cover.

Laminating plastic

- Laminating plastic comprise sheets of paper, fabric, asbestos, wood or similar materials which are first impregnated or coated with resin and bonded together by heat and pressure to form commercial materials.
- Those materials are hard, strong, impact resisting unaffected by heat or heat or water and have good machining characteristics which permit is fabrication into gears handles, bushings, furniture and many other articles.
- Laminations are classified into three categories depending upon the pressure required to sure the resin in manufacture :-

- Laminations cured at 0 to 2 kgf/cm2 called contact pressure Laminations.
- These cured at pressures below 27 kgf/cm2 are called low pressure Lamination.
- 80 to 140 kgf/cm2 are High pressure Lamination.
- → Commercially Laminates are available in sheets, rods tubes and special shapes Among these sheet form is more common.



Applications of plastic

- At present, plastics in many fields have become indispensable and at some places they have safely replaced other materials.
- In many fields plastics are going to replace even steel. people at present are thinking of making plastic wheels and plastic cycle have already been made.
- There is no single type of plastic, rather there is a huge variety of its forms.
- These are being consumed in nearly all industries in the form of laminated sheets and tubes, in the form of reinforced plastics

- ~~There Two methods~~
  - ~~→ Direct method~~
  - ~~→ Indirect method~~
- Polyvinyl chloride has been very much successful in replacing rubber in distribution of electricity.
- They are being used in radios, telephone hand pieces in telecommunication as high frequency insulation in automobiles in film industry and even in clothing.
- A great credit for all this goes to research in chemical technology which has been able to give us complete properties of a wide variety of plastics.

ADDITIVE MANUFACTURING PROCESS

What is Additive manufacturing

- Additive manufacturing is the formalized term for what used to be called rapid prototying and what is popularly called 3D printing.
- The term rapid prototyping (RP) is used in a variety of industries to describe a process for rapidly creating a system or part representation before final release or commercialization
- Users of RP technology have come to realize that this term is indequate and in particural does note effective describe more recent applications of the technology.
- Improvements in the quality of the output from these machines have meant that there is often a much closer link to the final product.

NEED

→ Initially, AM was used specifically to create visualization models for products as they were being developed.

→ It is widely known that models can be much more helpful than drawings or renderings in fully understanding the intent of the designer when presenting the conceptual design.

→ While drawings are quicker and easier to create, models are nearly always required in the end to fully validate the design.

→ Models were quickly employed to supply information about that is known as the '3 Fs' of Form fit & Funtion

→ Improved material properties meant that parts could be property handled so that they could be assessed according to how they would eventually work.

Fundamentals of Additive Manufacturing process

- Additive manufacturing technology uses 3 dimensional printing technology in order to create parts and assemblies without tooling. Additive manufacturing reducess design risk, provides efficiencies for the manufacturing process and is used for low-production part runs.

AM PROCESS CHAIN

Am involves a number of steper that move from the virtual CAD description to the physical resultant part.

- Different products will involve Am in different ways and to different degrees.

Small, relatively simple products may only make use of Am for visualization models while large more complex products with greater engineering content may involve Am during numerous stages and iterations throughout the development process.

- Later on, we will investigate thoroughly the different stages of the Am process but to summarize most Am processes involve to some degree at least the following eight steps.

1. CAD
2. STL convert
3. File transfer to machine
4. Machine setup
5. Build
6. Remove
7. post-process
8. Application

- The above mentioned sequence of steps is generally appropriate to all AM technologies. There will be some variations dependent on which technology is being used also on the design of the particular part.

Advantages of AM

→ AM provides a unique ability to fabricate components with high variability and flexibility in geometrical features.

→ It offers a path of fabricating some special components like high hollow contours or mold cavities with passages for internal cooling etc.

→ Great cost ~~path~~ savings can be obtained by the use of the AM route for part fabrication as compared to the conventional methods of manufacturing.

→ The time required to bring the component to market is greatly reduced by this route due to the enormous compaction of the design cycle in case of AM.

→ Appreciable strength-to-weight ratio metallic part can be fabricated since a high degree of freedom in design is permitted by the AM route.

Disadvantages of AM

→ Despite remarkable progress in the domain of AM, a variety of aspects like production speeds build scale economies precision, quality, raw materials communication interfaces etc.

→ Non-optimal build speeds

→ Relatively less accuracy

→ Decision regarding optimal part orientation

→ Restricated choice of raw material and resulting material properties.

- poor Surface finish
- pre-processing and post-processing requirements
- High System cost chiefly owing to limited buyers
- poor Structural Strength of parts fabricated via AM techniques.

Commonly used Terms (AM)

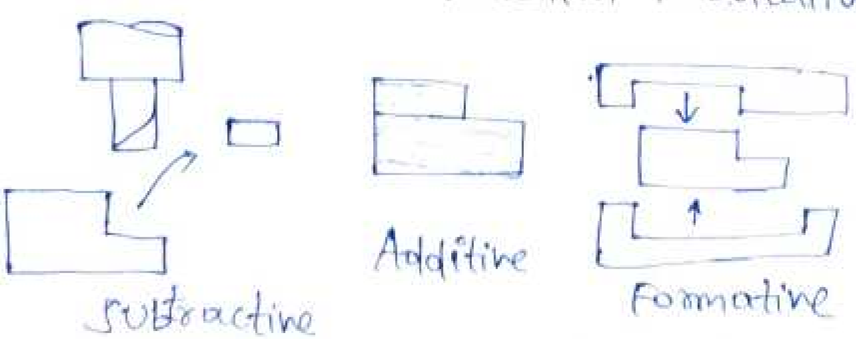
- The number of terms used by the engineering communities around the world is alarmingly large. perhaps this is due to the newness of the technology.
- It certainly does not help as. already there are so many buzz words used today.
- worldwide, the most Commonly used term is Rapid prototyping. The term is apt as, the key benefit of RP is its rapid creaction of a physical model.
- Some of the less commonly used terms include Direct CAD manufacturing, Desk-top manufacturing and Instant manufacturing..
- The rationale behind these terms are also speed and ease, though ~~at~~ not exactly direct or instant. CAD oriented manufacturing is another term and provides an insight into the issue of orientation often a key factor influencing the output of a prototype made by RP methods like SLA.
- There is yet another group which chooses to focus on the words Solid Freeform. Solid freeform manufacturing and Solid freeform fabrication.

Classification of additive manufacturing process

- The seven process categories are presented here.
- → Vat photo polymerization : processes that a liquid photopolymer that is contained in a vat and processed by selectively delivering energy to cure specific regions of a part cross-section.
- → Powder bed fusion : processes that utilize a container filled with powder that is processed selectively using an energy source most commonly a scanning laser or electron beam.
- → Material extrusion : processes the deposit a material by extruding it through a nozzle, typically while scanning the nozzle in a pattern that produces a part cross-section.
- → Material jetting : Ink-jet printing process.
- → Binder jetting : processes where a binder is printed into a powder bed in order to form part cross-section.
- → Sheet lamination : processes that deposit a layer of material at a time, where the material in sheet form.
- → Directed energy deposition : processes that simultaneously deposit a material and provide energy to process that material through a single deposition device.

Fundamental Automated processes

→ There are three fundamental fabrication process



- They are Subtractive - Additive & Formative process.
- In the Subtractive process is the exact reverse one starts with a single block of solid material larger than the final size of the desired objectect and material is removed until the desired shape is reached.
- In contrast, an additive process is the exact reverse: in the end product is much large than the material when it started.
- A material is manipulated so that successive portions of it combine to form the desired object.
- Lastly, the formative process is one where mechanical forces or restricting forms are applied on a material so as to form it into the desired shape.
- There are many examples for each of these fundamental fabrication processes.
- These include milling, turning, drilling, planning, sawing, grinding, EDM, laser cutting the like.
- Hybride machines combining two or more fabrication processes are also possible.
- For example in progressive press working it is common to see a hybrid of subtractive and formative processes.

Differences Between AM & CNC Maching

AM	CNC
• Based on subsequent addition of material	• Based on subsequent removal of material
• Based upon additive principle which entirely different from conventional manufacturing	• Based upon conventional manufacturing but with difference in control mechanism.
• Does not require tooling systems (tool, jig, fixture, etc)	• Requires sophisticated tooling system (tool, jig, fixture, etc)
• Number of setups is usually one thus reducing time lags	• Multiple setups are generally required before obtaining final product leading to time lags.
• Comparatively slower in-process construction	• Much faster process speed
• Modeller preperation is a simple process	• CNC station preparation is a relatively time-consuming process.
• Material density and part height greatly affect build time.	• Feature count as well as intricacy specially affect build time.
• Most AM processes are accompanied by one or other kind of post-processing operation.	• Post-processing is rarely mandatory in case of CNC machining.
• AM parts tend to undergo warping and distortion and also occurrence of layered contours.	• CNC parts have better polished looks and are rarely distorted during maching.

APPLICATION OF DESIGN

CAD MODEL VERIFication

- This is the initial objective and strength of RP system in that designers often need the physical part to confirm the design that they have created in the CAD system
- This is especially important for parts or products designed to fulfill aesthetic functions or that are intricately designed to fulfill functional requirements.

Visualizing objects

- Designs created on CAD systems need to be communicated not only almost designers within the same but also to other departments like manufacturing and marketing.
- Thus, there is a need to create objects from the CAD designs for visualization so that all these people will be reffering to the same object in any communications.
- Tom mueller in his paper entitled 'Application of stereolithography in injection molding': characterizes this necessity by saying : many people cannot visualize a part by looking a print Even engineers and toolmakers who ideal with print

m.

Marking Commercial Applications

- Frequently the marketing or commercial departments require a physical model for presentation and evaluation purposes, specially for assesment of the project as a whole.
- The mock-up or presentation model can be used. produced promotional brochures and related material for marketing and advertising even before the actual product becomes availables.

AEROSPACE INDUSTRY

- With the various advantages that RP technologies promise, it is only natural that high value-added industries like the aerospace industry have taken special interest in it even through initial investment costs may be high.
- There are abundant exmples of the use of RP technology in the aerospace industry.
- The following are a few example.
  -> Design verification of an Airline electrical Generator. -> Engine ~~verification~~ of an componets for Fanjet engine -> prototyping Air Inlet Housing for gas Turbine Engine. -> Fabrication of flight-certified production castings.
- It decided to use Heliey's Lom to create the design-verification model.
- The generaly is made up of an external housing and about 1250 internal parts.

- Such complex designs are diffiuct to visualize housing from two dimensional drawings.
- Thus Sundstrand decided to turn RP technology

AUTOMOTIVE INDUSTRY

prototyping Complex Gearbox Housing for Design verivatation

- Volkswagen has utilized Helysis's LOM to speed up the development of a Large complex gearbox housing for its Golf and passat car liner.
- The CAD model for the housing was extremely complex and dificult to visualize.
- VW wanted to build a LOM part to check the design of the and dificult to visualize.
- VW wanted to build a LOM part to check the design of the CAD model and then use the part for packaging studies

prototyping advanced Driver Control System

- At General motors in many of its divison RP is becoming a necessary tool in the critical race to be first to market.
- For ex- Delco Electronics its automative electronics subsidiary was invaved in the devlopment of the maestro project.

JEWELRY INDUSTRY

- The jewelary Industry has traditionally been regarded as one which is heavily craft-based and automation is generally restricted to the use of machine in the various individual stages of jewelry ~~degin~~ manufacturing.

- The use of RP Technology ~~by nanyang~~ in jewelary design and manufacturing system jointly developed by nanyang Teachnology in university and Rintic in stitute of manufacturing technology in singapone. The SLA was used successfully to create fine jewelry models.
- These were used as master pattern to create the rubber molds for making wax patterns that were later used in investment casting of the precious metal end product.
- These were used as master patterns to create the rubber molds for making wax patterns that were later used in investment casting of the precious metal end product.

Arts & Architecture → Arts & Architecture (1929–1967) was an American design, architecture, lndscape, and arts magazine. It was published and edited by John Entenza form 1938–1962 and David Travers 1962–1967.

→ History of Art & Architecture is about the study of images, objects and buildings. It is unique in developing high levels of visual literacy applicable to a range of career pathways.

Rapid prototyping medical App.

Rapid prototyping technologies have introduced a new approach for surgical planning and simulation. The technologies enable one to create anatomical objects in a three-dimensional view giving the surgeon a realistic representation of the target organ in the body.

Bioengineering Applications

- The book covers innovative breakthroughs in additive manufacturing process used for biomedical engineering. More, 3D printing is selected over traditional manufacturing process.
- Additive manufacturing process in biomedical Engineering: Advanced fabrication methods and Rapid Tooling Techniques acts as a first-hand reference for commercial manufacturing organization which are mimicking tissue organs by using additive manufacturing techniques.
- By capturing the current trends of today's manufacturing practices this book becomes a one-stop resource for manufacturing professionals, engineers in related disciplines and academic researchers.

Webs based Rapid Phototyping system

- Rapid prototyping manufacturing (RP&M) technique has shown a high potential to reduce the cycle and cost of product development.
- It has been considered as one of crucial enabling tools in digital manufacturing.
- manufacturing industry is evolving toward digitalization, network and globalization.
- RP&M technique using the internet can further enhance the design and manufacturing productivity, speed, and economy, as well as share the RP machines.
- web-based RP&M systems have been developed and employed to implement remote service and manufacturing for rapid prototyping.
-

- It enhances the availability of RP&M facilities & improves the capability of rapid product developement for a large number of small and medium size enterprises.

Flexible Manufacturing process

Introduction

- A flexible manufacturing system is highly automated group technology cell.
- FMS is a manufacturing system based on multi operation machine tools, incorporating integrated computer control with associated support function of automatic material handling.
- FMS consists of a
  - → Group of processing work stations
  - → Interconnected by an automated material handling and storage system. and
  - → controlled computer system.

Types of CIMS

The CIM can be divided into three types. They are

- → Special manufacturing system
- → Manufacturing ~~system~~ cell
- → Flexible manufacturing system

Special manufacturing system

- The special manufacturing system is the least flexible CIMS.
- Designed to produce a very limited number of different parts at high production rate.
- The configuration would be similar to transfer line.

Functions of FMS

- In a FMS, number of functions will be performed by each of the major subsystems and they are interdependent for successful operation of the entire system based on the various product manufactured.

- The major subsystems of a FMS are,
→ production equipment → support systems
→ Materials handling system → Automated storage and retrieval system → Bottom storing of parts
→ chip removal and washing stations → computer control system.

Advantages of FMS

- The correctly designed and implemented Flexible manufacturing offers the following benefits,
→ Greater labour productivity: Fewer workers requiring specialized education and skills.
→ Greater machine efficiency: Fewer machines, less floor space and less space for operator movement.
→ improved quality: Less wastage because on-line gauging allows immediate feedback and adjustment of the manufacturing process.
→ increased system reliability: intelligent, self-diagnosing controls decrease the time required to identify and correct hardware problems.

Disadvantages of FMS

- Substantial pre-planning activity is necessary.
- Expensive due to sophisticated manufacturing systems.
- Technological problems of exact component positioning and precise timing necessary to process a component.
- FMS's complexity and cost are resons for their slow acceptance by industry.

Concurrent engineering

- The traditional approach to launch a new product tends to separate the two functions, as illustrated.

• concurrent engineering refers to an approach to product design in which companies attempt to reduce the elapsed time required to bring a new product to market by integrating design engineering, manufacturing engineering and other functions in the company.

• product design develops the new design, sometimes with small regard for the manufacturing capabilities possessed by the company.

• All of these functions can contribute to a product design that not only performs well functionally, but is also manufacturable, assemblable, inspectable, testable, serviceable, maintainable, free of defects and safe.

• in addition to design for manufacturing and assembly, other objectives include design for quality, design for life cycle, and design for cost.

• Design for life cycle refers to the product after it has been manufactured. in many cases, a product can involve a significant cost to the customer beyond the purchase price.

• The manufacturer must often include service contracts that limit customer vulnerability to excessive maintenance and service costs.

• A product's cost is a major factor in determining its commercial success. cost affects the price charged for the product and the profit made on it.

Capstan and turrent lathe

• A capstan or a turrent lathe is a production lathe used to manufacture any number of identical pieces in the minimum time.

• These lathes are developement of engine lathes.

• The capstan lathe was first developed in the united states of america by pratt and whitney sometimes in 1860.

• The capstan or turrent lathe consists of a bed, all geared headstock and a saddle on which a four station tool post is mounted to hold four different tools.

- In a capstan or turret lathe there is no tailstock, but in its place a hexagonal turret is mounted on a slide which rests upon the bed.
- All the six faces of the turret can hold six or more number of different tools.
- The turret may be indexed automatically and each tool may be brought in line with the lathe axis in a regular sequence.
- The work piece is held in collects or in chucks.
- The longitudinal and cross feed movement of the turret saddle and cross-slide are regulated by adjustable stops.

Rapid prototyping (RP)

- Rapid prototyping (RP) is the name of a number of computer-based technologies that make it possible to quickly build a 3-D model of a part or physical objects directly from a computer Aided Design (CAD) file.
- In the highly competitive world of today, rapid time-to-market for new products is critical for manufactures to be successful.
- Three-dimensional prototype models are a key and essential step before the manufacture of most industrial and consumer products and parts.
- The process starts with software that slices the CAD model into thin layers.
- The computerized RP machine builds the cross-sections one layer on top of the previous to produce the finished prototype of the part.

Rapid prototyping methods

- The various RP technologies differ from the way the cross-sections are produced as well as the material that can be used.
- The most common rapid prototyping processes are
  - → stereolithography
  - → selective laser sintering and
  - → Laminated object manufacturing

① Special purpose machines (SPM)

Concept of Special purpose Machine (SPM) (SPM)

- SPM, special purpose Machines is a high productivity machine, with specially designed tooling and fixture, dedicated for mass producing the same component day in and day out.
- A judicious combination of limit switches, sensors, logic control, automatic job clamping etc. is the essence of a SPM.
- Special purpose machine tools are designed and manufactured for specific jobs and as such never produced in bulk.
- Such machines are finding increasing use in industries.
- The techniques for designing such machines would obviously be quite different from those used for mass produced machines.

General Element of SPM

- General Elements of SPM
- control system
- Electric power supply
- Drives and drive controls.

Input/Output control Equipment

→ Input/Output equipment for any machine tool provides communication mechanism.

→ With increase in automation, electro-Mechanical limit switches constitute most important communication mechanism.

→ These switches usually have single-pole contact block with one normally open (NO) and one normally closed (NC) contacts.

→ Time delayed contact limit switches are used for detecting machine jam-up by causing switch to remain actuated beyond a predetermined time interval.

→ Maintained contact switches are used for detecting where a second definite reset motion is desired.

→ Push-in roller limit switch is used for linear or rotary cam actuation.

control systems

→ control systems for machine tools range from relay panels, programmable controllers, computerized numerical controllers and drive systems to highly complex computers.

→ An automated factory consists of any of these in combination with robots, distributed control, and data communications network.

→ programmable controllers have been very effective in improving production line uptime, lower maintenance cost, increasing production volume and product uniformity, optimum space utilization etc.

→ The programmable controllers used should be compatible with the communications network.

→ in deciding the extent of automation, the cost/value ratios should be determined.

Electric power supply

→ Most of the drives of machines tools and controls require electric power supply.

→ uninterrupted power supply obtained by batteries or back up engine generator is essential for computer systems.

→ High production rates and high costs of idle time and materials demand that no part of a plant should be shut down unnecessarily.

→ Microprocessor technology is being used to achieve circuit protective devices to obtain precise co-ordination.

→ power supply for microprocessor based equipment should be clean, i.e. contain no voltage spike from any disturbances in the system or by external influence.

Drives and Drive controls.

- The rotary shafts and linear motion members are most important for any machine tool.
- The use of high efficiency motors is desirable. since drive efficiency is the product of all drive component efficiencies, all drive line components efficiencies, a should be efficient.
- This also reduces heat dissipation there by extending equipment life.
- Adjustable speed drives play a greater role in energy conservation.
- Both AC and DC motors are available with adjustable speeds.
- DC motors with no brushes and easily replaceable modular components are available.

productivity improvement By SPM

- The special purpose machines (SPM) and automatic machines are designed to operate continuously for 24 hours a day, with minimum supervision.
- The special purpose machines are generally product specific and they are required to be designed & developed for each specific requirement. sometimes it may be possible to cater to the jobs having similar features but differing in dimensions by change tooling concept.
- These special purpose machines (SPM) are either cam operated machine or they use hydraulics and pneumatics as actuating elements or combination of all the three ~~is achievable~~. of them.
- The productivity achieved after all these efforts is very high, productivity of 3 to 10 times is achievable.

→ However to fetch the fruits of these highly specialized

Principle of SPM design

→ Automation and technological advancements have drastically changed the manufacturing industry.

→ Designs for a wide array of applications, which include.

→ Specialized industrial machines.

→ Processing and packaging equipment.

→ Welded Automation.

→ Automated test equipment.

→ Tooling system for casting and sheet metal.

→ Articulating arms.

→ Part transfer chutes

→ Rapid prototyping

Special purpose Machine design service involve

- Conceptual design
- Reverse engineering
- Detailed drawing
- Legacy CAD conversions

(5) MAINTENANCE OF MACHINE TOOLS

Machine maintenance

- Machine maintenance is the means by which mechanical assets in a facility are kept in working order. Machinery maintenance involves regulatory servicing of equipment, routine checks, repair work, and replacement of worn or nonfunctional parts.

Types of Maintenance

- preventive maintenance
- predictive maintenance
- corrective maintenance

preventive maintenance

- preventive maintenance (PM) is a simple and popular maintenance strategy.
- preventive maintenance can help extend asset life, increase productivity, and ultimately decrease maintenance spending. → you wouldn't wait until your car's engine fails to get the oil changed so, you already know the value of preventive maintenance

→ Also called planned or preventative maintenance pm is conducted throughout an asset's normal downtime.

predictive maintenance → predictive maintenance is a technique that uses condition-monitoring tools and techniques to monitor the performance of a structure or a piece of equiment during operation

corrective maintenance → corrective maintenance is a maintenance take performed to identify isolate and rectify a fault so that the failed equipment. → machine or system can be restored to an operational condition within the tolerances or limits established for in-service operations.

→ corrective maintenance is planned when a run-to-failure maintenance strategy is used

→ This is when an asset is allowed to run until it breaks down and is then repaired or replaced

→ This Type of corrective maintence only works with non-critical assets that are easily and cheaply repaired or replaced or with systems have redundancies.

Schedule maintenance → Scheduled maintenance is a stin-in-time procedure aimed at avoiding break downs → Breakdowns can be dangerous to life and as far as possible should be minimized. → Scheduled maintenance practice incorporates (in it) inspection lubrication repair and overhaul of certain equipments which if neglected can result in brekdown.

Repair cycle Analysis → Repair cycle refers to the stages through which a repairable item passes from the time of its removal or replacement until it is reinstalled or placed in stock in a serviceable condition.

Type (i) Economic (ii) Non-Economic

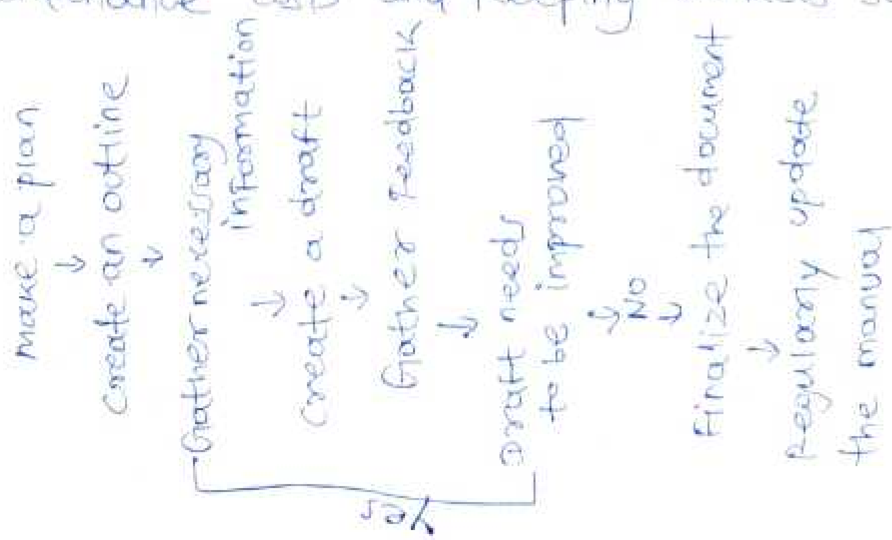
Economic - Addressed using cost models that calculate the possible costs of all support options and then identify the least-cost-solution.

→ Then the total cost of each option can be compared to determine the lowest option in terms of long-term support over the life of the system.

Non-Economic - Decision criteria are a list of rules or guidelines that are used to determine if there is an overriding reason why maintenance should be performed.

Repair Complexity. → In maintenance systems complexity can be defined based on technical and managerial aspects of a maintenance project.
→ Because relative complexity between two projects can be used as a yardstick, for resource allocation between them quantifying the complexity becomes important
→ To quantify the complexity of maintenance projects this thesis reports two models. → These apects may not be measured precisely due to uncertain situations. → The model uses an aggregation operator to mitigate confict of experts opinions on complexity relations. → Also complexity of a maintenance project can be investigated through time to repair (TTR)

Maintenance Manual - An operation and maintenance manual is a document that provides essential details about property and equipment upkeep.
→ O&M manuals provide maintenance presonael with detailed guidance on extending asset life cycles.
→ Minimizing ~~[illegible]~~ unplanned shutdowns reducing maintenance costs and keeping workers safe.



Computer Aided maintenance → For effective discharge of the maintenance function a well designed information system is an essential tool.
→ Such system serve as effective decision support tool in the maintenance planning and execution.
→ For optimal maintenance scheduling large volume of data pertaining to men money and equipment is required to be handled. → This is a difficult task to be performed manually.

Maintenance Record → Maintenance record as name suggests is a document that includes information regarding each repair and maintenance work that is done on asset or equipment. → In simple words it keeps tracker of assets failures and repairs.
→ It is one of best way to maintain health and safety management. → It also improves asset management as such record includes information

Why Record importance
→ prevent Expensive Repairs → Increase safety
→ Replacing Equipment → Reduces Labor workload
→ marge Bach machine.

Housekeeping → Housekeeping refers to the routine cleaning and organizing of the workplace.
→ Housekeeping orperations in the workplace are considered to be a fundamental tenet of occupational safety and are a mandatory workplace safety activity in most jurisdictions.
→ Hoos keeping is followed by 5s concept.

5S concept → 5S is the name of a workplace organization method that uses a list of five japanese words. → (1) Seiri (2) Seiton (3) Seiso (4) Seiketsu (5) Shitsuke • They all start with the letter 'S'.
• There are 5S phases • They can be translated from the japanese as. (i) sort (ii) straighten (iii) shine (iv) standardize (v) sustain

Seiri (sort) → • 5S seiri or sort is the first step in 5S. it refers to the sorting of the clutter from the other items with in the work area that are actually needed. Sorting Methods → • keeping only necessary items • Remove unnecessary items and dispose of them properly • Make work easier by eliminating obstacles. • Reduce chance of being disturbed with unnecessary items. • Remove all parts not in use

Seiton (straighten) • 5S seiton or straighten is the process of taking the required items that are remaining after the removal of clutter and arranging them in an efficient manner through the use of ergonomic principles and ensuring that every item "Has a place and that everything is in its place". • prevent loss and waste of time • Ensure first come first served basic. • Make workflow smooth and easy • All above work should be done on regular basic.

Seiso (shine) • 5S seiso or shine is the through cleaning of the area, tools, machines and other equipment to ensure that everything is returned to a "Nearly new" states. • use cleaning as inspection • prevent machinery and equipment deterioration • keep workplace safe and easy to work • keep work place clean and pleasing to work in.

Seiketsu (standardize). • standardize is the process of ensuring that what we have done within the first three stages of 5S become standardize. • That is we ensure that we have common standards and ways of working • standard work is one of the most important principles of lean manufacturing. • Maintain high standards of housekeeping and workplace organization at all times. • everything in its right place. • Every process has a standard. • keep each area consistent with one another.

Shitsuke (Sustain) • implementing behaviors and habits to maintain the established standards over the long term and making the workpiece organization the key to managing the process for success. • Toughest phase is to sustain many fall short of this goal. • Every one sticks to the rules and makes it a habit. • Regular audits and reviews • led to root cause of issues • Aim for higher 5S levels continuous improvement

Applications • 5S is now being applied to a wide variety of industries. • It has expanded from manufacturing to heath care, education, government and many other industries. • Although the origins of the 5S methodology are in manufacturing, it can also be applied to knowledge economy work, with information, software or media in the place of physical product.

Introduction to total productive Maintenance

Total productive maintenance • Total productive Maintenance (TPM) is a holistic approach to equipment maintenance that strives to achieve perfect production • TPM emphasizes proactive and preventive maintenance to maximize the operational efficiency of equipment.

• Analyzing the three letter of TPM. • Total - All encompassing maintenance and production individuals working together • Productive - Production of goods and servies that meet or exceed customer's expectations. Maintenance - Keeping equipment and plant in as good as or better than the original condition at all times. Total Quality management (TQM)

• Total - Made up of the whole • Quality - Degree of excellence a product or Service provides

• Management - Act, art or manner of handling, controlling, directing etc • Therefore, TQM is the art of managing the whole to achieve excellence.

• TQM emphasizes on empowering operators to help maintain their equipment and thereby creates a shared responsibility for equipment that encourages involvement by plant floor workers.

TQM VS TPM • The TPM program closely resembles the TQM program. • The similarities between TQM and TPM are given below • Total commitment to the program by top management is required in both programmes.
• Employees must be empowered to initiate corrective action. • A long-term outlook must be accepted as TPM may take a year or more to implement and is an ongoing process. • Also changes in employee attitude toward their job responsibilities must take place.

TQM VS TPM Maintenance Techniques Types of maintenance techniques The four types of maintenance techniques are corrective maintenance
• It implies that repairs are made after the failure of machine or equipment. Scheduled Maintenance • It is a stitch in time procedure aimed at avoiding breakdowns. Preventive Maintenance
• It is carried out before the failure arises or prior to the equipment actually breaks down. Predictive Maintenance • It is carried out before the failure arises • in this one the prediction of any fault, maintenance is being done

Features of TPM • The concept of 'true' TPM is that everyone from the operator to top management is responsible for maintenance activities
• in TPM, a management should also show interest in data concerning equipment uptime, utilization and efficiency.
• in short, everyone understands that zero breakdowns, maximum productivity and zero defects are goals to be shared by everyone under TPM. • TPM cannot be implemented overnight. • Normally it takes an organization at least two years to set an effective TPM system in place.

Benefits of TPM • increased equipment productivity
• improved equipment reliability • Reduced equipment down time. • increased plant capacity • extended machine line • Lower maintenance and production costs • improved team work between operators and maintenance people.
• Enhanced job satisfaction • improved return on investment • improved safety (Features) TPM activities are carried out in small teams with specific tasks. Every level in the overall organization must be represented by a team or more.