Experiment No: 1

AIM:-To study the working and construction details of Cochran and Babcock & Wilcox Boiler.

Apparatus: - Model of Cochran and Babcock & Wilcox Boiler.

Theory:-

Boiler: - A steam boiler is a closed vessel in which steam is produced from water by combustion of fuel.

Classification of Boiler:

Boilers are classified on the basis of following-

1. According to contents in the Tube:

***a) Fire tube boiler*: ** In fire tube boilers, the flue gases pass through the tube and water surround them.

B).Water tube boiler: In water tube boiler, water flows inside the tubes and the hot flue gases flow outside the tubes.

2. According to the pressure of steam:

A).Low pressure boiler: A boiler which generates steam at a pressure of below 80 bars is called low pressure boiler. Example-Cochran boiler, Lancashire boiler etc.

B).High pressure boiler: A boiler which generates steam at a pressure higher then 80 bar is called high pressure boiler. Example- Babcock and Wilcox boiler etc.

3.According to method of circulation of water:

A).Natural Circulation: In natural circulation boiler, circulation of water due to gravity or the circulation of water takes place by natural convection current produced by the application of heat, example-Babcock and Wilcox boiler, Lancashire boiler etc.

B).Forced Circulation: In the forced circulation boiler, circulation of water by a pump to increase the circulation. Example-Lamont boiler etc.

4. According to the Position of the furnace:

A).Internally fired boilers: In this, the furnace is located inside the boiler shell. Example-Cochran, Locomotive and Lancashire boilers.

B).Externally fired boilers: In this, the furnace is located outside the boiler shell. Example-Babcock and Wilcox boiler etc.

5. According to the axis of shell:

A).Vertical boilers: If the axis of the shell of boiler is vertical so the boiler is called as vertical boiler.

B).Horizontal boilers: If the axis of the shell of boiler is horizontal so the boiler is called as Horizontal boilers.

C***).Inclined boilers:*** If the axis of the shell of boiler is Inclined so the boiler is called as Inclined boiler.

COCHRAN BOILER:

Cochran boiler is a vertical, multitubular fire tube, internally fired, natural circulation boiler.

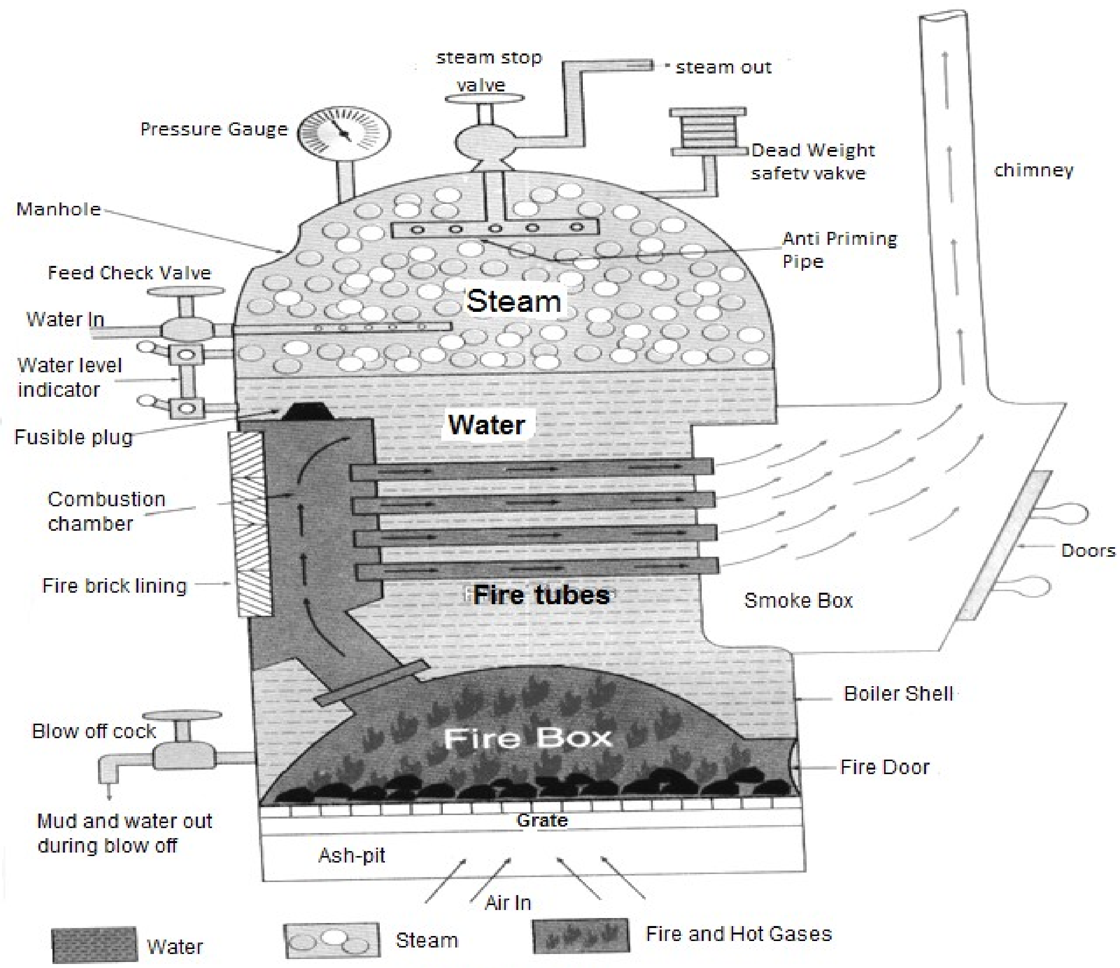
Construction:

Figure shows a Cochran boiler. It consists of a vertical cylindrical shell having a hemispherical top and furnace is also hemispherical in shape. The fire grate is arranged in the furnace and the ash pit is provided below the grate. A fire door is attached on the fire box. Adjacent to the fire box, the boiler has a combustion chamber which is lined with fire bricks. Smoke or fire tubes are provided with combustion chamber. These tubes are equal in length and arranged in a group with wide space in between them. The ends of these smoke tubes are fitted in the smoke box. The chimney is provided at the top of the smoke box for discharge of the gases to the atmosphere. The furnace is surrounded by water on all sides except at the opening for the fire door and the combustion chamber. The smoke tubes are also completely surrounded by water.

Different boiler mountings and accessories are located at their proper place.

Working:

The hot gas produced from the burning of the fuel on the grate rises up through the flue pipe and reaches the combustion chamber. The flue gases from the combustion pass through the fire tubes and the smoke box and finally are discharged through the chimney. The flue gases during their travel from fire box to the chimney gives heat to the surrounding water to generate steam.



COCHRAN BOILER

Specification of Cochran Boiler:

Diameter of the drum	→	0.9m to 2.75m
Steam pressure	→	6.5bar up to 15bar
Heating surface	→	120m^2
Maximum evaporative capacity	→	4000Kg/hr of steam
Height of the shell	→	5.79m

No of tubes	→	165
External diameter of flue tube	→	62.5mm
Efficiency	→	70to 75%

BABCOCK AND WILCOX BOILER:

Babcock and Wilcox boiler is a horizontal shell, multitubular, water tube, externally fired, natural circulation boiler.

Construction: Figure shows the details of a Babcock and Wilcox water tube boiler. It consists of a drum mounted at the top and connected by upper header and down take header. A large number of water tubes connect the uptake and down take headers. The water tubes are inclined at an angle of 5 to 15 degrees to promote water circulation. The heating surface of the unit is the outer surface of the tubes and half of the cylindrical surface of the water drum which is exposed to flue gases.

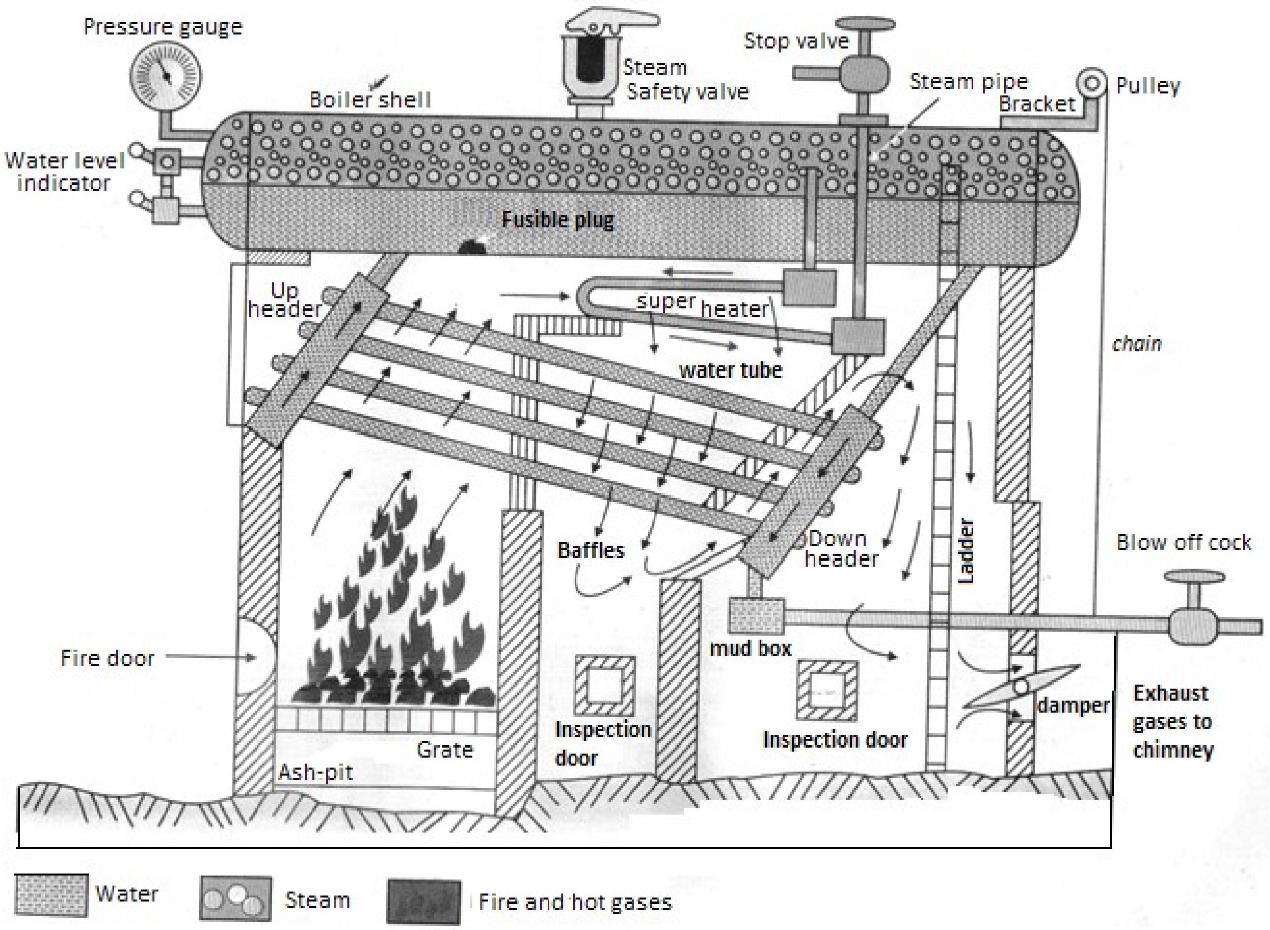
Below the uptake header the furnace of the boiler is arranged. The coal is fed to the chain grate stoker through the fire door. There is a bridge wall deflector which deflects the combustion gases upwards. Baffles are arranged across the water tubes to act as deflectors for the flue gases and to provide them with gas passes. Here, two baffles are arranged which provide three passes of the flue gases. A chimney is provided for the exit of the gases. A damper is placed at the inlet of the chimney to regulate the draught. There are superheating tubes for producing superheated steam. Connections are provided for other mounting and accessories.

Working:

The hot combustion gases produced by burning of fuel on the grater rise upwards and are deflected by the bridge wall deflector to pass over the front portion of water tubes and drum. By this way they complete the first pass. With the provision of baffles they are deflected downwards and complete the second pass. Again, with the provision of baffles they rise upwards and complete the third pass and finally come out through the chimney. During their travel they give heat to water and steam is formed. The flow path of the combustion gases is shown by the arrows outside the tubes. The circulation of water in the boiler is due to natural circulation set-up by convective currents (due to gravity). Feed water is supplied by a feed check valve.

The hottest water and stem rise from the tubes to the uptake header and then through the riser it enters the boiler drum. The steam vapours escape through the upper half of the drum. The cold water flows from the drum to the rear header and thus the cycle is completed.

To get superheated steam, the steam accumulated in the steam space is allowed to enter into the super heater tubes which are placed above the water tubes. The flue gases passing over the flue tubes produce superheated steam. The steam thus superheated is finally supplied to the user through a steam stop valve.



Babcock and Wilcox Boiler

Specification of Babcock and Wilcox Boiler:

Diameter of the drum	→	1.22 m to 1.83 m
Length of the drum	→	6.096 to 9.144 m
Size of water tubes	→	7.62 to 10.16 cm
Size of super heater tube	→	3.84 to n5.71 cm
Working pressure	→	100bar
Steaming capacity (Maximum)	→	40,000Kg/hr
Efficiency	→	60 to 80%

Experiment No: 2

***AIM*: -** To study the working and function of mountings and accessories in boilers.

Apparatus: - Model of mountings and accessories parts in boilers.

Theory:-

Boiler: - A steam boiler is a closed vessel in which steam is produced from water by combustion of fuel.

BOILER MOUNTINGS: -

The components which are fitted on the surface of the boiler for complete safety and control of steam generation process are known as boiler mountings. The following are the various important mountings of a boiler.

Pressure Gauge- It is usually mounted on the front top of the boiler shell. It is mounted on each boiler to show the pressure of the steam. Its dial is graduated to read the pressure in Kilograms per sq. centimeter. Bourdon’s pressure gauge is commonly used as shown in Fig. The essential elements of this gauge are the elliptical spring tube which is made of bronze and is solid drawn. One end of this tube is attached by lines to a toothed quadrant and the other end is connected to a steam space.

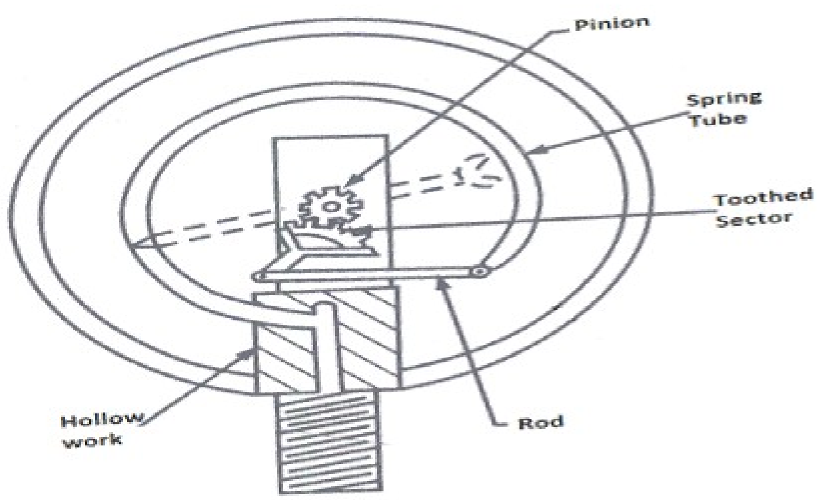


Figure- Pressure Gauge

Safety Valves- They are needed to blow off the steam when pressure of the steam in the boiler exceeds the working pressure. These are placed on the top of the boiler. There are four types of safety valves:

1. Dead weight safety valve
2. Lever safety valve
3. Spring loaded safety valve
4. Low water high steam safety valve

Spring loaded safety valve- A spring loaded safety valve is mainly used for locomotives and marine boilers. In this type the valve is loaded by means of a spring, instead of dead weight. A spring loaded safety valve is as shown in the Fig.

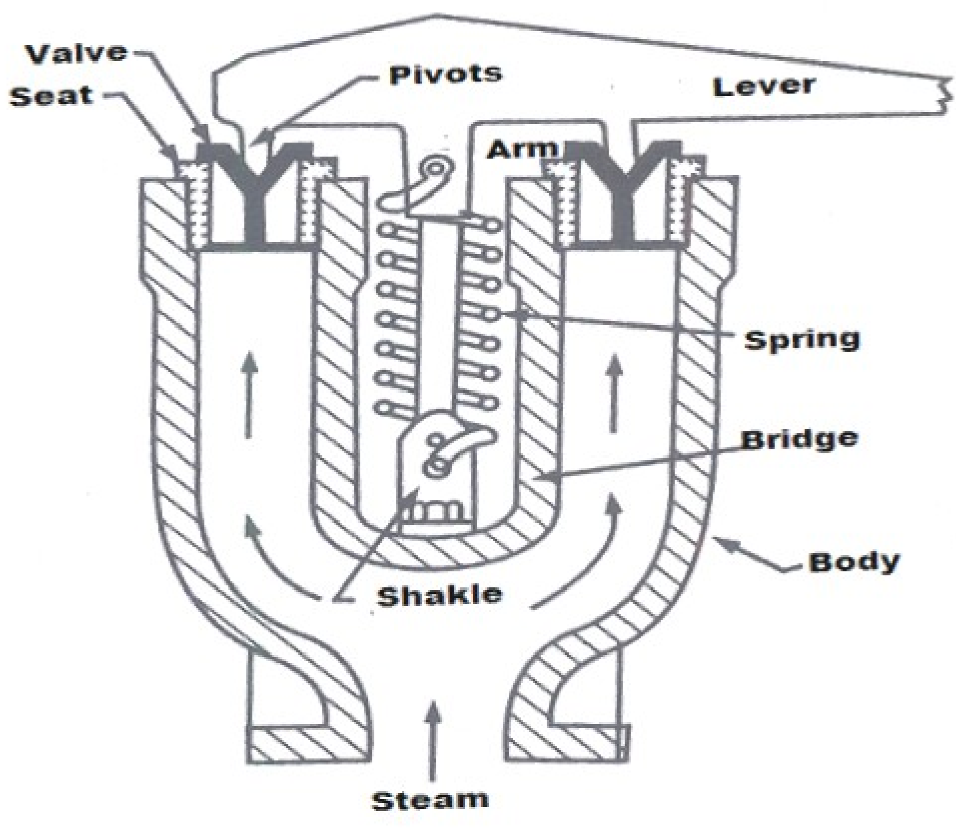


Figure- Spring Loaded Safety Valve

It consists of two valves, resting on their seats. Valve seats are mounted on the upper ends of two hallow valve chests, which are connected by a bridge. The lower end of these valves chests have common passage which may be connected to the boiler. There is a lever which has two pivots, one of which is integral with it and the other is pin jointed to the lever. This pivot rests on the valves and forces them to rest on their respective seats with the help of a helical spring.

Feed Check Valve- A feed check valve is shown in Fig. The function of the feed check valve is to allow the supply of water to the boiler at high pressure continuously and to prevent the back flow the boiler when the pump pressure is less than boiler pressure or

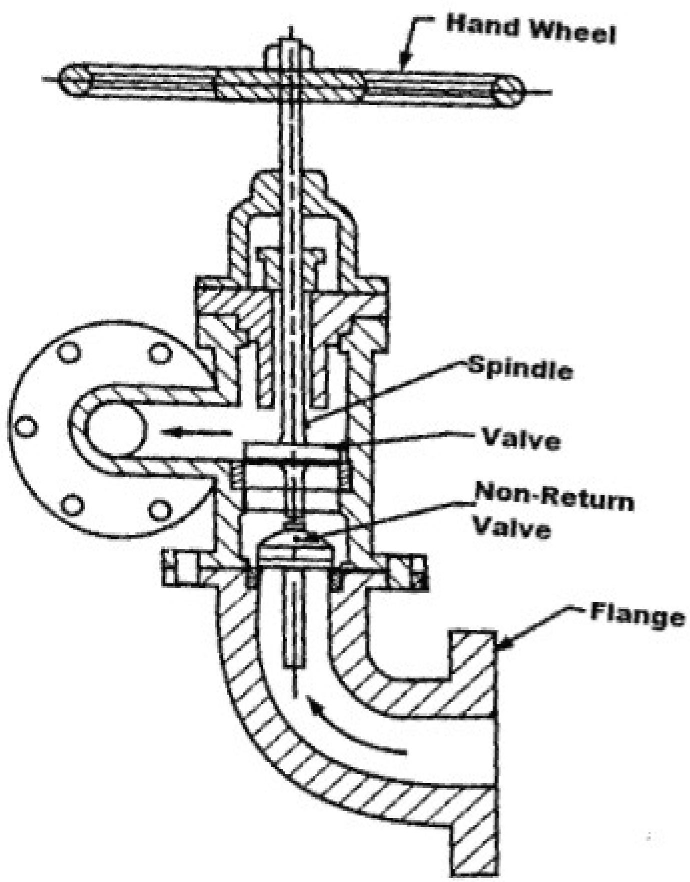


Figure- Feed Check Valve

when pump fails. Feed check valve is fitted to the shell slightly below the normal water level of the boiler.

Fusible Plug- It is fitted to the crown plate of the furnace of the fire. The function of fusible plug is to extinguish the fire in the fire box, when water level in the boiler comes down the limit and it prevents from blasting the boiler, melting the tube and over heating the fire-box crown plate. A fusible plug is shown in fig. It is located in water space of the boiler. The fusible metal is protected from direct contact of water by gun metal plug and copper plug. When water level comes down, the fusible metal melts due to high heat and copper plug drops down and is held by gun metal ribs. Steam comes in contact with fire and distinguishes it. Thus it prevents boiler from damages.

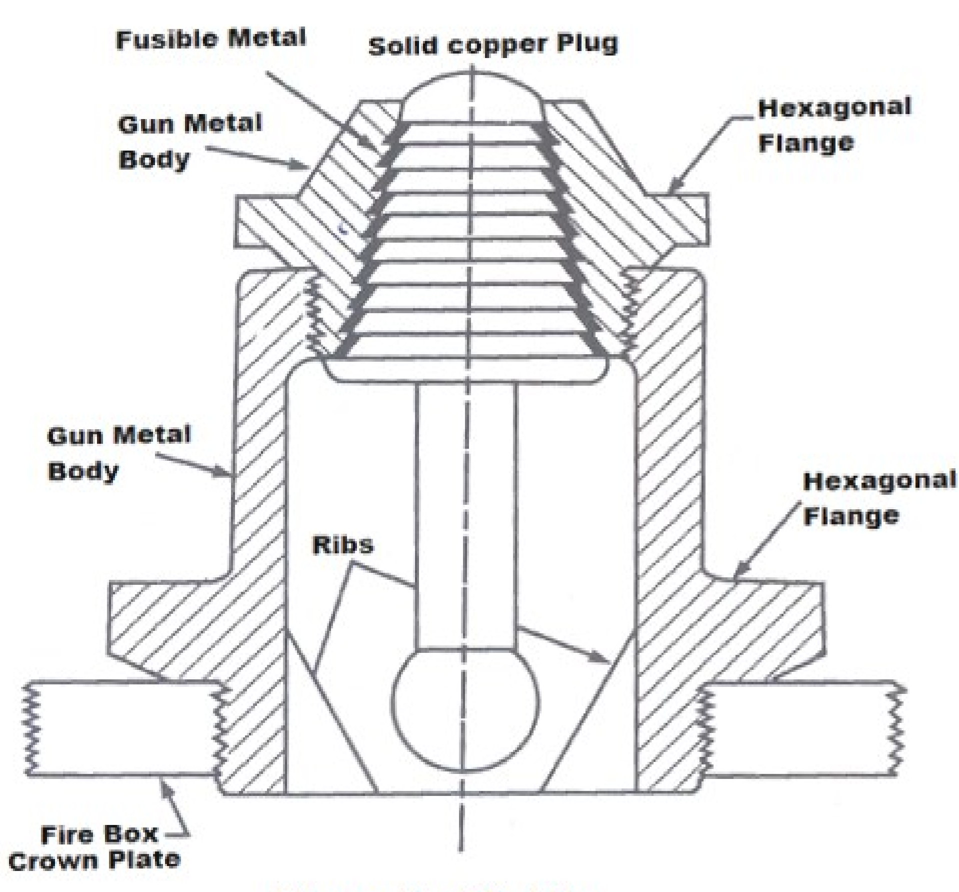


Figure- Fusible Plug

Blow Off Cock- The blow off cock as shown in fig., is fitted to the bottom of a boiler drum and consists of a conical plug fitted to body or casing. The casing is packed, with asbestos packing, in groves round the top and bottom of the plug. The asbestos packing is made tight and plug bears on the packing. Blow off cock has to principle function are:

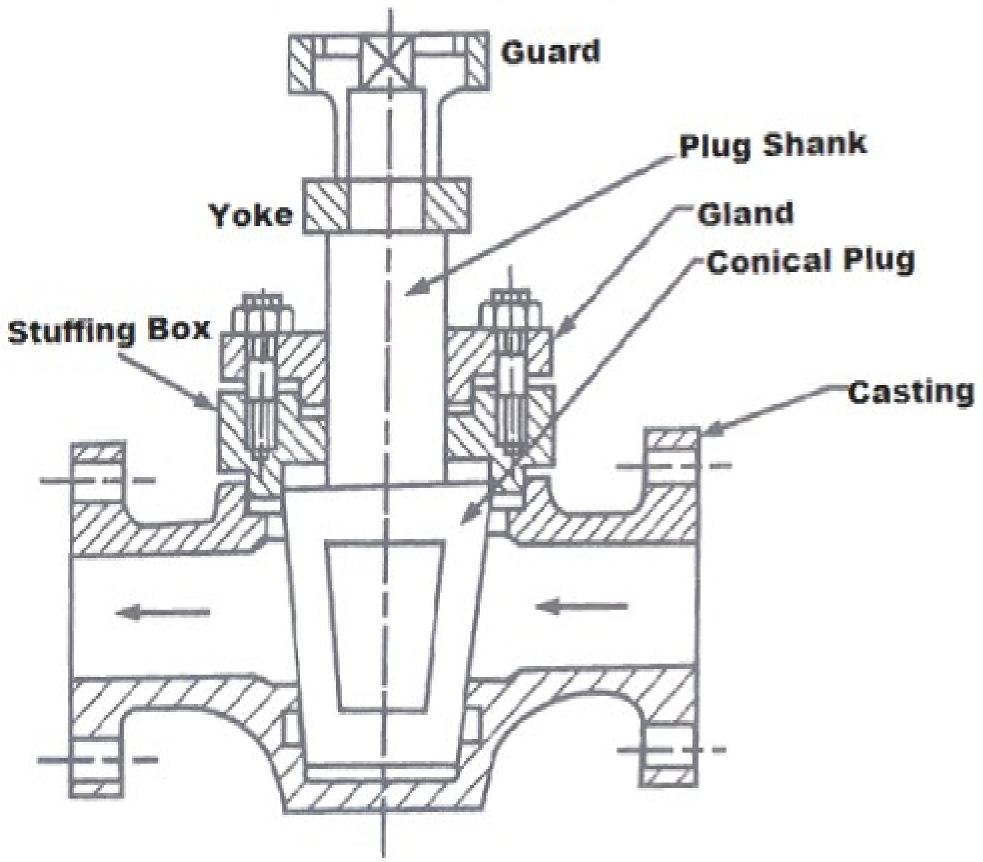


Figure- Blow Off Cock

1. To empty the boiler whenever required.
2. To discharge the mud, scale or sedimentation which are accumulated at the bottom of the boiler.

Water Level Indicator- It is an important fitting, which indicates the water level inside the boiler to an observer. It is a safety device, up on which the correct working of the boiler depends. This fitting may be seen in froth of the boiler, and are generally two in number. The upper end of the valve opens in steam space while the lower end opens in the water. The valve consists of a strong glass tube. The end of the tube pass through stuffing boxes formed in the hollow casting. These casting are flanged and bolted to the boiler. It has three cocks; two of them control the passage between the boiler and glass tube, while the third one (the drain cock) remains closed.

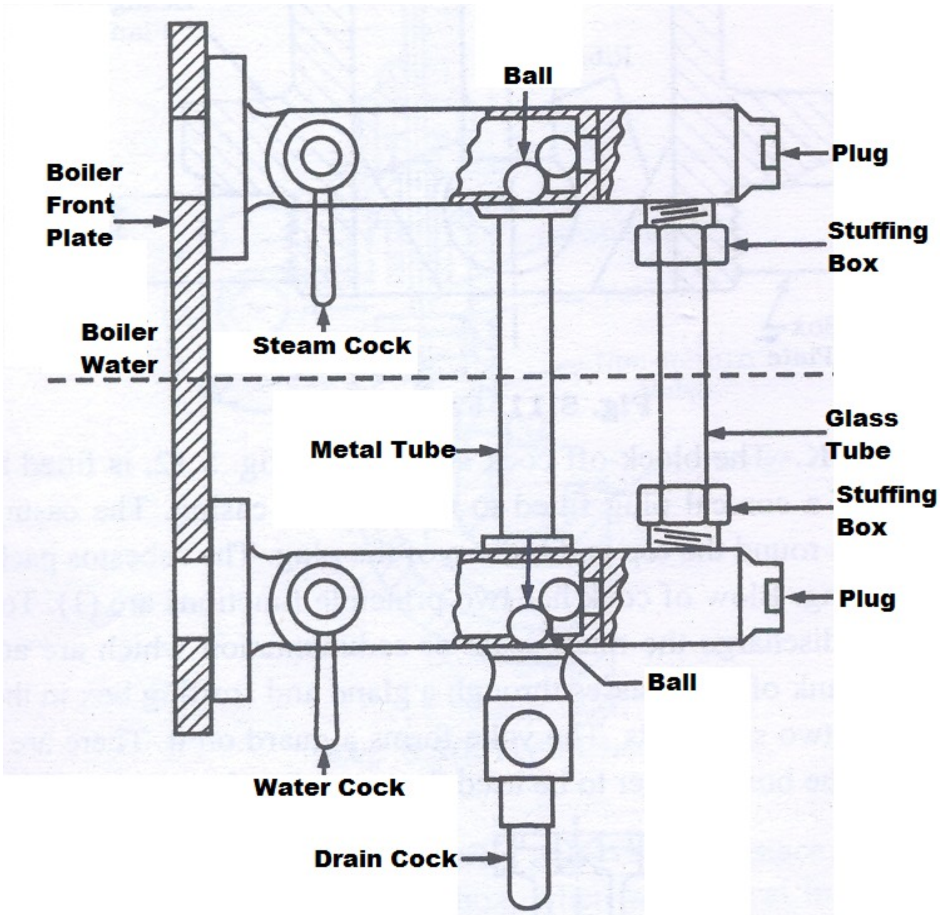


Fig. Water Level Indicator

Steam Stop Valve- A valve placed directly on a boiler and connected to the steam pipe which carries steam to the engine or turbine is called stop valve or junction valve. It is the largest valve on the steam boiler. It is, usually, fitted to the highest part of the shell by means of a flange as shown in fig.

The principal functions of a stop valve are:

1. To control the flow of steam from the boiler to the main steam pipe.
2. To shut off the steam completely when required.

The body of the stop valve is made of cast iron or cast steel. The valve seat and the nut through which the valve spindle works, are made of brass or gun metal.

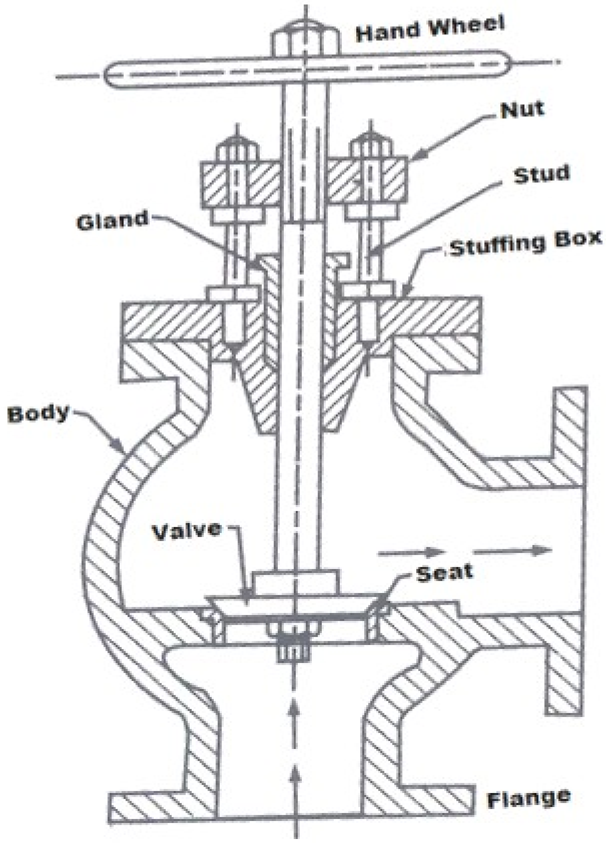


Figure-Steam Stop Valve

BOILER ACCESSORIES:

The appliances installed to increase the efficiency of the boiler are known as the boiler accessories. The commonly used accessories are:

Economiser- Economiser is a one type of heat exchange which exchanges the some parts of the waste heat of flue gas to the feed water. It is placed between the exit of the furnace and entry into the chimney. Generally economiser is placed after the feed pump because in economiser water may transfer into vapour partially, which creates a priming problem in feed pump water into the boiler drum. If economiser is used before feed pump it limits the temperature rise of water. As economiser is shown in fig.

It consists of vertical cast iron tubes attached with scraper. The function of scraper is to remove the root deposited on the tube, mechanically.

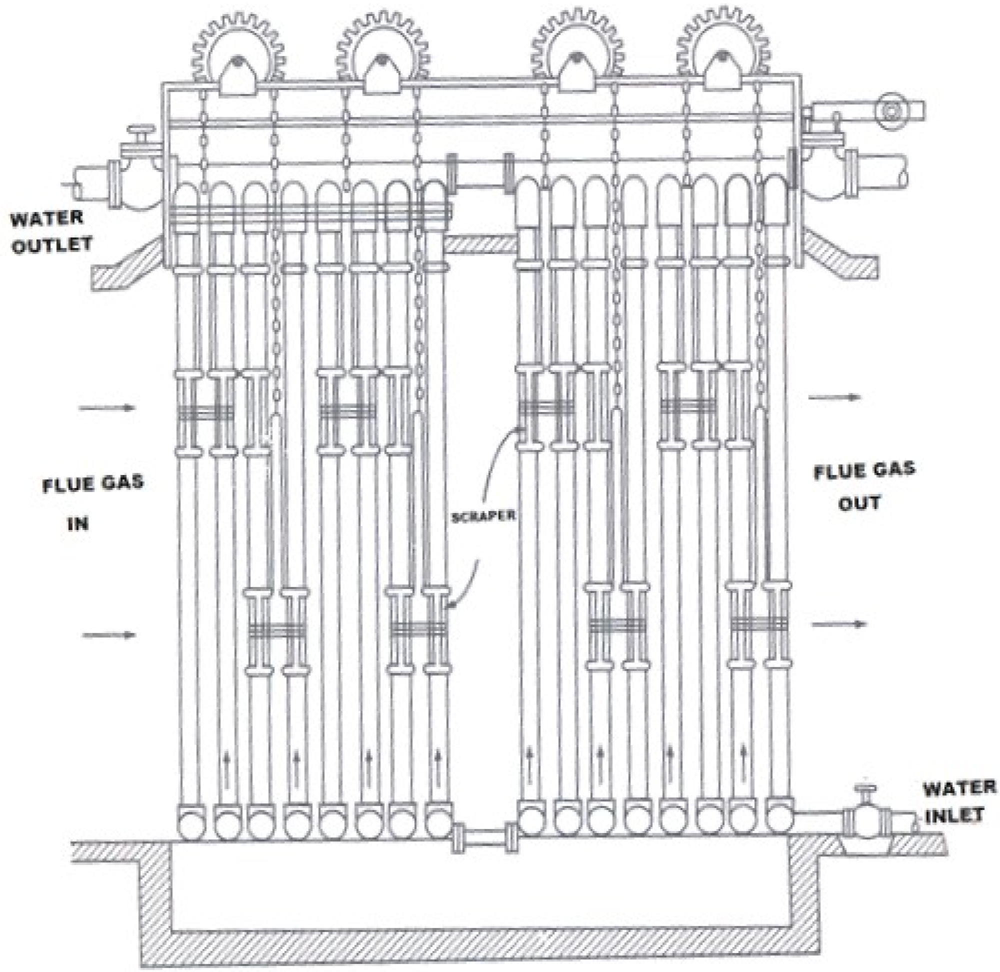


Figure- Economiser

Steam Injector- An injector is a device which is used to lift and force water into a boiler i.e. operating at high pressure. It consists of a group of nozzles, so arranged that steam expanding in these nozzles imparts its kinetic energy to a mass of water. There are many advantages of using injector such as they occupy minimum space, have low initial costs and maintenance cost. Though the steam required to operate the injector is much more than that in the feed pump for an equivalent duty; the injector has the advantage that practically the whole of the heat of the steam is returned back to the boiler.

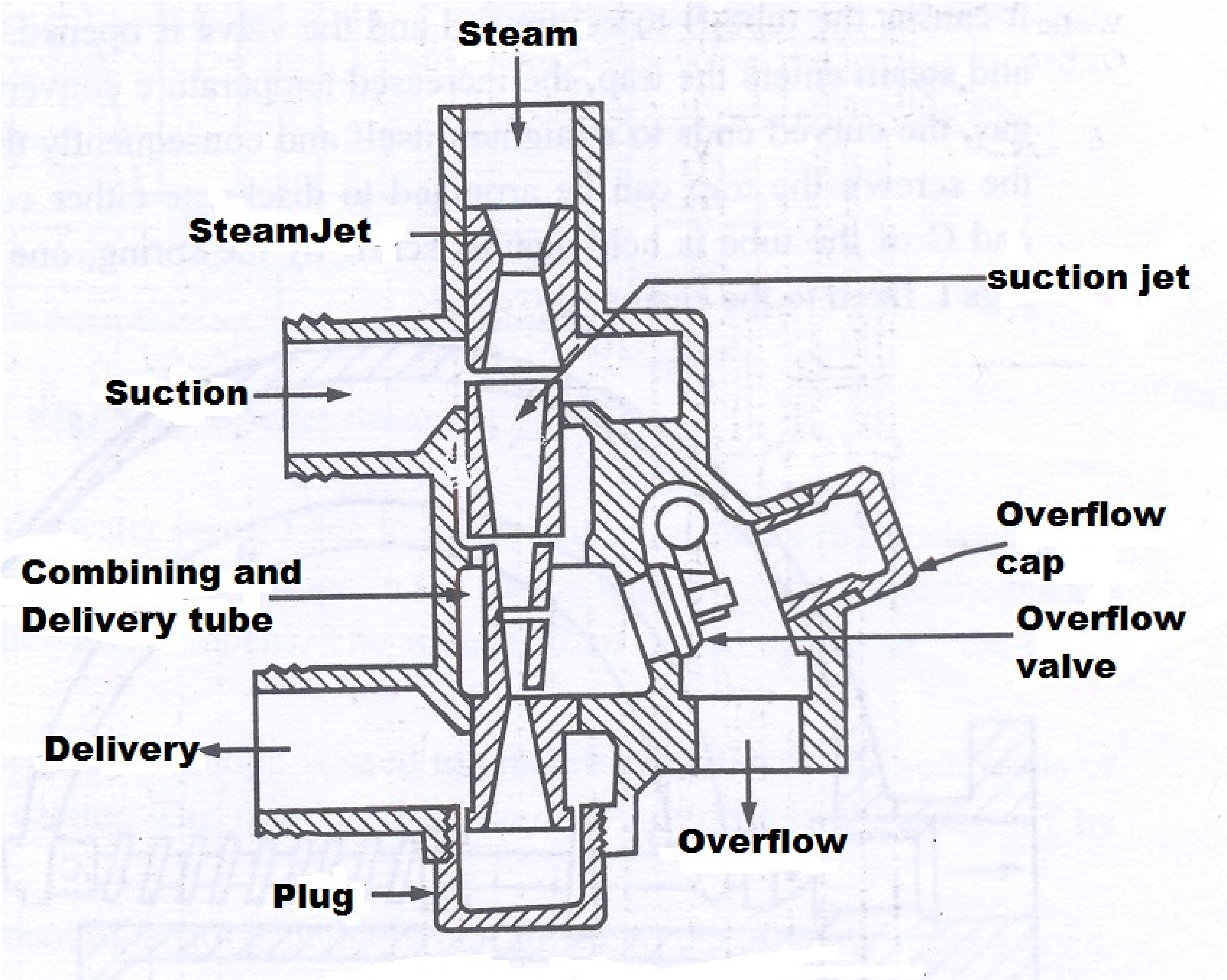


Figure- Injector

Super Heater- An element of steam generating unit in which the steam is super heated, is known is super heater. A super heater is used to increase the temperature of saturated steam at constant pressure. It is usually placed in the path of hot flue gases and heat of the flue gases is first used to superheat the steam as shown in figure. The steam enters in the down-steam tube and leaves at the front header. The overheating of super heater tube is prevented by the use of a balanced damper which controls the flue gas. Steam consumption of turbine is reduced by about 1% for each 5.5°C of superheat.

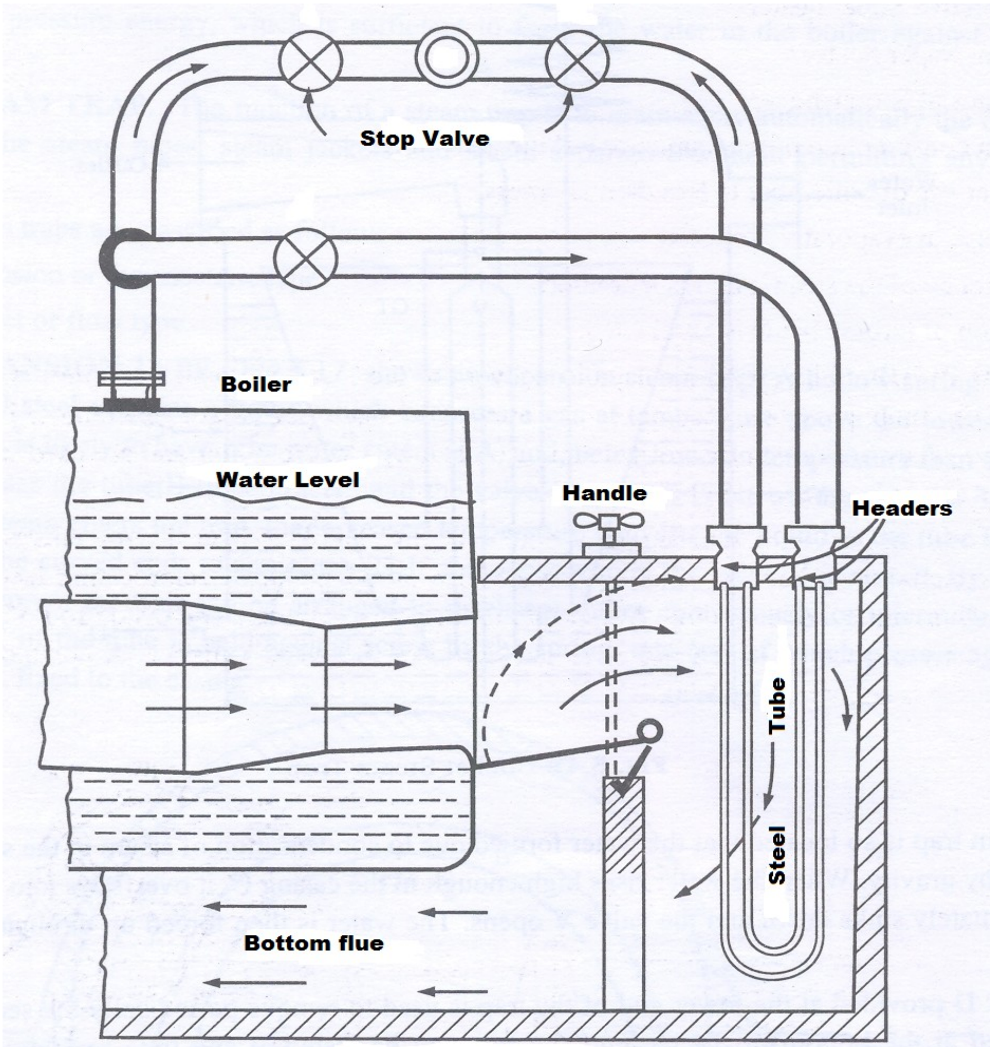


Fig. Super Heater

Feed Pump- The function of the feed pump is to pump the feed water to the boiler. The pumps may be rotary or reciprocating. The rotary pump is generally of high speed centrifugal type. They are driven by small steam turbine or by electric motor and are used when large quantity of water is to be supplied to boiler. The reciprocating pumps may be single or double acting. The most commonly used form of independent reciprocating feed pump is that in which the steam cylinder is directly connected to the rod or to the piston of the water cylinder.

Air Pre-heater- The function of air pre-heater is to increase the temperature of air before it enters the furnace. It is installed between the economiser and the chimney. The air required for the purpose of combustion is drawn through the air pre-heater and its temperature is raised when passed through ducts. The preheated air gives higher furnace temperature which results in more heat transfer to the water and reduces the fuel consumption. There are three types of pre-heaters:

1. Tubular type 2. Plate type 3. Regenerative type

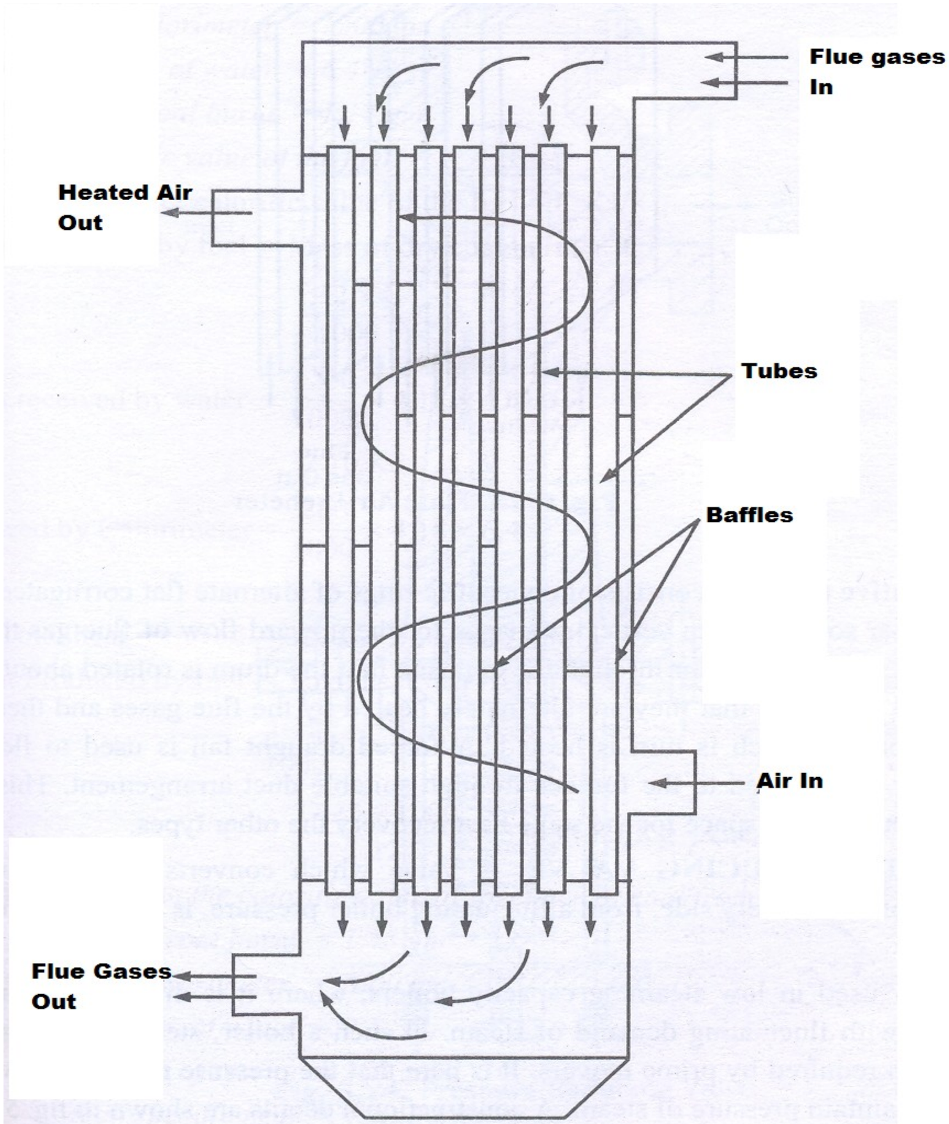


Fig- Tubular Type Air Pre-Heater

Experiment No:3

AIM: - To study Two stroke & Four stroke Diesel Engines.

APPARATUS USED: - Model of Two-stroke & Four-stroke Diesel Engines.

THEORY-

CYCLE- When series of events are repeated in order, it completes one cycle. Cycle is generally classified as Four stroke cycle and Two stroke cycle.

a) ***Four stroke cycle-*** In Four stroke cycle, four operations are required to complete one cycle. These four operations are suction, compression, power and exhaust.

b) ***Two stroke cycle-*** In a two stroke cycle, the series of events of the working cycle is completed in two strokes of the piston and one revolution of the crankshaft. The four operations i.e. suction, compression, power and exhaust are completed during two strokes of the piston.

ENGINE- A power producing machine is called an engine.

HEAT ENGINE- An engine which converts heat energy into mechanical energy is called a heat engine.

Types of heat engine –

a) External Combustion engine-The engine in which the combustion of fuel takes place outside the cylinder is called an external combustion engine.

b) Internal Combustion engine- The engine in which the combustion of fuel takes place inside the cylinder is called an internal combustion engine.

FOUR STROKE DIESEL ENGINE

Four-stroke cycle Diesel engine or Compression ignition engine or constant pressure cycle engine is meant for heavy duty applications, like heavy motor vehicles, stationary power plants, ships and big industrial units, train locomotive , tractor and bus application. In this the air compressed in the engine cylinder and fuel is injects through injector.

Working of the four stroke Diesel engine-

a) ***Suction Stroke-***The inlet valve opens during this stroke and only air is sucked into the engine cylinder. The exhaust valve remains closed. When the piston reaches Bottom Dead Centre (BDC), the suction stroke is completed as shown in Fig. (1) and inlet valve also closes.

b) ***Compression Stroke-*** The piston moves from Bottom Dead Centre (BDC) to Top Dead Centre (TDC) position. Both the valves remain closed. The air drawn during suction stroke is compressed.

c) ***Expansion or Power or Working Stroke-*** Just before the piston completes its compression stroke, the diesel injected gets ignited and the rapid explosion takes place. The expansion of hot gases pushes the piston down to BDC position. Both the valve remains closed and the useful work is obtained from the engine.

d) ***Exhaust Stroke-*** The piston moves from BDC to TDC, the exhaust valve opens and the inlet valve remains closed. The piston pushes the exhaust gases out through the exhaust valve to the atmosphere till it reaches the TDC position and the cycle is completed.

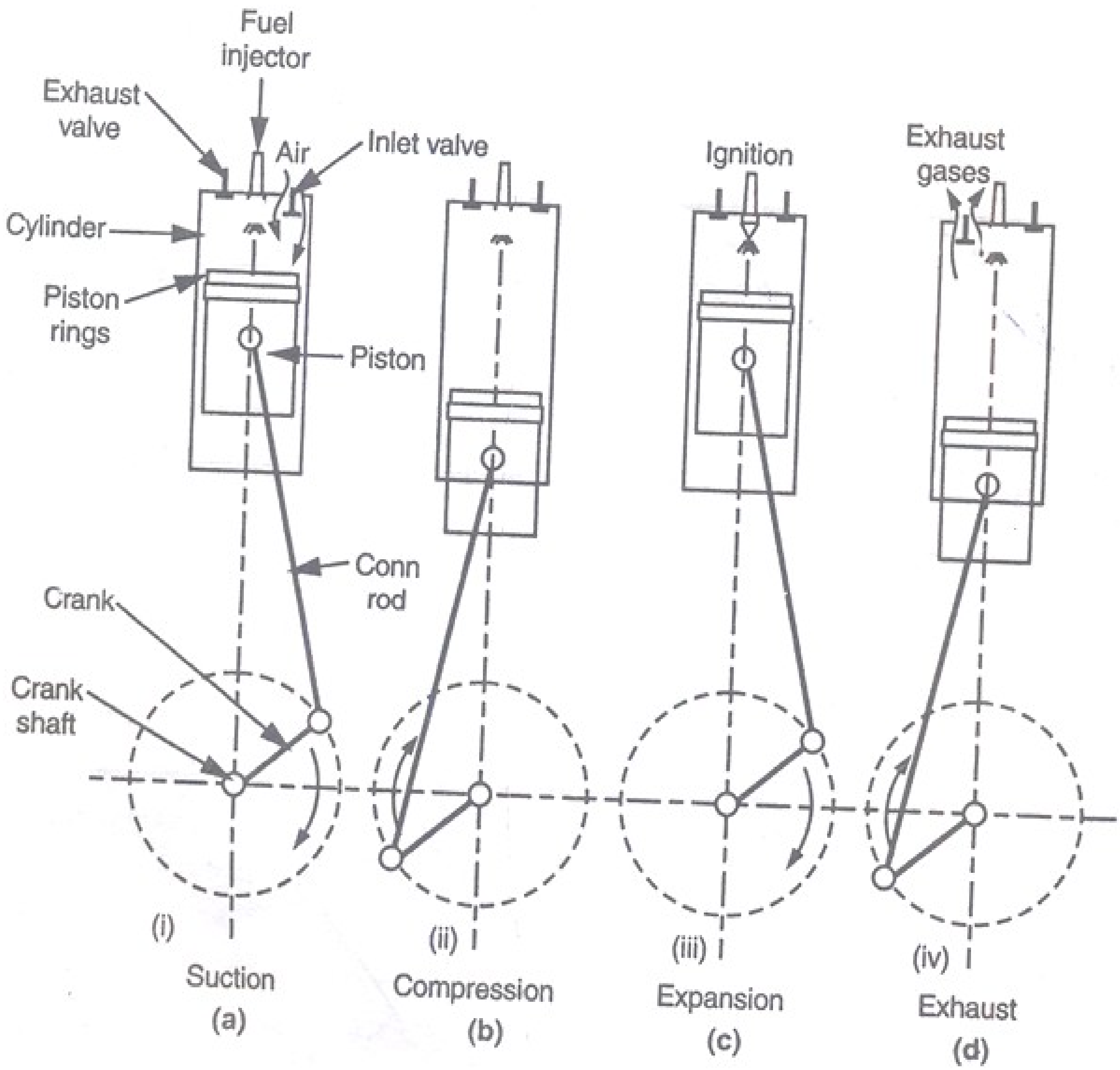


Fig- FOUR STROKE CYCLE DIESEL ENGINE

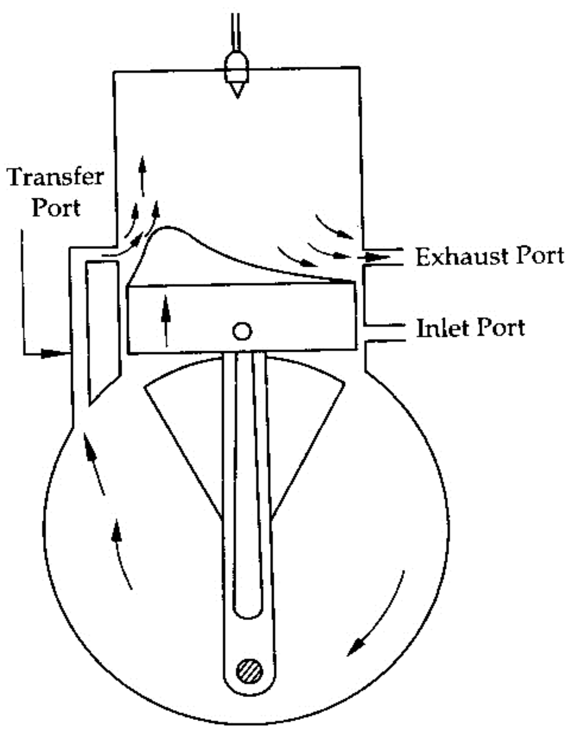
TWO STROKE DIESEL (C.I. ENGINE-)

The working principle of a two stroke diesel engine is discussed below:

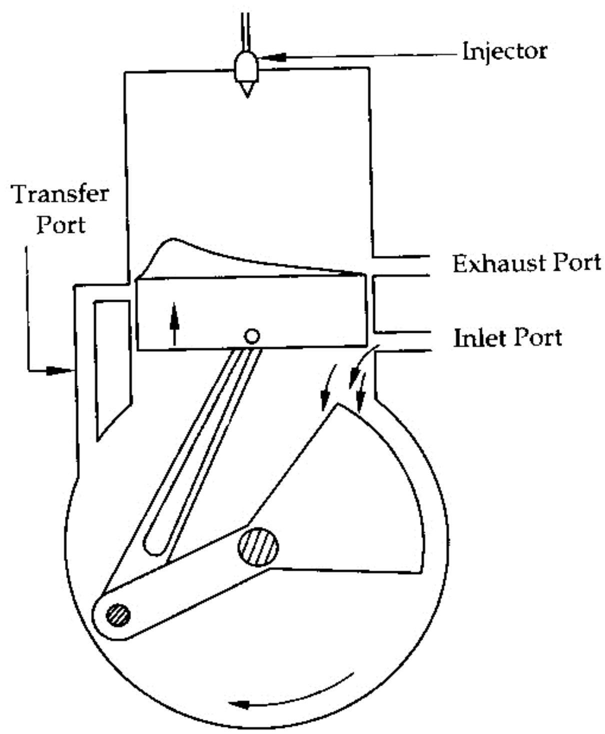
1st stroke: To start with let us assume the piston to be at its B.D.C. position (Fig. a). The arrangement of the ports is such that the piston performs the two jobs simultaneously.

As the piston starts rising from its B.D.C. position, if closes the transfer port and the exhaust port. The air which is already there in the cylinder is compressed (Fig. b).

At the same time with the upward movement of the piston, vacuum is created in the crank case. As soon as the inlet port is uncovered, the fresh air is sucked in the crank case. The charging is continued until the crank case and the space in the cylinder beneath the piston is filled (Fig. c) with the air. At the end of the stroke, the piston reaches the T.D.C. Position.



(A)



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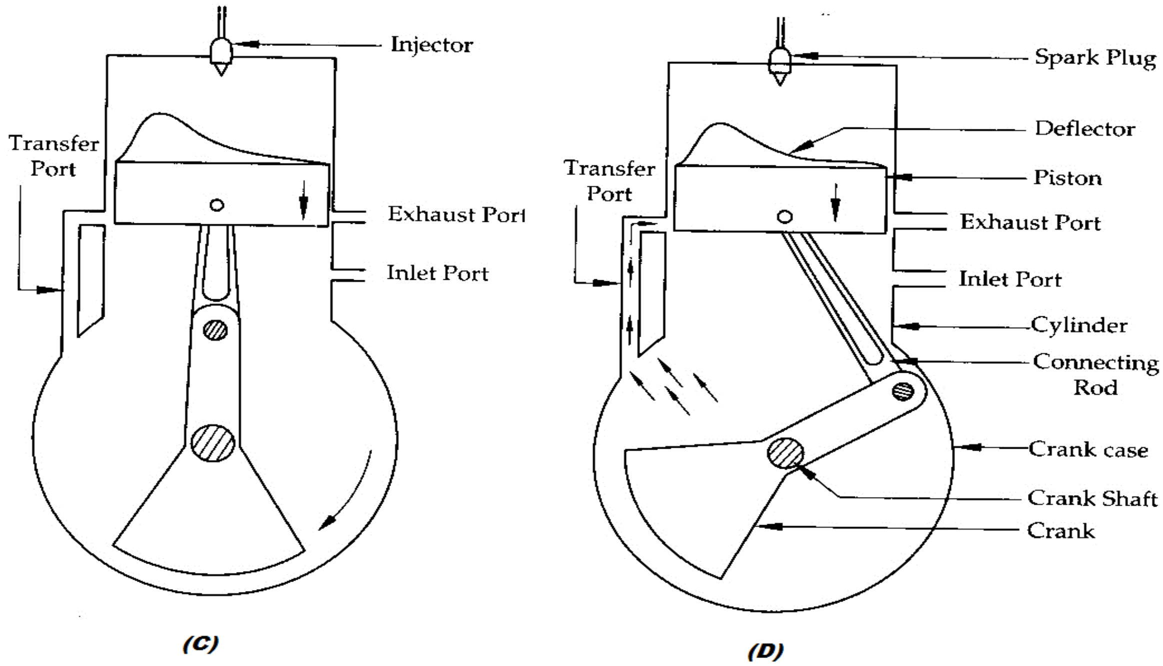


Figure- Working Principle of 2-stroke Diesel Engine

<u>2nd stroke</u>: Slightly before the completion of the compression stroke, a very fine sprays of diesel injected into the compressed air. The fuel ignites spontaneously.

Pressure is exerted on the crown of the piston due to the combustion of the air and the piston is pushed in the downward direction producing some useful power (Fig. c). The downward movement of the piston will first close the inlet port and then it will compress the air already sucked in the crank case.

Just the end of power stroke, the piston uncovers the exhaust port and the transfer port simultaneously. The expanded gases start escaping through the exhaust port and at the same time transfer port (Fig. d) and thus the cycle is repeated again.

The fresh air coming into the cylinder also helps in exhausting the burnt gases out of the cylinder through the exhaust port (Fig. d). This is known as scavenging.

***Experiment No:* 4**

***AIM: -* To study Two-stroke & Four-stroke Petrol Engines.**

APPARTUS USED: - Model of Two-stroke & Four-stroke petrol Engines.

THEORY-

CYCLE- When series of events are repeated in order, it completes one cycle. Cycle is generally classified as Four stroke cycle and Two stroke cycle.

Four stroke cycle- In Four stroke cycle, four operations are required to complete one cycle. These four operations are suction, compression, power and exhaust.

Two stroke cycles- In a two stroke cycle, the series of events of the working cycle is completed in two strokes of the piston and one revolution of the crankshaft. The four operations i.e. suction, compression, power and exhaust are completed during two strokes of the piston.

ENGINE- A power producing machine is called an engine.

HEAT ENGINE- An engine which converts heat energy into mechanical energy is called a heat engine.

Types of heat engine –

a) ***External Combustion engine-***The engine in which the combustion of fuel takes place outside the cylinder is called an external combustion engine.

b) ***Internal Combustion engine-*** *The* engine in which the combustion of fuel takes place inside the cylinder is called an internal combustion engine.

FOUR STROKE PETROL ENGINE-

In four stroke petrol engine or spark ignition engine all the events of the cycle i.e. suction, compression, expansion and exhaust take place in two revolutions of the crank shaft I.e. 720° of the crank rotation. Thus each stroke is of 180° crank shaft rotation. Therefore the cycle of operation for an ideal four stroke engine consists of the following four strokes:

a) ***Suction Stroke-*** The piston moves from Top Dead Centre (TDC) to Bottom Dead Centre (BDC). The inlet valve opens and a fresh charge of fuel and air mixture enters the cylinder. The exhaust valve remains closed. When the piston reaches Bottom Dead Centre (BDC), the inlet valve also closed.

b) ***Compression Stroke-*** The piston moves from Bottom Dead Centre (BDC) to Top Dead Centre (TDC) position. Both the valves remain closed. The charge drawn during suction stroke is compressed in this stroke.

c) ***Expansion or Power or Working Stroke-*** Just before the piston completes its compression stroke, the charge is ignited by the spark plug and the rapid explosion takes place. The expansion of hot gases pushes the piston down to

BDC position. Both the valve remains closed and the useful work is obtained from the engine.

d) ***Exhaust Stroke-*** The piston moves from BDC to TDC, the exhaust valve opens and the inlet valve remains closed. The piston pushes the exhaust gases out through the exhaust valve to the atmosphere till it reaches the TDC position and the cycle is completed.

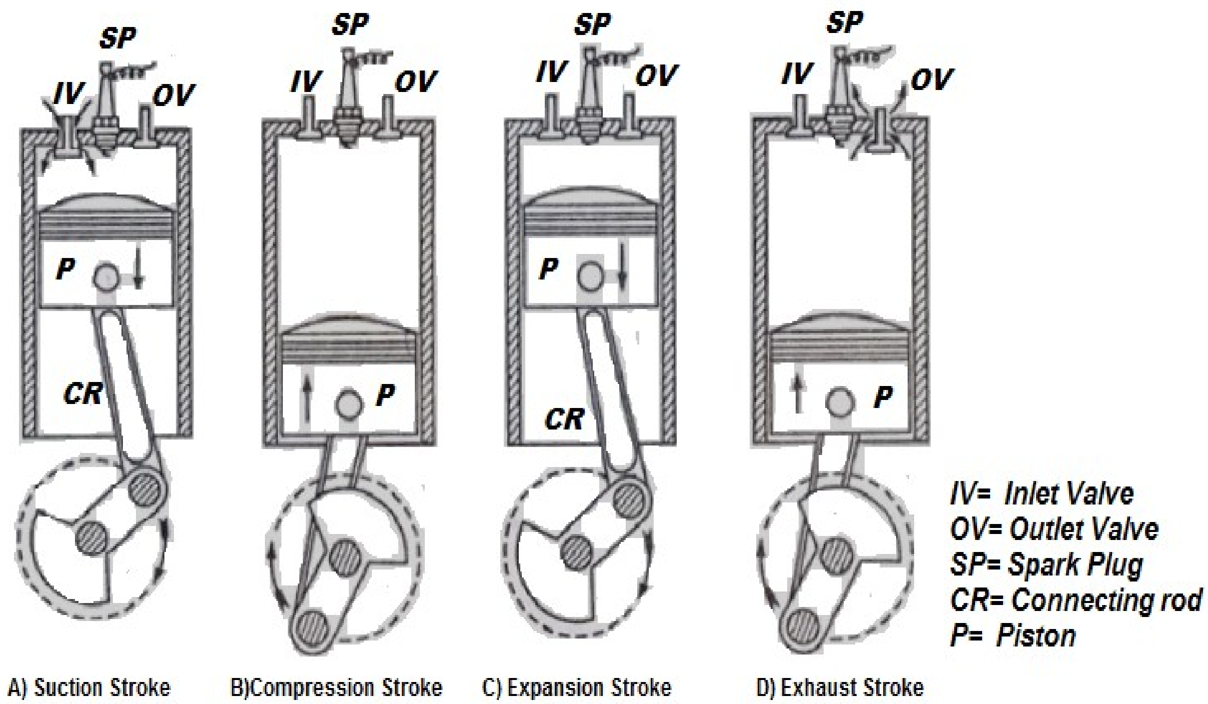


Figure- Four Stroke Petrol Engine

TWO STROKE PETROL (S.I.) ENGINE-

In two stroke cycle petrol engine, there are two strokes of the piston and one revolution of the crankshaft to complete one cycle. In two stroke engines ports are used instead of valve i.e. suction port, transfer port and exhaust port. These ports are covered and uncovered by the up and down movement of the piston. The top of the piston is deflected to avoid mixing of fresh charge with exhaust gases. The exhaust gases are expelled out from the engine cylinder by the fresh charge of fuel entering the cylinder. The mixture of air and petrol is ignited by an spark produced at the spark plug. The two stroke of the engine are-

First Stroke- Assuming the piston to be at the BDC position. The inlet port is converted by the piston whereas the transfer port and exhaust port are uncovered. The piston moves from BDC to TDC. The air petrol mixture enters the cylinder. On the upward movement of the piston, first of all the transfer port is converted and then immediately, the exhaust port is covered. Simultaneously the suction port also gets uncovered, the upward movement of the piston helps to compress the air fuel mixture at the top and creates partial vacuum at the bottom in the crankcase which gets filled with air fuel mixture by the atmospheric pressure. At the end of the stroke, the piston reaches the TDC position completing the compression stroke as shown in Fig. (a) and (b).

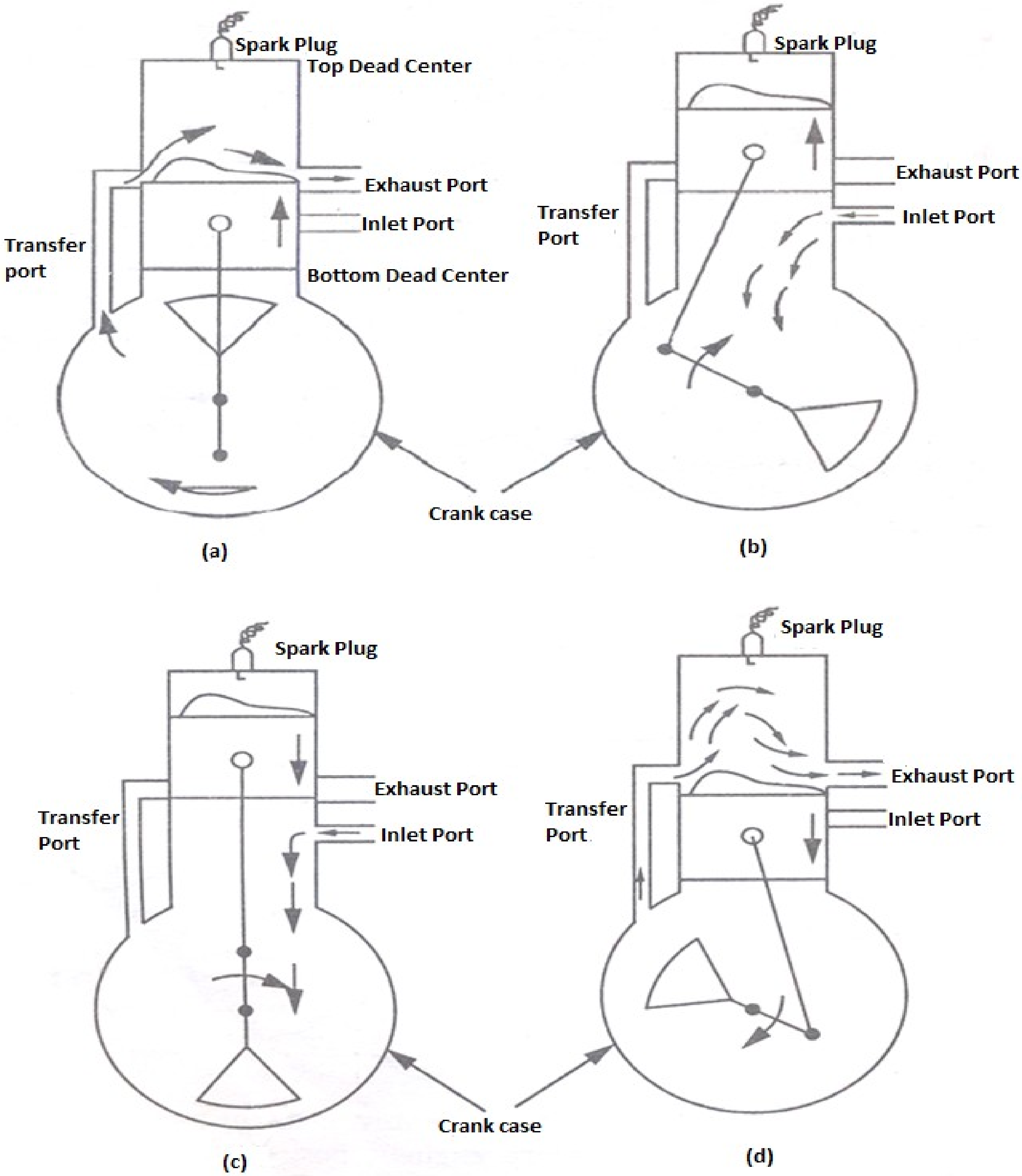


Fig-TWO STROKE CYCLE PETROL (S.I.) ENGINE-

Second Stroke- Just before the completion of the compression stroke, the compressed charge is ignited in the combustion chamber, by means of an electric spark produced by the spark plug. Combustion of air fuel mixture pushes the piston in the downward direction, on the power stroke producing useful work. The movement of the power action is over, the exhaust port is uncovered. The exhaust gases escape to the atmosphere. Further movement of the piston covers the inlet port and the fresh charge is compressed in the crankcase. Simultaneously the transfer port is also uncovered. The compressed mixture of air fuel enters the combustion chamber. The deflected shape of the piston avoids inter-mixing of the fresh charge and exhaust gases i.e. the fresh charge rises to the top of the cylinder and pushes out most of the exhaust gases. Thus the three actions, power, exhaust and induction are completed from TDC to BDC position completing one cycle i.e. two stroke of the piston and one revolution of the crankshaft as shown in Fig. (c) and (d).

<u>EXPERIMENT NO:</u>-5

AIM : - To study the various types of dynamometers.

APPARATUS USED : - Models of dynamometer.

THEORY:- The dynamometer is a device used to measure the torque being exerted along a rotating shaft so as to determine the shaft power.

Dynamometers are generally classified into:

1) Absorption dynamometers (i.e. Prony brakes, hydraulic or fluid friction brakes, fan brake and eddy current dynamometers)
2) Transmission dynamometers (i.e. Torsion and belt dynamometers, and strain gauge dynamometer)
3) Driving dynamometers (i.e. Electric cradled dynamometer)

PRONY BRAKE : - The prony and the rope brakes are the two types of mechanical brakes chiefly employed for power measurement. The prony brake has two common arrangements in the block type and the band type. Block type is employed to high speed shaft and band type measures the power of low speed shaft.

BLOCK TYPE PRONY BRAKE DYNAMOMETER :- The block type prony brake consists of two blocks of wood of which embraces rather less than one half of the pulley rim. One block carries a lever arm to the end of which a pull can be applied by means of a dead weight or spring balance. A second arm projects from the block in the opposite direction and carries a counter weight to balance the brake when unloaded. When operating, friction between the blocks and the pulley tends to rotate the blocks in the direction of the rotation of the shaft. This tendency is prevented by adding weights at the extremity of the lever arm so that it remains horizontal in a position of equilibrium.

Torque, $T = W*l$ in Nm Power

$P = 2\pi N* T/60$ in N-m/s

$= 2\pi N * W*l/60* 1000$ in kW

Where, W= weights in Newton

l = Effective length of the lever arm in meter and

N = Revolutions of the crankshaft per minute.

BAND TYPE PRONY BRAKE DYNAMOMETER: - The band type prony brake consists of an adjustable steel band to which are fastened wooden block which are in contact with the engine brake-drum. The frictional grip between the band the brake drum can be adjusted by tightening or loosening the clamp. The torque is transmitted to the knife edge through the torque arm. The knife edge rests on a platform or communicates with a spring balance.

Frictional torque at the drum = F*r

Balancing torque = W*l

Under equilibrium conditions, T = F*r = W*l in

Nm. Power = 2πN* T/60 in N-m/s

= 2πN * W*l/60* 1000 in kW

ROPE BRAKE DYNAMOMETERS: - A rope brake dynamometers consists of one or more ropes wrapped around the fly wheel of an engine whose power is to be measured. The ropes are spaced evenly across the width of the rim by flywheel. The upward ends of the rope are connected together and attached to a spring balance, and the downward ends are kept in place by a dead weight. The rotation of flywheel produces frictional force and the rope tightens. Consequently a force is induced in the spring balance.

Effective radius of the brake R = (D+ d)/2

Brake load or net load = (W-S) in Newton

Braking torque T = (W-S) R in Nm.

Braking torque =2πN* T/60 in N-m/s

= 2πN * (W-S)R/60* 1000 in

kW D= dia. Of drum

d = rope dia.

S = spring balance reading

FLUID FRICTION (HYDRAULIC DYNAMOMETER):- A hydraulic dynamometer uses fluid-friction rather than friction for dissipating the input energy. The unit consists essentially of two elements namely a rotating disk and a stationary casing. The rotating disk is keyed to the driving shaft of the prime-mover and it revolves inside the stationary casing. When the brake is operating, the water follows a helical path in the chamber. Vortices and eddy-currents are set-up in the water and these tend to turn the dynamometer casing in the direction of rotation of the engine shaft. This tendency is resisted by the brake arm and balance system that measure the torque.

Brake power = W*N/k,

Where W is weight as lever arm, N is speed in revolutions per minute and k is dynamometer constant.

Approximate speed limit = 10,000rpm

Usual power limit = 20,000kW

BEVIS GIBSON FLASH LIGHT TORSION DYNAMOMETER: - This torsion dynamometer is based on the fact that for a given shaft, the torque transmitted is directly proportional to the angle of twist. This twist is measured and the corresponding torque estimated the relation:

$$\mathbf{T = Ip * C * \theta / l}$$

Where $Ip = \pi d^4/32$ = polar moment of inertia of a shaft of diameter d

θ = twist in radians over length l of the shaft

C = modulus of rigidity of shaft material

APPLICATIONS:-

i) For torque measurement.
ii) For power measurement.

VIVA-QUESTIONS:-

(vi) How many types of method of shaft power measurement ?
(vii) How many types of mechanical brakes ?
(viii) Which type mechanical brake use for high speed and low speed shaft ?
(ix) What is mean by effective radius of the brake drum?
(x) Which types of bearing is same as the friction torque transmitted by a disc or plate clutch?

Stress Strain Diagram:

For Ductile Materials:

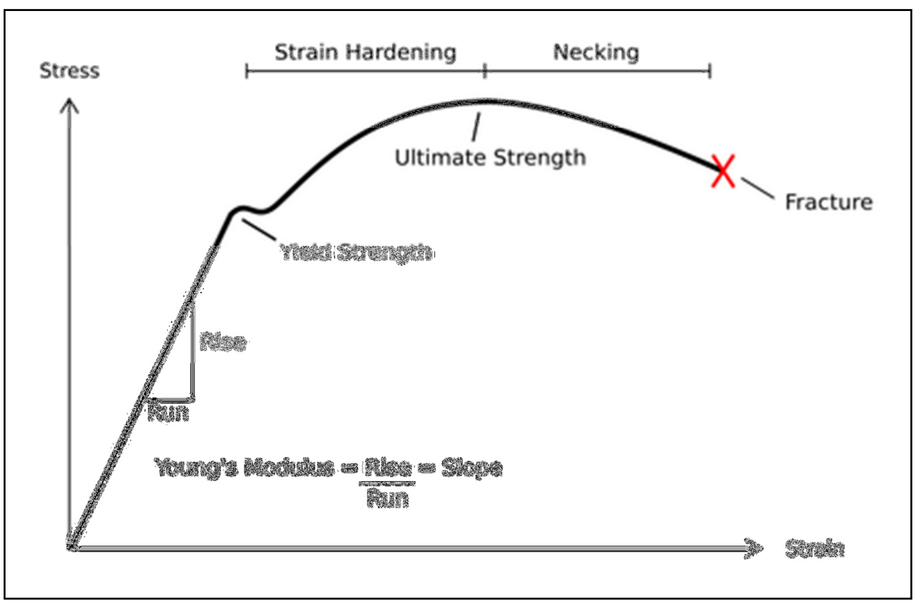
Ductile Materials:

Ductile materials are those which are capable of having large strains before they are fractured. Ductile materials can withstand high stress and are also capable of absorbing large amount of energy before their failure. A ductile material has a large Percentage of elongation before failure.

Some examples of ductile materials are aluminum, mild steel and some of its alloys i.e. copper, magnesium, brass, nickel, bronze and many others.

Stress Strain Diagram For Ductile Material:

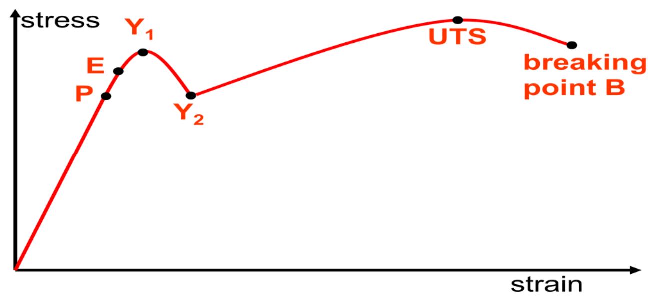
We have taken annealed mild steel as a ductile material.



Different Points On Stress Strain Curve:

- **Proportional Limit (σ_{PL})**

Proportional limit is the point on stress strain curve which shows the highest stress at which Stress and Strain are linearly proportional to each other where the proportionality constant is E known as modulus of elasticity. Above this point, stress is no longer linearly proportional to strain. On stress strain curve, proportional limit is shown by P. It is denoted by $\boldsymbol{\sigma_{PL}}$. For annealed mild steel the limit of proportionality occurs at **230 MPa**.



The above graph shows that the length of graph up to proportional limit (P) is a straight line which means that up to proportional limit stress is linearly proportional to strain.

- **Elastic Limit (σ_{EL})**

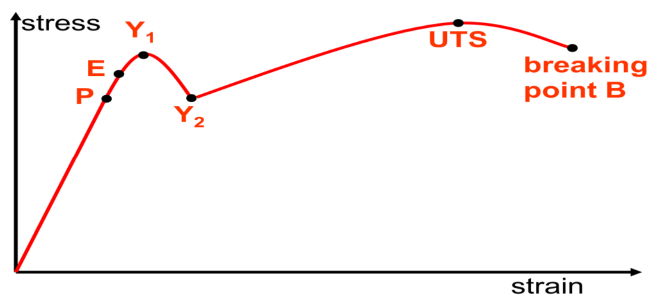
Elastic limit is the point which shows the maximum stress that can be applied to the body without resulting in permanent deformation when stress is removed. At elastic limit when the load is removed from the body, it returns to original size and shape. At elastic limit stress is no longer linearly proportional to strain. It is denoted by $\boldsymbol{\sigma_{EL}}$. For stress strain graph of mild steel, elastic limit is just close to proportional limit.

- **Yield point (σ_Y)**

Yield point is the point which shows the stress at which a little or no increase in stress results to large increase in strain that is material continues to deform without increase in load. At this point the material will have permanent deformation. It is denoted by $\boldsymbol{\sigma_Y}$. For steel, yield point is also just above proportional limit. Yield point is of two types:

- Upper yield point.
- Lower yield point.

Upper yield point is shown by Y_1 and lower yield point is shown by Y_2 as in diagram given below:



Among the common materials, only steel exhibits yield point. For annealed mild steel, upper yield point occurs at 260 MPa and lower yield point occurs at 230 MPa.

- **<u>Ultimate Tensile Strength</u> ($\boldsymbol{\sigma_U}$)**

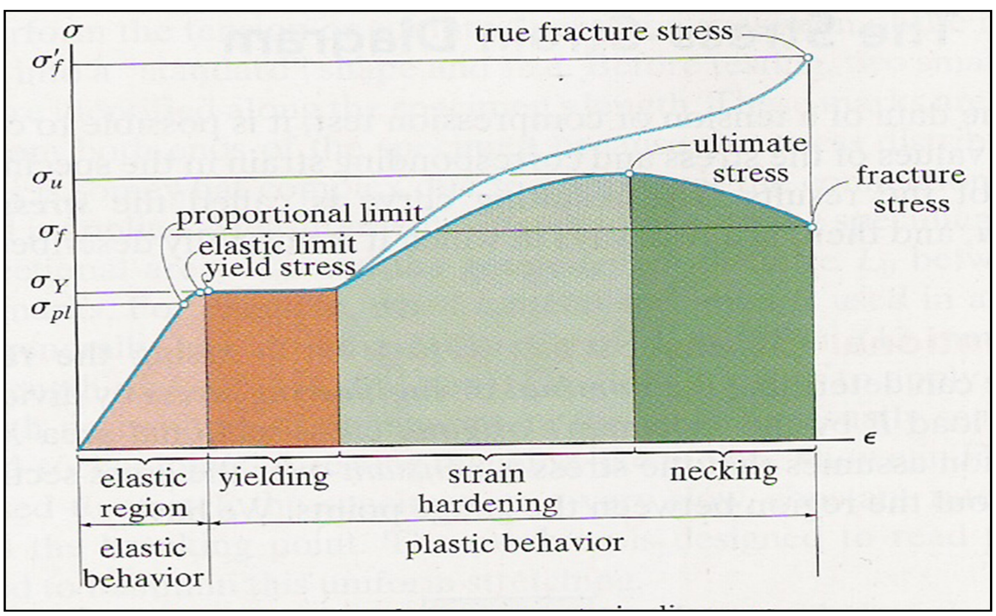
As the stress on material is increased further, the stress and the strain increases from yield point to a point called ultimate tensile strength (UTS) where stress applied is maximum. Thus ultimate tensile strength can be defined as the highest stress on the specimen which it can withstand. For annealed mild steel, ultimate tensile strength occurs at **400 MPa**. It is denoted by σ_U.

- **Fracture Stress (σ_F)**

After ultimate tensile strength, the applied stress decreases until the stress is obtained where material fractures called fracture stress. Fracture stress is also called breaking strength. It is denoted by σ_F.

Different Regions under Area of Stress Strain Curve:

This is the general diagram of stress strain curve, which elaborates different regions under stress strain curve.



- **Elastic region:**

Elastic region is the area under the curve from initial point to elastic limit. In this region material will return to its original size and shape when load is removed from the body.

- **Plastic region:**

Plastic region is the area under curve which starts from elastic limit to fracture point. Under the area body shows plastic behavior i.e. when the load is removed from body, it does not come back to its original size and shape.

- **Yielding region:**

This region starts from elastic limit to yield point where the body produces strain with a little or no increase in load.

- **Strain Hardening;**

Area from upper yield point to ultimate tensile stress is called strain hardening. Under this area the body will elongate only with increasing the stress until the stress is at maximum point whereas the cross sectional area will decrease uniformly.

- **Necking:**

Necking covers the area from ultimate tensile stress to fracture point. It is the region where cross sectional area of material will decrease in a localized spot and capacity of material to carry load will decrease. In necking region, stress strain curve has neck like curve.

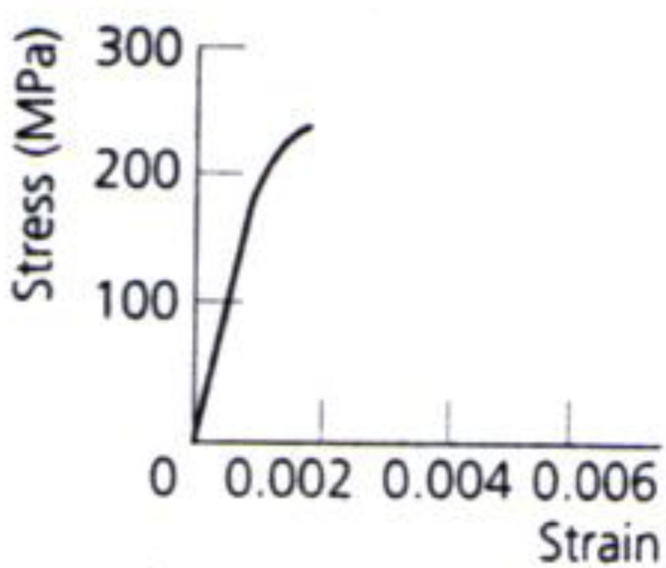
For Brittle Materials:

Brittle Materials:

Brittle materials are those which break suddenly under stress at a point just beyond elastic limit. They have little or no yielding before failure and their percentage of elongation is very low. If percentage elongation is equal to or less than 5%, we consider that material brittle.

Brittle materials include glass, concrete, cast iron and plaster.

Stress Strain Diagram for Brittle Materials:



Above graph shows that gray cast iron exhibit less plastic region i.e it fractures just after elastic limit so it is a brittle material.

Different Points On Stress Strain Curve:

- **Proportional Limit (σ_{PL})**

Like ductile material, proportional limit of brittle material (gray cast iron) is the point on stress strain curve which shows the highest stress at which Stress and Strain are linearly proportional to each other where the proportionality constant is E known as modulus of elasticity. Above this point, stress is no longer linearly proportional to strain. It is difficult to determine the point at which the limit of proportionality occurs, but it is approximately **200 MPa**. It is denoted by $\boldsymbol{\sigma_{PL}}$.

- **Elastic Limit (σ_{EL})**

Like ductile materials, elastic limit of brittle material is the point which shows the maximum stress that can be applied to the body without resulting in permanent deformation when stress is removed.
As shown in graph when the load is removed from gray cast iron (at elastic limit), it returns to original size and shape. At elastic limit stress is no longer linearly proportional to strain. It is denoted by $\boldsymbol{\sigma_{EL}}$.

- **Ultimate Yield Stress (σ_Y)**

Ultimate tensile stress is the ratio of ultimate load to original area of cross-section. At this point gray cast iron will have little permanent deformation and just after this point, gray cast iron fracture. We can say that yield point is the ultimate stress or breaking stress for gray cast iron. It is denoted by σ_Y. For gray cast iron, it occurs at **250 MPa**. For brittle materials yield point is not well defined.

ExperimentNo:7

AIM:-_To study the vapour compression Refrigeration System and determination of its C.O.P.

Apparatus: - Refrigeration Trainer.

Theory:-

In vapour compression refrigeration system working fluid is refrigerant which undergoes phase change at least during one process .i.e. it evaporator and condenses or changes alternately between vapour and liquid phases without leaving the refrigeration system. In evaporation, refrigerant absorbs latent heat from the cold body. This latent heat is used for converting the liquid to vapour, while condensing; it rejects latent heat to external body to create cooling effects in the working fluid.

Simple Vapour- compression Refrigeration Cycle-

In a simple vapour- compression Refrigeration cycle, there are four fundamental processes are required to complete one cycle. These are follows.

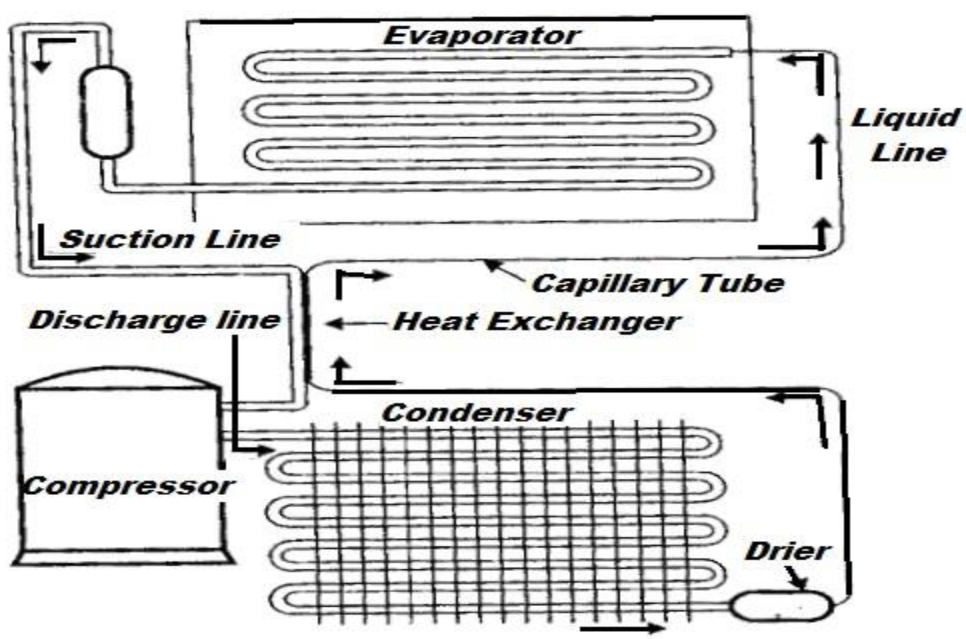


Figure- Flow diagram of simple vapour compression system

1) **Compression-** The function of compressor is to maintain the flow of the refrigerant in the system. It sucks the low pressure and low temperature refrigerant from the evaporator, compresses it by raising its pressure and temperature until the vapour temperature is greater than the condenser temperature. The cooling media of compressor is air or water.

2) **Condensation-** In the condenser, latent heat of vaporization is removed from the high pressure and high temperature vapours. The vapours are condensed into high pressure liquid. The high pressure and low temperature vapours are collected in the receiver tank until needed to flow ahead.

3) **Expansion-** From the receiver tank, the liquid refrigerants are passes through the expansion valve. The expansion valve controls the flow of liquid refrigerant to the evaporator. It is the dividing point between the high pressure and low pressure side of the system. When the high pressure liquid refrigerant passes through the expansion valve, some of it flashes into vapour and cools the remaining liquid to a low temperature of about -10°C.

4) **Vapourisation-** The low temperature and low pressure liquids enters the evaporator. It absorbs heat from the surroundings and changes into vapour form, after absorbing latent heat of vapourisation. The low temperature and low pressure vapours formed in the evaporator are sucked back by the compressor, completing the function of one cycle of compression refrigeration system.

Principal parts of a simple vapour compression refrigeration system-

The principal parts of a simple vapour compression refrigeration system shown in the flow diagram of figure. These parts are follow:

1) Evaporator
2) Suction line
3) Compressor
4) Discharge line
5) Condenser
6) Drier
7) Liquid line
8) Expansion Valve

Observations-

1) Expansion device used-capillary tube

2) Time for 10 revolutions of compressor energy meter (t_c)-___ sec.

3) Evaporator water flows- ______ Lit. /sec.

4) Water Temperature-

a) Evaporator inlet, t_{wi}- ____°C

b) Evaporator outlet, t_{wo}- ____°C

Calculations-

1) Refrigeration effect is balanced by water circulation;

So heat given by water=Referigeration effect

R.E. = $mc_p\Delta T$ kw

Where, m = mass flow rate of water, Lit. per second.

C_p = 4.2 KJ/Kg k

$\Delta T = t_{wi} - t_{wo}$

2) Compressor Work (CW) = (n X 3600) /($t_c \times$ EMC)

Where t_c = time for compressor energy meter disc

EMC = Compressor energy meter constant

3) Actual C.O.P. = R.E. / CW