ELEMENTS OF MECHANICAL ENGINEERING – 18ME15/25

VTU JUNE/JULY 2019 – SOLUTIONS

1a.

Renewable sources of energy:

i. Solar energy
ii. Hydroelectric energy
iii. Wind energy
iv. Biomass energy
v. Geothermal energy

Non- renewable sources of energy:

i. Fossil fuels
ii. Coal
iii. Oil
iv. Natural gas
v. Nuclear fuels

NUCLEAR ENERGY

- The nuclear fuels obtained from earth's crust contain nuclear energy that can be harnessed by: nuclear fission/fusion of atomic nuclei.
- The energy is released in the form of heat and light rays.
- It is a conventional as well as non –renewable energy source.
- Nuclear fusion requires high temperatures, therefore not practical.
- Nuclear fission reactions are popular and technology for harnessing it is well developed.
- Uranium-235 is an ideal fissile element found occurring naturally.
- One gram of U235 nucleus produces about 0.95MW power per day.
- Radiation hazards is one of the main harms of nuclear energy.
- Use of nuclear fuels is inevitable for meeting the ever growing need for energy.

Nuclear Fission

•Involves splitting of nucleus of heavy atoms like uranium, plutonium, thoriumetc. In a controlled chain reaction.

•During fission, heat is released and this can be used to generate high pressure steam to drive turbines and hence generate electricity.
•U-235isotopeisafissilematerialwhichisuseddirectlyasnuclearfuel.

Nuclear Fusion

•Involvesfusionoftwolighteratomstoformthenextheavierelement.E.g.fusionofdeuteriumandtritiumtoformhelium.
•Enormous amount of energy is released during nuclear fusion process.

1b.

Global Warming

The continuous rise in temperature of the planet is really upsetting. The root cause for this is global warming. Global warming begins when sunlight reaches the Earth. The clouds, atmospheric particles, reflective ground surfaces and surface of oceans then sends back about 30 % of sunlight back into the space, whilst the remaining is absorbed by oceans, air and land. This consequently heats up the surface of the planet and atmosphere, making life feasible.

As the Earth warms up, this solar energy is radiated by thermal radiation and infrared rays, propagating directly out to space thereby cooling the Earth. However, some of the outgoing radiation is re-absorbed by carbon dioxide, water vapours, ozone, methane and other gases in the atmosphere and is radiated back to the surface of Earth. These gases are commonly known as greenhouse gases due to their heat-trapping capacity. It must be noted that this re-absorption process is actually good as the Earth's average surface temperature would be very cold if there was no existence of greenhouse gases.

Some greenhouse gases.....

- Excess greenhouses gases leads a way to Globalwarming.
- Millions of pounds of methane gas are generated in landfills and agricultural decomposition of biomass and animal manure.
- Nitrous oxide is released into the atmosphere by various nitrogen-based fertilizers including urea and diammonium phosphate and other soil management utilizations.
- Once released, these greenhouse gases stay in the atmosphere for decades or even longer.
- These gases traps the heat escaping to the space.

OZONE DEPLETION

- The ozone layer is a natural layer of gas in the upper atmosphere that protects humans and other living things from harmful ultraviolet (UV) radiation from the sun.
- Although ozone is present in small concentrations throughout the atmosphere, most (around 90%) exists in the stratosphere, a layer 10 to 50 kilometres above the Earth's surface. **The ozone layer filters out most of the sun's harmful UV radiation and is therefore crucial to life on Earth.**
- Scientists discovered in the 1970s that the ozone layer was being depleted.
- Atmospheric concentrations of ozone vary naturally depending on temperature, weather, latitude and altitude, while substances ejected by natural events such as volcanic eruptions can also affect ozone levels.
- However, these natural phenomena could not explain the levels of depletion observed and scientific evidence revealed that certain man-made chemicals were the cause. These ozone-depleting substances were mostly introduced in the 1970s in a wide range of industrial and consumer applications, mainly refrigerators, air conditioners and fire extinguishers

Effects of ozone depletion for humans and the environment

- Negative effects include increases in certain types of skin cancers, eye cataracts and immune deficiency disorders.
- UV radiation also affects terrestrial and aquatic ecosystems, altering growth, food chains and biochemical cycles.
- Aquatic life just below the water's surface, the basis of the food chain, is particularly adversely affected by high UV levels.
- UV rays also affect plant growth, reducing agricultural productivity.
- Most man-made ozone-depleting substances are also potent greenhouse gases. Some of them have a global warming effect up to 14,000 times stronger than carbon dioxide (CO_2), the main greenhouse gas.

1c.

@ 12 bar

$h_f = 798.33$ kJ/kg ; $T_{sat} = 187.96^\circ C$

$h_{fg} = 1985.4$ kJ/kg

$h_{dry\ saturated} = h_f + h_{fg} = 798.33 + 1985.4$

$= 2783.73$ kJ/kg //

$h_{22\%\ wet\ steam} = h_f + (1-0.22)h_{fg}$

$= 798.33 + 0.78 \times 1985.4$

$= 2346.94$ kJ/kg //

$h_{Superheated\ steam} = h_f + h_{fg} + C(T_{sup} - T_{sat})$

$= 798.33 + 1985 + 2.25(250 - 187.96)$

$= 2922.92$ kJ/kg //

2a.

ii. First Law of Thermodynamics

(a) Closed system following a finite process:

⟶ The algebraic sum of net heat and work interactions between a system and a surrounding for a process equals to the change in internal energy of the system.

Mathematically,

$$Q - W = \Delta U$$

case (i) If $Q_{in} > W_{out}$, there will be increase in the internal energy of system.

case (ii) If $Q_{in} < W_{out}$, there will be decrease in the internal energy of the system

(b) Closed system undergoing a cycle:

⟶ The algebraic sum of net heat and work interaction between a system and its surroundings in a thermodynamic cycle is zero.

$$q - w = \Delta U$$

$$\sum_{cycle} q - \sum_{cycle} w = \sum_{cycle} \Delta U$$

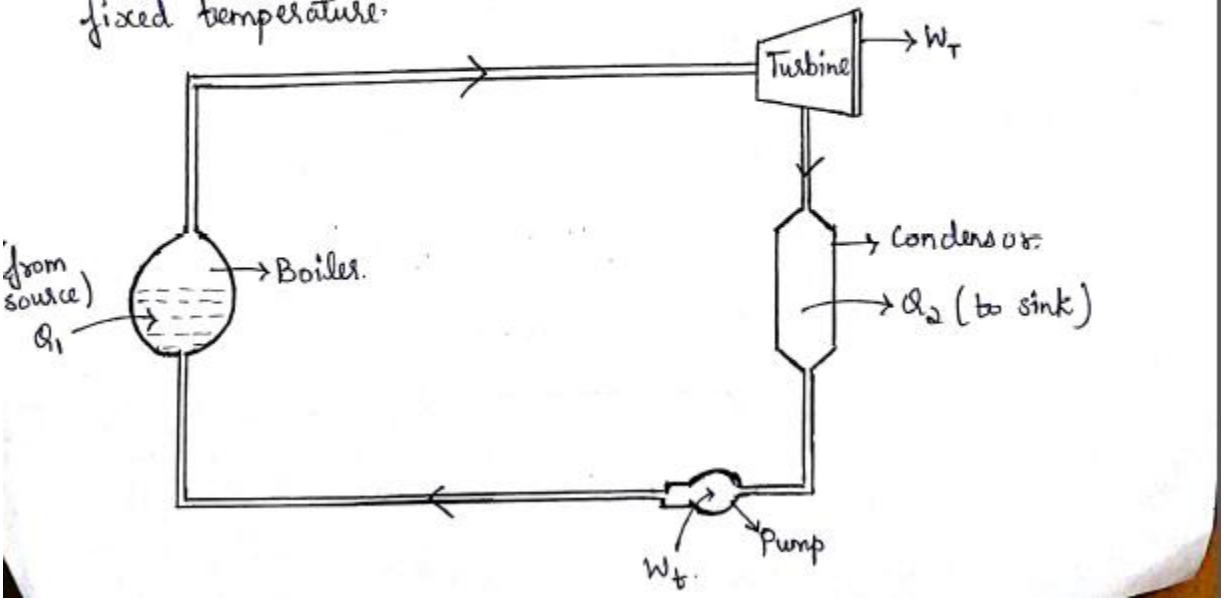
$$\oint q - \oint w = \oint \Delta U$$

$$Q - W = 0. \qquad \text{or} \quad \Delta U = 0.$$

iii. Second Law of Thermodynamics

i) Kelvin - Plank's statement -

"It is impossible for a heat engine to produce net work in a complete cycle if it exchanges heat only with bodies at a single fixed temperature."



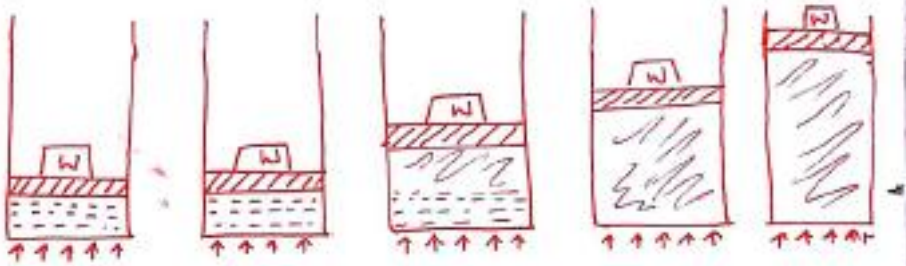
Here, Q_1 → heat supplied to boiler.
Q_2 → heat released from condensor.
W_T → Work done by the system (Turbine shaft work).
W_t → Work done on system by pump (external).

ii) Clausius statement -

"It is impossible to construct a device which operating in a cycle will produce no effect other than the transfer of heat from a cooler to a hotter body."

2b.

Steam formation :- (at constant pressure) from 0°c water,



(A) water at 0°C

(B) water at T_{sat}

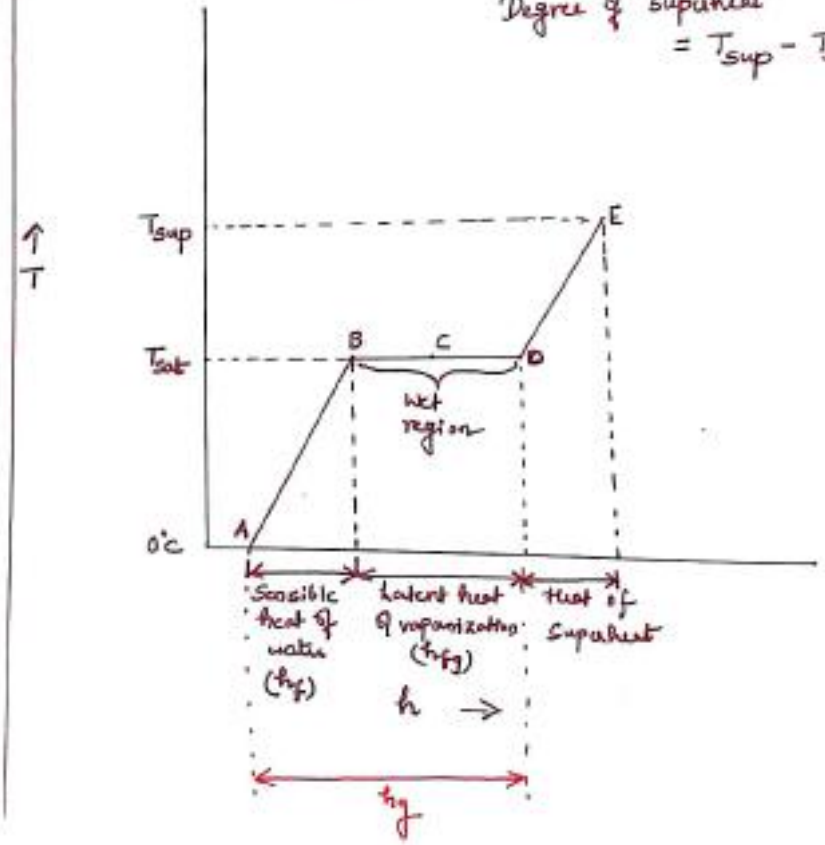
(C) Wet steam

(D) Dry saturated steam

(E) Superheated steam

T-h graph

Degree of superheat $= T_{sup} - T_{sat}$.



$h_g = h_f + h_{fg}$

Formation of steam explanation :-

Consider a piston and cylinder arrangement having 1 kg of water at 0°C. (point A).

Let a weight 'w' be added on top of the piston to maintain the pressure constant throughout the process.

Let this water be heated. The ~~heat~~ enthalpy of the system increases and the temperature starts to rise till the saturation temperature (boiling point) of the water is reached. (Point B)

If further heat is added to the system at point B, all of the heat will be used up to change the phase of water from liquid to steam (at point D). The temperature will remains constant during this phase change.

Between the points B & D, is the wet region, where not all the water at saturation temperature is converted into dry saturated steam. The steam in this region is called as wet steam which is characterized by suspension of water molecules in the steam.

Steam at any point (C) b/w B & D is known as wet steam

The steam at point D is called as dry saturated steam (which is completely dry and does not have any water molecules suspended in it).

If further heat is added to dry saturated steam, the temperature of steam starts increasing.

The steam beyond point (D) is called as superheated steam (Point E).

The temperature at which the superheated steam exist is called as Temperature of superheated steam. (T_{sup}).

As the heat supplied to the system is at constant pressure, the amount of heat supplied will be equal to increase in enthalpy of the system.

Note :- The boiling point (saturation temperature) of water changes according to the pressure and can be found out by steam table.

2c.

2c.

$P = 0.8 MPa$

$C = 2.25 kJ/kg$

i) when $x = 0.9$

$V_w = ?$

~~$h_w = ?$~~

$H_w = ?$

From Steam table for $P = 0.8 MPa$

$T_{sat} = 170.406$

$V_f = 0.0011478 \ m^3/kg$

$V_g = 0.24034 \ m^3/kg$

$h_f = 720.86 \ kJ/kg$

$h_g = 2768.3 kJ/kg$

$h_{fg} = 2047.4 kJ/kg$

Specific volume of wet steam,

$V_w = x V_g + (1-x) V_f$

$= 0.9(0.24034) + (1-0.9)\ 0.0011478$

$= 0.2164 \ m^3/kg$

Enthalpy,

$H_w = h_f + x \cdot h_{fg} = 720.86 + 0.9\ (2047.4)$

$= 2563.52 \ kJ/kg$

For Superheated steam at $T_{sup} = 300°C$

$V_{sup} = V_g \times \frac{T_{sup}}{T_{sat}}$

$= 0.24034 \times \frac{300+273}{170.406+273}$

$= 0.3105 \ m^3/kg$

$H_{sup} = h_f + h_{fg} + C(T_{sup} - T_{sat})$

$= 720.86 + 2047.4 + 2.25(300 - 170.406)$

$= 3059.84 \ kJ/kg$

3a.

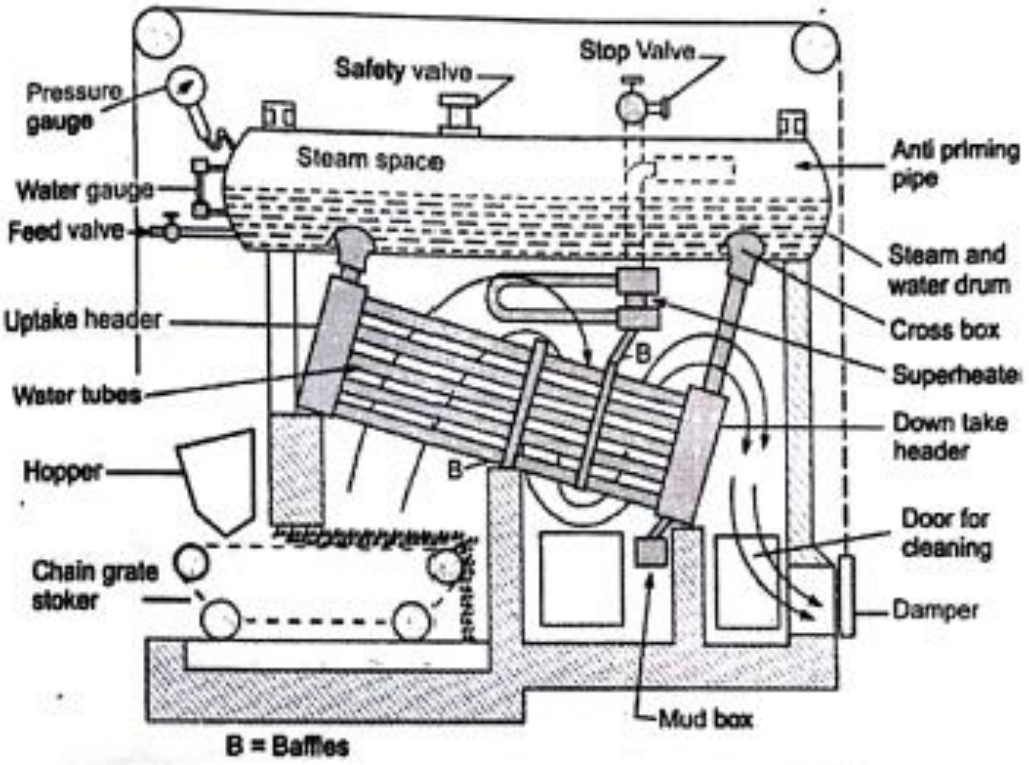
BABCOCK AND WILCOX BOILER

- It is a horizontal, externally fired water tube boiler.
- It can raise steam normally between 10 bar & 20 bar at a steam rate.
- A high capacity boiler of this type can produce steam up to a pressure of about 40 bar and steam rate as high as 4000 kg per hour.

Construction :-

- Babcock and Wilcox water tube boiler mainly consists of 4 parts :
  1. Water and Steam Drum
  2. Water tubes
  3. Chain Grate stoker
  4. Superheater tube.
- The water and steam drum is suspended from iron girders resting on iron columns.
- A number of inclined water tubes at a very low inclination of maximum upto 15° are connected at right angles to the end boxes or tubes called as headers.
- The header shown at the right end of the water tubes is called down take header and the other shown at the left end of the

water tubes is called uptake header.
- Each set of the headers are intern connected to the boiler drum.



- A mud box is provided just below the downtake header.
- Sediments in water due to its heavier specific gravity settles down in the mudbox as it is taken out through a blow off pipe.

- The moving grate is provided at the front end below the uptake header.
- Boilers of higher capacity are usually provided with a chain grate stoker, which consists of slowly moving endless chain of grate bar. The coal fed at the front end of the grate is burnt on the moving grate in the furnace and the residual ash falls at the other end of the grate into the ash pit.
- Boiler is fitted with a superheater which is placed in the combustion chamber underneath the boiler drum.

Working :→

- The water is introduced into the boiler drum through the feed valve
- A constant water level is maintained in the boiler drum.
- The water descends at the rear end into the downtake headers and then passes in the inclined water tubes, uptake headers and in the tubes connecting the uptake header and drum.
- During combustion, the hot gases from the furnace grate move upwards around the water tubes.
- There are baffle plates which guide the path of the flue gases in a particular direction as

shown in the figure inorder to have maximum coverage.
- It finally passes out of the boiler through the exit door and chimney.
- During this path of hot flue gases, the hottest gases emerging directly from the grate come in contact with the hottest portions of the water tubes near the uptake header.
- The water in these portions of the water tubes get vaporized.
- The water and steam mixture ascends or moves upward through the uptake headers to the boiler drum.
- Due to this flow, a continuous rapid circulation of water is established between the drum and water tubes.
- Eventually, the steam generated gets separated from water as it is lighter than water. The steam occupies the steam space in the boiler drum.
- The wet steam is then made to flow through the anti-priming device which separates the moisture making it as a dry saturated steam.
- This dry steam is then made to flow through the superheaters present in the combustion chambers.
- There is exchange of heat and the dry saturated steam is converted into superheated steam

3b.

Prime movers are defined as any machine that converts energy from any energy source into mechanical (shaft) power.

Pelton Wheel Turbine (An- Impulse turbine)

→ Pelton wheel turbine is a tangential flow impulse turbine, used for high heads and small quantity of water flow rate.

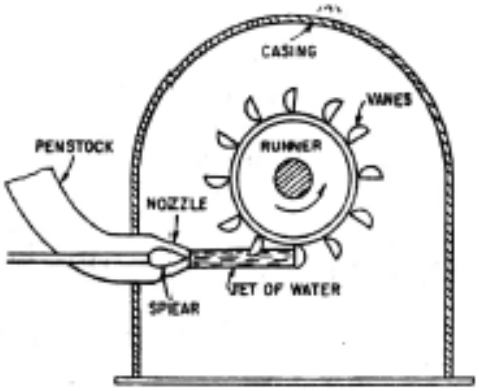


Fig : Pelton Wheel Turbine

→ It consists of following parts : (1) Nozzle with spear head (2) Runner/Rotor (3) Bucket/vanes (4) Casing.

Working:

→ Water from the dam reservoir having potential energy flows through the penstock and enters through nozzle.

→ The nozzle converts this potential energy into kinetic energy by increasing the velocity of water entering the nozzle.

→ High velocity jet of water from the nozzle strikes the hemispherical shaped buckets, fixed around the runner.

→ This high velocity water jet striking the bucket imparts an impulse force to the bucket.

→ This impulse force gives the runner rotary motion.

→ Hence, the shaft coupled to the runner wheel also rotatio thereby producing usefull shaft work.

→ Thus, potential energy of water converts into mechanical work.

→ Work produced at the output of turbine is used to drive (Shaft) a generator to produce electricity.

→ Water is discharged at tail-race after doing useful-work on runner.

(Hydraulic Energy → shaft work → electrical work)

4a.

Boiler Mounting :→

- Boiler mountings are the fittings or devices necessary for the safety and smooth operation of the boilers.
- The boiler mountings are listed as follows :

Boiler Accessories :→

Boiler accessories are auxillary fittings or devices required for the smooth operation of the boiler and to increase its overall efficiency.

The boiler accessories are listed as follows :⇒

Boiler Mountings:

① Safety Value.

Location: Fitted directly on the top of the boiler shell.

Function: To maintain a safe pressure inside the boiler. In case the pressure inside the boiler increases, the excess steam will automatically be released through the safety valves, thereby preventing the explosion of boiler.

② Water Level Indicator

Location: Fitted outside the boiler shell for clear inspection

Function: To indicate a safe water level inside the shell to avoid damage due to overheating in case of low water level.

③ Fusible Plug

Location: Fitted above the crown of the furnace

Function: To protect the boiler from explosion in case of overheating due to low water level. When the water falls below the minimum level, the

plug melts and allows the water to extinguish the fire in the furnace and the steam to escape through the plug hole.

(4) Pressure Gauge

Location: Fitted in front and at the top of the boiler shell for clear inspection.

Function: To indicate the pressure of the steam inside the boiler.

(5) Feed check Valve

Location: Fitted on the feed water pipeline very close to the furnace.

Function: To feed water into the boiler continuously. It has to regulate the rate of flow of feed water and prevent the backflow of water from the boiler.

4b.

Hydraulic pump is a mechanical device used to convert mechanical power into hydraulic energy.

(a)

Centrifugal Pump:

→ Centrifugal Pump is a power absorbing turbomachine used to raise liquids from a lower level to a higher level by creating the pressure required, using centrifugal action.

→ It converts mechanical energy into hydraulic energy (in form of pressure energy).

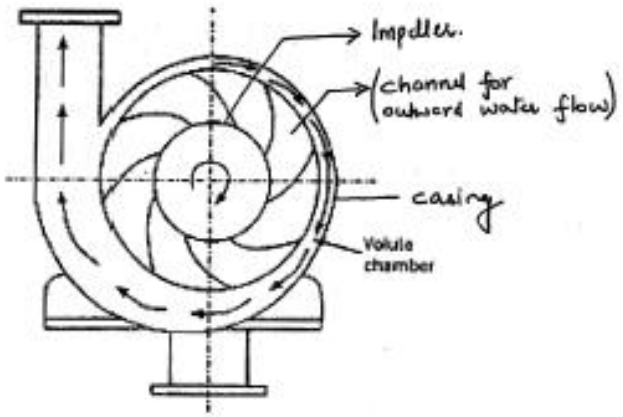


Fig: Centrifugal Pump

→ Construction

Main parts: (i) Impeller (ii) Casing (iii) Suction pipe (iv) Delivery pipe

→ Impeller is a rotating component of the pump.

→ Impeller consists of specially designed channel (passage for water flow), starting from centre toward the outer periphery in radial direction.

→ Casing is that part of the pump which receives the fluid being pumped by the impeller.

→ Casing is in spiral shape, with increasing cross-sectional area towards its outlet (To maintain velocity constant)

→ The inlet of the pump is connected to the sump, and outlet is connected to the delivery tank.

→ The pipe connecting sump & inlet of impeller is suction pipe

→ The pipe connecting outlet of pump & delivery tank is called as delivery pipe

Working :-

→ The motor drives the impeller, via a shaft.

→ As the impeller rotates, the water enters at the inlet of the impeller due to suction.

→ As the impeller rotates, the water entering the inlet of impeller is continously thrown out due to the centrifugal force.

→ The water passes through the specially designed channels in the impeller, towards the outer periphery of the impeller.

→ The casing space is filled by water continously, and is discharged to the delivery tank continously

→ The pressure head (m of water) developed by centrifugal action is entirely by the velocity imparted to the liquid by the rotating impeller.

→ Hence, speed of the shaft is enough to produce necessary centrifugal force for discharging.

5.a)

Q1. Explain the working of a 4-stroke Petrol Engine (Spark-Ignition Engine) with suitable diagram !

Ans 4-stroke Petrol Engine is an I.C Engine which completes one cycle of operation in four complete stroke of the piston and uses petrol as the fuel. It is also known as 4 stroke Spark-Igniting engine as the combustion process initiates by using a spark-Plug. It works on otto-cycle.

The figure below shows the four different strokes

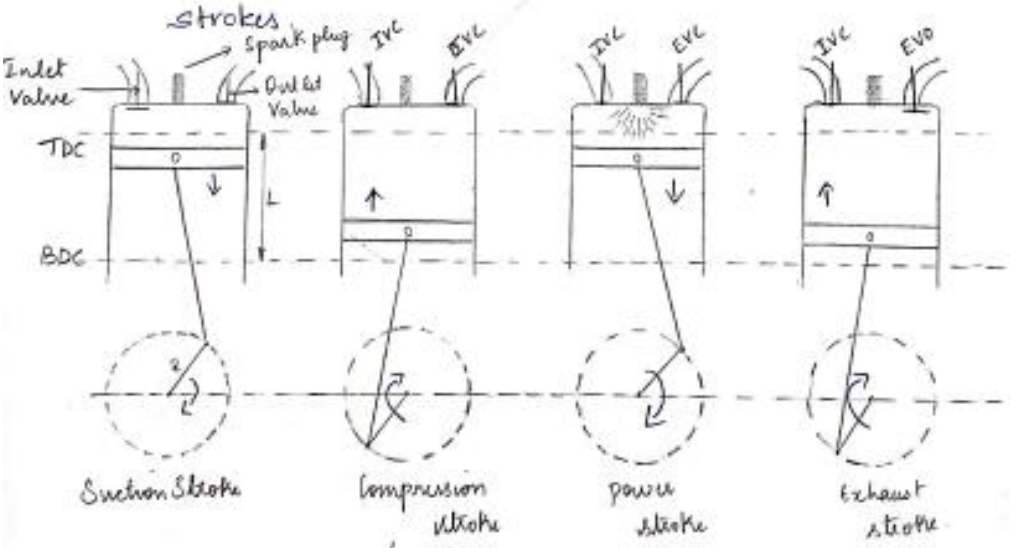


figure : 1.1

Suction stroke:

- The Piston moves from TDC to BDC, creating a partial vacuum in side the cylinder.
- Inlet valve is open and exhaust valve is closed.

- The air and fuel mixture is taken inside the cylinder due to the suction created by downward movement of the piston.
- Suction stroke completes during half - revolution of the crankshaft.
- Energy for this stroke is supplied during starting by cranking the engine, and flywheel supplies energy while engine is running.

Compression stroke:

- Compression stroke begins when piston starts moving from ~~Bottom~~ dead Centre (BDC) to Top dead Centre (TDC).
- Both Inlet and Exhaust valve is closed.
- The fresh air and fuel mixture taken in during the suction stroke, is compressed during this stroke
- Both pressure and temperature of fuel - air mixture increase
- Just at the end of compression stroke, the mixture is ignited with help of a spark - Plug. (const vol. heat addition)
- Combustion of mixture releases enormous amount of heat energy.

- Compression stroke completes in another half revolution of crankshaft.
- Energy for this stroke is supplied by cranking during starting, and flywheel supplies energy while engine is running.

5b.

Comparison between Petrol & Diesel Engine

Sl. No.	Description	Petrol Engine	Diesel Engine
1.	Cycle of operation	Works on Otto cycle (const. volume	Works on diesel cycle (const. pressure
2.	Fuel used	Petrol/gasoline	Diesel
3.	Admission of charge	Mixture of air-petrol enters the cylinder during suction stroke. Carburettor is used to supply air-petrol mixture	Only air enters into the cylinder during suction stroke. At the end of compression stroke, diesel is injected into hot compressed air.
4.	Ignition of fuel	Ignition takes place by means of spark plug	Fuel is ignited as it comes in contact with hot compressed air.
5.	Compression ratio	4:1 — 10:1	12:1 — 22:1
6.	Fuel consumption	More (due to low CR)	less (due to high CR)
7.	Flywheel/engine weight	Lighter (due to more uniform combustion, noise is less, vibration is less. Moreover, CR is less, low peak pressure)	heavier (combustion is non-homogenous so noise and vibration is more, CR is high and high peak pressure)
8.	Noise	less (homogenous combustion)	more (non-uniform combustion)

5(c). $N = 450 rpm$, $n = 1$

$D = 100mm = 0.1 m$

$L = 120 mm = 0.12 m$; $k = \frac{450}{2} = 225°$

A of diagram $= 10 A cm^2$

length of indicated diagram (l) $= 6.5 cm$

spring value , $K = 10 bar/cm$

IP = ?

$$P_m = \frac{A \times k}{l} = \frac{10 \times 4}{6.5} = 6.15 bar \quad \frac{bar_{cm} \times cm^2}{cm}$$

$$= 6.15 \times 10^5 \ N/m^2.$$

$$I.P = \frac{P_m \times L \times A \times n \times k}{60000} \ kW.$$

$$= \frac{(6.15 \times 10^5) \times 0.12 \times \frac{\pi}{4} \times (0.1)^2 \times 1 \times 225}{60000}$$

I.P = 2.17 kW Ans

6a) Vapor compression system

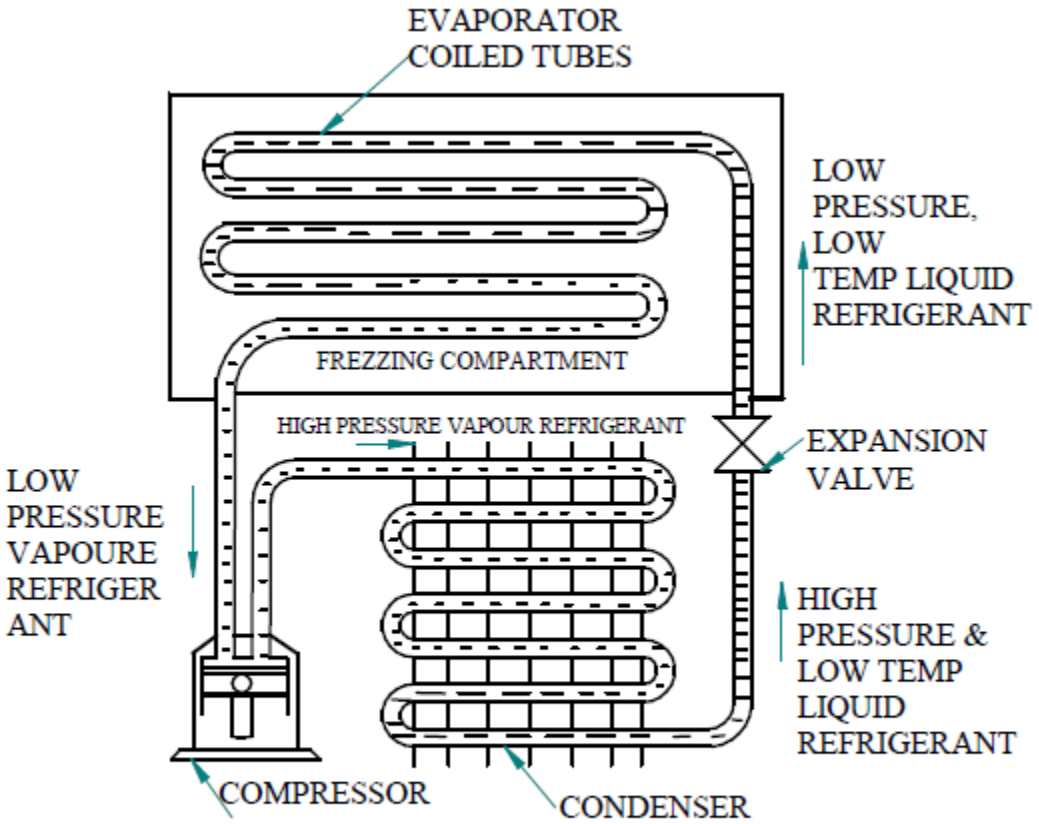


Figure 4.2 Vapour compression Refrigeration

The liquid ammonia vapouries in the evaporator coils, absorbing the latent heat from the freezing compartment thus keeping it cool and subsequently gives off heat when it condenses in a condenser. Dry ammonia vapour is dissolved in the cold water contained in the absorber, which will produce a strong ammonia solution which is flowing back from the heater-separator from the heat exchanger. The warm high pressure strong ammonia solution is passed to the heater-cum-separator provided with the heating coils. Heating of the high pressure strong ammonia solution will drive out the ammonia vapour from it and consequently the solution in the heater-separator becomes weak which in turn flows back to the heat exchanger. Where it warms up the strong ammonia solution passing through it. The high pressure ammonia vapour from the heater-separator now passes to a condensed. The high pressure ammonia liquid is now expanded to a low pressure and low temperature in the throttle valve. The low pressure condensed ammonia liquid at low temperature is passed onto the evaporator coils provided in the freezing compartment, where it absorbs the heat and evaporates.

6b) i) **Ton of Refrigeration**

A ton of refrigeration is defined as the quantity of heat absorbed in order to form one ton of ice in 24 hours when the initial temperature of the water is 0 C.

ii)**COP**

The COP of a refrigeration system is defined as the ratio of heat absorbed in a system to the work supplied.

iii) Ice making capacity

The amount of ice produced by the ice making machine in one hour from water at 0oC in to ice at 0 C.

$$\textbf{Ice making capacity of the machine} = \textbf{COP} = \frac{\textbf{W (3.5 x 3600)}}{\textbf{334.5}}$$

Where, 334.5 is the heat of fusion of ice from water.

6.c) Commonly used refrigerants

1. Chloro fluoro carbon (CFC)

These refrigerants have been identified as the most harmful ones for the ozone layer by the Montreal Protocol and are not in commercial use. They are used in large centrifugal chillers and air-conditioners of old cars.

E.g. Freon-11 (trichloro monofluoro methane), Freon-12 (dichloro difluoro methane), Freon-113 (trichloro trifluoro ethane).

2. Hydro chloro fluoro carbon (HCFC)

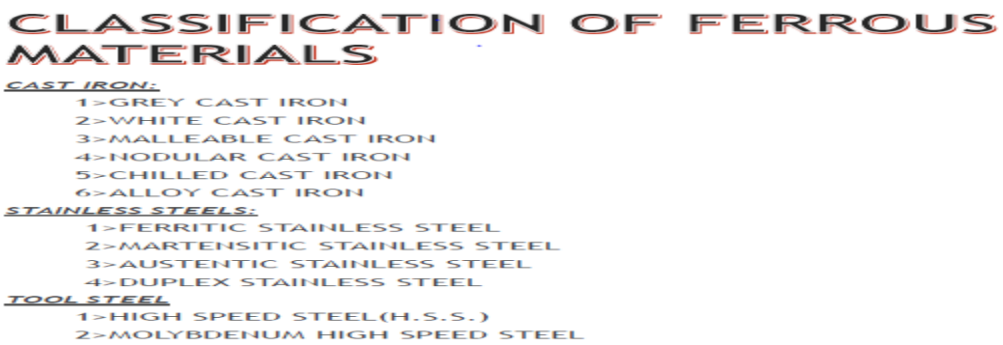
These refrigerants have been identified as slightly less harmful by the Montreal Protocol and will be phased by the year 2030. These are used in reciprocating compressors and centrifugal chillers as a temporary replacement for R-11 (Freon-11).

E.g. Freon-22 (monochloro difluoro methane), Freon-123 (dichloro trifluoro ethane).

3. Hydro fluoro carbon (HFC)

These are a new class of refrigerants that do not harm the ozone layer and are being used as a replacement for CFCs and HCFCs. These are used as replacement for R-12 and R-22 refrigerants and are being used in air-conditioners of new cars

7.a)



CLASSIFICATION OF NON-FERROUS MATERIALS

1>ALUMINIUM

2>LEAD

3>ZINC

ALLOYS OF COPPER

BRASS

- 1>ALFA BRASS
- 2>ALFA-BETA BRASS

BRONZE

- 1>PHOSPHOR BRONZE
- 2>GUN METAL
- 3>SILICON BRONZE
- 4>BELL METAL
- 5>MANGANESE BRONZE
- 6>MUNTZ METAL

ALUMINIUM

- 1>DURALUMIN
- 2>Y-ALLOY
- 3>MAGNELIUM
- 4>HINDALIUM

7.b)

What is composite material?

- Composite materials are materials made up of two or more materials, each having different physical and chemical properties, and combined together in a proper composition to produce a new material with properties that are superior to the individual components.
- Composite materials generally have two components -

1. Matrix 2. Reinforcement

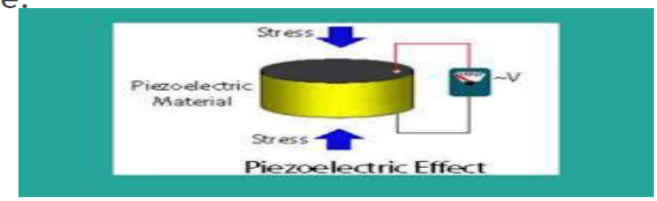
PIEZOELECTRIC MATERIALS

The literal meaning of piezoelectric is **"pressure electricity"**

Natural piezoelectric materials are crystalline materials that exhibit the piezoelectric effect

Piezoelectric Effect is the ability of certain materials to generate an electric charge in response to applied mechanical stress.

A deformation caused by pressure on the substance will create an electric current within the material. The mechanical pressure is therefore converted to voltage.



Properties

Natural piezoelectric materials are crystalline materials that exhibit the piezoelectric effect.
Often they are physically strong and chemically inert.
They change size when an electric current is applied.
When deformed they produce small but measurable electric current.

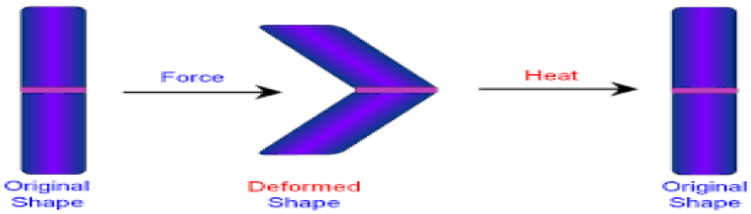
Industrial Applications

Industry	Application
Automotive	Air bag sensor, air flow sensor, audible alarms, fuel atomiser, keyless door entry, seat belt buzzers, knock sensors.
Computer	Disc drives, inkjet printers.
Consumer	Cigarette lighters, depth finders, fish finders, humidifiers, jewellery cleaners, musical instruments, speakers, telephones.

SHAPE MEMORY ALLOYS

SMA is an alloy that "remembers" its original shape.

After it is deformed, it returns to its pre-deformed shape on heating.



Two types - One way SMA and two way SMA.

Eg - copper-aluminium-nickel(CuAlNi), and nickel-titanium (NiTi), CuZnAl.

Properties :

Yield strength of SMA is lower than that of conventional steel, but higher than plastic or aluminum.

SMAs also display **superelasticity**(Pseudoelasticity)

Applications :

More fluid moment of joints and limbs in robots.

Plane wings with SMA wires can change shape by inducing voltages in them. This can replace hydraulic and electromechanical acutators.

Used for coupling tubing where tight fits between tubes can be achieved.

Super elastic property of SMAs can be used in cell phone antennas, eye glasses etc.

Optical fiber

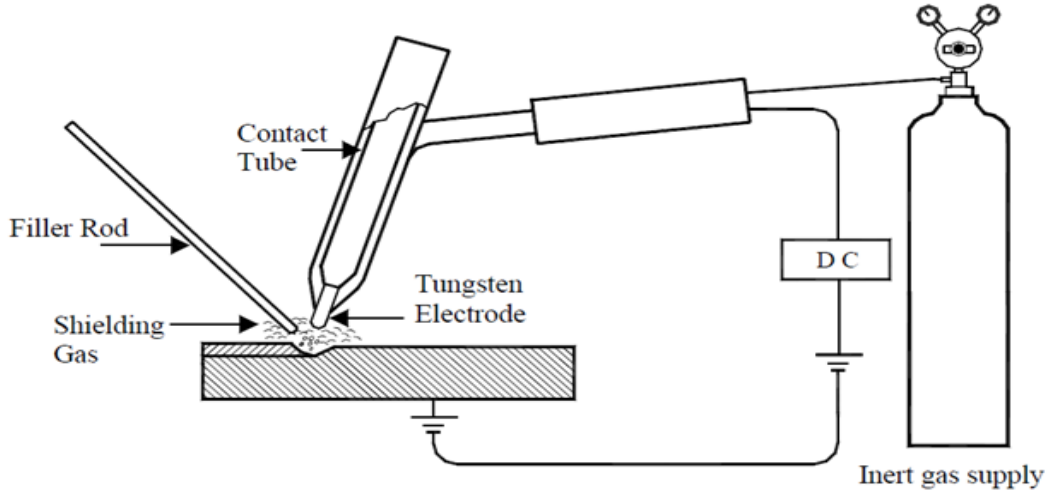
An optical fiber is a flexible, transparent strand of very pure glass that acts as a light pipe to transmit light between two ends of the fiber. Optical fibers have a core surrounded by a cladding layer made of dielectric material. The optical signals in the core are confined by establishing a refractive index that is greater than the cladding.

Applications of optical fibers

•Communication: medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications,
•Sensors: provide distributed sensing over distances of up to one meter
•Power transmission
•used as light guides in medical and other applications where bright light needs to be shone on a target without a clear line-of-sight path

7.c)

Tungsten Inert Gas Welding – TIG
(Gas Tungsten Arc Welding – GMAW)
Electrode Tungsten + Filler material

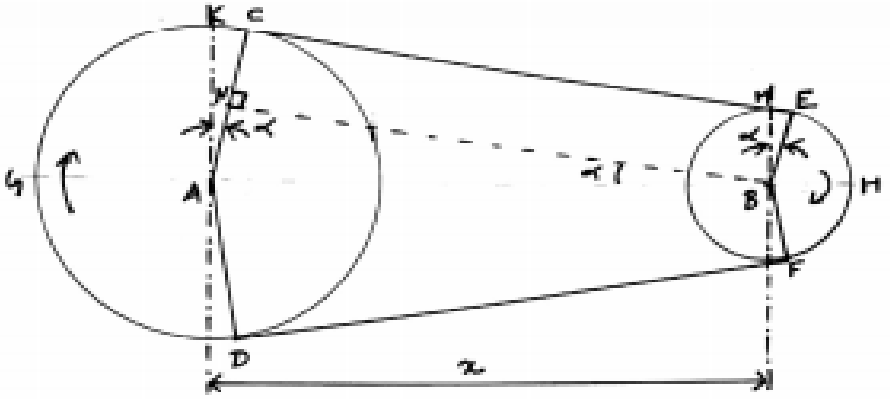


- *Working*

- Arc is struck between the non-consumable tungsten electrode and the work piece to fuse metals
- Arc is covered by a layer of shielding gas which acts as the flux and keeps the nitrogen and oxygen in the air from coming in contact with the molten puddle.
- When the puddle is formed on the base metal, the torch is moved along the joint until the workpiece is fused together
- A filler rod may or may not be used
- If a filler rod is used, it should be the same composition as the base metal.
- The filler rod is fed manually into the leading edge of the puddle.
- The torch may be moved in a semicircular motion to vary the width of the bead.

8.a)

Derivation – Length of open Belt Drive :-



Let x = Distance between centres of two pulleys (i.e. length AB)

r_1 = Radius of larger pulley, r_2 = Radius of smaller pulley

L = Total length of belt.

From B draw BN // to EC. But CE is tangent at C. Hence AC ⊥ CE,

which means $\angle ACE = 90^\circ$ or $\pi/2$ $\Rightarrow \angle ANB = 90^\circ$ or $\pi/2$ radians.

Let $\angle ABN = \alpha$ $\Rightarrow \angle KAC = \alpha$.

Length of Belt, L = Arc DGC + CE + Arc EHF + FD

$= 2\left[\text{Arc } GC + CE + \text{Arc } EH\right]$

$= 2\left[r_1\left(\pi/2 + \alpha\right) + BN + r_2\left(\pi/2 - \alpha\right)\right]$

In Δ ANB

$BN = \sqrt{(AB)^2 - (AN)^2}$

$= \sqrt{x^2 - (r_1 - r_2)^2}$

$AN = AC - CN$

$= (r_1 - r_2)$

Length of Belt, $L = 2\left[r_1\left(\pi/2 + \alpha\right) + \sqrt{x^2 - (r_1 - r_2)^2} + r_2\left(\pi/2 - \alpha\right)\right]$

$$\boxed{L = 2\left[\pi/2\,(r_1 + r_2) + \alpha(r_1 - r_2) + \sqrt{x^2 - (r_1 - r_2)^2}\right]}$$

8.b)

Advantages of V- belts:-

- Positive drive as slip between belt and pulley is negligible
- Operation is quite and smooth.
- High velocity ratio upto 10 can be obtained.
- Multiple V-belt drive increases the power transmitted manifold.
- May be operated in either direction with tight side at top or bottom.
- Can be easily installed and removed.

Disadvantages of V-belts:

- Cannot be used for large centre distances.
- Construction of pulleys is not simple.
- Not as durable as flat belts.
- Costlier as compared to flat belts.

8.c)

Different types of gears -

- SPUR Gear
- Bevel gear
- Helical gear
- Worm gear
- Rack and pinion

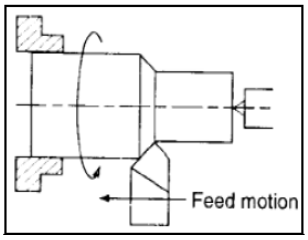
-→Helical Gear

- Used to transmit power between parallel or non parallel but non-intersecting shaft.
- Teeth are curved and helical in shape
- Smooth operation as it results in gradual gear engagement
- Used in smooth and quiet running

9a)

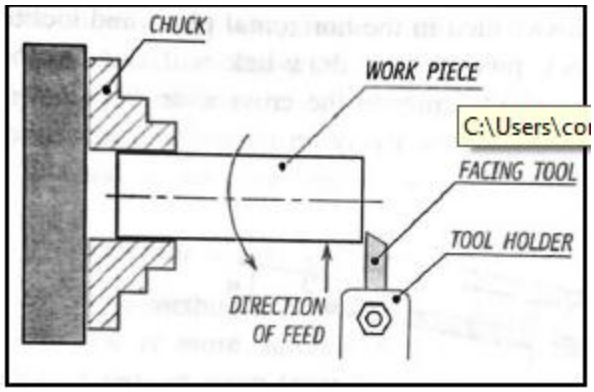
Turning:

Turning is a lathe operation in which the cutting tool removes metal from the outside diameter of a workpiece. In other words, reduction in the diameter of the workpiece due to cutting is called *turning*

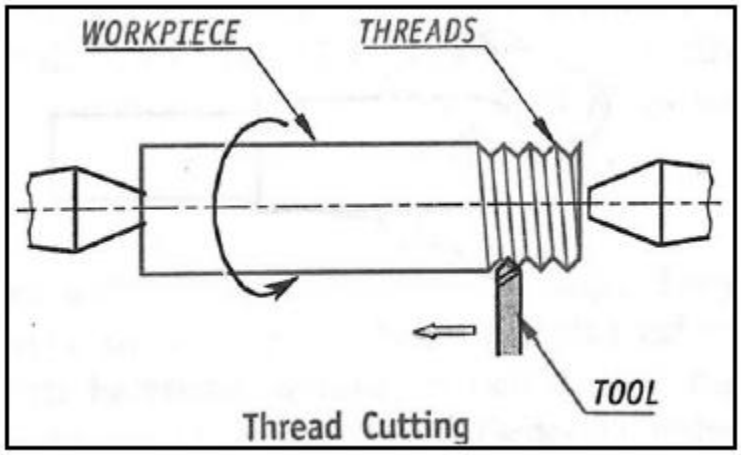


Facing

Facing is defined as an operation performed on a lathe to produce either flat surface or shoulder at the end of the workpiece. In facing, the direction of feed given is perpendicular to the axis of the lathe. The workpiece is held in the chuck and the facing tool is fed either from the end of the workpiece towards its centre or vice versa.



Thread cutting

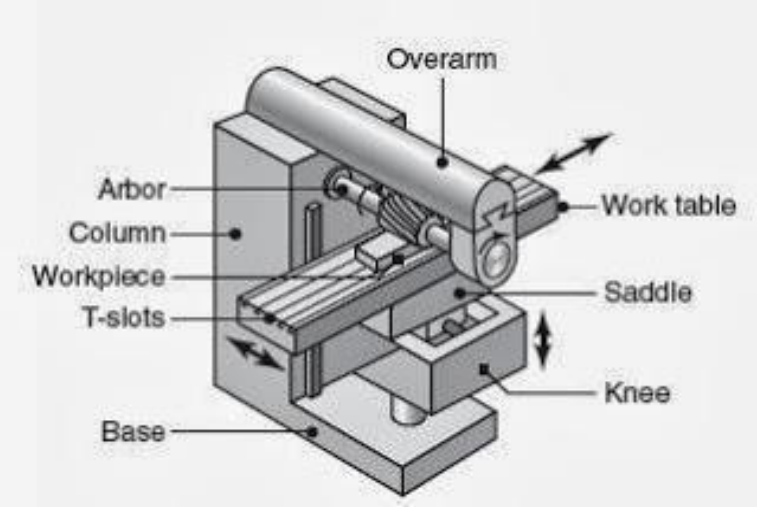


A *thread* is a helical groove formed on a cylindrical or conical rod. Thread cutting is the operation of producing helical grooves on a cylindrical or conical surface. Threads may be square or „V" threads. The threads of any pitch, shape and size can be cut on a lathe. A single-point cutting tool (V-tool or square tool) is used to cut threads on the work piece. It is of two types: external thread cutting and internal thread cutting.

Here the tool is moved longitudinally with a uniform motion while the workpiece is rotating at a uniform speed. By maintaining an appropriate gear ratio between the spindle on which the workpiece is mounted and the lead screw of the lathe, a screw thread of required pitch can be cut.

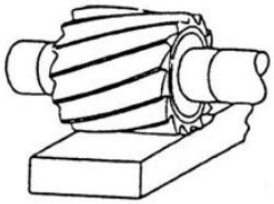
During thread cutting, both work piece and lead screw rotate at the same speed. The pitch of the lead screw is equal to pitch of workpiece. To cut threads, the tool is brought in contact with the workpiece. The tool is moved along the axis, generates the threads on the workpiece. This process is repeated several times till the required depth, pitch and finish is obtained. To produce V-threads, a pointed tool is used. To cut square threads, the tool is ground to a squared end.

9b) Horizontal Milling machine



9.c)

Plane milling: The plain milling is the operation of production of a plain flat horizontal surface parallel to the axis of rotation of a plain milling cutter. The operation is also called slab milling.



Angular Milling

- Milling operations in which the cutting tool's axis of rotation is at an angle relative to the surface of the workpiece. The process employs single-angle milling cutters—angled based on the particular design being machined—to produce angular features, such as chamfers, serrations, and grooves

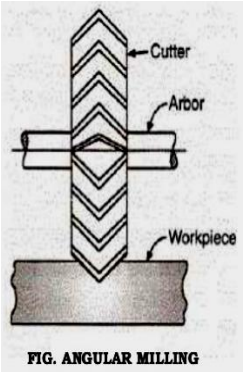
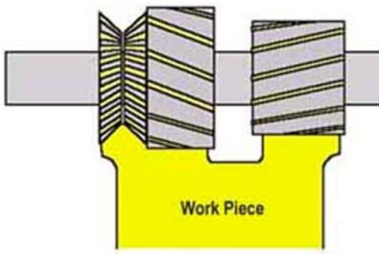


FIG. ANGULAR MILLING

Gang Milling

- Gang milling refers to milling operations which employ two or more cutters—typically of **varying size, shape, or width—on the same machine arbor.**
- Each cutter can perform the **same cutting operation, or a different one**, simultaneously, which produces more intricate designs and complex parts in shorter production times.



10a)

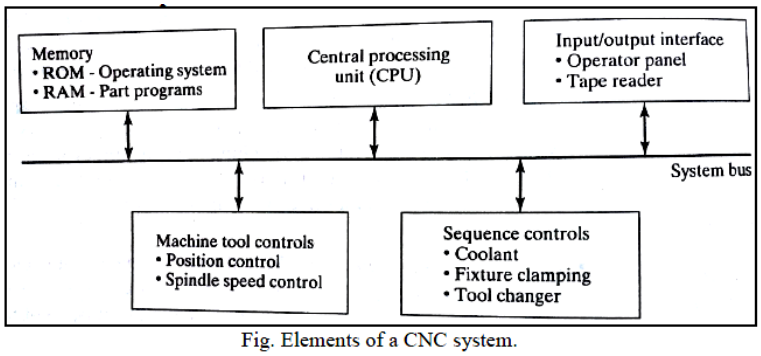


Fig. Elements of a CNC system.

1. Central processing unit (CPU)

The central processing unit (CPU) is the brain of the MCU. It manages the other components in the MCU based on software contained in main memory. Thc CPU can be divided into three sections: (1) control section, (2) arithmetic-logic unit (ALU), and (3) immediate access memory. The *control section* retrieves commands and data from memory and generates signals 10 activate other components in the MCU. In short, it sequences. coordinates. and regulates all of the activities of the MCU computer. The ALU consists of the circuitry to perform various calculations (addition, subtraction, multiplication), counting and logical functions required by software residing in memory. The *immediate access memory* provides a temporary storage for data being processed by the CPU. It is connected to main memory by means of the system data bus.

2. Memory The immediate access memory in the CPU is not intended for storing CNC software, A much greater storage capacity is required for the various programs and data needed to operate the CNC system. As with most other computer systems, CNC memory can be divided into two categories: (I) main memory and (2) secondary memory. *Main memory* (also known as *primary storage)* consists of ROM (read-only memory) and RAM (random access memory) devices. Operating system software and machine interface programs are generally stored in ROM. These programs are usually installed by the manufacturer of the MCU. Numerical control part programs

are stored in RAM devices. Current programs in RAM can he erased and replaced by new programs as jobs are changed. High-capacity *secondary memory* (also called *auxiliary storage* or *secondary storage)* devices are used to store large programs and data files, which are transferred to main memory as needed. Common among the secondary memory devices are floppy diskettes and hard disks. Flash devices are portable and have replaced much of the floppy or punched tapes traditionally used to store part programs. Hard disks are high-capacity storage devices that are permanently installed in the CNC machine control unit. CNC secondary memory is used to store part programs, macros, and other software.

10.b) Robots and general applications

An industrial robot is a programmable, multi-functional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks

Applications

1. Hazardous work environments 2. Repetitive work cycle 3. Consistency and accuracy 4. Difficult handling task for humans 5. Multi-shift operations 6. Exploratory robots explore environments that are inhospitable to humans such as space, military targets or areas of search and rescue operations. 7. Assistive robots help handicapped individuals by assisting with daily tasks including wheelchair navigation and feeding. 8. Material transfer, 9. Machine loading, 10. Welding, 11. Spray painting, 12. Processing operation, 13. Assembly and 14. Inspection

10.c) CNC Machining center

A machining center can be defined as a sophisticated CNC machine tool controlled by a computer running programs driven by numerical data, which can perform multiple machining operations like milling, drilling, tapping and boring operations at the same location control by making use of several area and a variety of tools with Automatic Tool Changer (ATC) unit:

The CNC machining centers can be broadly categorized into two varieties.

a) Vertical machining centers (VMC)

b) Horizontal machining centers (HMC)