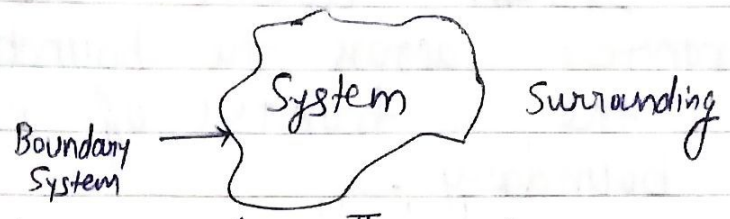
Thermodynamics



System of Thermodynamics :—

(i) open system
(ii) Closed system
(iii) Isolated system

Thermodynamics deals with the transfer of energy of all kind from one form to another. It is based on first and second law thermodynamics..

Thermodynamic system:—

Whenever a change is to be analaysised it is essential to specify the region in which the change takes place. This is done by drawing a boundary around a region. This boundary may be real or imaginary Everything within the boundary is called system while the region outside the boundary is surrounding.

Types of system:—

(i) Closed system ⇒ If the mass within the boundary of the system does not

change it is called closed system.
A closed system doesn't allow any mass transfer across the boundary but allow the transfer of energy across the boundary.

eg- Motor car battery.

(ii) Open system ⇒ If both mass and energy cross the boundary of the system it is called an open system.

eg- Motor car engine.

(iii) Isolated system ⇒ If neither mass nor energy cross the boundary of the system it is called isolated system.

eg- Universe, thermos ~~glass~~ plase.

Homogeneous system	Heterogeneous system
(i) Mixture of air & water paper.	(i) Water & steam
(ii) Solution of amonia in water.	(ii) ice & water
(iii) Water & Sugar	(iii) Water & oil

☆ Thermodynamic properties :—

A thermodynamic System has many characterstic directly & indirectly measure ~~mejarable~~ which describe or identify the system.
For example pressure, volume, surface area, temperature, mass, velocity, elevation and physical compositions are some of properties of a system.

(i) Intensive & Extensive :— If the properties are independent of the mass of the system it is called intensive property.
eg- pressure, temp., density, ~~v~~iscosity etc.

→ If the property is proposnal to the mass of the system it is called extensive property.
eg- Surface area, volume, potential energy etc.

(ii) Intrinsic & Extrinsic :—

An intrinsic properties are the characterstic of matter within the system which is measured ~~mejored~~ without reference of surrounding.
eg- mass, temp., pressure and internal energy

→ An extrinsic property is a characterstic of either the motion or the position of the system which is measured ~~mejored~~ with reference to the surroundings

eg – Velocity, kinetic energy, electrical potential (~~etc~~) etc.

→ The pressure of the system is the force extracted by a system on unique area of boundary.
If the total normal force F acts uniformly over the entire area A then $\boxed{P = \frac{F}{A}}$

Absolute pressure :– pressure is defined as force per unit area due to interaction of fluid particales amongs them self.
A zero pressure intensity occurs when molecular momentum is zero.
This occurs when there is a perfect vaccum. Pressure intensity measured from absolute zero pressure is called Absolute pressure.

Atmosphere pressure :– The pressure extended by the air surrounding the earth surface is turned as atmospheric pressure.

$$\boxed{P_{at} = \rho g h}$$

Gauge pressure :– The Gauges which are used for the measurement of fluid pressure the difference b/w fluid pressure & atmospheric pressure.

When the fluid pressure is more than atmospheric pressure the pressure recorded by Gauge, is called Gauge pressure.

~~Flow~~ ~~work~~

Work ⇒ A work is defined as the product of force and distance move in the direction of force.
This defination is used in mechanics.
However this defination of work can not be used in study of thermodynamic.
The reason is that thermodynamic is consulted with energy transfer b/w a system and its surroundings.
In thermodynamics work is energy transfer across the boundary of a system because of an intensive properties difference that exists b/w system & surrounding.

Heat :— Heat is that form of energy for which the driving force each temp. difference.
Heat is energy transfered across the boundary of a system because of a temp. difference b/w system & surrounding.

Gaseous Law :—

Boyles Law :— If the temp. of gas remains cons. the volume of the gas

is inversally proportional to the pressure

$$V \propto \left(\frac{1}{P}\right)_T$$

$$PV = \text{Constant}$$

$$\boxed{P_1 V_1 = P_2 V_2}$$

Charles Law :— If the pressure remain constant the volume of gas is directly proportional to the absolute temp.

$$V \propto (T)_P$$

→ Thermodynamic terms :—

(i) Phase :— If the quantity of matter is homogeneous & uniform through out in physical structure and chemical composition, it is termed as phase.

(ii) thermodynamic equillibrium :— A system is said to be a state of thermodynamic equillibrium, if the value of the property is the same and all points in the system.

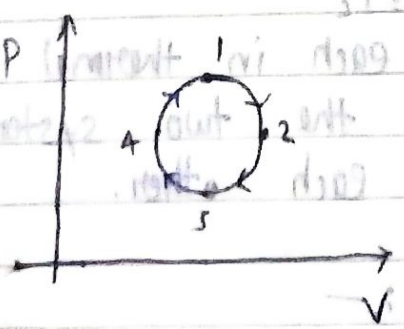
(iii) State :— State is the condition of the system at an instant of time describe by its properties such as pressure, density, temp. etc

(iv) Path :— The thermodynamic system passing through a series of a state constitute of path.

(v) Process :— A process is a transition in which a system changes from one initial state to a final state.

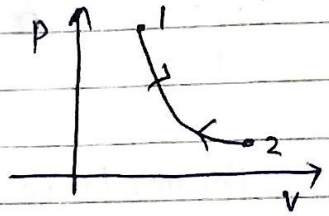
(vi) Cycle :— A thermodynamic Cycle is a sequence of some process that begins and ends at a same stage.

(vii) Cycling process :— If any system under goes through a series of processes from one state and ends with the same initial state with by forming a complete cycle. So that the property of the system at the end of the cycle are same as at the begining, the system is said to have under gone through a cyclic process.

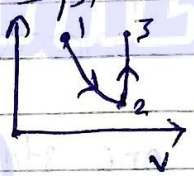


(viii) Reversible process :— A process is reversible if the system passes through a continuous series of equilibrium states.

If In other words, the process is called reversible if the initial state together with all energy transfered during the process can be completely restored in both system and ~~involvement~~ environment.

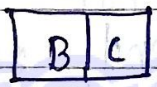


(ix) Irreversible process :— A process is irreversible if a system passes through a non-equilibrium states.

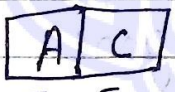


Zeroth law of thermo :—

If $T_A = T_B$



If $T_B = T_C$



$T_A = T_C$

If two system are each in thermal equilibrium with the third system then the two system are in thermal equilibrium with each other.

I^st Law of thermo :—

When a system undergoes a thermo cycle then the net ~~heat~~ supply to the system from the surrounding is equal to the net workdone

Adia patic process:— In this process no heat is transferred to or from the fluid during the process. In this process the system is insulated perfectly.

by the system on the surrounding

$$\oint Q = \oint W$$

When a process is executed by a system the change in energy is equal to the difference b/w the heat supplied and the work done during any change of state.

$$\Delta E = Q - W$$

Energy E is composed of kinetic, potential and internal energy, in a closed system kinetic and potential energy are negeligible.

$$\Delta U = Q - W$$

II nd Law of thermodynamics:—

Kavlin planc statement:—

It is impossible for a heat engine working on cyclic process to convert total heat applied into mechanical work.

Clausius statement:—

It is impossible to transfer heat from cold body to hot body with out any external work.

POWER PLANT

1) Hydro electric power plant / HEPP / Hydel power plant
2) Thermal power plant

3] Nuclear power plant
4] Diesel power plant

(i) HEPP :—

In Hydro electric power plant, kinetic energy and or potential energy of water is utilized to rotate the turbine. When water strike on turbine plate through an appreciable hight, then blades rotate the and generator attach with the turbine runs to produce electricity.

Advantages of HEPP :—

(A) Water is available in abundant (मुबलक). No fuel is required
(B) Running cost of HEPP is very low.
(C) It doesn't produce any harmful process so there is not need of disposited of burnt gas as ash.
(D) Hydraulic turbine can be started & stoped very shortly.
(E) Simple and economical operation
(F) System reality is very high than other power plants.
(G) Modern HEPP have higher operative light. of about 50 years.
(H) For variable rang of plot higher efficiency.
(I) HEPP also provide auxiliary benefit such a) irrigation, flood control, afforestation.

(J) No skilled workers are required for operation. Requirement of man power is also low.

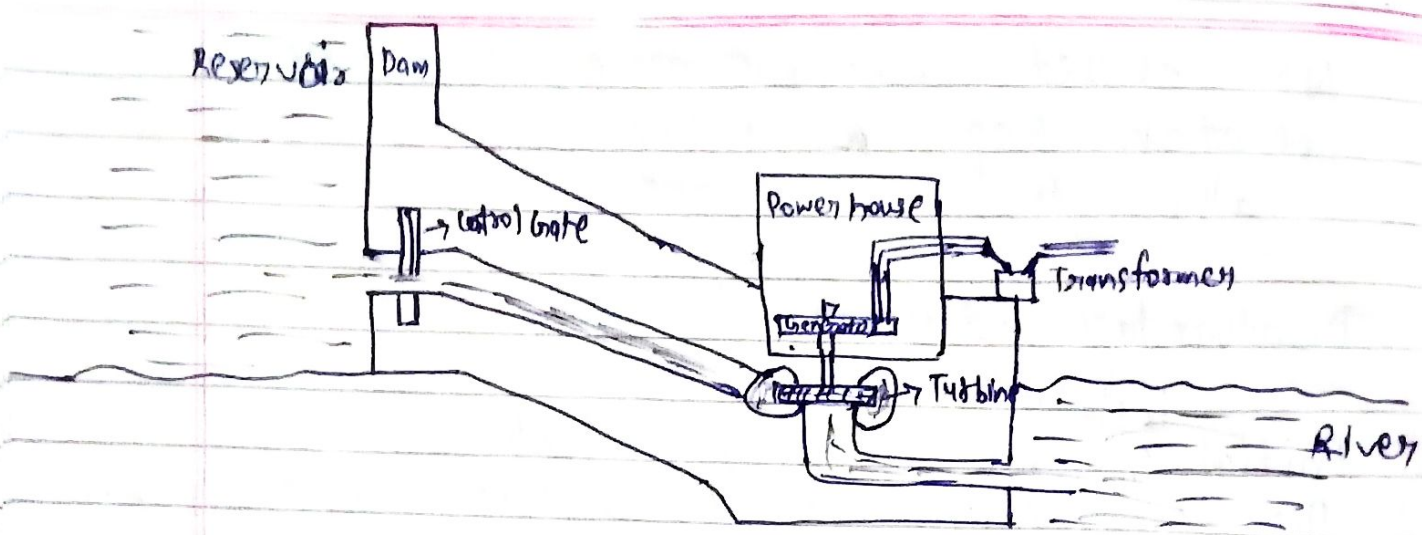
Disadvantage of HEPP

(i) Initial installation cost is very high.
(ii) The construction period is quite large.
(iii) Generation of power is directly dependent on availability of water which may vary from season to season.
(iv) Generally these power plants are very far from away load centre.
(v) Thus transmission cost increases & also transmission loss increases.
(vi) It also disturbes the ecology of that area. Uprooting pepole is brief problem

Selection of site for HEPP :—

Explain

(i) Availability of water
(ii) Capacity
(iii) Water Head
(iv) Transportation facility
(v) Distance from the load centre
(vi) land type of site



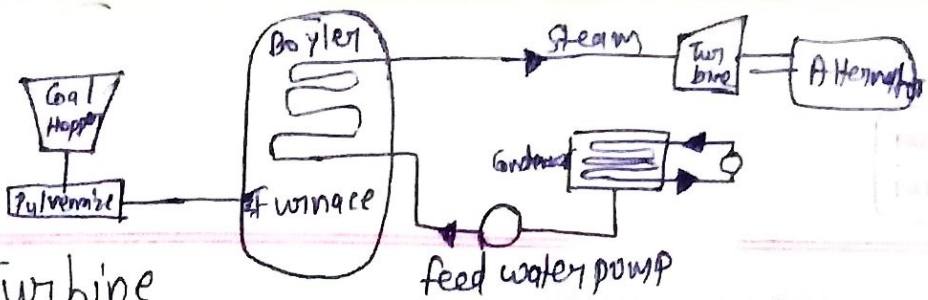
HEPP

2.] Thermal power plant :—

Thermal p.p. is the main source of power generation World's 2/3 of energy requirement is fulfilled by thermal power plant. Brown Coal is used as a fuel in these India's first thermal p.p. Husain's Sagar thermal power state was established in Hydrabad in 1920 Heat generated through burning fuel is used to make the steam. Steam strikes on turbine plats and need to run generator which produces electricity. In india 65% of total power requirement is fulfilled by thermal power plant.

Main parts of thermal p.p. ⇒

(i) fuel and combustion chamber
ii) Boyler



(iii) Turbine

(iv) condenser → exhaust steam condensed — by cold water circulation convert into water

(v) Feed water pump :- Water coming from condenser is fed in boyler by feed water pump. This helps in recovering the water, ~~exhausting~~ exhausting from turbine.

(vi) Deaerator :-

Disolved oxigen and flew gases in feed water can cause serious corrosion problems that can damage matellic surfaces. To eraddicate this problem and auxillary device is fitted into system which is called deaerator.

Advantage of thermal P.P. ⇒

(i) Comparatively low initially cost.
(ii) Require less space as compearce to HEPP
(iii) Coal is easily available and cheaper than other fuels
(iv) The cost of per unit generation is less than diesel & nuclear power plant.

Disadvantage :-

(i) Produces green house gas that cause global warming.
(ii) The over all efficiency of a thermal P.P is low (less than 30%)

3) Nuclear power plant :—

A nuclear P.P. is also thermal P.P. in which heat is generated by nuclear reactor. A radio active element is used in nuclear reactor. Nuclear power plant works on the principal on nuclear fission. Tarapur Atomic power station is india's first nuclear power plant went operational in 1969.

Components of NPP :—

(i) Nuclear reactor
(ii) Steam turbine
(iii) Moderator ⇒ (Reduces the speed of fast neutrons)
(iv) Culent
(v) Control rods :- These rods have great importance in nuclear reactor. These control rods absorb neutrons and control the fission chain rxn. These are made of cadamium & Boron.
(vi) Shielding :- Shielding of nuclear reactor is required so that radiation can be prevented reaching out side the reactor. Lead & concrete made wall heavy meter of thickness is used for Shielding.

Advantage :-

(i) It can be easily used where pole & water supply is less.
(ii) It requires small quantity of fuel.
(iii) Less space is require.
(iv) Remains uneffected by weather condition.
(v) There is no problem of fuel storage, like thermal P.P.

Disadvantage :-

(i) Radioactive base has negative effect on health of workmen and surrounding population.
(ii) Efficiency reduces in case of varing load.
(iii) High initial cost.

4.) DIESEL POWER PLANT :-

Diesel Power plant is a P.P. in which a diesel engine is used as the primemover for the generation of electrical energy. The diesel engine obtains energy from a liquid usually called

diesel and converts in into mechanical energy And alternater or DC generator mechanically coupled ~~capaled~~ to the diesel engine converts the mechnical energy into electorical energy. It is worth noting that the main difference blw a diesel engine and a steam turbine is that in the first case (D.P.P.) The chemical energy of combustion is released inside the cylinder where as the second case the energy is developed during combustion of ~~fu~~fuel is first transform into steam which inturn develops mechanical power in the turbine.

Requirement of diesel power plant:—

In many countries the demand of diesel ~~po~~ electric plant is increased for electric power generation because the difficulties experience in construction of new hydrolic plant and enlargement of old hydro plant.

The diesel plants are more efficient than any other heat engine of comparable ~~size~~ size. It is cheap in first cost (initial setup cost) It can be started quickly and bought into surface. It can burn a fairly wide ~~white~~ range a fuel.

The diesel engine will provide the most economic mean of electricity on small scale particularly where there is no convinent side for micro hydro plant and cheap fuels are not available and load factors are considerally large. The following factor should be consider while selecting site for diesel power plant:—

Explain
(i) Distance from load centre
(ii) Availability of land
(iii) Availability of fuels
(iv) Availability of transportation facilities
(v) Distance from populated area.
(vi) Type of land

:-
Marites & De-Marites :—
Diesel electric power plants have many advantages over other type of power plants.

(i) The design and installation of such power plants is very simple.
(ii) Such plants can be located at any place.
(iii) Such plants can be quickly procured, installed and comissioned
(iv) The layout, design and construction of foundations and buildings for such power plants are simple and cheap.

(v) Such plants require less space for fuel storage and are free from ash handling problems.
(vi) Such plants can be started and put out load quickly.
(vii) The over all capital cost including installation per unit of installed capacity is lesser than the steam power plant.
(viii) The efficiency of such power plant falls very little with the uses in comparison with steam power plant.

(5) Gas turbine power plant ⇒

A gas turbine engine obtains its power from burning of fuel in combustion chamber and using thus produces gases to drive a turbine. Now it is taken in use for power generation because of its low capital cost and high reliability. Another excellent feature of this power plant is quick starting. A wide variety of fuel side natural gas, powder coal etc. can be used as a fuel in a gas turbine p.p.

Advantage :-

(i) Due to its low $\frac{\text{weight}}{\text{kW}}$ per kW power out put it is used in aircraft.

wide

(ii) A ~~white~~ range of fuel can be used.
(iii) Less flow space is required.
(iv) It can be started in a short time
(v) Requirement of water for cooling is not much. Thus it can be installed where water supply is less.
(vi) It can be installed near the load centre Thus the transmission lose and cost reduces
(vii) The capital cost per unit power generation is low.

Disadvantage :—

(i) Air and dust filters are required to protect the turbine plate.
(ii) A large part of power generated by turbine is used to run the compression.

Boiler

(i) ~~Boiler cells~~
The equipment used for producing steam is called steam generator is called Boiler.
The water is content in boiler ~~cell~~ drum called cell.
The heat release by compression of fuel which may be solid, liquid or gas is transferred to water which converts its into steam at desired pressure & temperature.
The steam thus generation ~~for~~ is used for

(i) Power generation
(ii) Heating
(iii) Industrial process → (for textile work)

explain Important terms used in Boiler

(i) Boiler cell
(ii) Combustion chamber
(iii) Grate
(iv) Furnace
(v) Heating surface
(vi) Mountings → (Safety device, idicator to check water level)

Requirements of good boiler ⇒

The boiler should be capable of generating steam at the required pressure and of the required quality quickly and with minimum fuel consumption.

→ For efficient heat transfer the water and gases should have maximum velocity without incurring (होना उत्पन्न) frictional loses. The Boiler should be light in weight, should need least amount of brick work construction and should occupy small floor area.

→ The initial cost, installation cost & maintenance cost of the boiler should not be too high.

→ The Boiler should meet the fluctuatdemand on steam supply without be over heated.
→ The Boiler should have minimum joints and those too should be away from direct plane.
→ There should be not deposition of mud and other particles on the heated surface.
→ The different part of the boiler should be easily approachable for repairs.
→ The boiler should conform to the safety regulation as let down in the boilers acts.

Selection of Boiler :-

(i) Before making a choice for the best type of boiler for a new installation the following factor should be given due consideration.
(ii) Rate of steam generation in kg/hours.
(iii) Pressure at which the boiler is required to operate at the quality of steam required.
(iv) ~~tube~~ Whether the steam raised is to be used at a steady or flauctuating load.
(v) Type of fuel to be used. (i.e. solid, liquid & gas)
(vi) Comparative initial coast
(vii) Boiler efficiency

Classification of steam boiler :—

(i) On the bases of relative position of hot gases & water
(A) Fire tube boiler
(B) water tube boiler

(ii) Method of firing
(A) Internally Fire boiler
(B) Externally Fire boiler

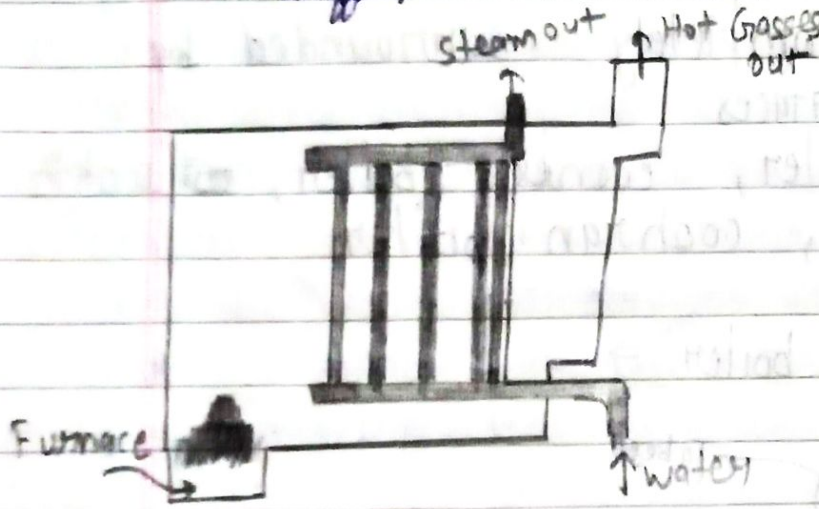
(A) Fire tube boiler :- In the fire tube boiler the hot gases pass through the tubes that are surroundally by water. The products of combustion leaving the furnace are pass through tubes which are arranged within the water space. The heat energy of fuel gases is transferred to water which is converted into steam.
The fuel gases are then dis-charged to the atmosphere through chemney.
Examples of Fire tube boiler are - simple vertical boiler, cochran boiler, lancashine boiler, connish boiler, scokth marrie boiler and locomotive boiler

(B) Water tube boiler :-

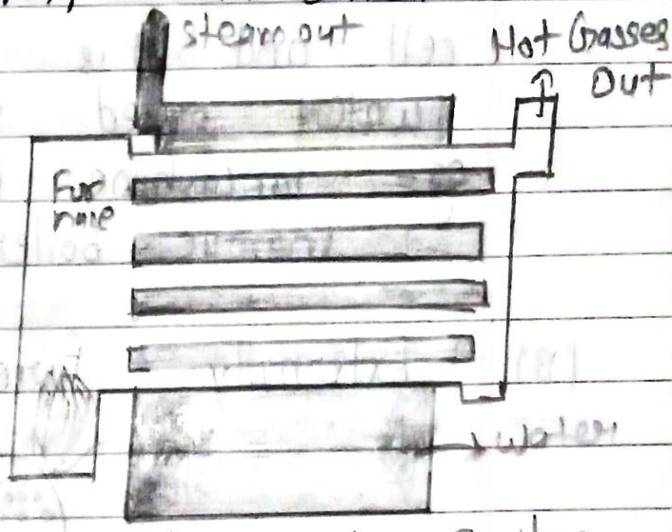
In water tube boiler the tubes contain water and hot gases produced by combustion of fuel flow outside.

A bank of water tube is connected with steam water drum through two set of header. The hot gases from the furnace are made to flow around the water tube a sufficient no. of times. The gases thus give up their heat get cold & are discharged to the chemney.

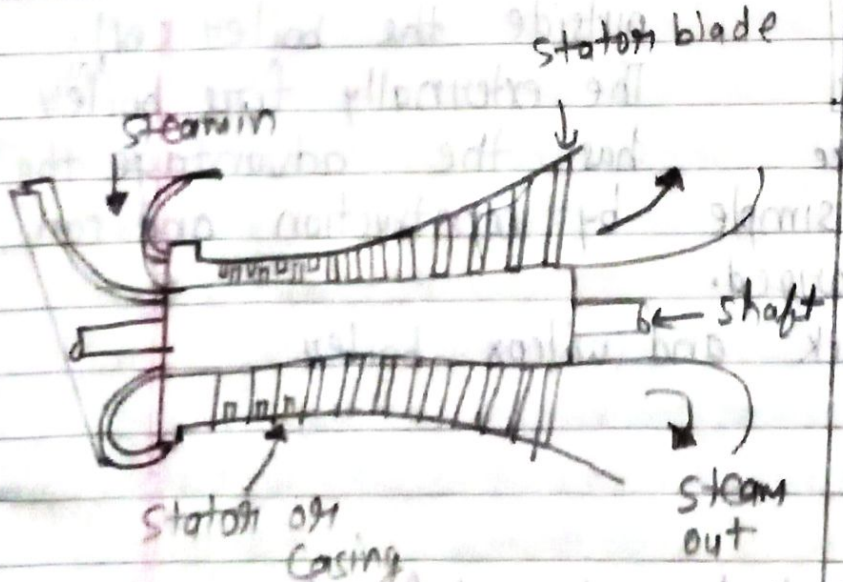
eg - Babcock and wilcox boiler, stirling boiler, lamont boiler, loeffler boiler, benson boiler, velox boiler.



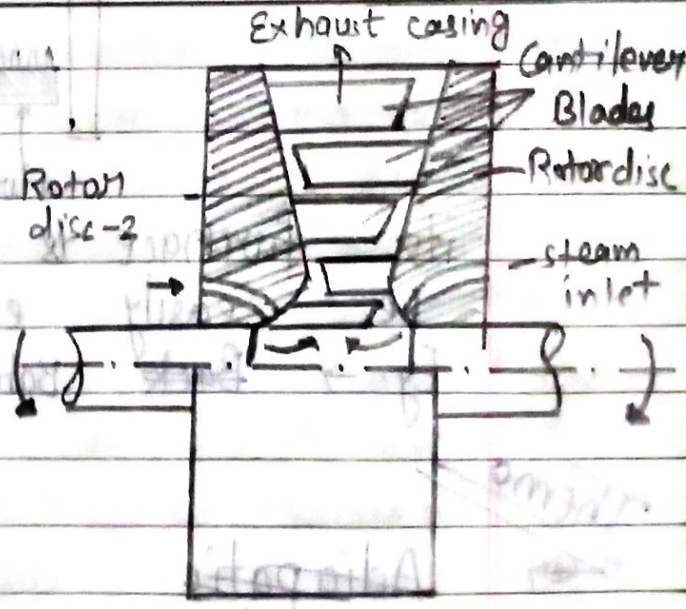
Water tube boiler



Fire tube Boiler



Axial flow turbine



Radial Turbine
(Ljungstrom turbine)

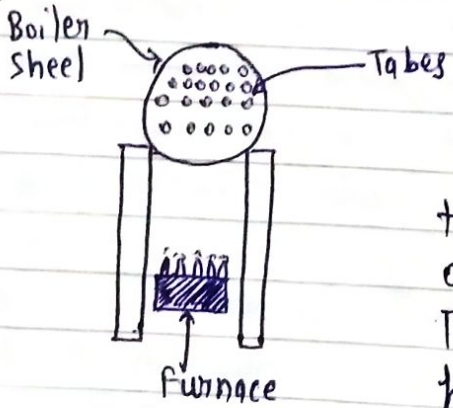
(ii) Method of firing :—

(A) Internally fire boiler ⇒

In internally fired boiler the furnace is provided inside the boiler cell and is completely surrounded by water pulled surfaces

eg- Lancashine boiler, cornish boiler, scotch marrie boiler, cochran boiler

(B) Externally fire boiler ⇒



In externally fire boiler the furnace is provided outside the boiler cell. The externally fire boiler has the advantage that its furnace is simple by construction and can be easily enlarged.

Eg. → ~~Back~~ Babcock and wilcox boiler

Thermo

→ ~~Adiapatic~~

→ Anthelpy :— Anthelpy is defined as the sum of internally energy and product of pressure & volume.

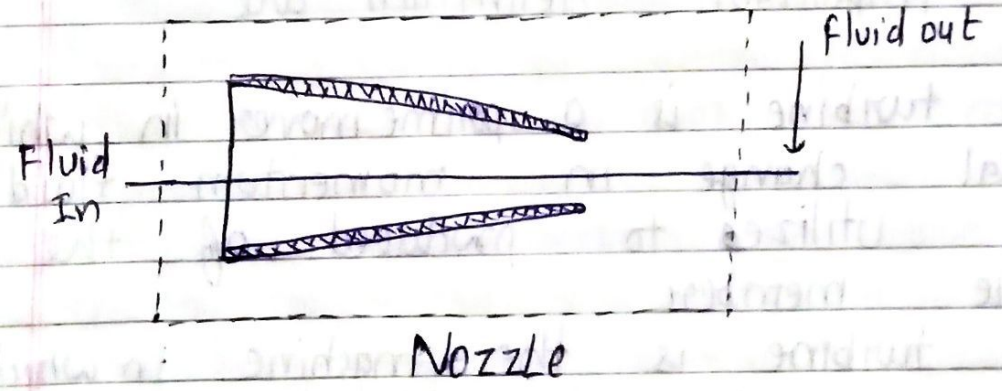
$$H = U + PV$$

Antropy:- The term antropy means transformati
. It is an thermodynamic properties
of working substant which increases ~~the~~ with ~~incre~~ the addition by
heat & decreases with its removed.
Change in specific entropy = ds

$$ds = \frac{dQ}{T}$$

~~Adiapatic process:~~

Steam Turbine



1. Impulse Turbine
2. Reaction Turbine
3. Radial Flow Turbine
4. Tangential flow turbine
5. Axial flow turbine.

Turbine can be defined as expanter in one words. Steam turbine first energy of

primemover → It is an engine that converts fuel to useful work and it is source of power for its propulsion.

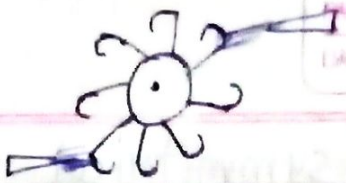
steam is converted into kinetic energy by nozzle. And follower by blade passage Thus a high velocity steam generates that acts on the curve blades, which changes the flow direction of steam due to which momentum of steam changes. Due to change in momentum of steam, a force is to be exerted on the blades fixed on the rotor. And power (rotorary) is developed due to the rotation of these blades. The steam turbine is universally used as primemover in all steam power plants.

→ Few important defination are

(i) The turbine is a prime mover in which gradual change in momentum fluid are utilized to produced of the mobile member

(ii) The turbine is the machine in which the rotorary motion is obtained by the gradual changes of the momentum of fluid.

(iii) The turbine is the prime mover in which the rotorary motion is obtained by centrifugal force. brought into action by changing the direction of the jet of the fluid escaping from the nozzle at high velocity.



(i) Impulse turbine :-

In Impulse turbine, action of the steam take places in such a manner that the steam is expended only in nozzle. Thus enthelpy drop of steam take place in nozzle and converted into kinetic energy ~~thes~~ This high kinetic energy acts on moving plate and generates power.

It many consists of a nozzle or a set of nozzle, a rotor mounted on the shaft, one set of moving blades attach through the rotor and a casing.

First steam enters to the nozzle and converted to a high velocity steam of 1000m/s. The steam strikes the blades and reduce along the passage of blade and comes out with the appriciation amount of velocity.

→ For a good economie the blade ~~ste~~ speed should be nearly half of the steam speed. So blade velocity is about 500 m/s, which is very high and produces about 30k R.P.M of rotor, which is too high for practical use.

(ii) Reaction turbine :-

In reaction turbine, action of steam takes place in such a manner that steam is expended in both nozzle as well as blade passage. So the blades

are symmetrical in this type of turbine
In this type of turbine, we utilize the principale of impulse and reaction both. Their are no. of raws of moving blades attach to the rotor and an equal no. of fixed blades attach to the casing
After expantion in nozzle, steam pases through the first raw of fixed blade then steam undergoes a small pressure drop, after then it enters in first raw of moving blade and just as in the impulse turbine. A change in direction occur and their for the momentum of steam changes that generate power.


(reaction turbine)

(iii) Axial turbine ⇒

In Axial flow turbine, flow of steam is along the axis of the shaft. Generally it is used for large turbo generators and in all modern steam power plants. The principle of energy generation from the steam is enthelpy of steam energy is converted in K_E by passing through a nozzle and blade passage.

(iv) Radial Flow turbine:-

In which the steam flows in the radial direction. In its simplest form the turbine consists of two independent disk attach to two shafts which rotate in opposite direction. Each sharp carry its independent alternator, generating AC and running in parallel at the same speed the steam which enters fills the centre space of the turbine and then flows radial through the blades. This type of turbine can be warmed and started quickly so it is very suitable for use at times of peak load.

(v) Tangential Flow turbine:-

In this type of steam turbine, the steam flows in the tangential direction. The nozzle directs steam flows in tangentially into buckets milled in the periphery (periphery) of a singal field And on exit the steam turns through a reversing chamber, re entry the bucket further round the periphery. This process is repeated in separate time. [As the steam flowing several nozzle with reversible chamber may be used around the wheel periphery = periphery.

peri - phery.

Unit - 2

~~Centrifugal~~ Pumps

(2)

Centrifugal pump :—
Components of C.P. ⇒

(i) Impeller (ii) Casing (iii) Suction pipe
(iv) Delivery pipe.

(Steran &

A Hydrolic machine which converts the mechanical energy into hydrolic energy is called pump. The Hydrolic energy of pump is available in the form of pressure energy.

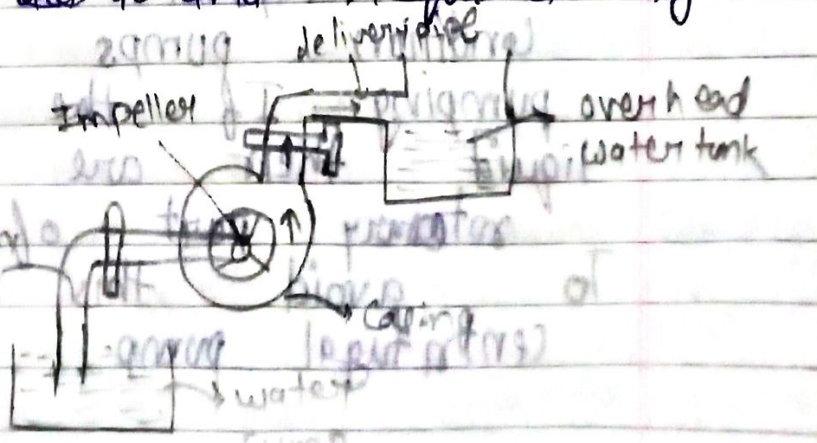
Different type of pumps are used for industrial purposes, irrigation system, domestic uses, sewage extention.
When mechnical energy is converted in hydrolic energy by mean of centrifugal force then ~~that~~ this type of pump is called centrifugal pump.
(~~dddds~~ ~~dfe~~

(i) Impeller :— It is rotating part of the centrifugal pump. A set of curve blades are mounted on the shaft. And shaft is collected to the rotating shaft of the electric motor.

(ii) Casing :- Casing is the outer most covering of centrifugal pump. It is an air tight passage surrounding the impeller. The K_E of water discharged from the impeller is converted into pressure energy. Then the water leaves the casking and enters into delivery pipe.

(iii) Suction pipe :- One end of a suction pipe is connected to the inlet of the pump. And other end is deeped into water sump. A foot valve is fitted at the lower part of the pipe, it opens upward direction. A strainer is also fitted at lower end of the suction pipe which prevents the entry of leaves or of solid waste.

(iv) Delivery pipe :- One end of delivery pipe is connected to the outlet of the casing and other end delivers the water at required height.



Cavitation ⇒ When the pressure of liquid flowing through pump becomes lower than its vapour pressure then the vapour bubbles generate in liquid. These vapour bubbles strike on the ~~middle~~ metal surface and generate high pressure. This high pressure can demage the surface of pump also noise and vibration is produced. This phenomina is called cavitation.

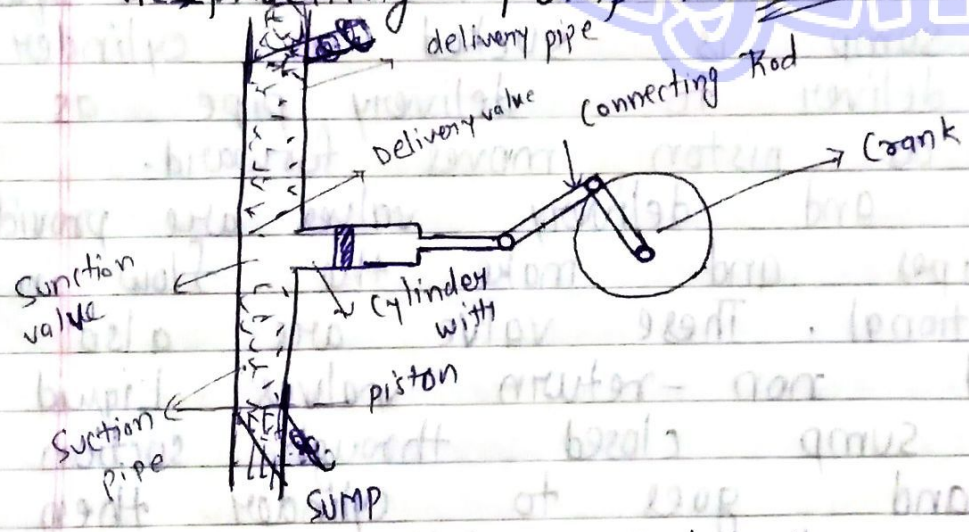
~~Applied~~ Priming ⇒ Priming of the pump is a process of filling ~~in~~ liquid in suction pipe, casing of pump and delivery pipe upto delivery valve ~~wall~~ so that the air come these parts of pump can be removed and filled with the liquid to be pump.
It is impossible to operate of centrifugal pump when its casing is filled with vapour or air. In this condition pumps become incapable of pumping. If the pump ruins without liquid their are chances of demaging rotary part of pump.
To avoid this problem priming of centrifugal pump.

Application of centrifugal PUMP:—

Explain

(i) For domestic water supply
(ii) For waste water management
(iii) In fire protection system
(iv) For irrigation system
(v) Other than these centrifugal pump is widely used in dairy form, food processing and production line

Reciprocating pump ⇒



A singal acting reciprocating pump

When a pump converts mechanical energy into hydrolic energy by means of reciprocating (backward & forward) motion of piston in a fluid chamber then it is called reciprocating pump. Main part of reciprocating pump

(i) Suction pipe
(ii) Suction valve
(iii) Reciprocating parts (piston, rod & connecting

(4.) Delivery pipe
(5.) Delivery valve

fluctuating discharge

Working principle :—

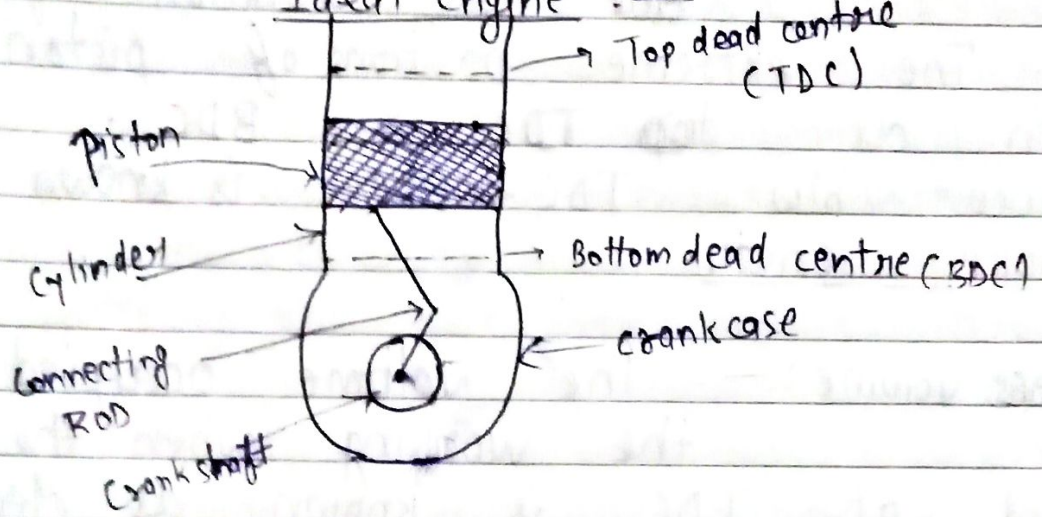
A singal acting reciprocating pump a piston is fitted in cylinder and connected with crank by means of a connecting rod. When the crank rotates the piston moves forward & backward in cylinder. While its backward motions the liquid in sump is sucked in cylinder and deliver to delivery pipe as soon as piston moves forward. Suction and delivery valves are provided in pipes and make the flow in unidirectional. These valve are also called non-return valves. Liquid in sump closed through suction pipe and goes to cylinder then delivery to the delivery pipe.

Application to the Reciprocating pump.

(i) In wind mill
(ii) In Hand pump
(iii) Axial and radial pump
(iv) Sump drift irrigation system also uses reciprocating pump.
(v) It is used for inflation of tyres.
(vi) In boiler water feed

I.C. Engine ⟹

Ideal Engine :—



Introduction :—

Engine converts heat energy into mechanical energy. Engines are broadly classify into internal combustion Engine (I.C. Engine) & external Combustion Engine. As imply by the name I.C. engines are those engines in which combustion take place inside the engine cylinder. These are petrol, gas, & diesel engines. In external combustion engine combustion take place outside engine cylinder. These are steam engine, gas turbines and steam turbines.

Important terms of I.C. Engine :—

(i) Cylinder bore :— The inner ~~term~~ diameter of cylinder in which piston moves is known as cylinder bore.

(ii) Stroke length :— piston moves in cylinder due to rotation of crank shaft. The extreme positions of piston are known as TDC & BDC. Distance b/w TDC & BDC is known as stroke length.

(iii) Clearance Volume :— The volume occupied by the working when the piston reaches at TDC is known as clearance volume.

(iv) Swept volume :— The volume swept by the piston, when it moves b/w TDC & BDC is known as swept volume or displacement volume or stroke volume.

(v) Total cylinder volume :— The volume occupied by the working substance when the piston is at bottom dead centre (BDC) is known Total cylinder volume.

(6.) Mean effective pressure :— MEP (P_m) is defined as constant pressure acting on the piston during the working stroke.

(P_m) Mean effective pressure = Work done by stroke volume.

(7.) Air standard efficiency :- It is the ratio of output or work done to heat input or heat supply.

Classification of internal combustion Engine ⇒

(i) On the basis of fuels :—
Petrol engine, Diesel engine, Gas engine, Bifuel engine.

(ii) According to the arrangement of cylinders :—
Vertical engines, Horizontal engines
Radial engines, V-type multi cylinder engines.

(iii) According to method of ignition :—
Compression ignition engine (Diesel engine)
Spark ignition engine (petrol, gas engine)

(iv) According to the speed of engine :—
Low speed engine
Medium speed engine
High speed engine

(v) According to no. of strokes per cycle :—
4-stroke cycle engine
2-stroke cycle engine

(vi) According to no. of cylinders :—
Single cylinder engine
Multi " "

(vii) According to cooling system :—
Air cooled engines, water cooled engines

(6) According to method of starting :—
(a) By compressed air (b) By electrical motor

(7) According to field of operation :—
(i) Stationary station (used at pumping station, power station etc.)
(ii) Mobile engine
(a) Auto mobile
(b) Marion
(c) Loco motive
(d) Aircraft engine

2 Stroke Engine

In two stroke engine, the working ~~site~~ cycle is completed in ~~2 strokes~~ 2 strokes of piston or one revaluation of the crank shaft. This is achieved the by carring out the suction & compression processes in one stroke, expension & exhast process in the 2 stroke.

The 2 stroke engine has portes instead of valves. The opening & closing of ports are controlled by piston.

Two stroke cycle petrol Engine ⇒

(i) Suction stroke :- In this stroke, piston by moving downward BDC, both the transfer port and exhust

port and are opened. The fresh air fuel mixture closed into the engine cylinder from crank cash.

(ii) Compression stroke :— In this stroke, the piston by moving upwards first cover the transfer port then exhust port. After the fuel is compressed as the piston moves upward. In this stage the inlet port opens and fresh air fuel mixture enters into crank cash.

(iii) Expansion stroke :— During compression stroke the piston reaches the TDC, The charge is ignited with help of the spark pluge. It suddenly increases the pressure & temp. of the products of combustion & volume remains constant. Due to rise in pressure the piston is pushed downwards with greater pressure. During the expenssion some of the heat energy produced is transformed into mechanical work.

(iv) Exhaust stroke :— In this stroke piston mores downward and exhaust port is opened. The burnt gases (product of combustion) are exhausted from cylinder through exhaust port into atmosphere.

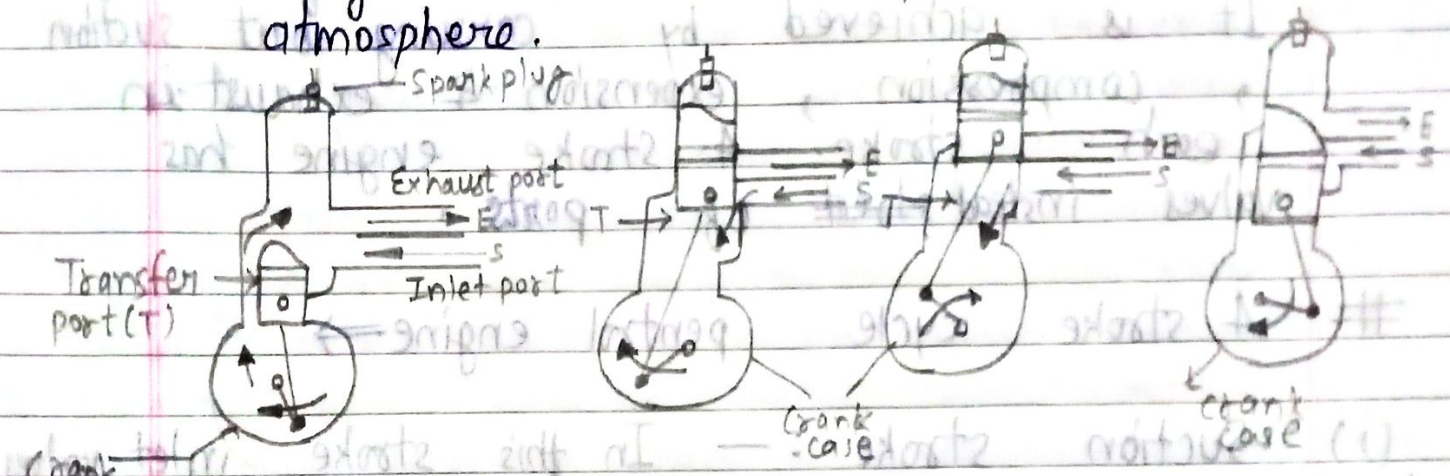
2 stroke cycle diesel engine :-

(i) Suction stroke :- In this stroke the piston while moving downward BDC both exhaust & tranfer port are opened. The fresh air flows into the engine cylinder from the crank cash.

(ii) Compression stroke :- In this stroke, the pist by moving upwards first covers the transfer port then exhaust port after that the air is compressed as the piston moves upward. In this stroke the inlet port opens and the fresh air enters into (ranok ~~prime~~ cash.

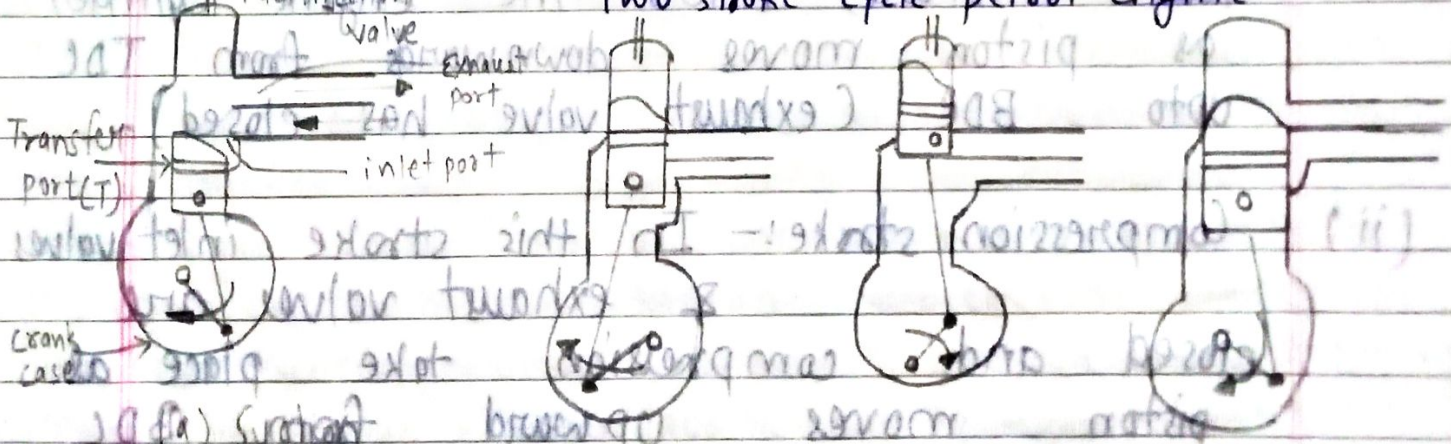
(iii) Expenssion stroke :- Just before the piston reaches the TDC (During compression stroke) the fuel is injected in the foom of very fine spray into the engine cylinder. At this point temperature of compressed air is sufficien high to ignite the fuel. Due to product of combustion, pressure & temp. increases suddenly and piston is pushed with great force. During the expension some of the heat energy produced is transfered into mechanical work.

(iv) Exhaust stroke :- In which the exhaust port is opened and the piston move downward. The burnt gases are exhausted through the exhaust port into the atmosphere.



(a) Suction (b) Compression (c) Expansion (d) Exhaust

Two stroke cycle petrol Engine



(a) Suction (b) Compression (c) Expansion (d) Exhaust

Two stroke cycle Diesel Engine

4 stroke engine

In 4 stroke engine the working cycle is comple in 4 stroke or 2 revolution of crankshaft. It is achieved by carrying out suction, compression, expension & exhaust in each stroke. 4 stroke engine has valves instead ~~steel~~ of ports.

4 stroke cycle pentrol engine ⟹

(i) Suction stroke :— In this stroke inlet valv open and charge (air-fuel mixture) enters the engine cylinder as piston moves downwards from TDC upto BDC (exhaust valve has closed).

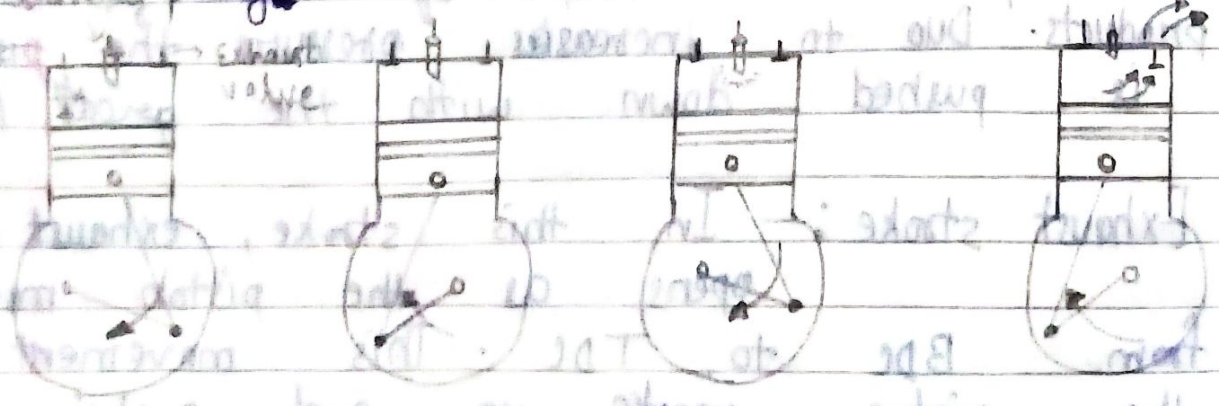
(ii) Compression stroke :- In this stroke inlet valves & exhaust valves are closed and compression take place as piston moves upward from BDC to TDC. Due to compression the pressure & ~~com press~~ temp. of charge increase considerably. This completes one revolution of crank shaft.

(iii) Expension stroke :- In this stroke just before the piston reaches TDC [during compression stroke), the charge is ignited with the help of spark pluge. It suddenly increases the

pressure & temp. of the combustion products but the volume remains constant so due to rise in pressure, the piston is pushed down with great pose force. During the expension, some heat energy is convered into mechanical energy. In this stroke both inlet & exhaust values are closed.

(iv) Exhaust stroke :— In this stroke, the exhaust valve opens and piston moves from BDC to TDC, upward movement of piston pushes out the product of combustion from the engine cylinder to atmosphere through exhaust valve. This complete second revaluation of crank shaft.

In four stroke pentrol engine air & fuel are mixed in carborater in proposnate quantity and ignition take place just before TDC in compression through spark plug.



(a) Suction stroke (b) Compression (c) Expansion (d) Exhaust stroke

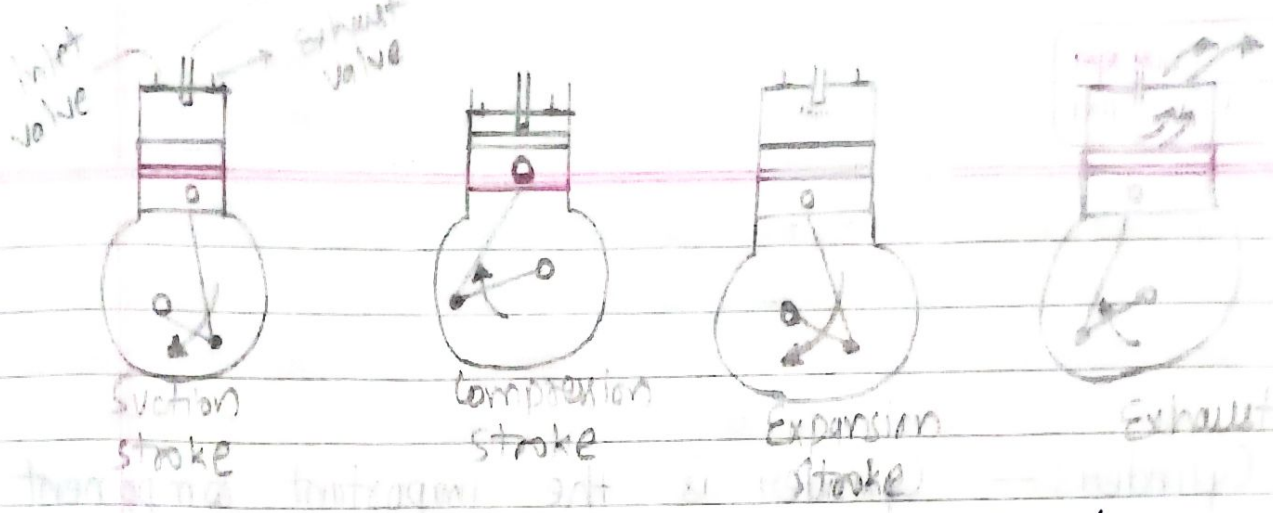
4 stroke cycle diesel Engine :-

(i) Suction stroke :- The inlet valve opens and pure air is sucked into cylinder as the piston moves downward from the TDC. It continuous till the piston reaches as BDC.

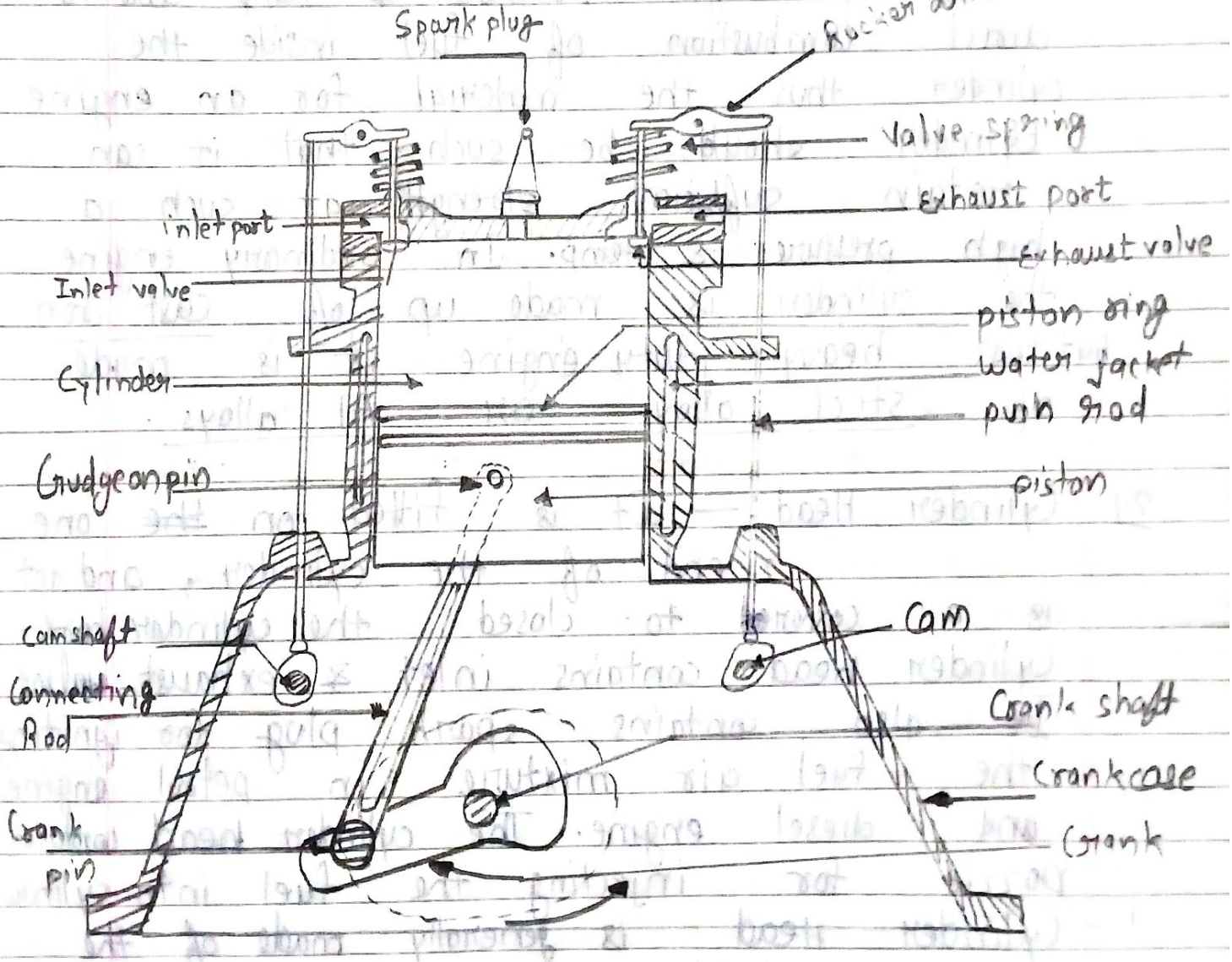
(ii) Compression stroke :- The inlet valve & outlet valve are closed and air is compressed as the piston moves upward from BDC to TDC. Due to compress pressure & temp. of air increases this completes one revaluation of crank shaft.

(iii) Expansion stroke :- Just before the piston reaches the TDC fuel oil is injected in the form of very fine spray into the engine cylinder. At this point temp. of compressed air is sufficiently high to ignite the fuel. Which suddenly increases the pressure & temp. of the combustion products. Due to increases pressure the piston is pushed down with the great Force.

(iv) Exhaust stroke :- In this stroke, exhaust valve opens as the piston moves from BDC to TDC. This movement of the piston moste up and pushes out the burnt gases to atmosphere from the engine cylinder.



Description of various part of I.C. Engine.



Main Components of I.C. Engine

1.) Cylinder :— Cylinder is the important component of engine since it has to with stand very high pressure & temp. due to direct combustion of fuel inside the cylinder thus the material for an engine cylinder should be such that it can retain sufficient strength at such a high pressure & temp. In ordinary engine the cylinder is made up of cast iron but for heavy duty engine it is made of steel alloy or Al alloys.

2.) Cylinder Head :— It is fitted on ~~the~~ one end of the cylinder, and act as a covered to closed the cylinder bore. Cylinder head contains inlet & exhaust valve It also contains spark plug for igniting the fuel air mixture in petrol engine and diesel engine. The cylinder head contains nozzle for injecting the fuel into cylinder Cylinder Head is generally made of the same material as cylinder block.

3.) Piston & piston rings :—

Piston ~~terms~~ transmit the gas force to connecting

rod & then to crank shaft. It is heart of I.C. Engine. It has good heat conducting property and also greater strength at higher temperatures.

Piston rings are in circular shape and made of special steel alloys which retains elastic properties even at high temp. Generally two set of rings are mounted on the piston. The function of upper ring is to provide air tight seal to prevent the leakage of burnt gases into the lower portion. Similarly the function of the lower ring is to provide effective seal to prevent leakage of oil into the engine.

(4.) Valve & Valve mechanism:- Valve is the device to close & open passage. In I.C. engine two valve are used for each cylinder that is inlet & exhaust valve. Valves are usually mushroom shape with conical sitting surface. The valve mechanism get its power and direction from the cam shaft which gets motion from crank shaft.

Crank shaft lifts a cam and follower mechanism that is pushed rod. The push rod of operates one and rocker arm. The other hand of rocker arm presses the valve rod.

(5.) Connecting rod :- It is linked b/w piston & crank shaft, its main function is to transmitt force from the piston to crank shaft in working stroke. It is in tapper shape in which upper & (small) is fitted into the piston & lower end (Bigger) to the crank shaft.

(6.) Crank shaft & Crank cash → Crank shaft is the part of power transmission system, through which the reciprocating motion of the piston is converted into the rotating motion with the help of connecting rod. The crank shaft is made by casting & forging of heat treatment Alloy steel. Crank cash which holds the cylinder and crank shaft of I.C. engine also serves as a sump for the lubricanting oil.

(7.) Fly wheel :- A fly wheel is a fairly heavy steel wheel attach to rear and of the crank shaft its function to the maintain constant speed of the engine. The size of the fly wheel depends upon the no. of cylinder & general construction of the engine.

Comparison b/w 2 stroke & 4-stroke

4 stroke	2 stroke
1.] One working stroke for every two revolution of the crank shaft.	1.] One working stroke for each revolution of the crank shaft.
2.] Engine is heaving.	2.] Engine is light
3.] Engine design is complicated.	3.] Engine is simple
4.] More costly	4.] Less costly
5.] Engine is water cooled.	5.] Engine is air cooled
6.] Engine require more space.	6.] Engine requires less space.
7.] Complicated lubricating system.	7.] Simple lubricating system.
8.] Engine creates less noice.	8.] Engine creates more noice.
9.] It consumes less lubricating oil.	9.] It consumes more lubricating oil.
10.] Less wear & tear of the moving parts.	10.] More wear & tear of the moving parts.

~~Types of~~ Lubrication system :—

Lubrication is essentially required for proper maintenance of moving parts in I.C. engine. In I.C. engine moving parts are lightly to wear out due to continuous rubbing action of the part with another.

Function of Lubrication system :—

(i) To reduce friction in b/w moving parts.
(ii) To reduce wear of moving parts.
(iii) To act as cooling agent for removing heat.
(iv) To keep the moving engine part clean.
(v) To prevent metalic component corrosive attack.
(vi) It makes piston gas tight.

Properties of Lubricating oil ⟹

(i) Viscosity :- It is the one of the most important property of engine lubricating oil.

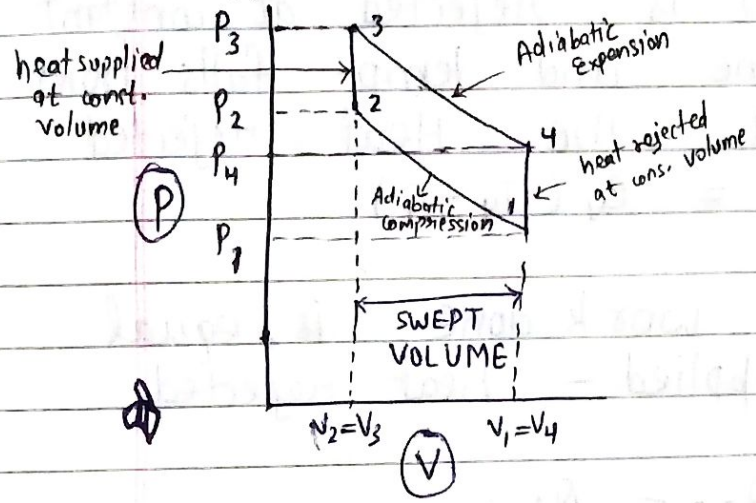
(ii) Oiliness :- It is the characteristic property of an oil. An oil is said to be useful when it has oiliness. This property is highly desirable.

(iii) Flash point :- The flash point is defined as the lowest temp. at which the lubricating oil with flash when a small flame is passed across its surface.
Flash point of lubricating is very high.

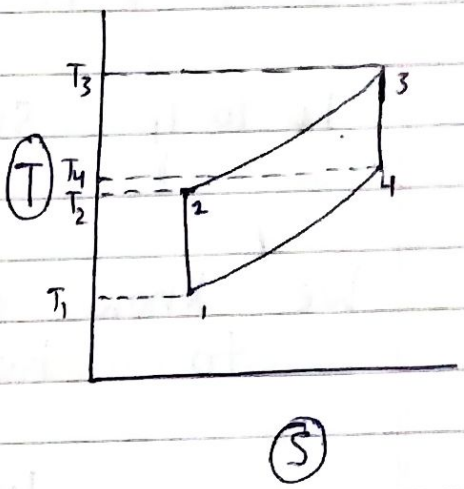
Type of Lubricating System :—

(1) Splash lubricating (2) Forced lubricating

Efficiency of OTTO Cycle :—



PV- dig



T-S Dig

Let the cylinder contains 1kg air. At point 1 the piston is at the beigning of suction stroke.

Process 1-2 :— Compression take place adiabatically. No heat is exchanged. In this process temperature raises from T_1 to T_2 and volume reduces from V_1 to clearance Volume V_2

Process 2-3 :— Heat is supplied at constant volume the temp. is raised from T_2 to T_3 so that heat supplied

$$Q_{2-3} = C_v (T_3 - T_2)$$

Process 3-4 :— Expension take place adiabatically. No heat is interchange. The temp. falls from T_3 to T_4 and volume increase from V_3 to V_4.

Process 4-1 :— Heat is rejected at constant volume and temp. falls from T_4 to T_1 so that the Heat rejected

$$Q_{4-1} = C_v (T_4 - T_1)$$

We know that work done is equal to heat supplied − heat rejected.

$$W = Q_{2-3} - Q_{4-1}$$

$$W = C_v (T_3 - T_2) - C_v (T_4 - T_1)$$

∴ Therefore the air is standarded a efficiency

$$\eta = \frac{W}{\text{workdone by heat supplied}}$$

$$\eta = \frac{\text{workdone by heat supplied}}{C_v (T_3 - T_2) - C_v (T_4 - T_1)}$$

$$\eta = \frac{C_v (T_3 - T_2) - C_v (T_4 - T_1)}{C_v (T_3 - T_2)}$$

$$\eta = 1 - \frac{C_v (T_4 - T_1)}{C_v (T_3 - T_2)}$$

$$\eta = 1 - \left(\frac{T_4 - T_1}{T_3 - T_2} \right)$$

Process 1-2 is adiabatic compression process so that $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

~~$\frac{T_2}{T_1} = \gamma - 1$~~

~~$T_2 = T_1(\gamma - 1)$~~ $\quad T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

Let r = compression ration = $\frac{V_1}{V_2} = \frac{V_4}{V_3}$

$T_2 = T_1 (r)^{\gamma-1}$ ——— (1)

Process 3-4 is adiabatic expension process so that $\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma-1} = (r)^{\gamma-1}$ ——— (2)

from eqn - (1) & (2)

$$\frac{T_2}{T_1} = \frac{T_3}{T_4}$$

$$\frac{T_4}{T_1} = \frac{T_3}{T_2}$$

Now efficiency $\eta = 1 - \frac{T_1}{T_2}$

from eqn - (1)

we get ~~$\eta = 1 - (r)^{\gamma-1}$~~

$$\boxed{\eta = 1 - \frac{1}{(r)^{\gamma-1}}}$$

mean effective pressure of OTTO cycle :—

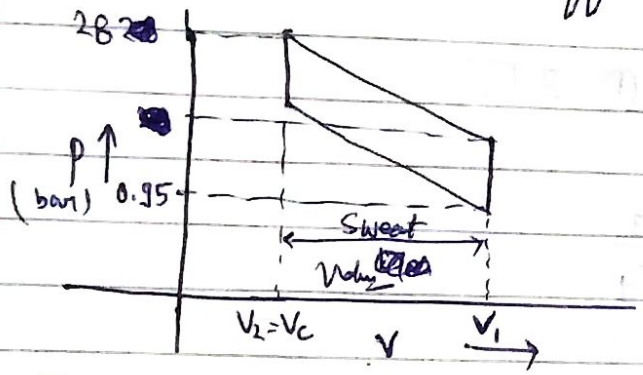
$$MEP = \eta P_1 (\alpha - 1)(r^{\gamma-1} - 1) / (\gamma - 1)(r - 1)$$

~~Comparison between~~

Q. A Engine working on a OTTO cycle has a clearness of 17% of stroke (swept) volume and inital pressure 0.95 bar and temp. 30°c If the pressure at the end of constant volume heating is 28 bar Find

(i) Air standard efficiency
(ii) The max. temp. in the cycle
(iii) Ideal mean effective pressure.

Ans—



Temp. = 30+273 = 303 K = T_1

P_1 = 0.95 bar P_3 = 28 bar

$V_c = 0.17 V_s$ $\gamma = 1.4$

$$V_1 = 0.17 V_s + V_s = 1.17 V_s$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\frac{T_2}{303} = \left(\frac{1.17 V_s}{0.17 V_s}\right)^{1.4-1}$$

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$T_2 = (303)\left(\frac{117}{17}\right)^{0.4}$$

$$r = \left(\frac{117}{17}\right)^{0.4} = (6.88)^{0.4}$$

$$T_2 = (303)(6.88)^{0.4} = 303 \times 2.16$$

$$T_2 = 654.48\ K$$

$$\eta = 1 - \frac{1}{(r)^{\gamma-1}}$$

$$\eta = 1 - \frac{1}{(6.88)^{0.4}} = 1 - \frac{1}{2.16}$$

$$\boxed{\eta = 0.53}$$

$$MEP = r_c P_1 (\alpha - 1)(r_c^{\gamma-1} - 1) / (\gamma - 1)(r_c - 1)$$

~~6.88 x 0.95~~

$$\left\{ \alpha = \frac{P_3}{P_2} = \frac{28}{14.13} \right.$$

$$\left. \alpha = 1.98 \right\}$$

Adiabatic process :—

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$0.95 (1.17 V_s)^{\gamma} = P_2 (0.17 V_s)^{\gamma}$$

$$0.95 \left(\frac{1.17 V_s}{0.17 V_s} \right)^{\gamma} = P_2$$

$$P_2 = 0.95 \times (6.88)^{1.4} = 14.13 \text{ Bar}$$

Constant volume

$$V_2 = V_3$$

$$\frac{T_2}{P_2} = \frac{T_3}{P_3}$$

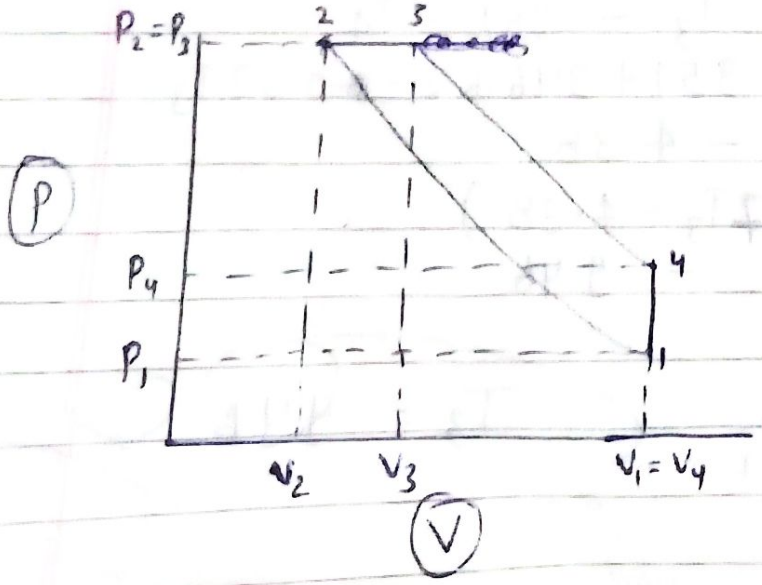
$$T_3 = \frac{654.48}{14.13} \times 28 \Rightarrow \boxed{T_3 \approx 1297 K}$$

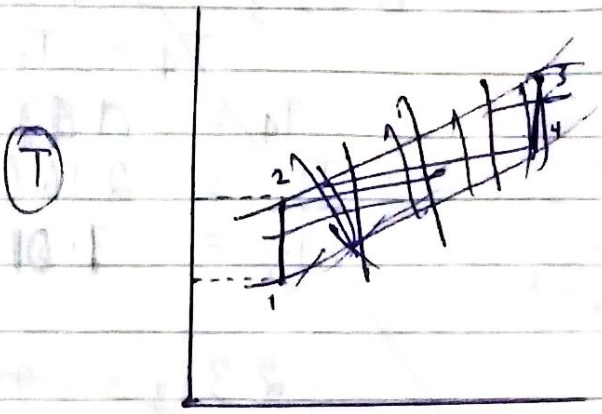
$$MEP = 6.88 \times 0.95 (1.98 - 1)((6.88)^{0.4} - 1) / (1.4 - 1)(6.88 - 1)$$

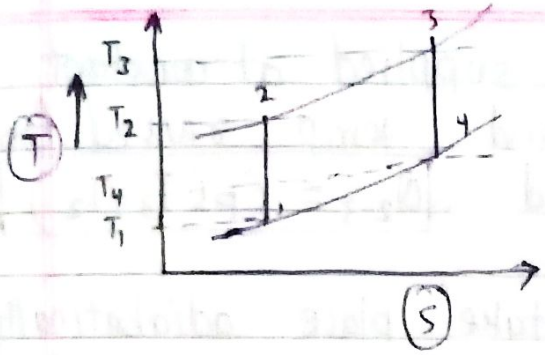
$$MEP = 6.88 \times 0.95 \times 0.98 \times 1.16 / 0.4 \times 5.88 \approx \text{~~17.44 Bar~~}$$

3.164 Bar

Diesel cycle :—







T-S Diagram

It is also known as constant pressure cycle. This is an important cycle on which ~~cold~~ diesel engine works. The ideal diesel cycle consist of two adiabatic constant pressure and a constant volume processes.

The following assumption are made in the working of diesel cycle.

(i) The working substance is assumed to be air with constant specific heats.

(ii) Heat is supplied at constant pressure.

(iii) Heat is rejected at constant volume.

(iv) Compression & expension processes are adiabatic.

(v) The working substance is taken in the engine and exhausted from engine at constant pressure.

Let the cylinder contain 1kg air. At point 1 the piston is a begining of stroke.

(i) Process 1-2 ⇒

Compression take place adiabatically. And no heat is interchanged. In this process temp. raises from T_1 to T_2. And volume reduces from V_1 to clearness V_2.

(ii) Process 2-3 :- Heat is supplied at constant pressure and temp. raised from T_2 to T_3. Heat supplied $\boxed{Q_{2-3} = C_p(T_3 - T_2)}$

(iii) Process 3-4 :- Expension take place adiabatically. And no heat is interchanged. In this process temp. fall from T_3 to T_4 and volume increase from V_3 to V_4.

(iv) Process 4-1 :- Heat is rejected at constant volume and temp. falls from T_4 to T_1.

Heat rejected $\boxed{Q_{4-1} = C_v(T_4 - T_1)}$

Workdone = Heat supplied − Heat rejected.

$$W = Q_{23} - Q_{4-1}$$

$$W = C_p(T_3 - T_2) - C_v(T_4 - T_1)$$

air standard efficiency $\eta = \dfrac{\text{Workdone}}{\text{Heat supplied}}$

$$\eta = \frac{C_p(T_3 - T_2) - C_v(T_4 - T_1)}{C_p(T_3 - T_2)}$$

$$\eta = 1 - \frac{C_v(T_4 - T_1)}{C_p(T_3 - T_2)}$$

$C_p - C_v = R$

$$\boxed{\eta = 1 - \frac{(T_4 - T_1)}{\gamma(T_3 - T_2)}}$$

$$r = \frac{V_1}{V_2} = \text{Compression ration} = \frac{V_4}{V_2}$$

$$\eta = 1 - \frac{1}{\gamma}\left(\frac{T_1}{T_2}\right)\left(\frac{T_4/T_1 - 1}{T_3/T_2 - 1}\right) \quad \text{---(1)}$$

Cut off ratio :— (ρ) It is defined as ratio of combustion chamber volume at the end of fuel combustion to the combustion chamber fuel at begining of the fuel combustion

Cut off ration $\boxed{\rho = \frac{V_3}{V_2}}$

process 1-2 is adiabatic compression process so that $\frac{T_2}{T_1} = (r)^{\gamma-1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$ — (2)

process 3-4 is adiabatic expension process so that $\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma-1} = \left(\frac{V_3}{V_2} \times \frac{V_2}{V_4}\right)^{\gamma-1}$

$$\boxed{\frac{T_4}{T_3} = \left(\frac{\rho}{r}\right)^{\gamma-1}} \quad \text{— (3)}$$

By charles law :—

$$\boxed{\rho = \frac{V_3}{V_2} = \frac{T_3}{T_2}}$$

$\frac{T_4}{T_1} = \frac{T_4}{T_1} \times \frac{T_1}{T_3}$ $\quad \frac{T_4}{T_1} = \frac{T_4}{T_3} \times \frac{T_3}{T_2} \times \frac{T_2}{T_1}$

$$\frac{T_4}{T_1} = \left(\frac{\rho}{r}\right)^{\gamma-1} \times \rho \times (r)^{\gamma-1}$$

$$\boxed{\frac{T_4}{T_1} = \rho^{\gamma}} \quad \text{— (4)}$$

putting value of eqn -②, ③, ④ in eqn ①

$$\eta = 1 - \left(\frac{1}{\gamma}\right)\left(\frac{1}{r^{\gamma-1}}\right)\left(\frac{\rho^{\gamma}-1}{\rho-1}\right)$$

$$MEP = \frac{P_1 r^{\gamma-1}\left[\gamma(\rho-1) - r^{1-\gamma}(\rho^{\gamma}-1)\right]}{(\gamma-1)(\gamma-1)}$$

Q. An air standard diesel cycle has a compression ratio of 14 The pressure at the beigning of the compression stroke is 1 bar & temp. is 300k The maximum cycle temp. is 2500 K Determine the cutoff ration & thermal efficiency.

Ans -

$$r = \frac{V_1}{V_2} = \frac{V_4}{V_2} = 14$$

$P_1 = 1$ bar, $T_1 = 300$ k , $T_3 = 2500$ K

$$\frac{T_2}{T_1} = (r)^{\gamma-1} = (14)^{1.4-1}$$

$$T_2 = 300 \times (14)^{0.4}$$

$$T_2 = 300 \times 2.873 \Rightarrow \boxed{862.12\ K = T_2}$$

$$\rho = \frac{V_3}{V_2} = \frac{T_3}{T_2} = \frac{862.12}{2500}$$

$$\boxed{\rho = 2.89}$$

$$\eta = 1 - \left(\frac{1}{\gamma}\right)\left(\frac{1}{r^{\gamma-1}}\right)\left(\frac{\rho^{\gamma}-1}{\rho-1}\right)$$

$$\eta = 1 - \left(\frac{1}{1.4}\right)\left(\frac{1}{(2.87)^{1.4-1}}\right)\left(\frac{(2.89)^{1.4}-1}{1.89}\right)$$

$$\eta = 1 - \frac{3.43}{1.89 \times 2.87 \times 1.4}$$

$$\eta = 1 - \frac{3.43}{7.59}$$

$$\eta = 1 - 0.45 = 0.55$$

$$\boxed{\eta = 0.55}$$

Comparision b/w petrol engine (S.I. engine) & Diesel (C.I. engine)

Variable factor	S.I. engine	C.I. engine
(i) Fuel	Petrol	diesel
(ii) Thermodynamic cycle	otto cycle	Diesel cycle
(iii) Compression ratio	6 to 10	15 to 25
(iv) Thermal efficiency	upto 26%.	upto 40%.
(v) Fuel Cost	Petrol is very costly	Diesel is compartively cheaper.
(vi) Fuel air ratio	10 - 17%.	18 to 100%.

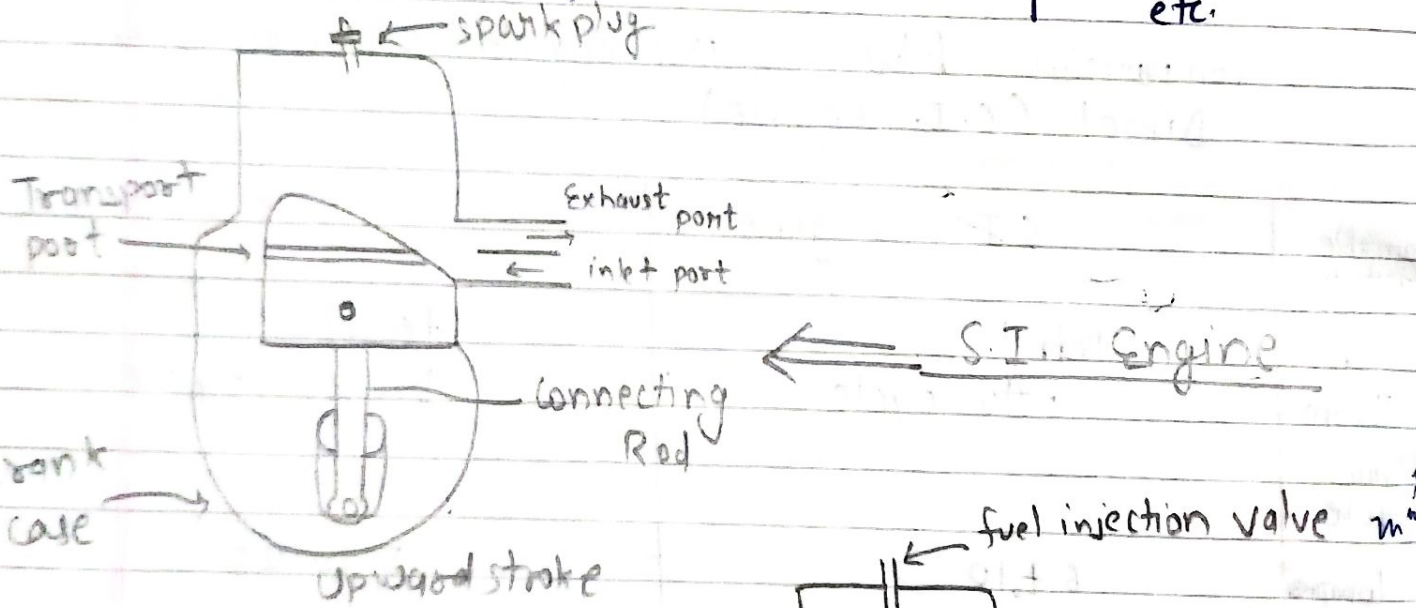
→ Indicated power = $\frac{KP_{mi}LAn}{60000}$ KW

→ Break power = $\frac{2\pi NT}{60000}$ KW

{ Frictional power = IP − BP }

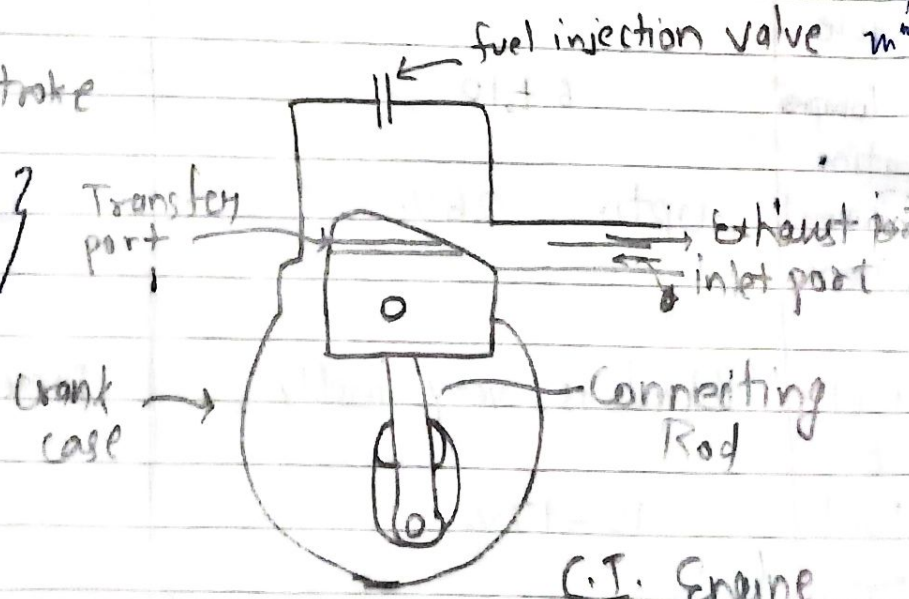
12/3/19

(viii) Initial cost	Low	Comparatively high
(viii) Fuel supply system	Carburator	Fuel pump, fuel injector
(ix) Over heating trouble	More due to low thermal efficiency	less due to high thermal efficiency
(x) Application	Used in light vechile – scooters, motorcycles, car etc.	Generally used in heavy duty vechale like buses, truck, tractors, locomotive etc.



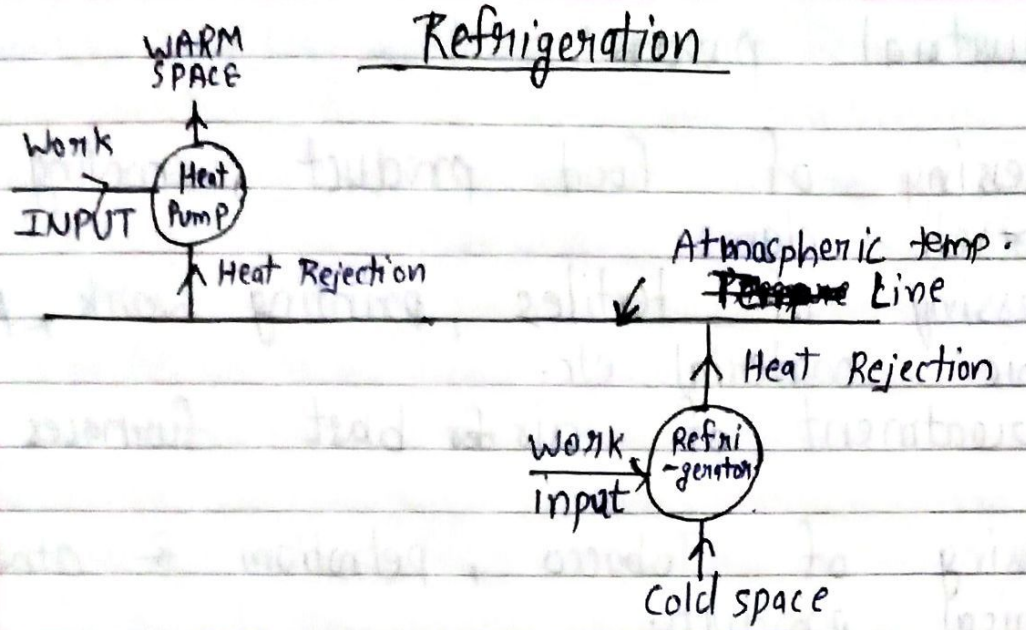
S.I. Engine

{ mechanical efficiency = $\frac{BP}{IP} \times 100$ }



C.I. Engine

Refrigeration



Symmetric Diagram of Heat pump & Refrigeration System

→ Refrigeration is defined as maintenance of a system at the temp. lower than that of it surrounding by continuous removal of heat from it.

Application of Refrigeration :— It is mainly classified into 3 main categeory.

(i) Preservation perishable items ⇒

→ For making ice & ice plant

→ For cold storage & refrigerator in which perishable force like dairy products, fruits, vegetables, juices, fish, meat etc. can be stored.

→ For preservation of photographic films, arcuological documents etc.

(ii) Industrial process :—

→ Processing of food product, cooling of concrete dams
→ Processing of textiles, printing work, photographic material etc.
→ Treatment of air for blast furnaces
→ Processing of Tobacco, petrolium & other chemical products.

(iii) Providing comfortable environment :—

→ Air conditioning of residence, hospital, hotel, restorant, theatre etc.
→ Industrial air condition

Refrigerator & Heat Pump :—

Refrigerator & Heat pumps are the machine which are used to remove heat from the body at low temp. level and then transfer the heat to another body at high temp. When the main purpose of the machine is to cool some object the machine is called refrigerator.

→ The term Heat pump is applied to a machine whose main object is to heat

a cyclic medium which may already heat warmer than it surrounding.

→ It accordance which Clausius's statement of second law of thermodynamics, heat does not flow from low temp. body to a high temp. body to its own.

→ The transfer of Heat against a reverse temp. gradiant is possible if work is supplied to the machine.

→ Since both the refrigeration & Heat pump are identical in the operation. One machine can serve both the purposes. A domestic unit may provide a cold space for food storage and supplied heat to water simultaneously

Coefficient of Performance ⇒

$$COP = \frac{\text{Heat extracted at low temp.}}{\text{Work input}}$$

$$COP = \frac{\text{Refrigerator Effect}}{\text{Work input}} = \frac{N}{W}$$

where N = Net refrigerating effect, kilo J/sec
Heat extracted at the given time.
W = work input on the system in a given time to produce the refrigerating effect
In most of cases the value of COP is much more than 1.
COP of the refrigerator base on theoritical value of N & W is termed as theoritical COP.

→ The theoritical value of N & W are calculated by appling the law of thermodynamic the refrigeration cycle. The COP of refrigerator base on the actual value of N & W is termed as actual COP.

→ The values of N & W in these case are the actual test value which are obtained during a test on the refrigerator. Relative COP is defined as "the" ratio of actual COP to theoritical COP.

→ The efficiency of Heat pump is called reciprocal thermal efficiency [R.T.E], is the ratio of heat rejected at high temp. to work input

$$\text{R.T.E.} = \frac{\text{Heat Rejected at high temp.}}{\text{Work input}}$$

$$= \frac{\text{Heat extracted at low temp.} + \text{Work input}}{\text{work input}}$$

$$\text{R.T.E.} = 1 + \frac{\text{Heat extracted at low temp.}}{\text{Work input}}$$

$$\text{R.T.E.} = 1 + \text{COP}$$

Comparision b/w Refrigerator & Heat pump ⇒

Refrigerator	Heat Pump
(i) Refrigerator is a machine for producing ~~cooled~~ Cold.	(i) Heat pump is a machine for suppling Heat.

(ii) A refrigerator reject Heat to atmosphere.	(ii) Heat pump extracts Heat from atmosphere.
(iii) COP of a refrigerator is defined as the ratio of refrigerating effect to the work input.	(iii) COP of Heat pump is defined as the ratio of Heat reject to work input.
(iv) COP of refrigerator is less than that of Heat pump.	(iv) COP of ideal Heat pump = 1 + COP of ideal refrigerator.

Refrigerant :- The working fluids use in the refrigerating machine are known as refrigerants. The most quality use refrigerants are halogenated compound like (i) Freon -11 (tri chloro mono floro methane) $CHCl_3F$
(ii) Freon-22 (Mono chloro di-floro methane) $CHClF_2$
(iii) NH_3 etc.

→ All refrigerants have their own properties which limit their efficient use in particular type of refrigerating machine.

Properties of Refrigerants ⇒

→ High latent (गुप्त ऊष्मा) Heat of evaporation :- The latent heat of evaporation of the refrigerant should be high to ensure a greater amount of heat to be absorb from the cold space.

2] Low specific Heat ⇒ The specific heat of the liquid refrigerant should be low. This minimises the amount of vapour form during floating in the expession valve and help to improve the refrigerating capacity.

3] High COP & low power input per ~~tonn~~ turn of refrigeration ⇒ The refrigerants which keep high value of COP with low power input per turn of refrigeration are desirable.

4] High thermal conductivity ⇒ The refrigerant should have a high value of thermal conductivity to ensure better heat transfer in the condensor and evaporator.

5] Low freezing point ⇒ The freezing point of refrigerant must be well below the lowest temp. of cycle ~~sho~~ so that their is no danger of freezing of the refrigerant

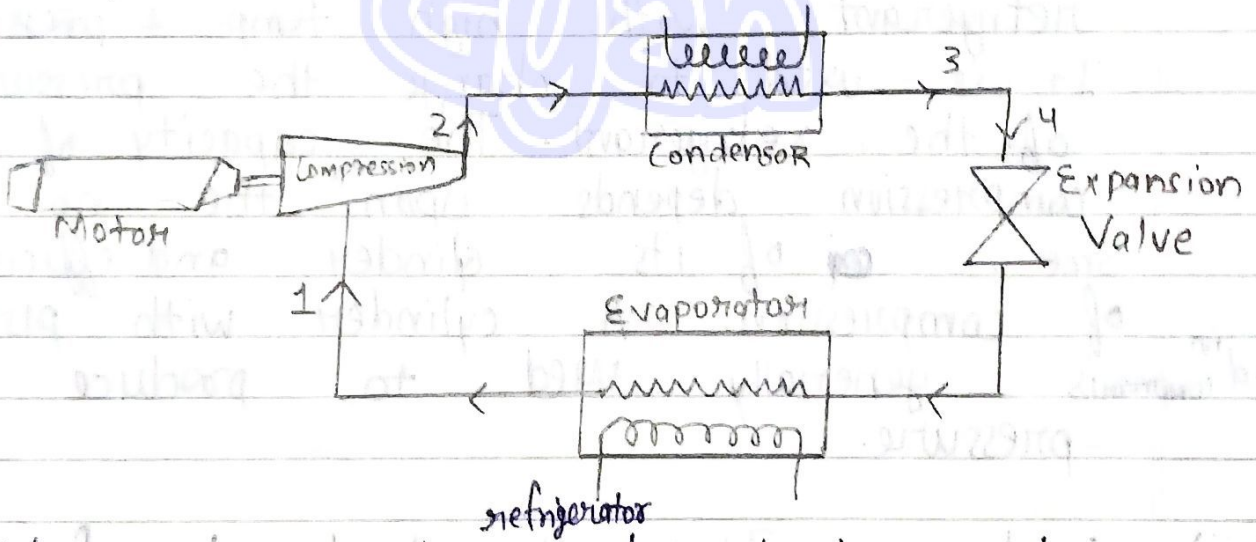
6] High critical temp. & pressure ⇒ The critical temp

& pressure of refrigerant must be well above the maximum operating pressure and temp. limits.

7.) Non - Toxic

8.) Low cost 9.) Non - corrosive
10.) chemically stable 11.) Non- inflamable
12.) Less leakage tendency

Vapour Compression Cycle ⇒



Vapour compression cycle involves condensing and evaporating of the refrigerant again & again. The refrigerant is the fue fluid which at normal temp. may exist either as the liquid on condensation or as the vapour on evaporation depending upon pressure.
During evaporation the refrigerant exhaust the large amount of heat from the evaporator.

During condensation, the refrigerant heat out latent heat to water circulati in the condensor. It is the closed cycle. A simple vapour compression cycle consist of 4 main components:-

(i) Compression (ii) Condensor
(iii) Expension valve (4.) Evaporator

(i) Compression :- Heat converts the refrigerant with low pressure & temp. obtain from evaporator into a refrigerant with high temp. & pressure. It is used to change the pressure of the refrigerant. The capacity of the compression depends upon the no. of Size of its qlinder and efficiency of compression. A cylinder with piston fitted in compressis generally used to produce high pressure.

(ii) Condensor :- It is the heat transferring equipment that absorb the latent heat from the vapour refrigerant obtained from compressor and converts into liquid ~~states~~ refrigerant. It selection is done on the bases of capacity of refrigeration system and the quantity of the refrigerant used. It is used to produce cooling in the refrigerating system.

(iii) Evaporator :— It is also used like condensor for transferring of the heat but in this the heat is provided to the refrigerant ~~that is~~ and is converted into vapour form It is also known as cooling unit & Freezer.

(iv) Expansion Valve :— The amount of refrigerant used in the evaporator keep changing. Expansion valve is used for controlling heat. It is also called control valve.

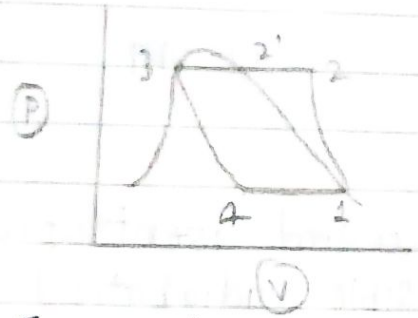
Explanation of PV & TS Diagram of VCC ⇒

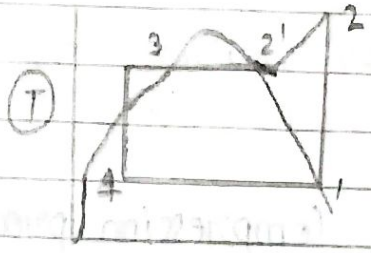
(i) Compression process 1-2 :— ~~reversant~~ isentropic (reversible adiabatic) Compression of vapour take place from low temp. & pressure at state 1 to high temp. & pressure at state 2.
If the state of vapour at the beginning of compression is saturated or superheated the compression is called Dry compression While if initial state of vapour is wet the compression is called wet compression.

(ii) Condensation process 2-3 :— Vapour at high press. & temp. is delivered to the condenser where it rejects heat at constant pressure. The Heat come Auto-rejection is carried out in two state.
→ The first stage 22' where superheat tellectual spiritual is rejected and the vapour become ecial for Saturated.

→ Second stage 2'→3 ⇒ Where the vapour is condensed giving it ~~selection~~ latent heat at cons. pressure.

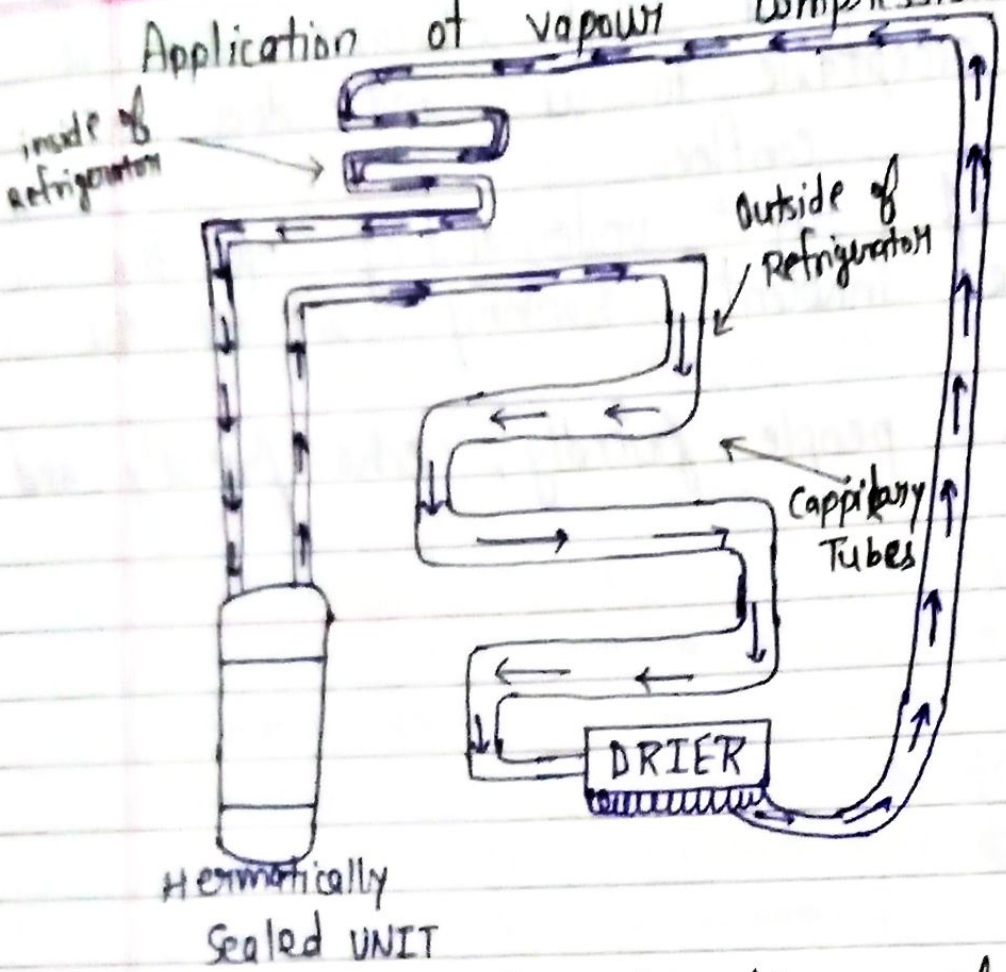
3.] Throttling process 3-4 ⇒ The High pressure liquid refrigerant is expaned irreversiablly ~~through~~ an expansion valve to a low ~~temp. I.~~ pressure p. This is called throtting process. During throttling process ~~enthalpy~~ remains constant. But due to drop in pressure, the liquid starts boiling and the latent heat for this is provided by the fluid ~~int~~ itself. Thus there is fall in temp. of the ~~temp~~ refrigerant. The temp. of the refrigerant is about −10°c.





(4.) Evaporation process 4-1 ⇒ The liquid ~~pressure passes~~ passes ~~through~~ to the evaporator where it absorbs latent heat of evaporation from the space to be cooled (refrigerator) and gets evaporated. The final state of refrigerants depend on the quality of heat absorb and it mainly wet, dry ~~or~~ or superheated. Vapour mixture

Application of vapour compression cycle ⇒



Symmetric diagram of the Refrigerator

Domestic refrigerator consist of following main components :—

(i) Compressor (ii) Condensor (iii) Expansion device
(iv) Evaporator

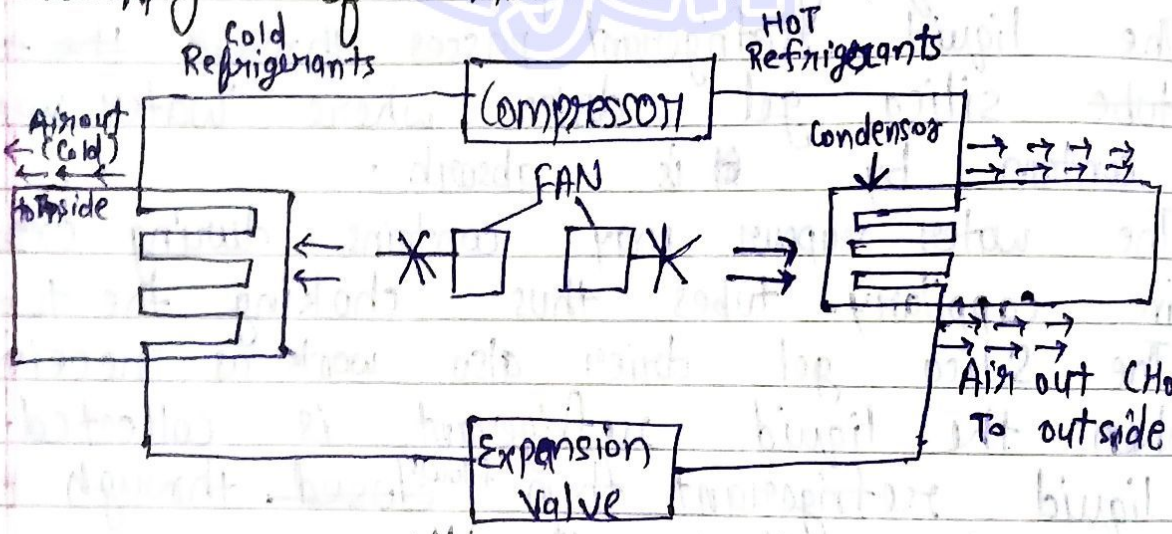
→ In the refrigerator, heat is absorbed from food product and this heat is released into the room where it is caped.
→ It keeps the material inside it at a temp. lower than atmosphere.
→ It prevents the growth of food destroying micro organism thus preserving the food product.
→ In an domestic refrigerator generally freon 12 is used as a refrigerants.

→ It works on the principle of V.C.C.
The reciprocating compressor is coupled to an electric motor and together sealed in a box which is called hermatically sealed unit. It is sealed to prevent leakage of the refrigerant.
→ The compressor compresses refrigerant vapour to high pressure & temp. It is then supply to condenser tube which are placed at the back of the refrigerator. The condensor is air cooled. The refrigerant vapour condeses as a closed loop through the condensor tube giving heat to atmosphere.
→ The liquid refrigerant passes through the condensor tube silica gel drier, where water vapour contain, by is absorb.
The water vapour may contains during expansion in cappilary tubes thus choking the tube.
→ The Silica gel drier also work as receiver when the liquid refrigerant is collected. The liquid refrigerant then flows closed through cappilary tubes where it is throttled.
The cappilary tube is the long (about 2-3m.) copper tube with small (about 0.8mm) inside diameter.
The pressure of the refrigerant drops as come out at the cappilary tube. The liquid refrigerant passes through evaporator tube coil which are placed refrigerator inside the refrigerator at the top wound
The evaporator coil form around the freezer chest. The freezer chest is the coldest

portion of the refrigerator where ice is formed. The liquid refrigerator absorb the latent heat from the air in the figure chest and it is evaporat

→ The air in different ~~point~~ zone of refrigerator is cooled by natural convension. The refrigerant vapour flow to the compressor thus repeating the cycle.

Working of Air conditioner :-



The main function of air conditioner is to maint the temp. of humidity of air. The other function is ~~used~~ to control the air motion and distribution of air in the space and also maintain purity of air by removing dust and harmful gases.

The following are the main of A.C.

(i) Compressor (Hurmitically sealed with moto
(ii) Condensor
(iii) Capillary tube

Evaporator
Fan

The window type A.C. is the simplest example of vapour compression cycle used in a package of A.C. In this unit cooling, filtering and air distribution systems are combined in a compact package which has obtained world wide popularity.
High pressure, High temp. refrigerant vapour coming out of compressor is condensed in the condenser using outside air as coolent. The liquid refrigerant is passed through capillary tube to reduce the pressure and then it is passed through evaporator.
The air from the room is passed over the evaporator where it is cooled to required temp. and then discharge in the room itself.
The refrigerant vapour coming out at lower pressure from the evaporator is compressed in compressor and cycle is repeated.
The compressor is hummitical shield unit. This kind of unit has the compressor, its motor and all moving parts ~~compat~~ operating within a shield gas type housing which is welded.
The condenser coil is continuous spoiled of copper tuming to which aluminom rings are ~~welde~~ welded increase the heat transfer surface area.
A propeler type condenser fan ~~when~~ it located

in front of the condensor coil. This fan cool condensor coil by drawing air outside & exhaust air outside.

The evaporator is located at the front of room AC. It is also made of copper taming and has aluminum ring welded at right angle to the tube to increase heat transfer area. This largest surface area for condensor coil is necessary because in addition to the air which enter through the evaporator, heat resulting from the compressor action also enter the refrigerant and this total heat must be discharged.

The water vapour condensed on the surface of the evaporator coil during De-humidity of air is collected in tray and drained out.

Air conditioning - It is defined as syntanous and effective control of temp., humudity, air motion and purity. Air conditioning is of 2 types

(i) Comfort air conditioning
(ii) Industrial air conditioning

(i) Comfort A.C. ⇒ Some of the major application of comfort A.C. are

(i) Residence (ii) Hotel & Restorant (iii) Consumer stores
(iv) large building (v) transportation (vi) Offices
(vii) Hospital (viii) Theatre & Auditorium

(2) industrial A.C. ⇒ The following are some of the industrial application of A.C.

(i) Laboratary (ii) Steel manufacturing (iii) Photographic and
(iv) farm animals (v) textile

(i) Comfort A.C. ⇒ The purpose of comfort A.C. is to create atmospheric condition must more suitable to human health, comfort, efficiency. The following factors are controlled for human comfort.

(i) Temperature:- It is very important factor which effect the human comfort to a great extend. The range of temp. for human comfort is 22.8°C to 25°C.

(ii) Humidity:- Control of Humidity is not only necessary for human comfort but it also increases the efficiency of workers. For human comfort relative humidity is kept with in the range of 35% - 60% with air motion 5m per min. to 8 m/min.

(iii) Air Purity:— People do not feel comfortable with in contaminated air even with in except temp. and humidity ranges. So proper filteration cleaning and purification is necessary to keep it free from dust, dirt & other impurities

4) Air movement & CIRCULATION :- Even if temp., humidity and air purity are satisfact a certain amount of air motion is necessary for human comfort. Moreover the air movement & its circulation are required to be control in order to ensure uniform temp. & equal distribution of air throughout the space to be air condition.

Metal Casting

1) Furnace
2) Pattern
3) Casting process (i) Mould (ii) Cavity

→ Furnace is a device used for high temp. heating. The name derives from Latin word furnax which means oven. The heat energy to fuel a furnace may be supplied by fuel combustion, by electricity such as electric arc furnace.

(2) Pattern :- Pattern is the model of the part to be cast with certain modifications from which either a few or a large no. of mould may be made. The pattern for a sand casting is the beginning step in the production of cast bar.

Pattern allowances :- Patterns are not made exactly the same size as the desired casting. Such as pattern to produces casting which are under size.
Allowaness must there fore be made for shrinkage, distortion, finish and shape.

Types of pattern :- The following are the various type of pattern:
(i) Solid pattern (ii) Split pattern (iii) loose piece pattern
(iv) Gated pattern (v) Sweep pattern

The simplest form is solid or single piece pattern. Many pattern can not be made in a single piece because they can not be removed from sand. To eliminate this difficulty some patterns are made in two parts.

so that half of the pattern will rest in lower part of mould and half in the upper part. The split in the pattern occurs a the parting time of the mould. The loose piece pattern has two loose piece that are necessary to facilited with drawing it ~~Bread~~ from the mould.
In production work where many casting are required gated pattern may be used such patterns are made of ~~melt~~ metal to give them strength and to eliminate any wrapping tendency.

Casting :- In casting process the material is given in desire shape by melting it. Theire are 7 type of casting depending on the type of mould employed

(i) Sand casting (ii) Shell mould casting
(iii) Die casting (iv) Permanent mould casting
(v) Centrifigal casting (vi) plaster mould casting
(vii) decission investment casting

(i) Sand Casting :-

This process is known as sand casting. It is the method generally used with cast iron, steal and many of the non-ferrous metal and alloy.

(ii) Shell mould Casting :- It is the process in which the molten metal is casted into a thin shell mould. The mould is made

sand with the thermosetting plastic binder.

iii) Die Casting :— In this process molten metal is forced into a metallic die or mould under pressure, The pressure being maintain untill the solidification is completed. This process is employed on such material Al, Zn alloy and other low melting alloys.

iv) Permanent mould casting :— It reverses from die casting in that the molten metal is casted directly into a metallic mould without the use of pressure.

v) Centrifugal casting :— In this process, the molten metal is casted into the mould under centrifugal force.

vi) Plaster mould casting :— The molten metal is casted into a mould composed primarily of Gypsum.

vii) decission investment casting :— In this process, small parts can be casted accurately. A special expendable wax or plastic pattern is used to make a investment.

Manufacturing Technology :-

Manufacturing Technology is the detail of study of radius process used to produce & the parts and assemble to them into the machine.

Classification of Manufacturing Process ⇒

1. Primary shaping process
2. Machining process
3. Joining process
4. Surface finishing process
5. Process effect change in properties

1/ Primary shaping process

(A) Casting ⇒ Casting is a manufacturing process in which the liquid material is powred into a mould which contain a hollow cavity of desire say & them allow to solidfy then Solidfy part is Casting.

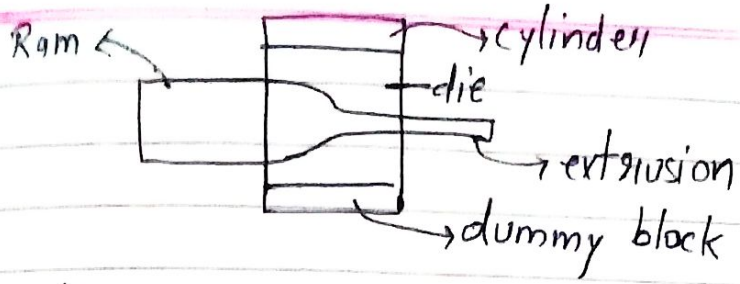
(B) Forging ⇒ Forging is a process of a shaping metal into its finished shap by pressing or heating it against anvil or die.

(C) Rolling ⇒ Rolling is a metal forming process in which metal stock is passed through one or more pairs of roll to reduce the thikness and to the make thikness.

(i) Hot Rolling :- If the temperture of metal of is above the recrytalisation temp. then the process is called hot rolling.

(ii) Cold Rolling :- If the temp. of metal is below the recrytalisation temp. then the process is called Cold Rolling.

(D) Extruding :- Extruding is a process used to create objects of a fix crossectinal profile.
A material push through a die, desire crossectinal



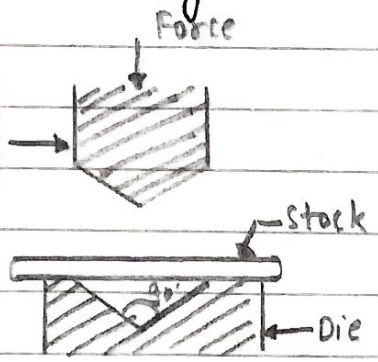
2) Machining process :-

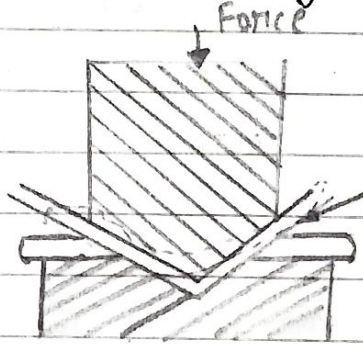
(A) Turning ⇒ Turning is a process in which the material is removed by cutting tool from rotating work piece.

(B) Facing ⇒ Facing is a process by which metal is removed from surface that is perpendicular to the axis of rotation.

(C) Chamfering ⇒ It is used to shape of the corner.

(D) knurling ⇒ It provides gripping of Job or workpiece.





BENDING OPERATIO

2.) Mechanical machine design

(A) CAD (Computer Aided design)
(B) CAM (Computer Aided Manufacturing
(C) CIM (Computer integrated manufacturing

Manufacturing process ⇒

(i) Metal Casting :-

In Casting process the material is given desire shape by melting it.
The Malton metal is powred in a cavity of a desire shape and size of the product to be produced allowing it to solidfy. ~~the~~ cavity is made in a suitable material held in a box called Mould. After solidfication the end product is ~~extracted~~ exerted (उत्सर्जित) from the mould.

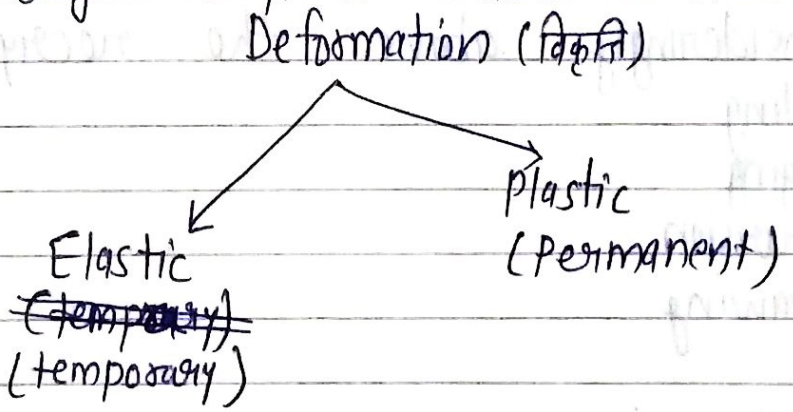
(ii) Machining :-

The process of removing the unwanted material from a given work

piece to give it the required shape is known as Machining. In this process material is removed from the unwanted reasons of the raw material to get the desired shape and size.

(iii) Forming :-

Forming process includes a wide variety of techniques which makes use of suitable force, pressure or stresses like tension, compression, shear or their combination to cause a permanent deformation of the material to give it the required shape & size. Unlike machining method in this process no material is removed but it is only displaced and deformed.



(iv) Joining :- In this process two or more pieces are joint together to produced the required shape & size of the product the point maybe temporary or permanent. The permanent joint may be made by furing the metals together as in welding EDC, . The temporary joints can be done by using nuts, bolts, screws

(v) Powder metallurgy ⇒ It is an art of produced product from metallic powder by pressure

In this process fixed powder material are pressed into a desire shape in die. and then heated in a control atmosphere to band the controlling surfaces of the particle and set the desire properties. The product model from power metallurgy are gear tungstone wire or electric Bulbs cutting tools etc.

* Hot Working process :— Hot working of metal is defined as a process of forming metals by deformation ~~and~~ at temp. above the recrystalization temp. The temp. at which crystalization take i.e. new grains are formed, is called Recrystalization temp. Therefore most Hot working process are carred out an at tempartures consideringly above the recrystalization temp.

(i) Rolling
(ii) Forging
(iii) Extursion
(iv) Drawing

(i) Rolling :—

The process of Rolling consists essentially of passing the Hot material blw two Rolls which revolving opposite direction and which are so spread that the distance blw them is less than the height of the entering Bar. In this

way the cross-section is decreased while the length is increased.

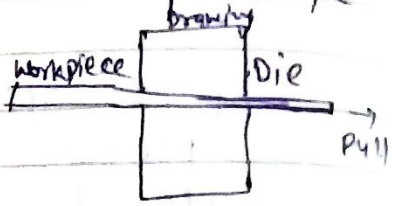
2.) Forging :—

Forging is a art of working metals by the application of sudden blows or by steady pressure. In these process, the metal is made to flow into the desire shape by proper manipulation with a Hammer or press either with or without the use of Dies.

3.) Extursion :— It is the process of forcing metal in the plastic state out through a die which control the shape of the crossection The machine for this purpose consist of chamber containing the plastic metal and the hydrolic ~~presser~~ system which forces the metal through hardern dies in a way much the same as that where by tooth-pest is forced from a tube.

4.) Drawing :— Hot drawing is the opreation of either pushing or pulling hot plastic metarial through a die in order to change its crossection or shape.
One hot drawing process may be refer as capping.
Around disk cut out of material of suitable is heated to forging temp.

The disk is placed over a die and a plunger forces the metal dawn through a die forging a cup shape object.



* **Cold working process :→**

Cold working is defined as the shaping of metal by plastic deformation at a temp. below a Re-crystalization temp.

Cold working processes :—

(i) Cold rolling
(ii) Shearing
(iii) Cold drawing
(iv) Bending.

(i) Cold Rolling :— It is process to used to finish sheet & bar shock for special purposes. It is Ac complied in rolling mill similar to those used in hot rolling.

In this case the mill are known resistally construced in order to maintain the accuracy and the rolls are polished.

The sheets for cold rolling mills are prepared by hot rolling process

and are then carefully picked and washed to clean the surface of scale and for an materials.
~~The sheet~~ The sheet is then fed to the mill and in succesive stages is rolled down to the desire thickness.

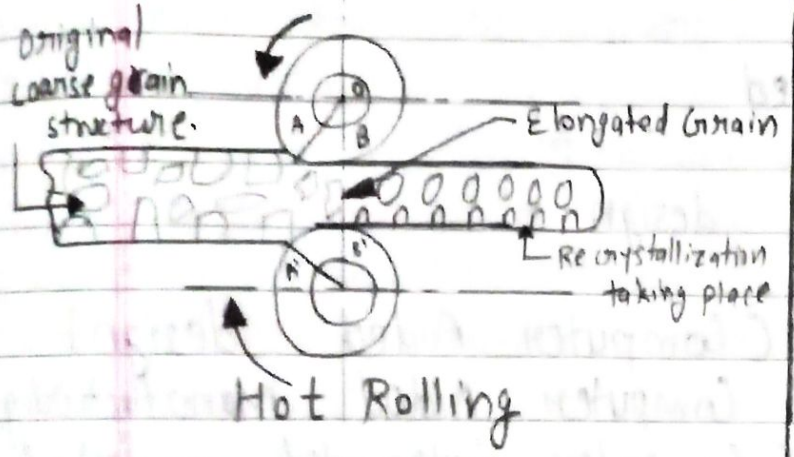
(ii) SHearing :—

Cutting metal involves stressing it in shear above its ultimate strength blw adjacent sharp edges. As the punch descent on the metal, pressur first causes plastic deformation to take press. The metal is highly placed adjacent to punch and die edges. And fracture start both side of sheet as the deformation continuous. When the ultimate strength of material is reached, the fracture progresses and ~~clearnes~~ keeps the clearness to current and both edges are of equal sharpness the fracture meet at the centre of the sheet.

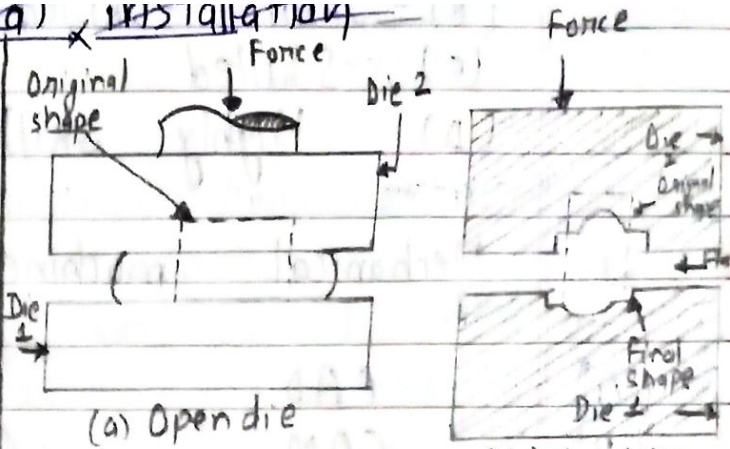
(iii) Cold drawing :— temp.

(iv) Bending :— Bending may be consider as an ~~popular~~ operation in which the surface area of the articlies not ~~ab~~ appricibly change,
~~appropriat~~ appropriately

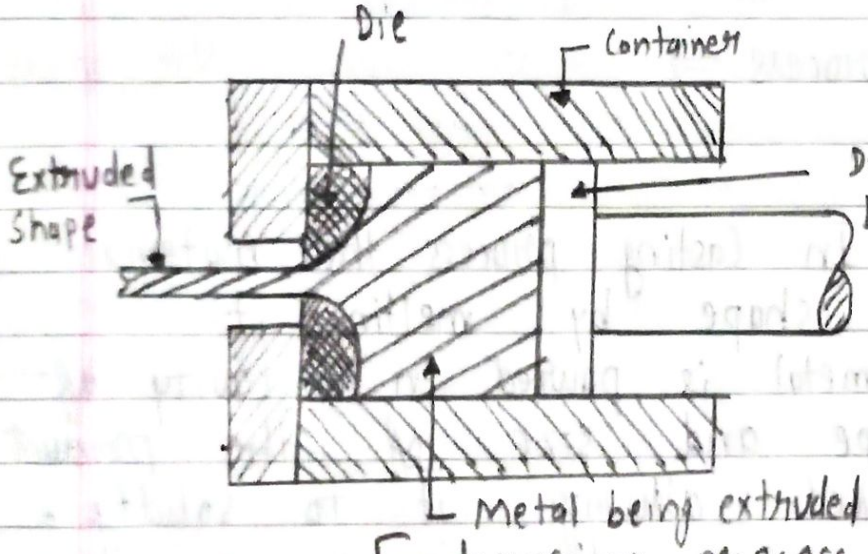
Electrical & Installation



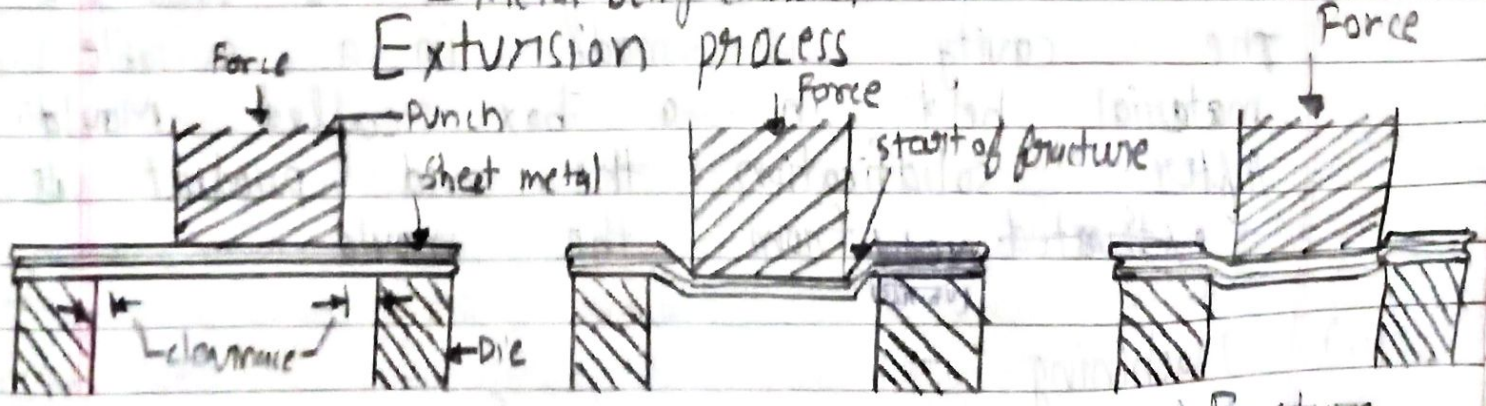
Hot Rolling



Forging process



Extrusion process



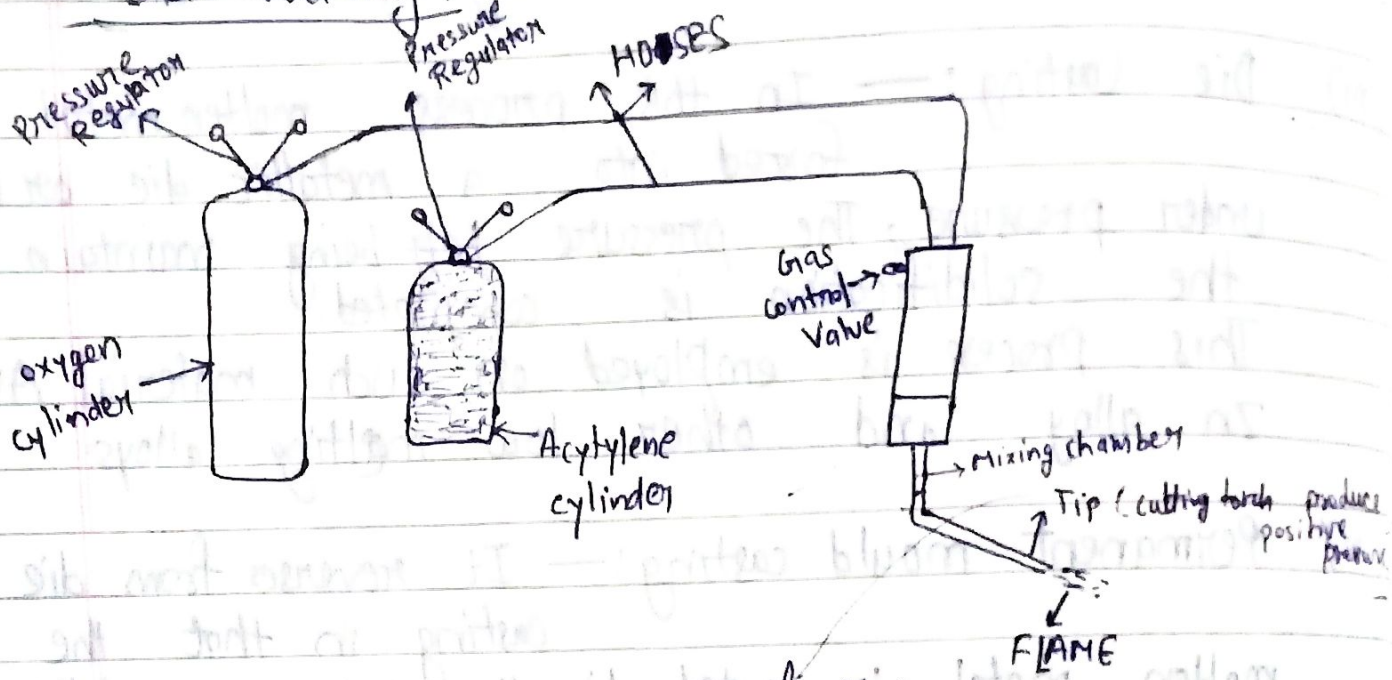
(a) Punch contacting Metal

(b) Plastic deformation

(c) Fracture complete

SHEARING

Gas Welding :-



Gas welding is the ~~diffusion~~ fusion welding process. It joints metal fusing the heat of combustion of an oxygen & ~~flule~~ fuel gas (acytylene, hydrogen, propane, butene) mixture. The intense heat thus produces melts and fuses together the ~~age~~ edge of part to be welded generally with the addition of filler metal Usually oxygen & acytylene are used in gas welding process.

Oxi- acytylene welding :- In this welding process, acytylene is mixed with oxygen in correct proportion in the welding torch and ignited. The plane resulting at the tip of the torch is sufficiently hot to melt the parent metal. The Oxi-acytylene flame reaches a time of about 3200 C and thus the

flame
made by playing the ~~plane~~ upon the adgecent surface of the prepaired joint And by using a filler metal is also melt and fills into the joints.

Gas welding requires careful manupulation of the plane and of the welding torch. The hole in the tip of the welding torch must be shooted to the perticular job and they affect ~~heat~~ distjibution and amount of heat.

Equipment ⟹ ~~In the~~ Basic equipment used to carried out gas welding are

1. Oxygen & acytylence gas cylinder
2. Oxygen & acytylence pressure regulator
3. Oxygen & acytylence hoses
4. welding torch
5. filler rods

1/ O & A gas cylinder:— Oxygen cylinders are painted black and the valve outlets are screwed right hand. But Acytylene cylinder painted Red and the valve outlets are screwed left handed.
Oxygen cylinder is the solid drawn cylinder out of mild steel of alloy steel.
Acytylene cylinder is also a solid drawn steel cylinder and Acy. cylinder is filled with a porus material such a balsa wood and some other absorbing material which is saturated with a chemical solvent called aceton.
Since high prossure acetylene is not stabled.

It is dissolved acetone which is dissolved in large volume of gas and it is released

The small compartment in the porus material prevent the sudden decomposition of the acytylene through out the mass.

Acytylene gas generator is used to generate acytylene gas at the plare of use. It is much cheaper to produced this gas. Acytylene gas is generated by carbied - to - water method.

(ii) O & A pressure regulator :— The pressure of the gases obtain from the cylinder is considerally higher than the gas pressure used to operate the welding torch. The purpose of using a gas pressure regulator

→ To reduce the high pressure of the gas cylinder to a suitable working pressure.

→ To produce a steady flow of gas under bearing cylinder pressure.

3) Oxygen & Acy. gas hoses :— The hoses for the supply of the oxygen from the pressure regulator) to the welding torch is coloured blue and as right hand thread connection, where as the acytylene hose is coloured Red and has left hand thread connection.

The welding hose has a simlest lining which is manufactured from rubber and

re-inforced by wraped cotten plies. The forces to be used should be stronge non- porous & flexible.

4. Application of gas welding :—

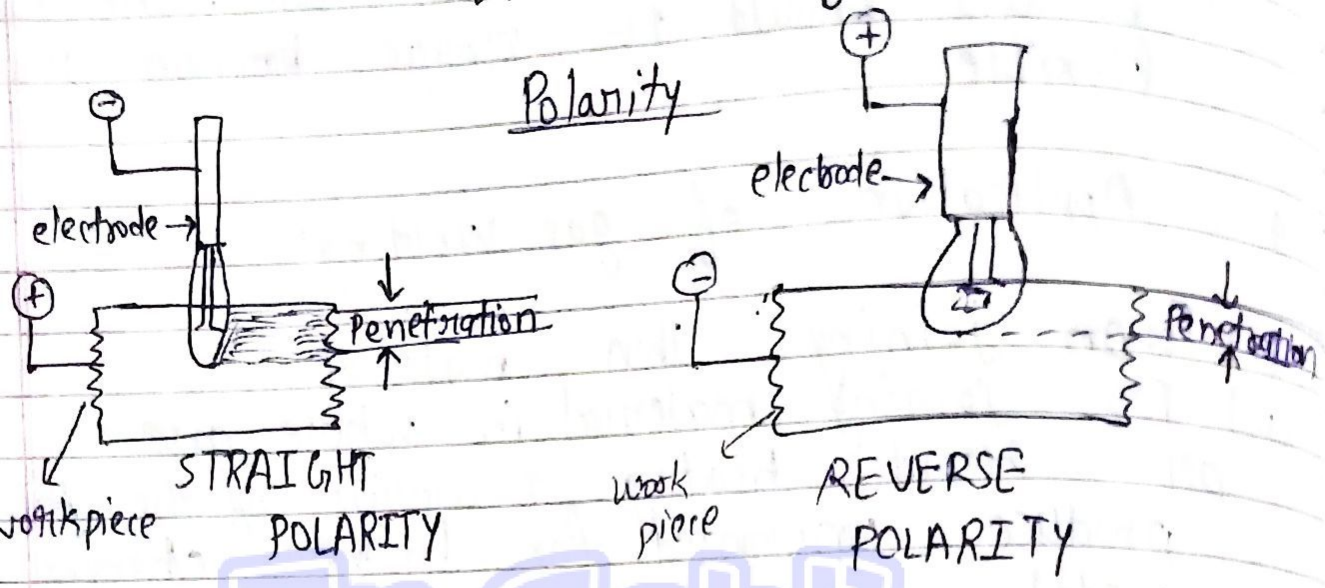
(i) For joining thin material
(ii) For joining material in whose case or rapid heating & cooling of the job good produce unwanted for harmful changes in metal.
(iii) For joining most ferrous and non ferrous. eg - carbon steel, alloy steel, cast iron, aluminium, copper, nikale, magnesium & its alloy et
(iv) In automobile aircraft industry, in steel metal plant etc.

Disadvantage of Gas welding :—

(i) Heavy section can not be joint economically.
(ii) Flame temp. is less than the temp. of arc.
(iii) Gas flame takes a lot time of heat up the metal than an arc.
(iv) ~~Most~~ More safety problems are associated with the handling & storage of
(v) Acytylene & oxygen are whether expansive.

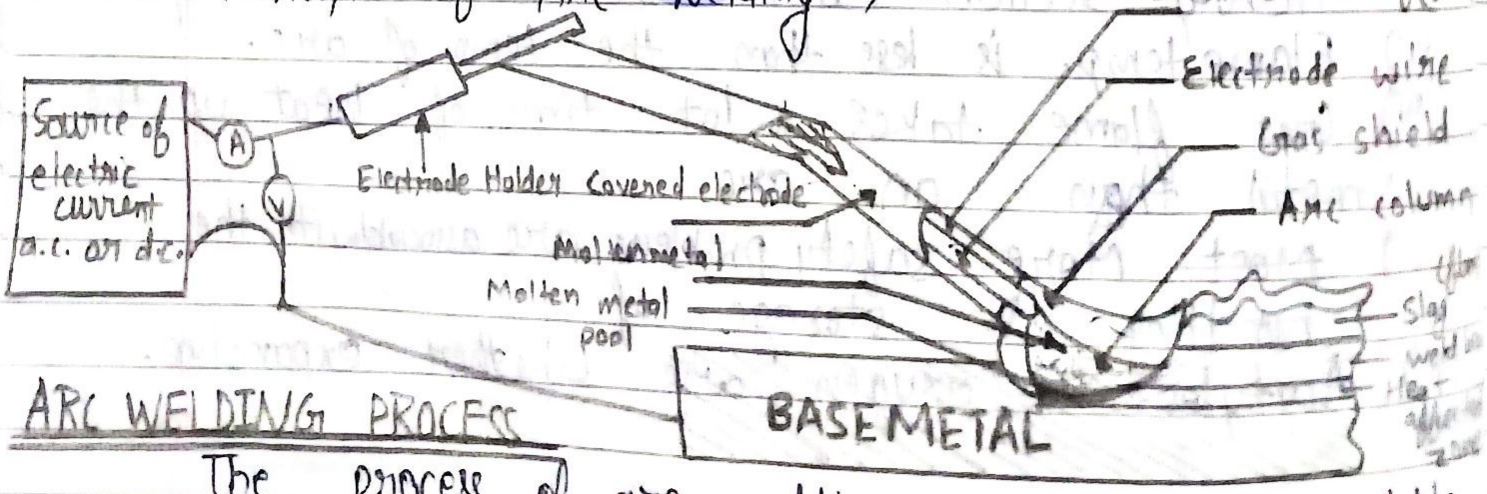
Arc welding

Polarity



* Arc welding :- It is fusion welding process in which welding heat obtained for an electric arc set a either b/w the base metal and one electrode or b/w two electrodes. Arc welding is widly accepted as the best, most economical & most practical method of joining the metal.

Principle of Arc welding ⇒



ARC WELDING PROCESS

The process of arc welding required the suitable electrode, low voltage, high current producing electrical equipment, cable and the work piece.

The work piece is attached to one of the cable and electrode to the other cable. And electric arc is then strucked blw workpiece & electrode as an large ~~cobre~~ current jumps blw electrode & the workpiece, producing large heat. Next electrode moved alone the seams of the metal to be welded. Allowing sufficient time for the arc heat to melt and ~~two~~ fuse the metal -

Electrode :- Electrode is the piece of wire or a rod with or without flux covering which carries current of welding & at one end it is gripped in the holder and arc is setup at the other.

Welding electrodes are of two type :-

(i) Consumable (ii) Non-consumable

(i) Consumable electrode ⇒ There are low melting point electrode made up of different metal & their alloys. When the arc blw the electrode & job ~~struck~~ is strucked, the end of the electrode starts melting and transfer to the job in the form of droplets. The electrode itself the filler metal.

(ii) Non consumable electrode ⇒ These type of electrode do not melt during the welding. It maintains the arc which melts the base metal. They are made up of high melting point material like carbon, pure tungston and alloy tungston. In welding

process using non-consumable electrodes, filler metal addition may or may not be needed depending upon the plate thickness and type of joint.

Effects of straight or reverse polarity :—

Straight polarity ⇒ (i) Welding current upto 1000 A can be used. And Deep penetration

(ii) Reverse polarity ⇒ (i) Current employed are generally less than 125 A to avoid over heating

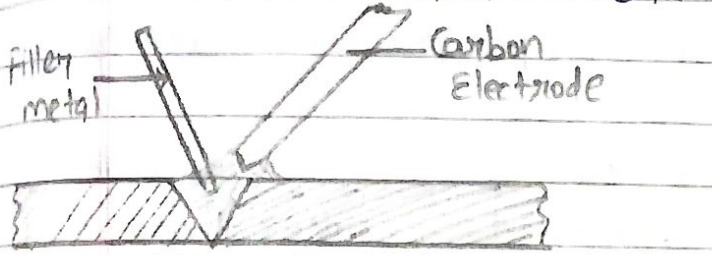
(ii) Least penetration.

Types of Arc welding :—

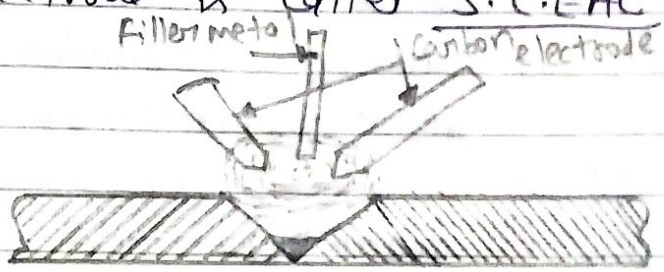
(i) Carban Arc welding
(ii) Shielded metal Arc welding
(iii) Submerged Arc welding
(iv) Tig Arc welding (Tungstone inneret gas)
(v) Mig Arc welding (metal inneret gas)

(1) Carbon Arc welding ⇒ It is an arc welding process where in fusion is produced by heating the working piece with electric arc struck b/w carbon electrode & work piece. Filler metal may or may not be used. Carbon arc welding is of two type :—

(i) Single carbon electrode Arc welding :— The process in which the welding heat is obtained from electric arc setup b/w the base metal and one electrode is called S.C.E.A.C.



Welding with single carbon electrode



Twin carbon electrode

(ii) Twin carbon electrode Arc welding :— Unlike single carbon electrode arc welding the arc is maintained b/w two carbon electrode.

Welding with two electrode is very similar to gas welding, in that the heat is generated above the work and is played upon it.

Advantages of carbon Arc welding :—

(i) Heat into the work piece can easily controlled by changing the arc length.
(ii) Process is simple & good welding skill can be acquired in short time.
(iii) Total welding cost is less as compare to other welding processes.
(iv) Equipment required for carbon Arc welding is simple & easily available.
(v) Process is very suitable for butt welding of thiner work piece (1 to 2 mm thickness)

Disadvantages of Carbon Arc welding :—

(i) There are changes of carbon being transferred from electrode to weld metal, thus causing harder weld deposit in case of ferrous material.

(ii) In the absence of proper electrode geometry and it confind spaces arc blow results which ~~keep~~ gives poor welds with blow holes.

(iii) A separate filler metal is needed which (when use) slows down the welded speed.

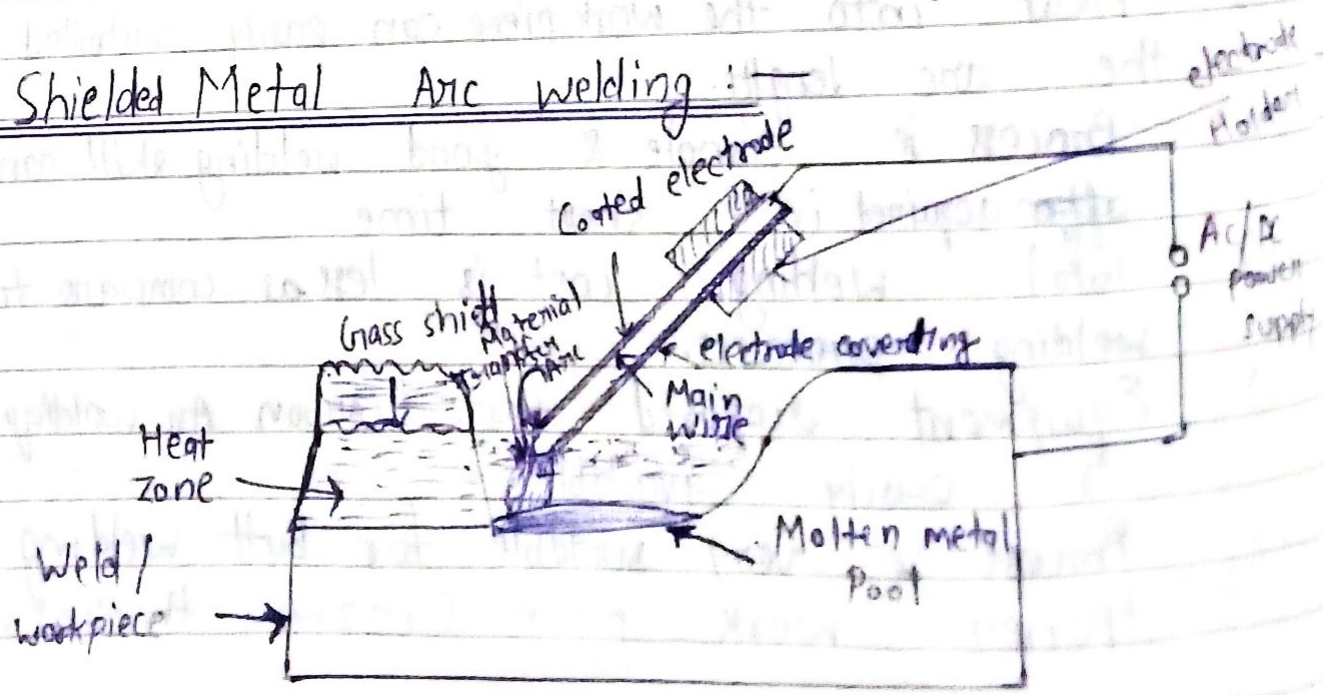
Application of C.A.W. ⇒

(i) C.A.W. process can be used for welding steel, aluminium, Ni, Cu, & good no. of other alloy.

(ii) C.A.W. can also be employed for brazing, pre-heating and post heating of the welded joint.

(iii) C.A.W. can be used for repairing casting.

Shielded Metal Arc welding :—



It is an arc welding process where fusion is produced by heating the workpiece with an electric arc setup b/w a flux coated electrode & workpiece. The flux covering decomposes due to arc heat and performs many function like arc stability, weld metal protection, the electrode itself melts & supply the necessary filler metals.

Principle:-

Heat required for welding is obtained from the arc struck b/w a coated electrode & workpiece. The arc temp. thus the arc heat can be increased & decreased by employing higher or lower arc current. The flux coating melts, producer the gases shield and slaged prevent atmospheric contamination of the molten weld metal.

Advantage:-

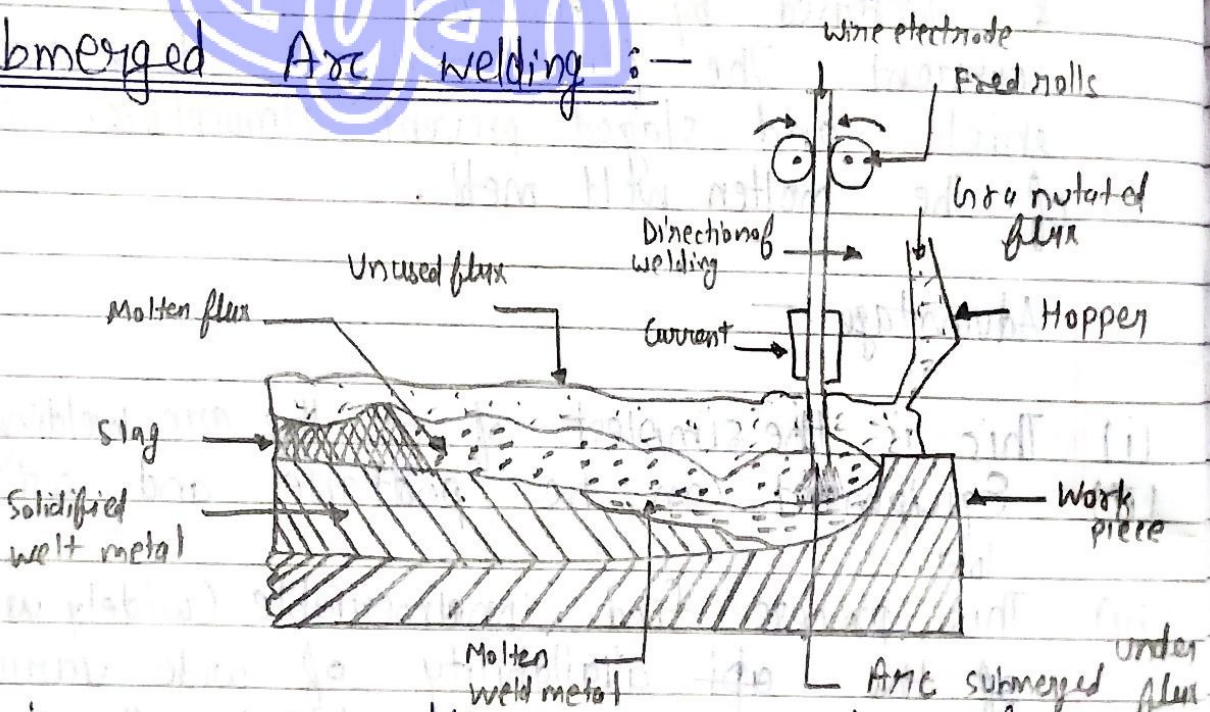
(i) This is the simplest of all the arc welding process.
(ii) Equipment can be portable and cost is fairly low.
(iii) This process find innumeriable (widely used) because of the availability of wide variety of electrode
(iv) A big range of metals & alloys can be welded.
(v) Welding can be carried out in any position with highest weld quality.

Limitation:-

(i) Because of the limited length of each electrode and brittle flux coating, mechanisation is difficult.
(ii) The process uses stick electrode & thus it is slower.
(iii) Because of flux coated electrode the chance of slage intrapment and other related defacts are more.
(iv) Because of fumes partical of slage the arc & metal ~~of~~ transfer is not very clear & thus welding control in this process is a bit difficult.

(3) Submerged Arc welding :-

Submerged Arc Welding ⇒



It is an arc welding process where fusion is produced by heating with an electric arc. ~~In submerged arc welding~~ blw the bare metal and electrode and the job. In this process, the region of the arc is completely submerged in a finely crushed mineral acting as a flux.

The continuously fed ~~belt~~, bare metal electrode melts and ~~ates~~ acts as filler rod.

Principle :- In this process instead of flux covered electrode granular flux and a bare electrode is used. Arc b/w electrode & job is the heat source and remains burried under the flux. The flux serve as a shield & protects the molten weld pool from atmospheric contamination.

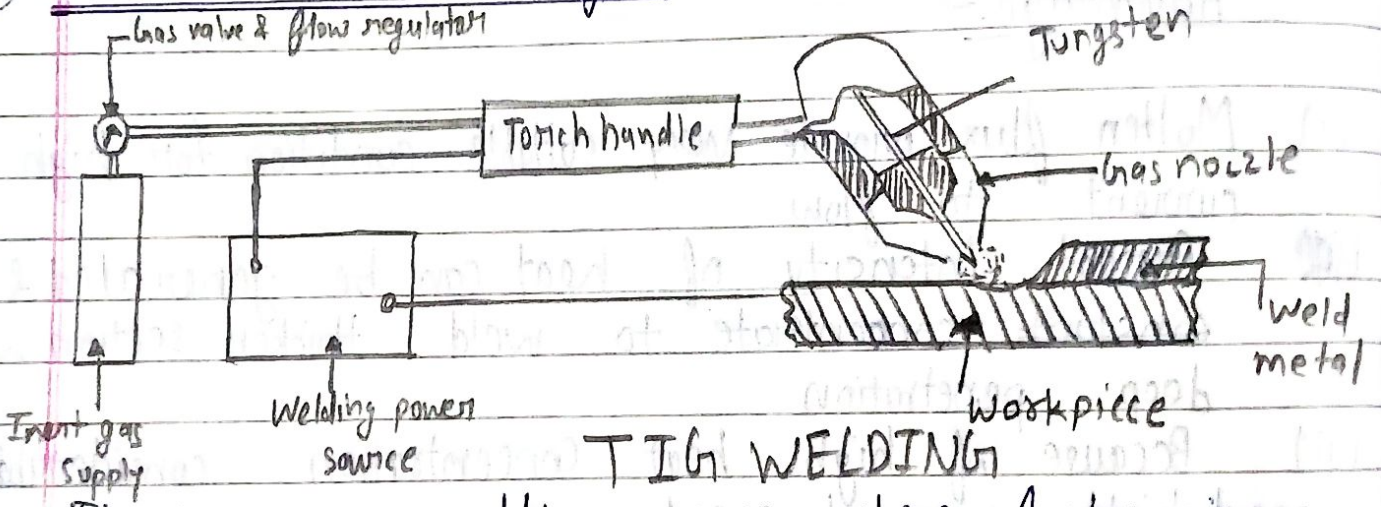
Advantage :-

(i) Molten flux provide very suitable condition for high current to flow.
(ii) Great intensity of heat can be generated & caped ~~constant~~ concentrate to weld thicker section with deep penetration
(iii) Because of high heat concentration considerably speed ~~shield~~ can be used.
(iv) Because of high heat concentration & faster welding speed weld distortion is much less.
(v) High metal deposition rates can be achieved.
(vi) Very neat appearance and smooth weld shaps can be prepared.

Disadvantage :—
(i) Since the operator cannt see the welding being carried out, he cann't ~~accurately~~ the process accurately of welding

(ii) The process is limited to welding in flat position & the metal more than 4.8 mm thick.
(iii) Flux is subject to contamination that may cause weld ~~poro~~ corrosity
(iv) Weld metal chemistry ~~difficult~~ difficult to control
(v) Cast iron, aluminium alloys, Mg alloy, lead alloy, & Zn cannot be welded by this process.

(4) TIG welding :—



TIG WELDING

It is an arc welding process where fusion is produced by heating the job with an electric arc struck b/w a tungsten electrode & the job. The shielding gas (Ne, Ar, He, N etc.) is used to avoid atmospheric contamination of the molten weld pool. A filler metal may be added if required.

Principle :—

A single tungsten electrode is used in thick welding. A weld zone is

protected by inner gas felt through the water cooled electrode holder. AC / DC can be used, the selection of current can be made by the kind of metal to be welded. Direct current with straight polarity is required for steel, cast iron, Cu alloys, stanless steel. While reverse polarity is not widely used. AC is used for Al, mg, cast iron etc.

Advantages:-

(i) No flux is used, hence there is no danger of flux entrapment when welding refrigerator and air conditioner.
(ii) Because of clear visibility of the arc and the job, the operator can excercise a betterment control over welding process.
(iii) This process can be weld in all positions and produces smooth & sound weld with less spatter
(iv) Tig welding is very much suitable for high welding of thin material (as thin as 0.125 mm).
(v) It is the very good process of welding non-ferrous metals and stanless steel.

Dis advantages:-

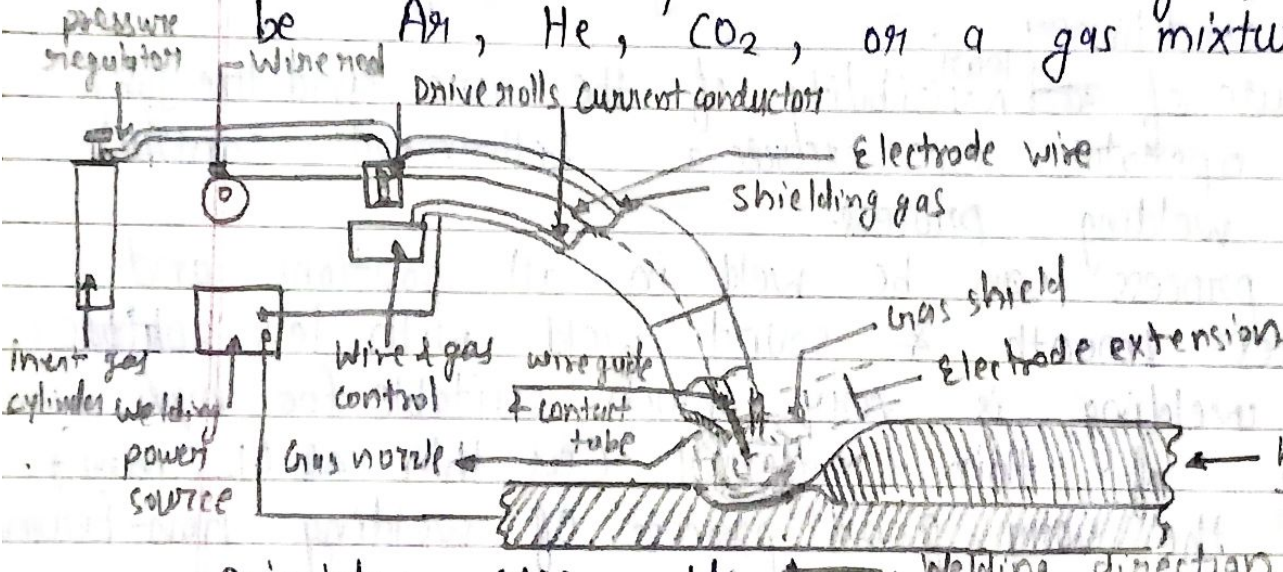
(i) Under similar application Mig welding is much faster process as compared to Tig welding. Since tig welding require a separate filler rod.
(ii) W if it transfer to the molten weld pool can contaminate same. Tangston inclusion is hard &

brittle.

(iii) Filler rod and it heat by chance comes out of inert gas shield can caused weld metal contamination

(iv) Equipment cost higher than that of the shielded metal arc welding.

(5) **MIG Welding** ⇒ It is an arc welding where fusion is produced by heating the job with an electric arc estabished b/w a continuously fed metal electrode & the job. No flux is used but the arc & molten metal are shielded by an inert gas, which may be Ar, He, CO_2, or a gas mixture.



Principle :- MIG welding using consumable electrode is accomplished by employing shielded arc b/w the consumer bare wire electrode & the workpiece. In this process a wire is fed continuously through a gun to the contact surface that imparts current through the wire.

Advantages :—

(i) Because of continuously fed electrode mig welding process is much faster as compare to Tig welding or stick electrode welding.
(ii) It can be produced joint with deep penetration.
(iii) Thick & Thin both types of workpiece can be welded effectively.
(iv) Large metal deposition rate are achieved by mig welding.
(v) No flux is used, MIG welding processes smooth neat, clean, & spatter free welded surfaces which requires for no further cleaning.
(vi) This help reducing total welding cost.

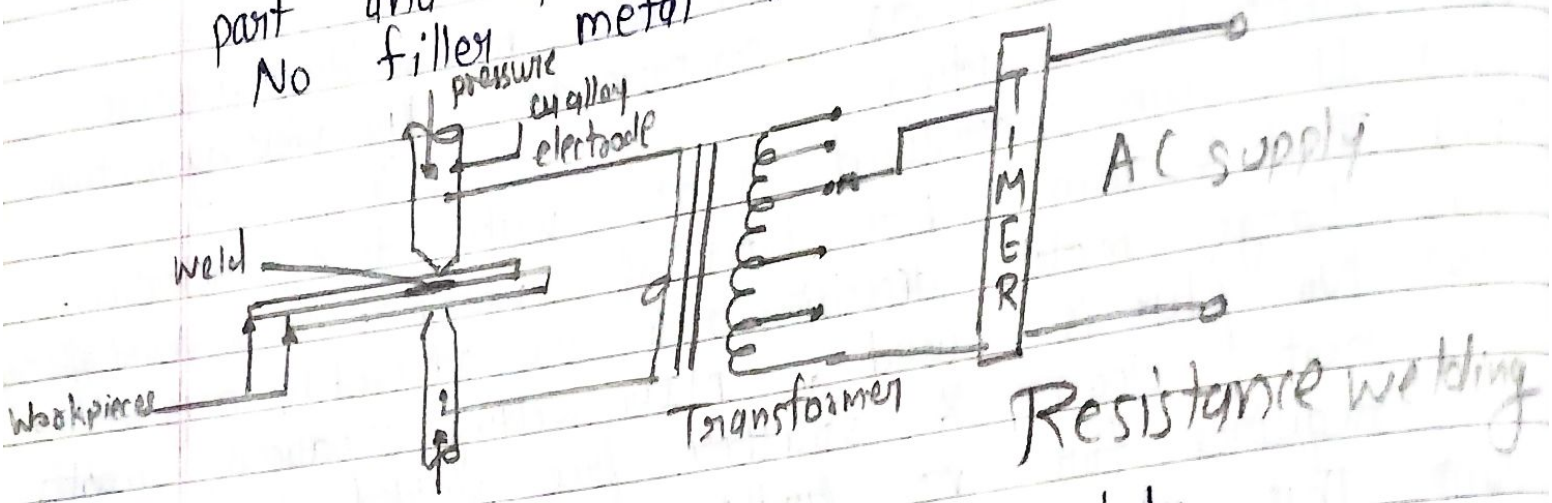
Disadvantages :—

(i) The process is slightly more complex as compare to TIG welding. Because of no. of variable (like electrode stick, torch angle, welding parameter, type & size of electrode, welding torch manuplication) are required to be control effectively to achieve good result.
(ii) Welding equipment is more complex, more costly & less portable.
(iii) Weld metal cooling rates are higher than with the process that deposite slage over the weld metal.

Resistance Welding

Resistance welding is the group of welding processes where fusion is produced by the heat obtained from resistance of the work to the flow of electric

current in the circuit of which the work is the part and by the application of pressure.
No filler metal is needed.



Resistance welding

Principle:-
There are two factor mainly

(i) The generation of heat at the place where the two pieces are to be joint.
(ii) Application of pressure at the place where the weld joint is to be formed.

Advantage:-

(i) Fast rate of production.
(ii) No filler rod is needed.
(iii) Less skill worker can do the job.
(iv) Both similar and disimilar metal can be melted
(v) High reliability & re-productivity are obtained.

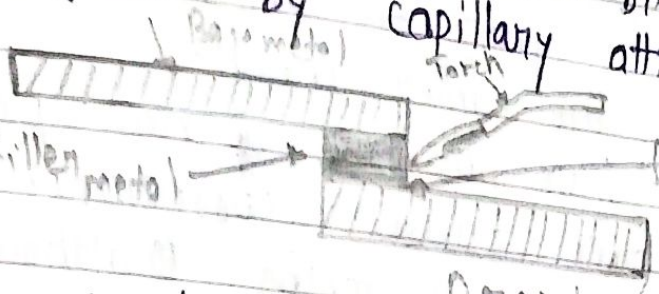
Dis Advantage:-

i) Initial cost of equipment is high.
ii) Skilled persons are needed for maintenance of equipment & its control.

In some material Special surface preparation is required.
Biggest job thickness can not be welded.

BRAZING

Brazing is defined as joining of metal parts by means of a non-ferrous filler metal or alloy that melts at a temp. above 427°C but below that of metal being joint. The filler metal is distributed blw closing fitted surface of the joint by capillary attraction.



Brazing involves the melting of a comparatively low melting point filler material against the base metal piece to be joint while they are clean & free from oxides, greases etc.
It is not necessary to melt base metal the molten brazing filler material wets the base metal surfaces, spread along the joint by capillary fraction & solidifies to form the brazed joint. The high fluridity of the molten filler material is an important factor in obtaining sucessful brazing joint.

Advantage
Brazing can be used to joint a large variety of dissimilar metal.
Properly brazed joint are pressure tight.

& diff. regions. (iii) piece of greatly different thickness can be easily joint by brazing.
(iv) Brazing can joints cast materials to rod metals.
(v) Brazing can maintain prodcition production tolerance.

This has the power to
2) knowledge
3) Creators
pursue careers
they love, to
take care to themselves.
→ Social media
enriched democracy
& equality by enabling
everyone to send out
Large audience
→ Busniess.
→ free knowledge
→ chating
→ Youtube
→ funds
→ Help people charity
→ explore the talent
→ MEM

Limitation :—

(i) Brazing requires tightly mating parts to ensure capillary flow of the filler metal.
(ii) Flux residues if not properly remove can cause corrosion.
(iii) Large assemblies although brazable may be made more economically by welding.
(iv) Brazing fluxes and the filler rod may involve toxic fume & poisions vapour.
(v) Braz joints do not give satisfactary result when use that elevated temp.

ACTING

SOLDERING

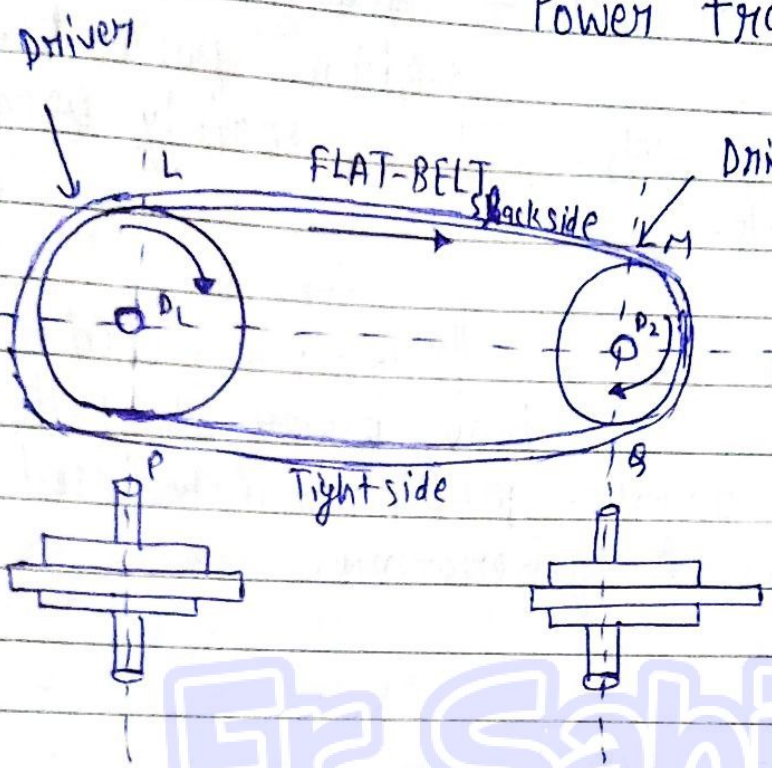
Soldering is defined as the group of joining proces where in fusion is produced by heating at suitable temp. and by using of filler metal having a melting point at exceeding 427°C & below the melting point

of base metal.
The filler metal (solder) is usually distributed blw the properly fitted surfaces of the joint by capillary attraction. Soldering is a common process for joining steel, cu, & other material metal at low temp.
Soldering is used to making low ~~material~~ mechanical strength joint. The filler metal is used has a low melting point & it is called Solder.

Advantage :—

(i) Proper Soldering is air & liquid tight.
(ii) Low heat input compare to ~~greezing &~~ brazing & welding.
(iii) Good electrical & thermal conductivity of the joint.
(iv) It is easily to make ~~cast~~ rejoint by soldering.

Power transmission



Belt - drives :- The belt drive is used to transmit power from one shaft to another by means of pullys. The belt & ropes are wrapped round to two pully and the end are then connected to form an endless connector.
The belts or ropes must be intension so that motion is transmitted from one shaft to another without slit.

Classification of Belts :-

(i) Light Drives Belt
(ii) Medium Drives Belt
(iii) ~~High~~ Heavy Drives Belt

(i) Light Drives Belt :- These type of belt used to transmit small power at belt speed upto 10m/s. It is mainly used in repulsion machine.

(ii) Medium drives belt :- These are used to transmit medium power at belt speed b/w 10 - 22 m/s. It is mainly used in machine tools.

(iii) Heavy drive belt :- These are used to transmit heavy power at belt speed more than 22 m/s. It is mainly used in Compressors & generators.

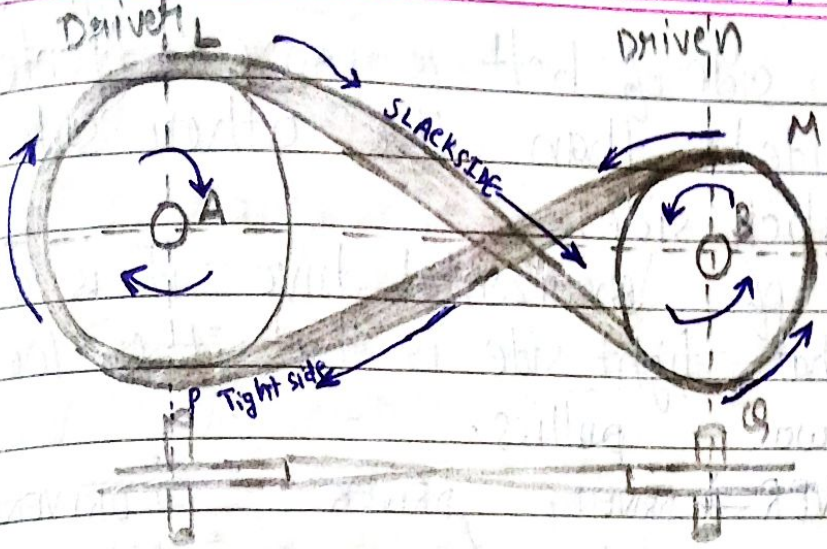
According to shape :-

(i) Flat shape belt :- It is used where moderate amount of power is to be transmited. It is used where distance b/w two pollies is not more than 8 meter. It is also recomended where distance b/w two pollies is very less.

(ii) V-shape belt :- It is used where moderate amount of power is to be transmitted. It is used where two pollies are very near.

(iii) Circular type belt :- In this shape of belt is circular same as rope. It is used where large amount of power transmitted. It is used where distance b/w two pollies are more than 8 meter.

CROSS BELT



Cross belt drive to adopted when the driven pully to be rotated in the opposite direction to that of the driving pullies. Cross belt drive can transmit more power open belt drive as the angle of wrap is more. The two main disadvantages of the cross belt drive are:—

(i) It bends in two different plane, the belt wears out more at the point where the two ends of the belt meet.

(ii) For small centre distance the belt is not fully utilized because of its larger slanted (तिरछा) run off.

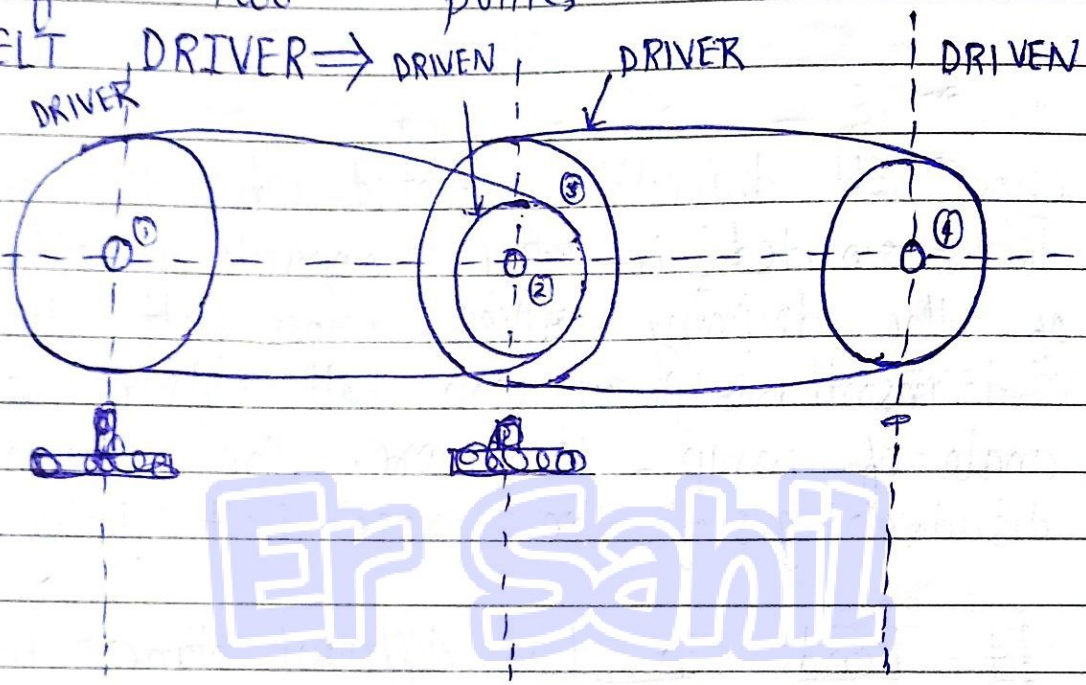
OPEN ~~FLAT~~ BELT DRIVE :— The open belt drive is used when the driven fully is desire to be rotated in the same ~~differe~~ direction as the driven podly. Open belt drives are used to connect 2 parallel shafts having a centre distance upto 15m, depending on the belt width and other conditions. While transmitting

tightener

power one side of belt is more ~~tritented~~ (known as tight side) than the other side (known as slack side).

In case of horizontal drive it is always desired that tight side is that the lower side of two pullies.

COMPOUNT BELT DRIVER ⇒ DRIVEN, DRIVER, DRIVEN



When it is required to have large velocity ratio, ordinary the size of the driven pully is quite big. The compount ~~and~~ belt drive is used when power is transmitted through one shaft to another shaft by using no. of intermediate pullies.

Velocity ratio :- It is the ratio of speed of driven pullies to ~~and~~ that of driving pullees.

let N_1 & N_2 = rotational speed of driver and driven pullies in RPM respectively.

D_1 & D_2 is diameter of driver & driven respectively.

t = Thickness of the belt

length of the belt that passes over the driver pully in one minutes = $\pi N_1 D_1$

Length of the belt that passes over the driven pully in one minutes = $\pi N_2 D_2$

The Length of the belt passes over the driver & driven in one minute is equal so that

$$\pi N_1 D_1 = \pi N_2 D_2$$

$$\boxed{N_1 D_1 = N_2 D_2}$$

$$\boxed{\frac{N_2}{N_1} = \frac{D_1}{D_2}}$$

Velocity ratio = $\frac{\text{Rotational speed of driven}(N_2)}{\text{Rotational speed of driver}(N_1)} = \frac{D_1}{D_2}$

When the thickness of the belt is consider then, velocity ratio = $\frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t}$

Velocity ratio of compound belt drive

= In compound belt the power is transferred from one shaft to another through no. of pullies.

Let 1 is driver pully & 2 is driven pully because 2 & 3 are keyed on the same

shaft therefore the pully 1 also drive the pully 3 and pully 3 drives the pully 4.

D_1, D_2, D_3, D_4 = Diameter of pully 1, 2, 3, 4 resp.

N_1, N_2, N_3, N_4 = rotational speed of pullies 1, 2, 3, 4 in rpm.

Velocity ratio

$$[V\text{-}R]_{1\text{-}2} = \frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{---(1)}$$

$$[V\text{-}R]_{3\text{-}4} = \frac{N_4}{N_3} = \frac{D_3}{D_4} \quad \text{---(2)}$$

($N_3 = N_2$ being keyed of same shaft)

multiple (1) by (2)

$$[V\text{-}R]_{12} \times [V\text{-}R]_{3\text{-}4} = \frac{N_2}{N_1} \times \frac{N_4}{N_3} = \frac{D_1}{D_2} \times \frac{D_3}{D_4}$$

$$[V\text{-}R]_{12} \times [V\text{-}R]_{3\text{-}4} = \frac{N_4}{N_1} = \frac{D_1 D_3}{D_2 D_4}$$

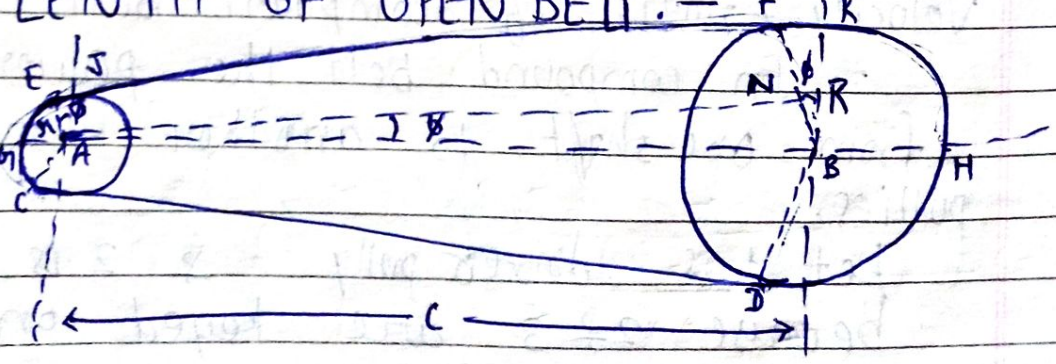
If n no. of pullies are used

velocity ratio

$$[V\text{-}R] = \frac{N_n}{N_1} = \frac{D_1 D_3 D_5 \cdots D_{n-1}}{D_2 D_4 D_6 \cdots D_n}$$

when n is always even no.

LENTH OF OPEN BELT :-



Let A & B with the pully center & CD & EF are comman tangent to the 2 pully circle.
The total length ~~comprises~~ cumprises
(a) The length in contact with smaller pully
(b) The length in contact with larger pully
(c) The length is not in contact with either pully.

Let L is equal to the total length of belt.
r_1 is equal to the radius of small pully.
R is _____ larger pully.
C is centre distance b/w two pullies.

Let E & F be the point of contact of the belt on the upper side of two pullies and ϕ is the angle $\angle JAE$.
Draw AN $\parallel$ EF, the $\angle BAN$ will be equal to ϕ.

$$\cos\phi = \frac{AN}{AB} = \frac{AN}{C}$$

$$\cos\phi = \frac{AN}{C} \Rightarrow C = \frac{AN}{\cos\phi}$$

$$AN = C\cos\phi$$

and

$$BN = C\sin\phi = R - r_1$$

$$\boxed{\sin\phi = \frac{R - r_1}{C}}$$

Total length L = arc GE + EF + arc FH + CD
= $2\times$(arc GE + EF + arc FH) —— (1)

Geogmetric of figure find that

$$\sin\phi = \frac{BN}{AB} = \frac{R-r}{c}$$

ϕ is very small so that

$$\phi = \frac{R-r}{c} \quad \text{——(2)}$$

(arc = radius x angle)

$$\text{arc } GE = r \times \left(\frac{\pi}{2} - \phi\right) \quad \text{——(3)}$$

$$\text{and arc } FH = R \times \left(\frac{\pi}{2} + \phi\right) \quad \text{——(4)}$$

$$EF = c\cos\phi$$

$$EF = c\sqrt{1-\sin^2\phi}$$

$$EF = c\sqrt{1 - \left(\frac{R-r}{c}\right)^2}$$

$$EF = c\sqrt{\frac{c^2 - (R-r)^2}{c^2}}$$

$$EF = \sqrt{c^2 - (R-r)^2}$$

$$EF = c\left[1 - \frac{1}{2}\left(\frac{R-r}{c}\right)^2 + \frac{1}{4}\frac{(R-r)^4}{c^2} - \cdots\right]$$

$$EF = c\left[1 - \frac{1}{2}\left(\frac{R-r}{c}\right)^2 \cdots\right]$$

$\left(\frac{R-r}{c} \rightarrow \sin^2\phi\right)$

ϕ is very small so that

$$EF = c\left[1 - \frac{1}{2}\phi^2\right]$$

$$EF = c\left[1 - \frac{1}{2}\frac{(R-r)^2}{c^2}\right] \quad \text{——(5)}$$

Total length $L = 2\left[r\left(\frac{\pi}{2} - \phi\right) + c\left(1 - \frac{1}{2}\left[\frac{R-r}{c}\right]^2\right) + R\left(\frac{\pi}{2} + \phi\right)\right]$

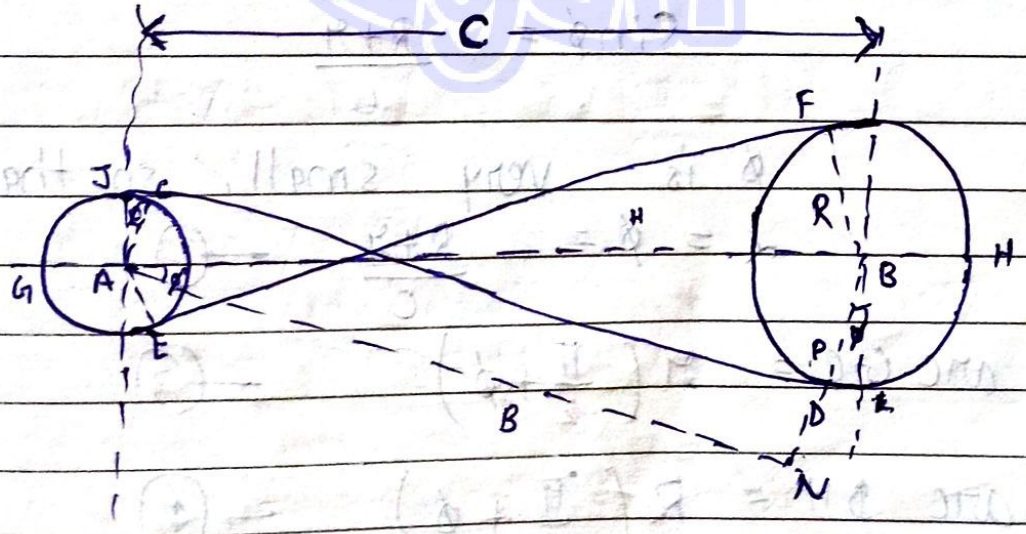
$= 2\left[\frac{\pi}{2}(r+R) + \phi(R-r) + c - \frac{1}{2}\frac{(R-r)^2}{c}\right]$

$= \pi(r+R) + 2\phi(R-r) + 2c - \frac{(R-r)^2}{c}$

$= \pi(r+R) + 2\frac{(R-r)^2}{c} + 2c - \frac{(R-r)^2}{c}$

Total length $L = \pi(r+R) + 2c + \frac{(R-r)^2}{c}$

LENGTH OF CROSS BELT :—



We know that in cross belt, both pully rotate in opposite direction.

Let A & B with the pully center & CD & EF are common tangent to the (cross) 2 pully circle.

Lap angle $\begin{cases} \theta = 180 - 2\alpha \\ \theta = 180 + 2\alpha \end{cases}$

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AN || CD meeting on line BD at N so that

$\angle BAN = \phi$ and we have

and $\angle CAJ = \angle DBK$

Let L = total length of cross belt.
r = radius of small pully.
R = radius of larger pully.
C = center distance b/w two pully

then $AN = C\cos\phi$

and $BN = C\sin\phi = R + r$

total length of belt $L = (\text{arc } EGC + CD + \text{arc } DHF + FE)$

$= 2(\text{arc } GC + CD + \text{arc } DH)$ —— (1)

From Geometric of figure find that

$$\sin\phi = \frac{R+r}{C}$$

ϕ is very small so that

$$\alpha = \phi = \frac{R+r}{C} \quad \text{—— (2)}$$

$$\text{arc } GC = r\left(\frac{\pi}{2} + \phi\right) \quad \text{—— (3)}$$

$$\text{arc } DH = R\left(\frac{\pi}{2} + \phi\right) \quad \text{—— (4)}$$

$$CD = C\cos\phi$$

$$CD = C\sqrt{1 - \sin^2\phi}$$

$$CD = C\left[1 - \frac{1}{2}\sin^2\phi + \cdots\right]$$

$\because$ ϕ is very small so that

$$CD = C\left[1 - \frac{1}{2}\phi^2\right]$$

$$CD = C\left[1 - \frac{1}{2}\left(\frac{R+r}{C}\right)^2\right] \quad \text{—— (5)}$$

$$\text{Total Length } L = 2\left[r\left(\frac{\pi}{2}+\phi\right) + R\left(\frac{\pi}{2}+\phi\right) + C - \frac{1}{2}\frac{(R+r)^2}{C}\right]$$

$$= 2\left[\frac{\pi}{2}(r+R) + \phi(R+r) + C - \frac{1}{2}\frac{(R+r)^2}{C}\right]$$

$$= \pi(r+R) + 2\frac{(R+r)^2}{C} - \frac{1}{2}\times 2\frac{(R+r)^2}{C} + 2C$$

$$\boxed{L = \pi(r+R) + 2C + \frac{(R+r)^2}{C}}$$

It can be noted that length of belt in case of cross belt drive depends only on the sum of pulley radii and the centre distance whereas in case of open belt drive it depends on the sum as well as the difference of the pulley radii apart from the centre distance.

Slit of BELT :-

In belt drive the motion of belts and shaft is considered assuming a form frictional grip b/w the belt and the shaft if the difference in tension b/w tight and slack side of the belt is too large to be resistate by friction b/w belt & the pulley, whole of the portion of the belt which is in contact with the pulley begins to slit. This results in relating motion b/w the belt & the pulley which is known as slip. And it is expressed as a percentage. Thus the result of belt slipping is to reduced the velocity ratio of system.

Let S_1 = % slip b/w the driver pulley & belt

S_2 = % slip b/w the driven pulley & the belt

$$[V\text{-}R] = \frac{N_2}{N_1} = \frac{D_1}{D_2}$$

$$[V\text{-}R]_s = \frac{D_1}{D_2}\left[1 - \frac{S_1}{100}\right]\left[1 - \frac{S_2}{100}\right]$$

$$\frac{D_1}{D_2}\left(1 - \frac{S}{100}\right) \quad \left(\text{if } S = S_1 + S_2\right)$$

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \cdots x^n$$

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Creep of Belt:- The material of belt is elastic therefore the belt passes from the slag side to Tight ~~back~~ side, a certain portion of the belt extend and it contact again when the belt passes from the tight side to slag side. These uneven extation of belt due to ~~very~~ varing tension ~~of belt~~ on it cause relative motion b/w surface which is known as creep of belt.

$$\frac{D_1}{D_2}\left[1-\frac{S_1}{100}\right]\left[1-\frac{S_2}{100}\right][V-R] = \frac{N_2}{N_1} = \frac{D_1}{D_2}$$

$$[V-R] = \frac{D_1}{D_2}\,\frac{E+\sqrt{\sigma_2}}{E+\sqrt{\sigma_1}}$$

where σ_1 & σ_2 = stress in belt on the tight & slack side respectively.

and E = Young's modulus of raw material of belt.

Slip of belt	CREEP of belt
(i) The relative motion b/w belt & pulley due to insufficient friction grip of belt on pulley is called Slip.	(i) The relative motion b/w belt & pulley due to variation in belt length. is known as Creep.
(ii) Slip is caused due to a smoothness of pulley surface.	(ii) Creep is caused due to variation - in tension tight side & slack side.
(iii) The magnetude of slip is depend on the frictional grip b/w belt & pulley and angle of lap.	(iii) The magnetude of creep depends on the elasticity of material and a stresses on two sides of belt i.e. tight & slag side.

(iv) With slip, the velocity ratio depend on diameter of pulley and slip b/w belt & pulley.

(iv) With Creep, the velocity ratio depend on diameter of pulley, elasticity of material and a streeses on two side of belt.

Q.1 A shaft runs at 100 rpm and drive another shaft at 150 RPM through belt drive. The diameter of driving pulley is 500 mm. Determine the driven pulley. (a) belt thickness is 5mm

$$[V\text{-}R] = \frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t}$$

$$\frac{3}{2} = \frac{500 + 5}{D_2 + 5} = \frac{3}{2} = \frac{505}{D_2 + 5}$$

$$D_2 + 5 = \frac{1010}{3}$$

$$D_2 = 336.66 - 5$$

$$D_2 = 331.66 \text{ mm}$$

(b) A slip on 2% on each pulley.

Ans-

$$[V\text{-}R] = \frac{D_1}{D_2}\left[1 - \frac{S_1}{100}\right]\left[1 - \frac{S_2}{100}\right]$$

$$\frac{150}{100} = \frac{500}{D_2}\left[1 - \frac{2}{100}\right]\left[1 - \frac{2}{100}\right]$$

$$\frac{3}{2} = \frac{500}{D_2}(1 - 0.02)(1 - 0.02)$$

$$D_2 = \frac{1000}{3}(0.98)(0.98)$$

$$D_2 = \frac{98 \times 9.8}{3} = = 320.1 \text{ mm}$$

76
98
98
784
8 82 x
360 4 (324)

Q.2 An engine shaft running at 250 RPM is required to drive at machine shaft by mean of a belt. The pulley on engine shaft is 2m diameter and that of machine shaft is 1mm diameter. if the thickness of belt is 4.5mm find the speed of belt when

(i) There is no slip
(ii) There is slip of 4%

Ans- (i)

$N_1 = 250$ rpm, $d_1 = 2m$, $d_2 = 1m$
$t = 4.5mm$

$$[V.R] = \frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}$$

$$\frac{N_2}{250} = \frac{2 + 450}{1 + 450} = \frac{452}{451}$$

$$N_2 = \frac{250 \times 452}{451} = 250 \times 1.002$$

$$\frac{N_2}{250} = \frac{2 + 0.0045}{1 + 0.0045} = \frac{2.0045}{1.0045}$$

$$N_2 = 250 \times \frac{2.0045}{1.0045} = 250 \times 1.995$$

$$\boxed{N_2 = 498.88 \text{ rpm}}$$

Belt speed = Linear vel. of machine shaft
$= \pi d_2 N_2$
$= 3.14 \times 1 \times 498.88 = 1566.48$ m/s

1m = 1000mm

$$(v+R) = \frac{N_2}{N_1} = \frac{D_1 + t}{D_2 + t}\left(1 - \frac{S}{100}\right)$$

$$N_2 = 250 \times \frac{200+4}{1000+4}\left(1 - \frac{4}{100}\right)$$

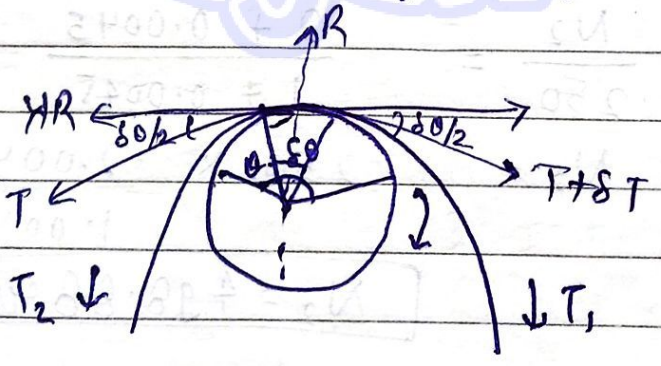
~~$N_2 = 500 \times 0.06 = 30$~~

$$N_2 = 498.8 \times 0.96 = 479 \text{ rpm}$$

$$\text{Belt speed} = \pi N_2 D_2$$
$$= 3.14 \times 479 = 1503.2 \text{ m/s}$$

Ratio of Tension on tight & slack sides of flat belts :—

T_1 = tension on tight side
T_2 = ——— slack side
θ = angle of contact b/w belt & pulley
μ = friction coeffi.
R = Reaction of pulley on the belt.



Resolving the forces in tangential

$$\delta R + T\cos\delta\theta/2 - (T+\delta T)\cos\delta\theta/2 = 0$$

$\because$ $\delta\theta$ is very small

$\mu R + T - T - \delta T = 0$

$\mu R = \delta T$ ——— (1)

Resolving the forces in radial dir.

$R - T \sin\frac{\delta\theta}{2} - (T - \delta T)\sin\frac{\delta\theta}{2} = 0$

$\because \delta\theta$ is very small

$R - T\frac{\delta\theta}{2} - T\frac{\delta\theta}{2} - \delta T\frac{\delta\theta}{2} = 0$

$R = T\delta\theta$ ——— (2)

from eqn - (1) & (2)

$\frac{\delta T}{\mu} = T\delta\theta$

$\frac{\delta T}{T} = \mu\delta\theta$

$\int_{T_2}^{T_1}\frac{dT}{T} = \mu\int_0^\theta \delta\theta$

$[\ln T]_{T_2}^{T_1} = \mu[\theta]_0^\theta$

$$\boxed{\frac{T_1}{T_2} = e^{\mu\theta}}$$

Power transmitted by belt drive

$$\boxed{P = (T_1 - T_2) \times V} \text{ watt}$$

$T_{max} = T_1 + T_c$

$$T_c = mv^2$$

$$T_c = \frac{T_{max}}{3} = m V_{max}^2 = \frac{T_{max}}{3}$$

$$T_1 = \frac{2\,T_{max}}{3}$$

$$V_{max} = \sqrt{\frac{T_{max}}{3m}}$$

$$T_0 = \frac{T_1 + T_2}{2}$$

driver shaft

$$\tau = \frac{P \times 60}{2\pi N}$$

driven shaft

$$\tau = (T_1 - T_2)\, r_2$$