LABORATORY MANUAL

BASICS OF MECHANICAL ENGINEERING LAB

ME - 107 - F

B.TECH, I & II SEMESTER

World College of Technology & Managment,Gurgaon

BASICS OF MECHANICAL ENGINEERING LABORATORY (ME-107-F)

ME-107F : BASICS OF MECHANICAL ENGINEERING LAB

L T P	Sessional 25 Marks
- - 2	Exam 25 Marks
	Total 50 Marks
	Duration of Exam 3 Hrs.

Notes :

(i) At least 10 experiments are to performed by students in the semester.

(ii) At least 7 experiments should be performed from the above list; remaining three experiments may either be performed from the above list or designed and set by the concerned institution as per the scope of the syllabus.

LIST OF EXPERIMENTS

1. To study the Cochran and Babcock & Wilcox boilers.
2. To study the working and function of mountings and accessories in boilers.
3. To study Two-Stroke & Four-Stroke Diesel Engines.
4. To Study Two-Stroke & Four-Stroke Petrol Engines.
5. To study the vapour compression Refrigeration System and determination of its C.O.P.
6. To study the functioning of Window Room Air Conditioner.
7. To study the constructional features and working of Pelton Wheel Turbine, Francis Turbine and Kaplan Turbine.
8. To calculate the Mechanical Advantage, Velocity Ratio and Efficiency of Single Start, Double Start and Triple Start Worm Wheel.
9. To calculate Mechanical Advantage, Velocity Ratio and Efficiency of Single Purchase and Double purchase winch crab and plot graphs.
10. To find the percentage error between observed and calculated values of stresses in the member of a Jib Crane.
11. To study simple screw jack and compound screw jack and determine their efficiency.
12. To find the Mechanical Advantage, Velocity Ratio and Efficiency of a Differential Wheel & Axle.
13. To perform tensile test, plot the stress,-strain diagram and evaluate the tensile properties of a given metallic specimen.

List of Experiments:

1. To study the working and construction details of Cochran and Babcock & Wilcox Boiler.
2. To study the working and function of mountings and accessories in boilers.
3. To study Two stroke & Four stroke Diesel Engines.
4. To study Two-stroke & Four-stroke Petrol Engines.
5. To study the vapour compression Refrigeration System and determination of its C.O.P.
6. To study the functioning of Window Room Air Conditioner.
7. To study the Constructional features and working of Pelton Wheel Turbine, Francis Turbine and Kaplan Turbine.
8. To study the construction & working of centrifugal pump.
9. To study the working of single plate clutch.
10. To study different type of gears used for power transmission.

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.

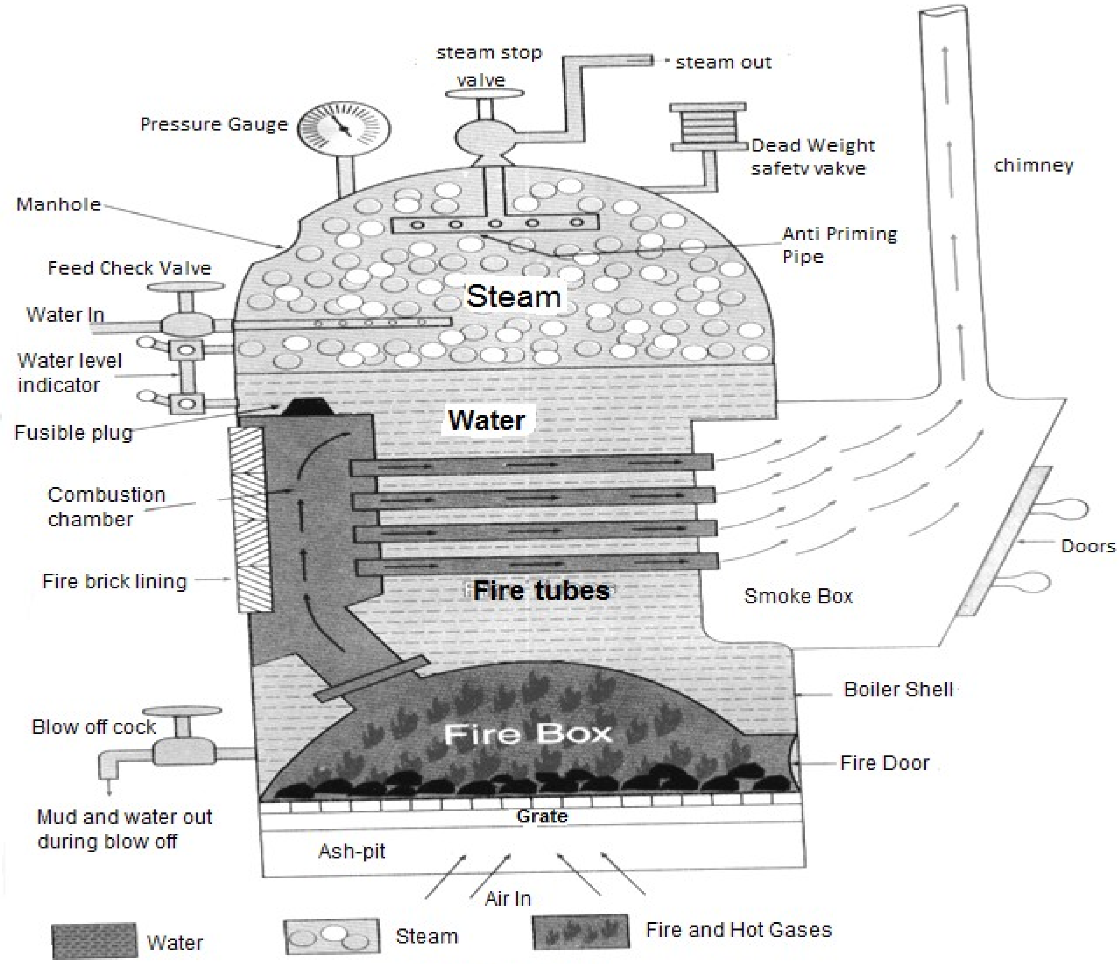
Construction:

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.

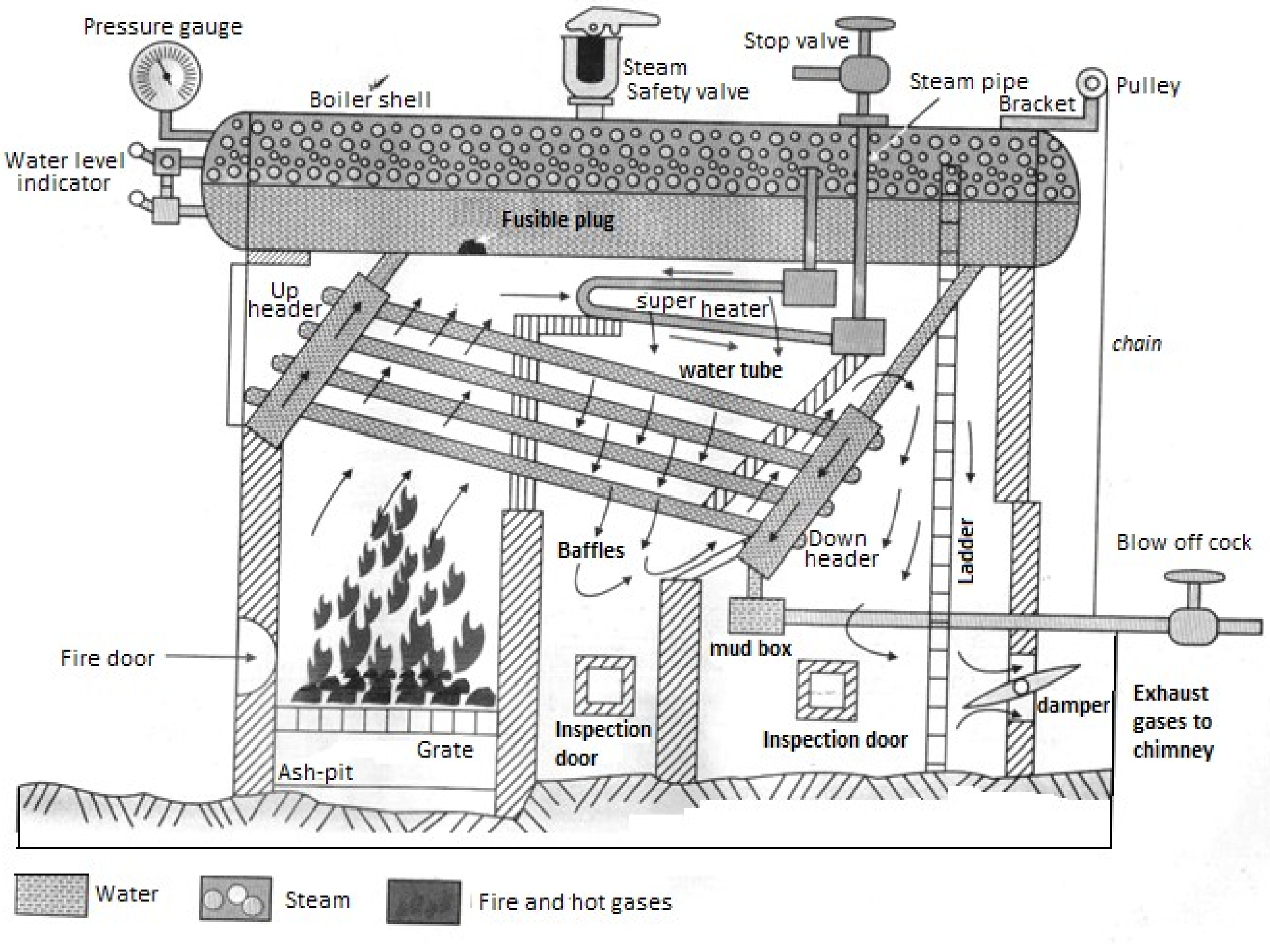
Below the uptake header the furnace of the boiler is arranged. The coal is fed to the chain grate stoker through the fire door. There is a bridge wall deflector which deflects the combustion gases upwards. Baffles are arranged across the water tubes to act as deflectors for the flue gases and to provide 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.

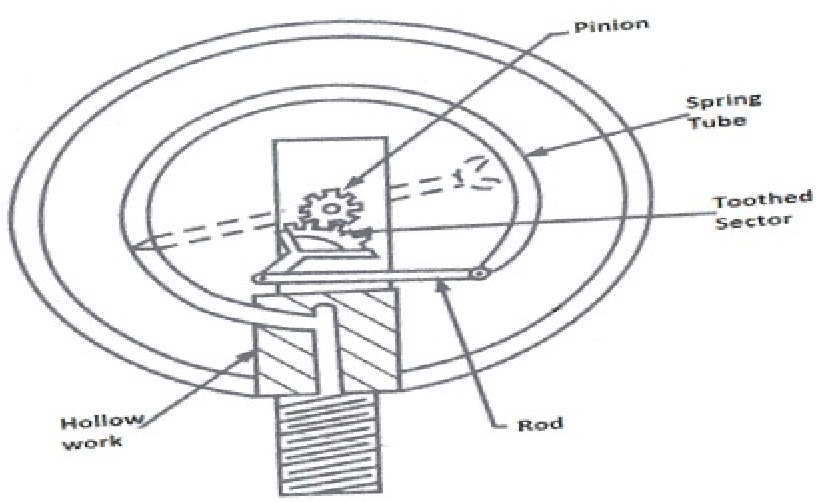


Figure- Pressure Gauge

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.

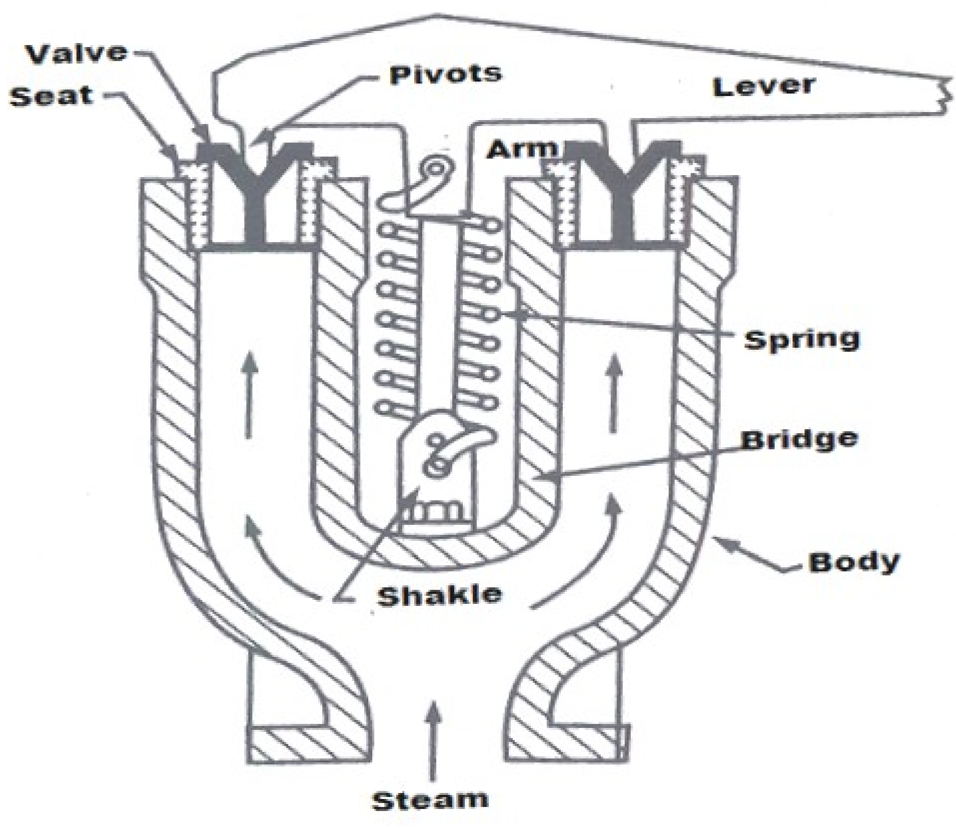


Figure- Spring Loaded Safety Valve

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

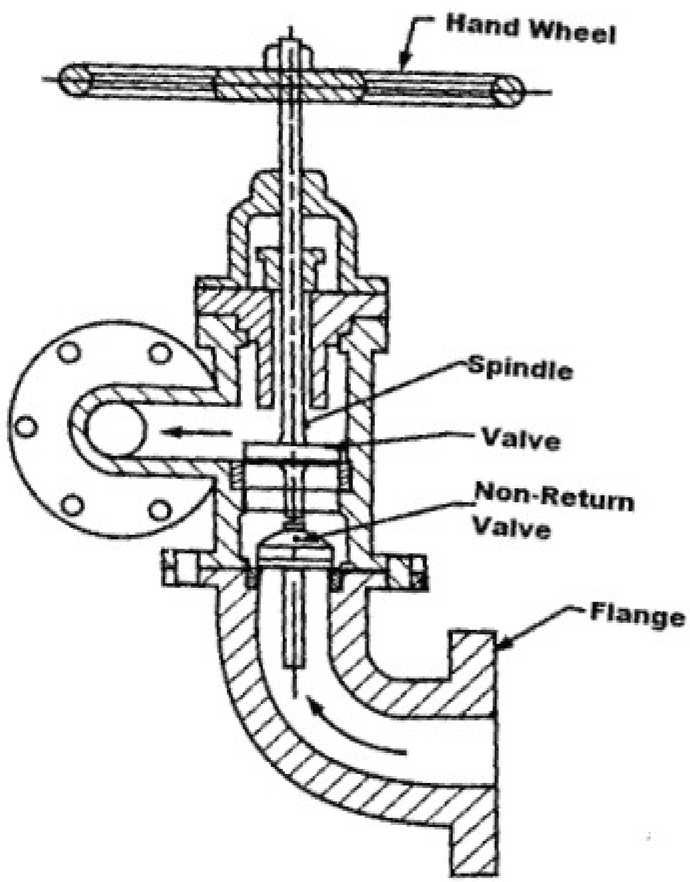


Figure- Feed Check Valve

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.

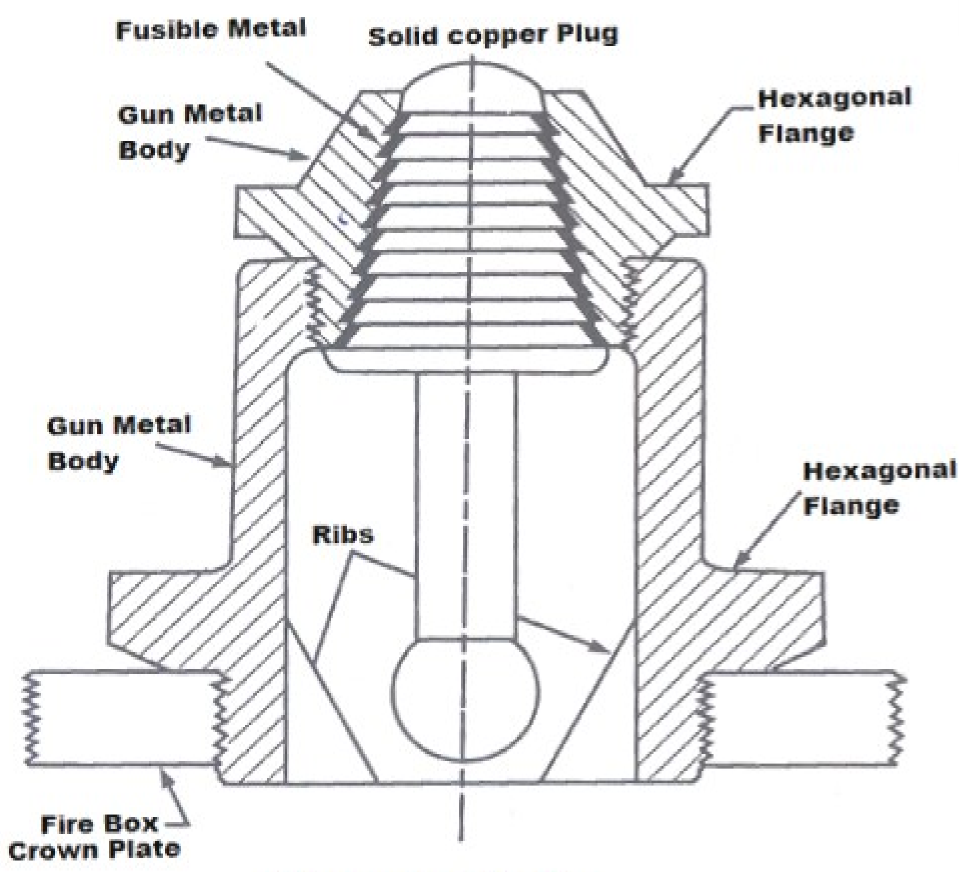


Figure- Fusible Plug

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:

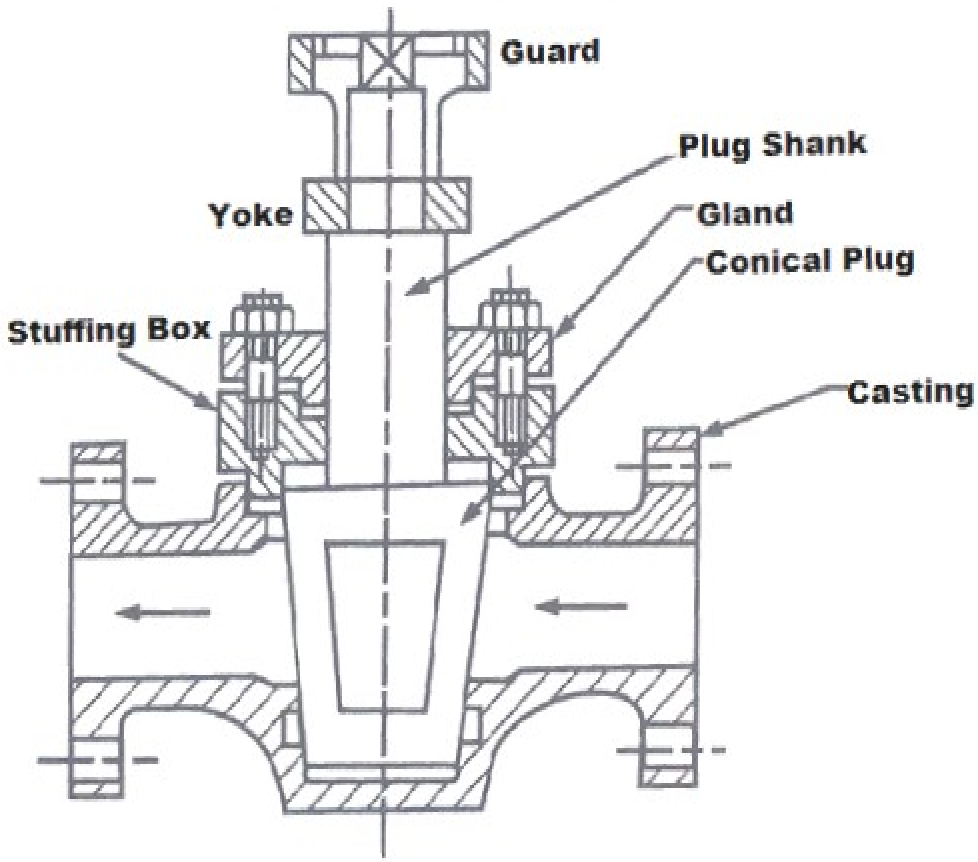


Figure- Blow Off Cock

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.

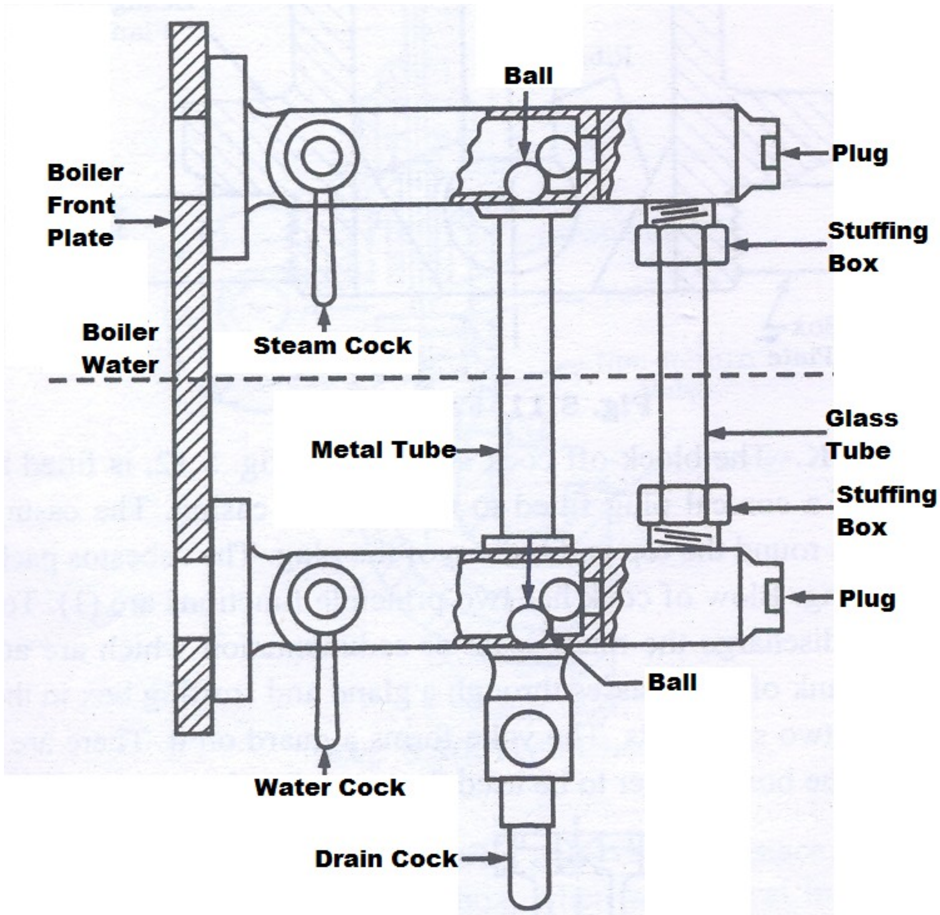


Fig. Water Level Indicator

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.

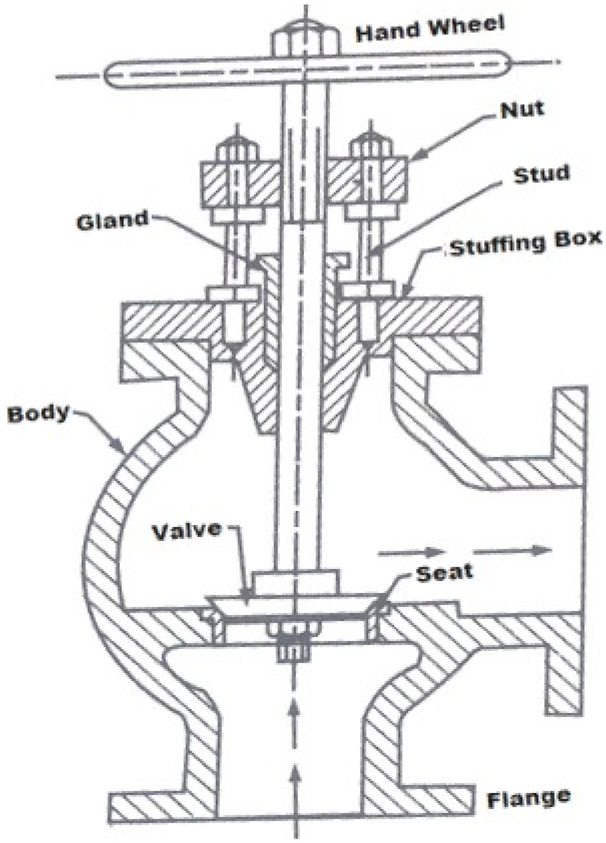


Figure-Steam Stop Valve

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.

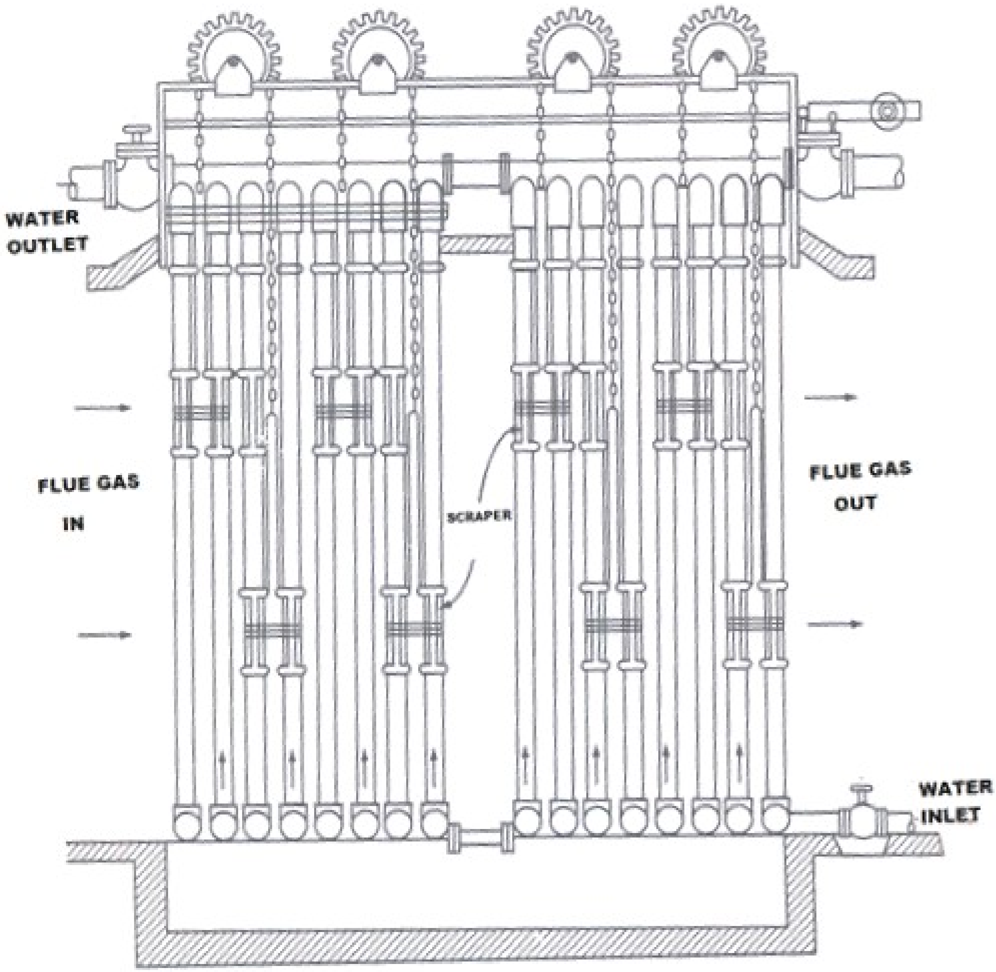


Figure- Economiser

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.

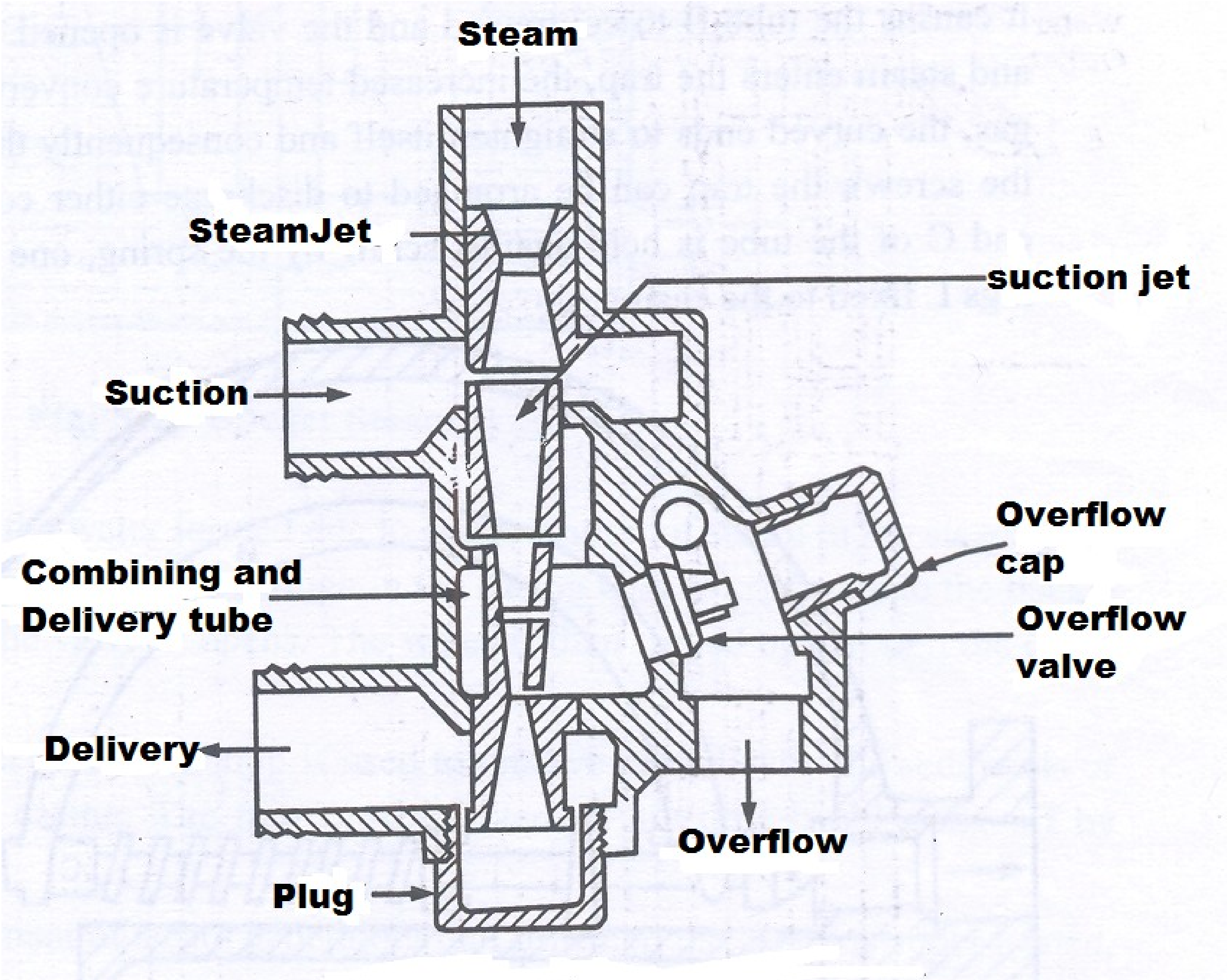


Figure- Injector

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.

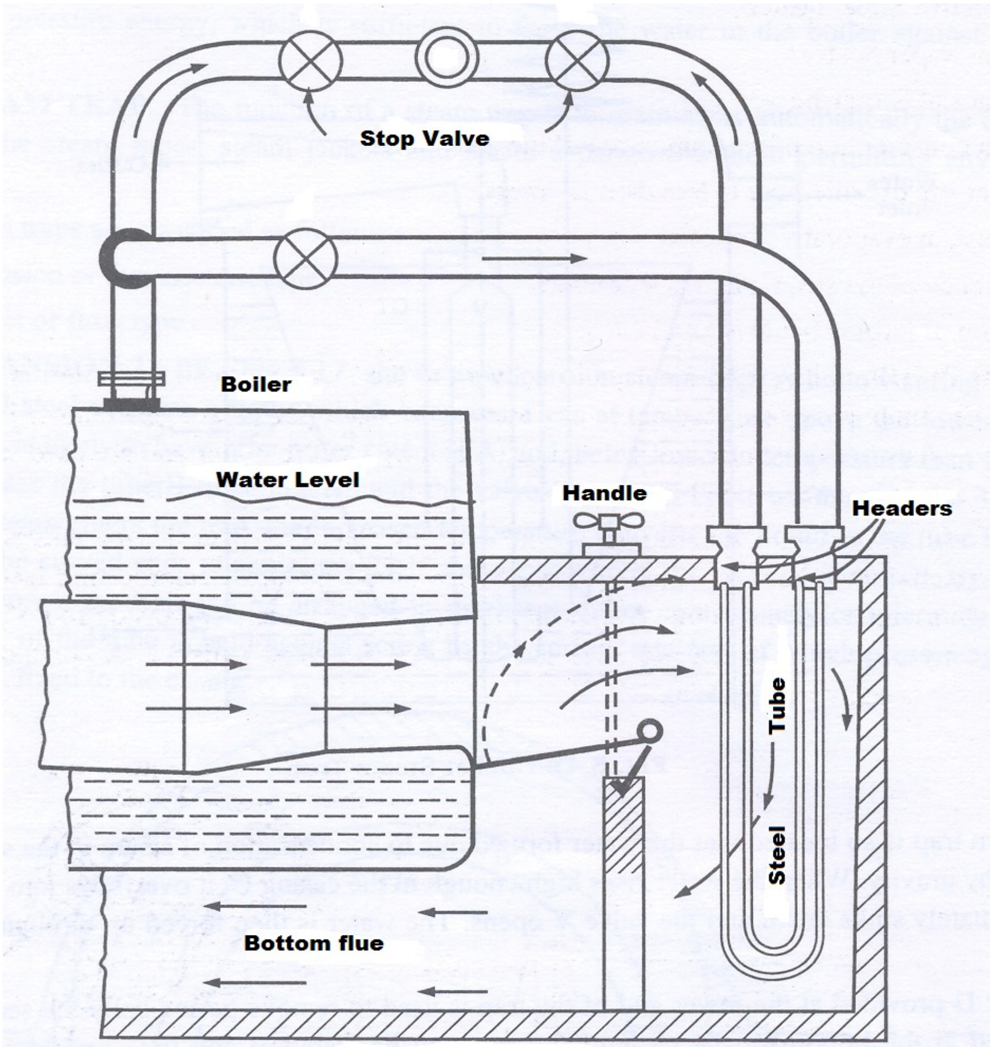


Fig. Super Heater

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

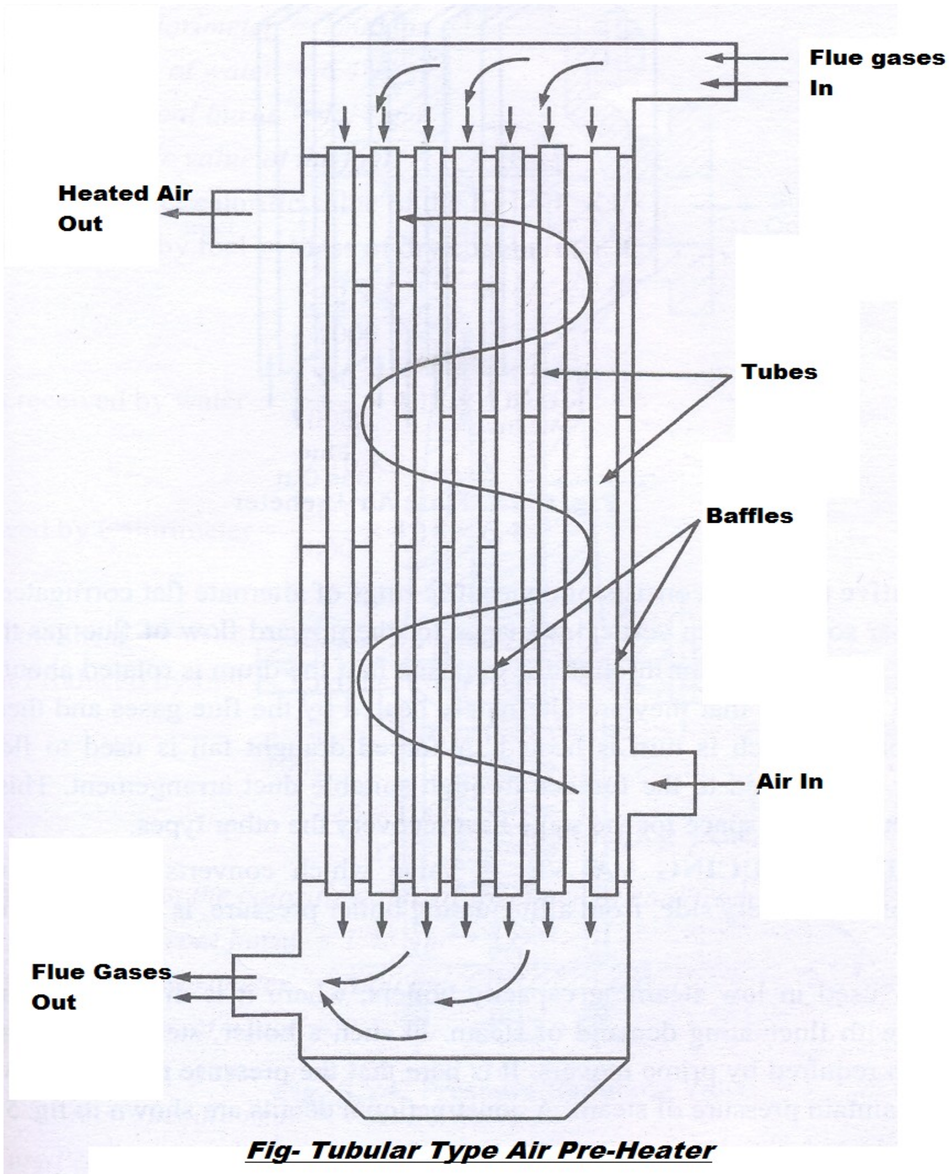


Fig- Tubular Type Air Pre-Heater

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.

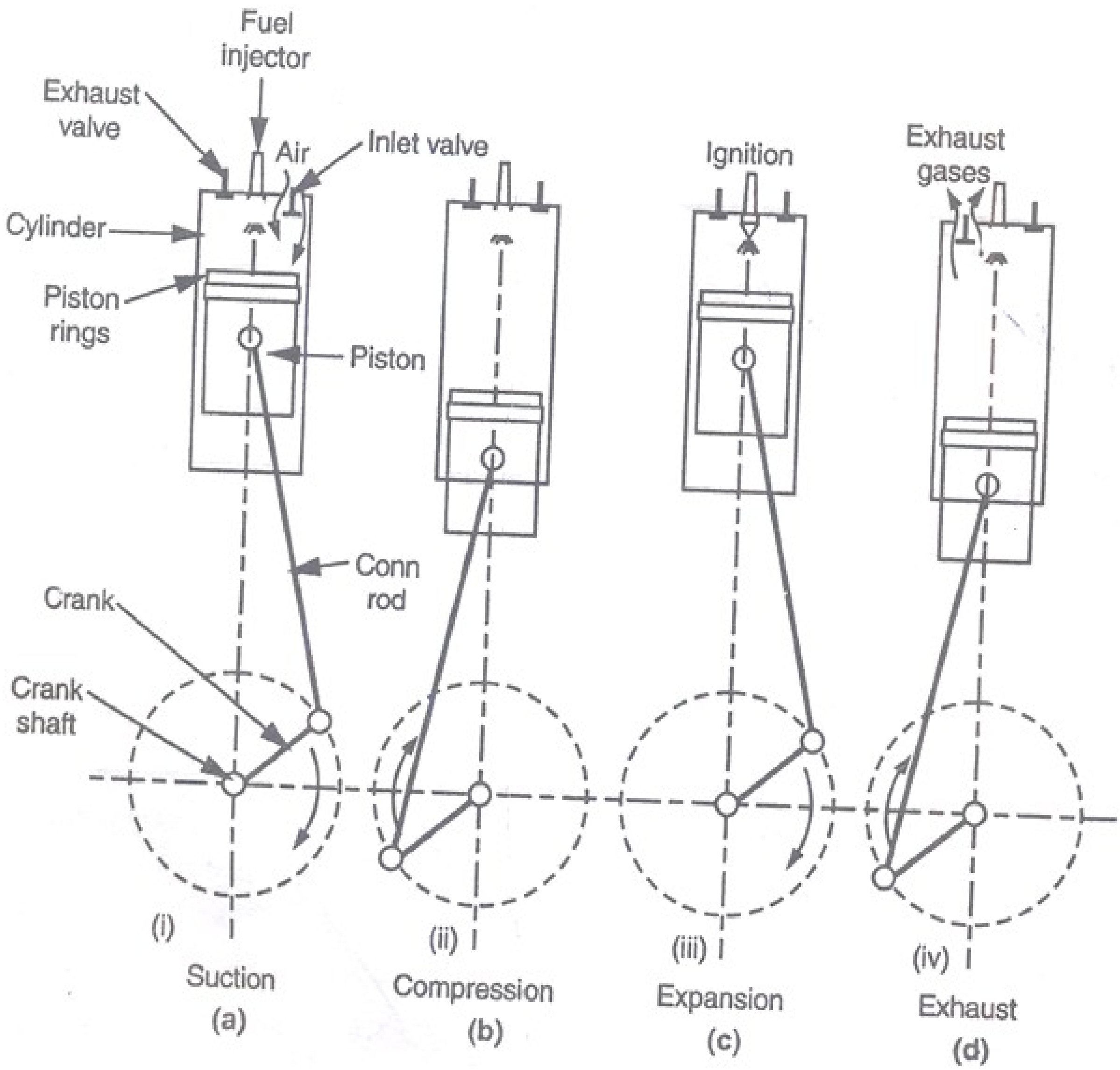


Fig- FOUR STROKE CYCLE DIESEL ENGINE

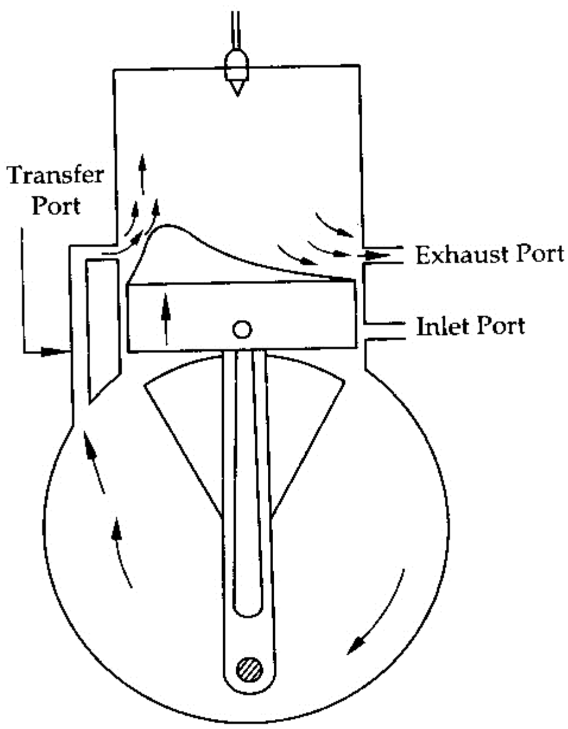
TWO STROKE DIESEL (C.I. ENGINE-)

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

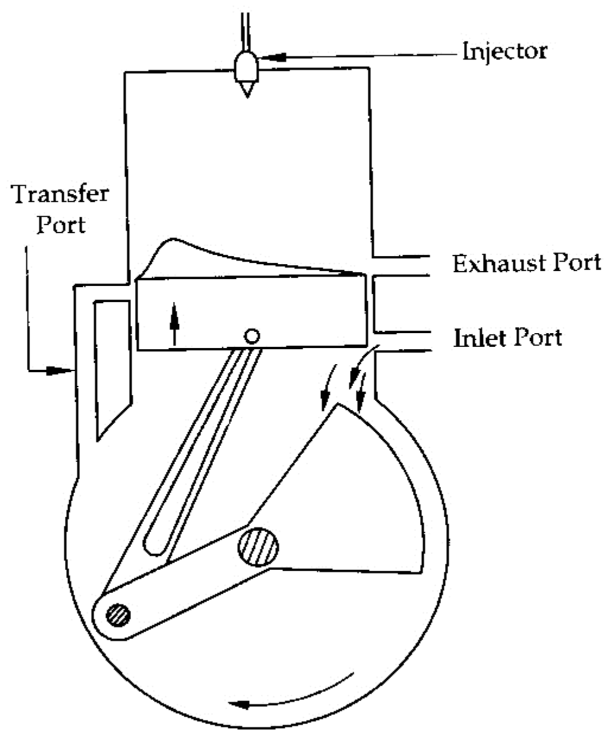
1st stroke: To start with let us assume the piston to be at its B.D.C. position (Fig. a). The arrangement of the ports is such that the piston performs the two jobs simultaneously.

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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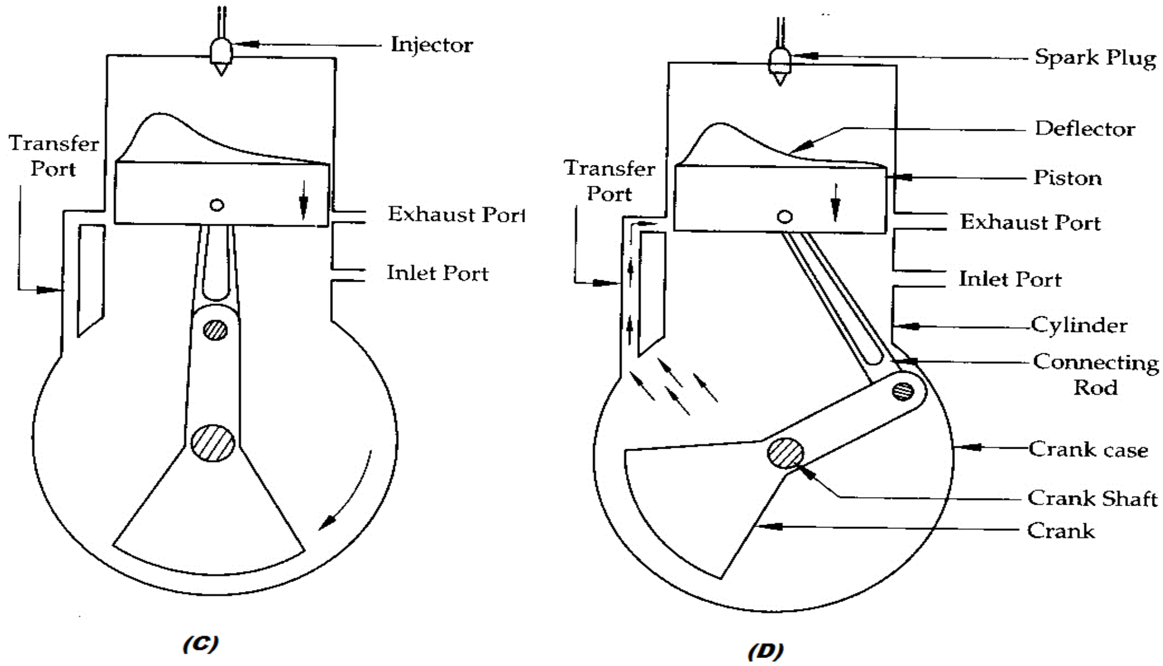

Figure- Working Principle of 2-stroke Diesel Engine

2nd stroke: 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.

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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.

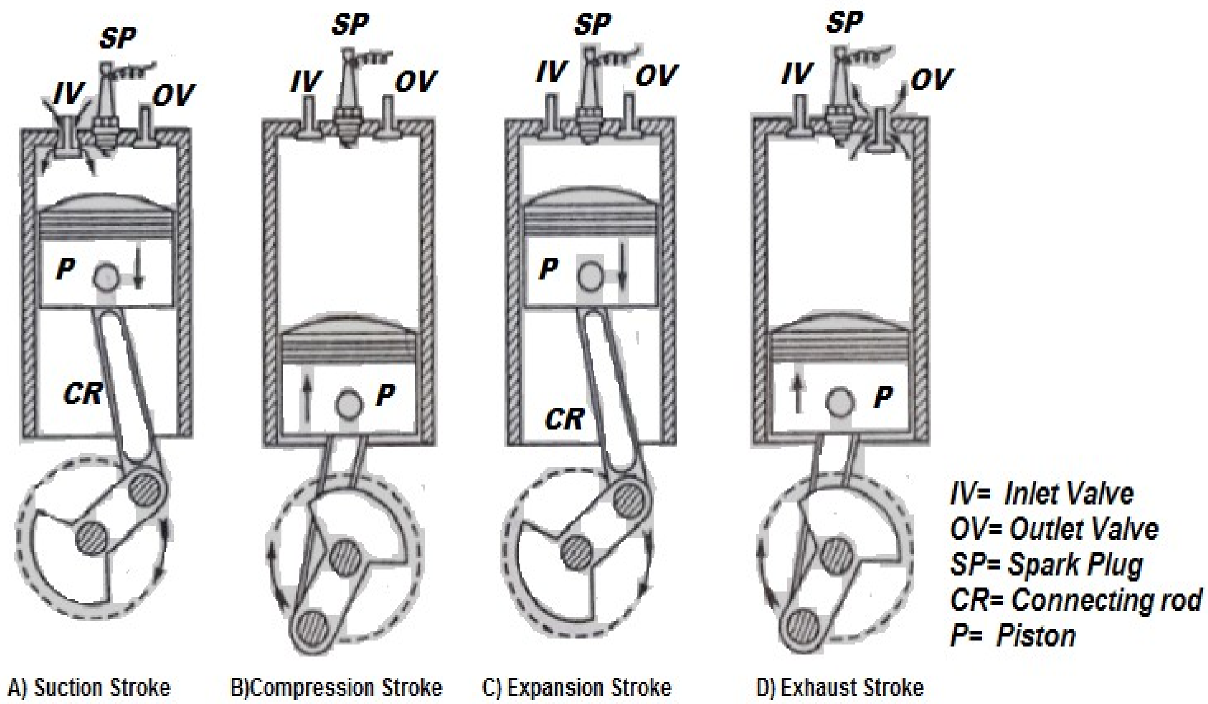


Figure- Four Stroke Petrol Engine

<u>TWO STROKE PETROL (S.I.) ENGINE-</u>

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).

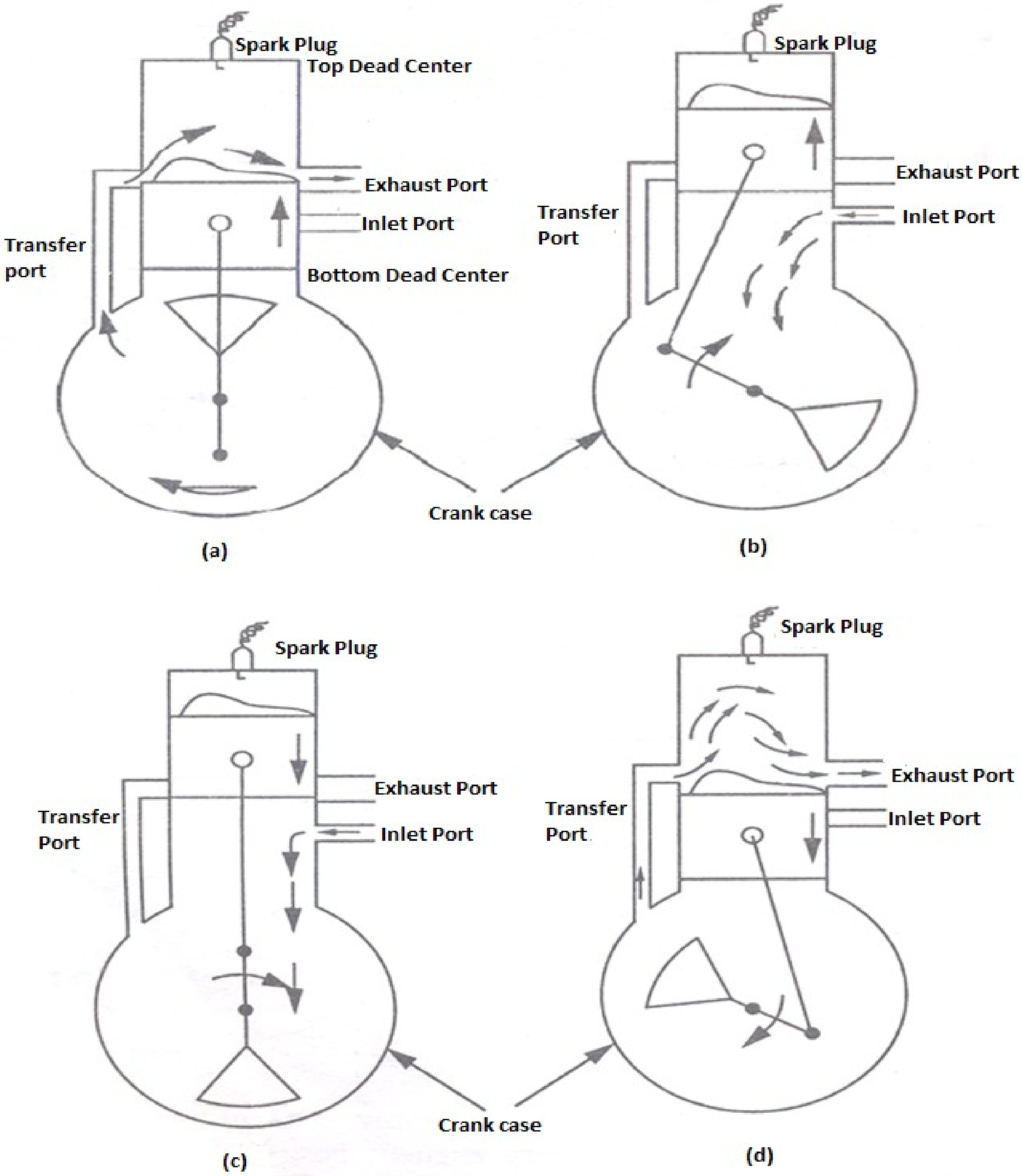


Fig-TWO STROKE CYCLE PETROL (S.I.) ENGINE-

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).

Experiment No: 5

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.

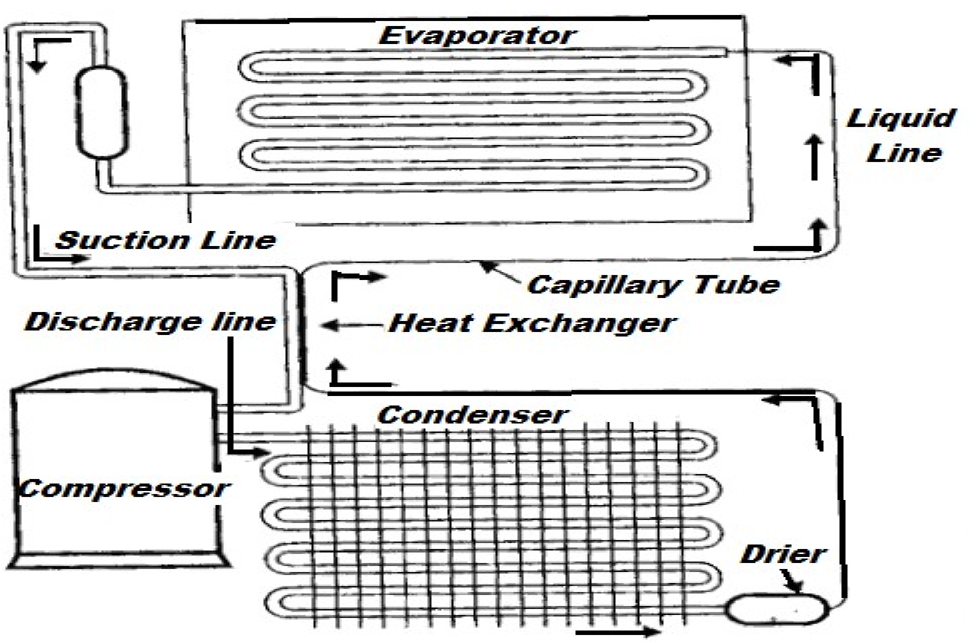


Figure- Flow diagram of simple vapour compression system

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 × EMC)

Where t_c = time for compressor energy meter disc

EMC = Compressor energy meter constant

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

EXPERIMENT NO. 6

Aim: To study the functioning of Window Room Air Conditioner.

Apparatus: A model of window room air conditioner.

THEORY: A room air conditioner is a compact air conditioner unit which can be placed in a particular room for its air conditioning. The room may be an office, a residential room such as bed room, living room etc. The window type units are air cooled and are mounted in a window or wall of room to be air conditioned. They do not need any duct work. It have a complete refrigeration plant, i.e. compressor, condenser, refrigerant, valves and evaporator coils.

The units are also provided with thermostat control and filtering equipment.

A window room air conditioner is shown in Fig. 6.2

A window type air conditioner consists of following sub-assembles:

Sub assembly	*Parts*
1. System assembly	(i) Evaporator (ii) Capillary (iii) Condenser (iv) Strainer (v) Compressor
2. Motor, fan and blower assembly	(i) Fan (ii) Blower motor (iii) Motor mounting brackets.
3. Cabinet and grill assembly	(i) Cabinet (ii) Grill
4. Switch board panel	(i) Selector switch (ii) Relay (iii) Thermostat (iv) Fan motor capacitor

Working: The cool and low pressure vapour refrigerant is drawn from the evaporator to the compressor and it is compressed to high pressure and temperature Generally, in this refrigerant is Freon gas i.e. R–12 or R–22 and a hermetic compressor is used. This high pressure and temperature gas enters the condenser. The high pressure and temperature gas runs through a set of coils so it can dissipate its heat and it condenser into a liquid. This liquid passed through the capillary and then flows through the evaporator. As refrigerant comes out of the capillary, its temperature and pressure falls. This low temperature and pressure gas runs through a set of coils that allow the gas to absorb heat and cool down the air inside the building. The compressor drawn this low pressure vapour and cycle is repeated.

Most air conditioner also function as dehumidifiers. They take excess water or moisture from the air and exit to the atmosphere through the pipe.

Some factors should be kept in mind while a selecting an air conditioner for a room:

(i) size of the room
(ii) wall construction, whether light or heavy
(iii) heat gain through ceiling.

(iv) the proportion of outside wall area which is covered with glass
(v) whether the room is to be used in the day time or at night only
(vi) the exposure to the sun of the walls of the room to be air conditioned
(vii) Room ceiling height
(viii) Number of persons likely to use the room
(ix) Miscellaneous heat loads such as wattage of lamps, radio, television, computer and etc.

A line diagram of air circuit is shown in Fig. 6.1.

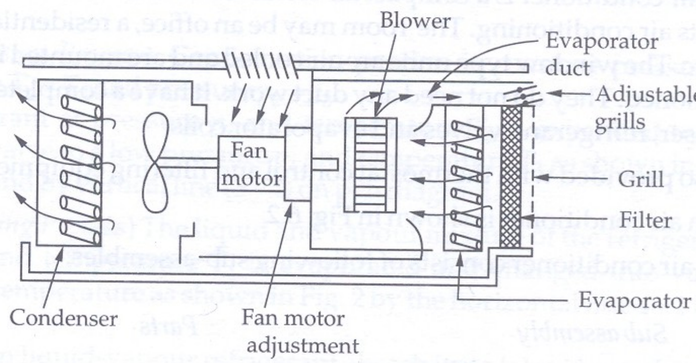


Fig. 6.1

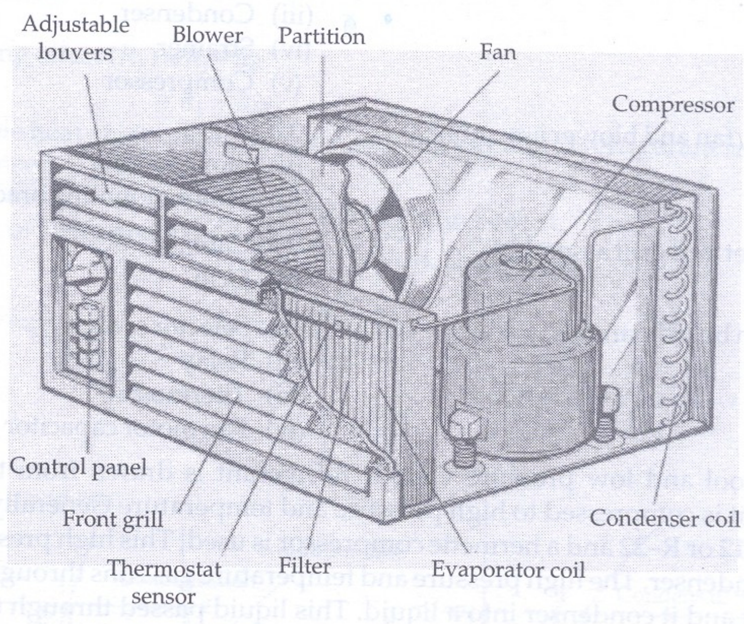


Fig. 6.2

EXPERIMENT NO. 7

Aim: To study the constructional features and working of Pelton Wheel Turbine, Francis Turbine and Kaplan Turbine.

Apparatus: Model of Pelton Turbine, Francis Turbine and Kaplan Turbine.

THEORY:

Pelton Turbine

A pelton turbine is shown in Fig. 7.1. Pelton turbine is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the intel of the turbine is only kinetic energy.

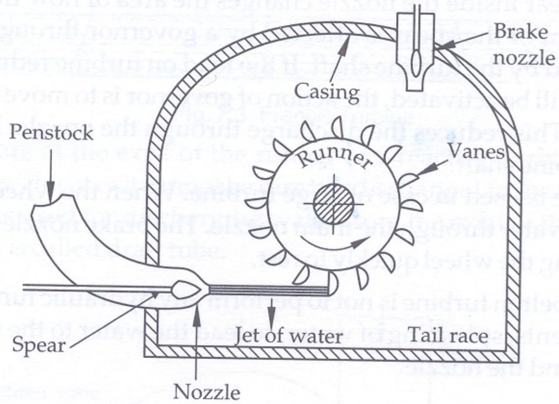


Fig. 7.1 Pelton Turbine

Water from the reservoir is brought to the turbine through penstocks, at the end of which a nozzle is fitted. The nozzle converts whole of the available head into the kinetic head in the form of a high velocity jet. The jet strikes the buckets mounted on the rim of a wheel called *runner*. The force of jet causes the runner to rotate and mechanical power is produced. In the end, the water goes to the tail race.

Number of nozzles depends upon specific speed. However, maximum number of nozzles can be up to 6.

Components of a Pelton Turbine

(1) Runner with Bucket: The runner of a pelton turbine consists of a number of double cupped buckets fixed to the periphery of the wheel. Each bucket has a sharp edge at the centre called the splitter. The jet strikes each bucket at this splitter and is divided into two sides, thus avoiding any unbalanced thrust on the shaft. It is shown in Fig. 7.2.

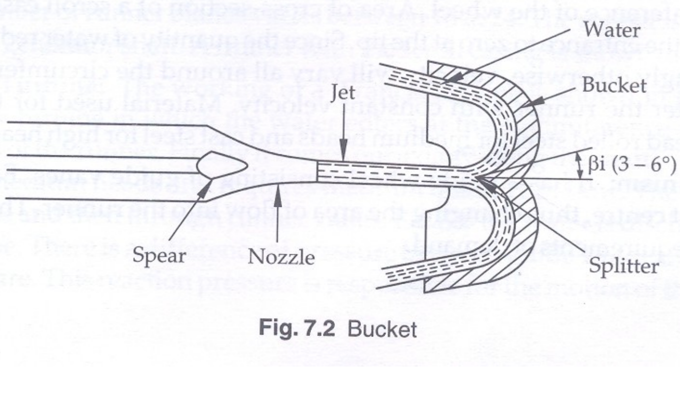


Fig. 7.2 Bucket

To get full reaction of the jet, it has to be turned through 180° by the bucket. But then, the jet may strike the incoming bucket retarding the speed of the runner. Therefore, the angle through which the jet is turned is kept between 160° to 170°. Average value is taken as 165°.

The bottom portion of the buckets is usually cut which also facilitates the jet to pass through the succeeding bucket.

Material for bucket is cast Iron for low head plant and cast steel, stainless steel and bronze for medium and high heads. The buckets are either cast integral with the wheel or bolted to the rim.

Bolted arrangement is preferred as the damaged bucket can be easily replaced.

(2) Nozzle with guide mechanism: The function of the nozzle of a pelton wheel is to convert the available pressure energy into high velocity energy in the form of jet. The quantity of water required is proportional to the load on the turbine. Therefore, to control the flow through the nozzle, some sort of a regulating or a governing mechanism is necessary. This is generally done by using a spear inside the nozzle.

The movement of spear inside the nozzle changes the area of flow through it, thus varying the discharge. The movement of the spear is affected by a governor through a servomechanism. The governor itself is operated by the turbine shaft. If the load on turbine reduces and the runner tries to speed up, the governor will be activated, the action of governor is to move the spear into the nozzle to reduce the area of flow. This reduces the discharge through the nozzle. Reverse will happen if the load increases on the turbine shaft.

A small brake nozzle is used in case of large turbine. When the wheel is to be stopped, besides cutting off the supply of water through the main nozzle. The brake nozzle also directs the water on to the back of buckets to bring the wheel quickly to rest.

(3) Casing: Casing of a pelton turbine is not to perform any hydraulic function. However, a casing is necessary to avoid accidents, splashing of water, to lead the water to the tail race and to support the housing for the bearing and the nozzle.

Reaction Turbine

Reaction turbine is a pressure turbine *i.e.* the water enters the wheel under pressure after passing through the guide vanes. At the outlet of turbine, the pressure is atmospheric or below atmospheric if the discharge is taken through a draft tube into the tail race. Owing to this difference of pressure, the water flows through the vanes of the turbine towards the outlet. The difference of pressure between guide vanes and runner called reaction pressure is responsible for the motion of the runner. Therefore, such a turbine is called reaction turbine.

A reaction turbine operates under pressure and has more pressure at the inlet than at the outlet.

Francis Turbine

A Francis turbine has the following main components:

(1) Penstock: It is the water ways used to carry the water from the reservoir to the turbine.

(2) Scroll casing: It is the casing around the turbine wheel and it equally distributes the water around the circumference of the wheel. Area of cross-section of a scroll casing reduces uniformly from maximum at the entrance to zero at the tip. Since the quantity of water reduces from maximum to zero correspondingly otherwise, velocity will vary all around the circumference of the wheel and water will not enter the runner with constant velocity. Material used for the casing is generally concrete for low head rolled steel for medium heads and cast steel for high heads.

(3) Guide Mechanism: It has a guide wheel consisting of guide vanes. Each guide vane can be moved on its pivot centre, thus changing the area of flow into the runner. This regulates the flow to meet the varying requirements of demand.

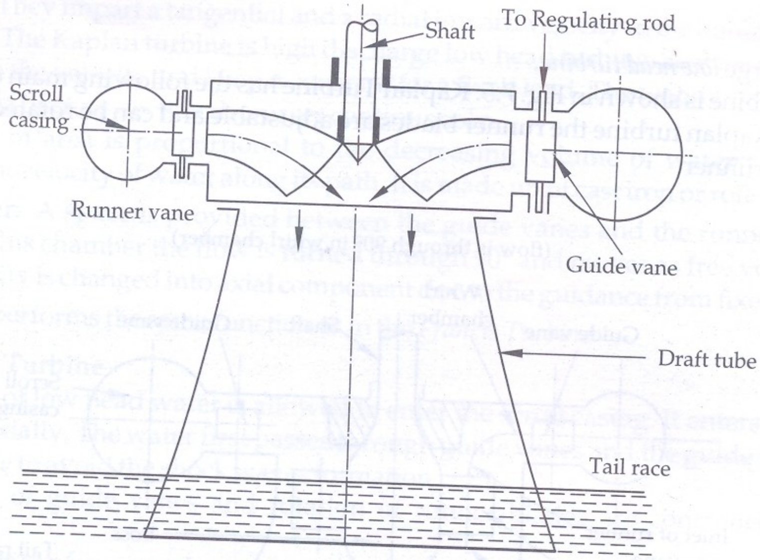


Fig. 7.3 Francis Turbine

(4) Draft tube: The pressure at the exist of the runner of a reaction turbine is generally less than atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exist of the turbine to the tail race. This tube of increasing area is called draft tube.

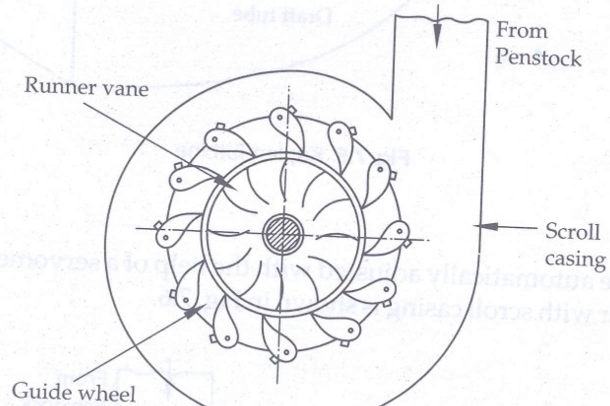


Fig. 7.4 Runner with scroll casing

(5) Runner: The runner of Francis turbine is a circular wheel on which a series of radial curved vanes are fixed. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The number of runner blades varies between 16 to 24. The runner is keyed to the shaft which is coupled to the generator shaft. A runner with the scroll casing is shown in Fig. 7.4.

Working of a Francis Turbine: The working of a Francis turbine is shown in Fig. 7.3. A Francis turbine is a mixed flow turbine in which the water enters at the circumference of the runner and travels towards the axis of the runner. Finally it comes out axially along the shaft.

It operates under medium heads and requires medium quantity of flow. The water first passes through the guide vanes and then through runner vanes. Finally the water is discharged into the tail race through a draft tube. There is a difference of pressure between guide vanes and runner which is called as reaction pressure. This reaction pressure is responsible for the motion of the runner.

Kaplan Turbine

It is a high discharge *low head turbine*.

A Kaplan turbine is shown in Fig. 7.5. Kaplan Turbine has the following main component:

(1) Runner: In Kaplan turbine the runner blades are adjustable and can be rotated about pivot fixed to the boss of the runner.

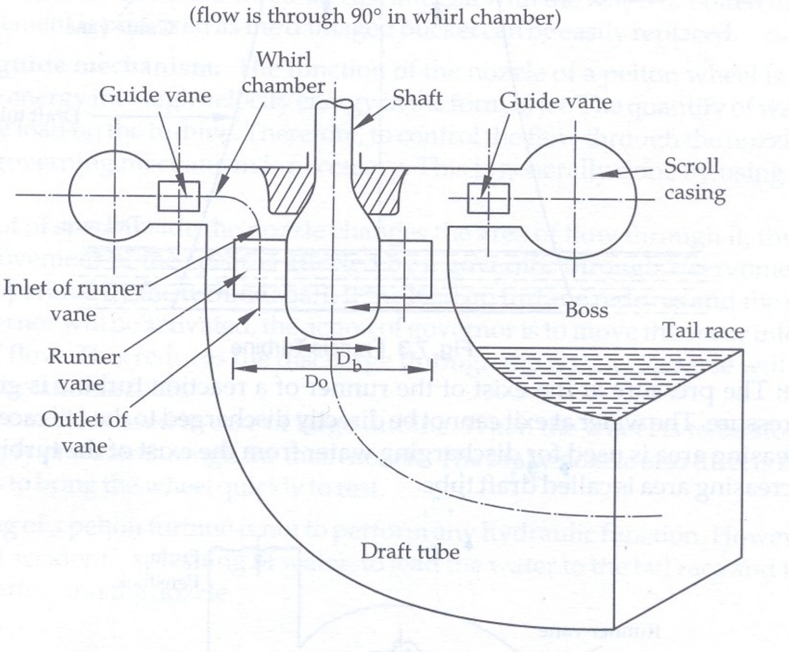


Fig. 7.5 Kaplan Turbine

The runner blades are automatically adjusted with the help of a servomechanism. It is made up of stainless steel. A runner with scroll casing is shown in Fig. 7.6.

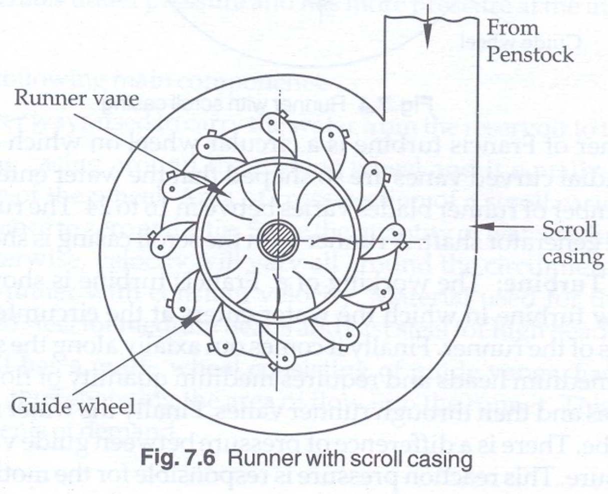


Fig. 7.6 Runner with scroll casing

(2) Guide Vanes: They impart a tangential and a radial inward velocity to the liquid.

(3) Scroll Casing: The Kaplan turbine is high discharge low head turbine. So it needs a scroll casing in order to increase the velocity and keep it constant for a fixed load. The water first enters the spiral casing in which area of cross-section decreases continuously.

The reduction in area is proportional to the decreasing volume of water to be handled. It maintains a constant velocity of water along its path. It is made up of cast iron or rolled steel.

(4) Whirl Chamber: A space is provided between the guide vanes and the runner, it is called as whirl chamber. In this chamber the flow is turned through 90° and moves as free vortex. The radial component of velocity is changed into axial component due to the guidance from fixed housing.

(5) Draft Tube: It performs the same function as in the *Francis Turbine*.

Working of Kaplan Turbine

The high discharge of low head water is allowed to enter the scroll casing. It enters axially into the runner and leaves axially. The water first passes through guide vanes and the guide vanes direct the water at proper angle to avoid the shock waves formation.

The movement of guide vanes and rotation of runner blades are controlled by means of servomechanism.

There is a difference of pressure between guide vanes and the runner which is responsible for the motion of the runner. After passing through the runner the water is discharged to tail race through draft tube.

Experiment No: 8

AIM: - **To study the construction & working of centrifugal pump.**

Apparatus used: - Model of centrifugal pump.

THEORY:- A Centrifugal pump is rotodynamic or dynamic pressure pump where the working fluid or liquid or liquids is subjected to whiling motion by means of backward curved blades mounted on a wheel called impeller. A centrifugal pump is named so, because the energy added by the impeller to the fluid is largely due to centrifugal effects. The liquid enters the impeller at its centre called the eye of the pump and the impeller discharge the liquid into the casing surrounding the impeller. The developed pressure head is purely due to the whirling motion of the liquid imparted by the rotating impeller and is not due to any displacement or impart.

A layout of a centrifugal pump is shown in Figure.

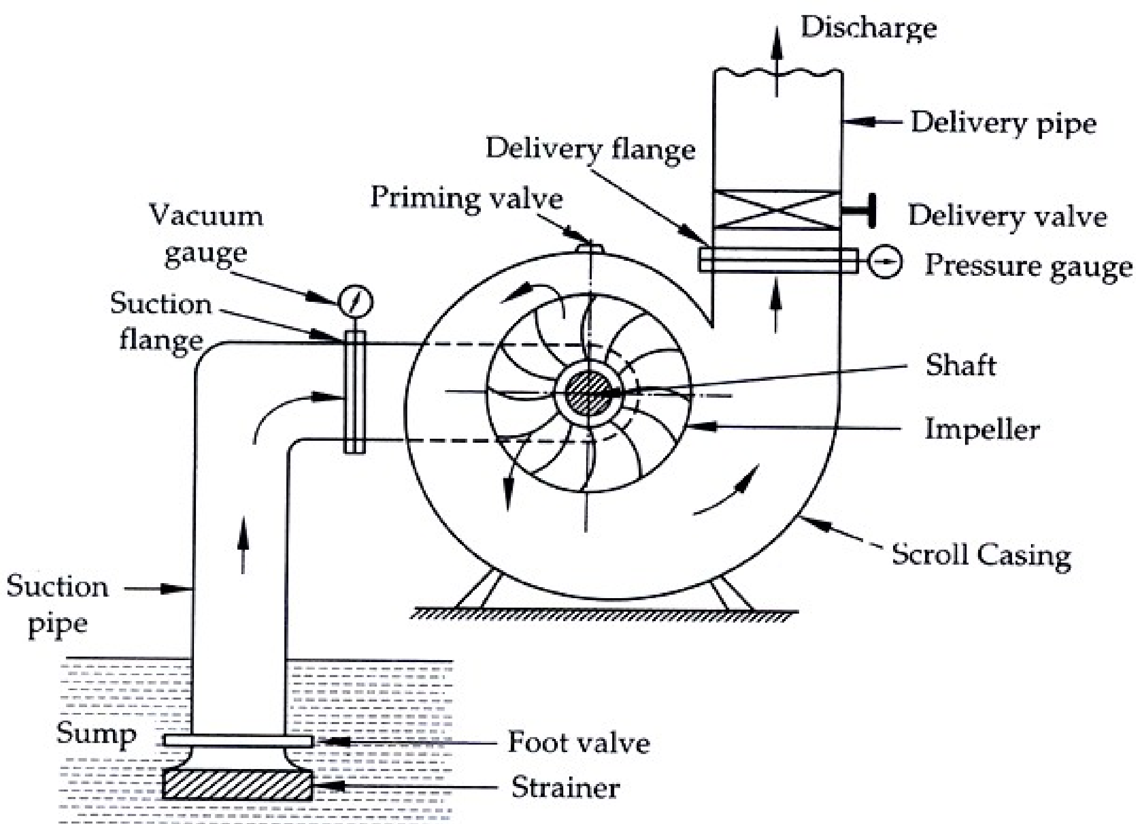


Fig. Centrifugal Pump

The main components of a centrifugal pump are:

1. Strainer and foot valve
2. Suction pipe
3. Pump (A) Impeller (B) Casing
4. Delivery valve
5. Delivery pipe

1. ***Strainer and foot valve:*** It is fitted at one end of the suction pipe and is submerged in water in such a way that it is always a few meters above the surface of water from the sump enters the suction pipe through the strainer and foot valve.

Foot valve is a non return valve i.e. it does not allow the water to go back to the sump.

2. ***Suction pipe:*** A pipe whose one end is connected to the inlet of the pump and the other end dips into the water in a sump is known as suction pipe. Pipe fitting should be air tight because a pump cannot run if it contains air pockets.

3. ***Pump:*** The pump mainly consists of an impeller and casing. The water enters the impeller at its center, called eye of the pump and impeller discharges water into the casing.

(A) ***Impeller***: The rotating wheel of a centrifugal pump is called impeller. It has a number forward curved or backward curved blades, depending upon whether it is a slow speed or a high speed impeller. When the impeller rotates, a negative pressure (lower than the atmospheric pressure) is created near the eyes of the pump and water enters the impeller. The pressure head created by the centrifugal action is entirely due to the velocity imparted to water by the rotating impeller, and not due to any displacement or impart.

(B) ***Casing:*** The casing of a centrifugal pump is similar to the casing of a casing of a reaction turbine. It is an air tight passage surrounding the impeller and is designed in such a way that the K.E. of the water discharged at the outlet of the impeller is converted into pressure energy before the water leaves the casing and enters the delivery pipe.

Volute casing is used for single stage pump and diffuser casing for multistage pumps.

4. ***Delivery valve:*** The delivery valve connects the pump outlet and the delivery pipe. It remains closed before the pump is switched on. When the

pump builds up its pressure, it is opened and can be used to control or vary the discharge.

The delivery valve is closed again before the pump is switched off so that the delivery pressure is not transmitted to the suction pipe.

5. ***Delivery pipe:*** A pipe whose one end is connected to the outlet of the pump and delivery the water at a required height is known as delivery pipe.

<u>WORKING OF A CENTRIFUGAL PUMP:-</u>

To start the pump priming is the first step for the working of pump. The priming is the operation of filling the suction pipe, casing of the pump, and the portion of the delivery pipe up to the delivery valve, so that no air pocket is left. The presence of a small air pocket may hamper the working of pump as the density of air is usually very low compared to liquid being pumped.

The centrifugal action developed is directly proportional to the density of fluid in contact with impeller, the presence of air result in negligible pressure rise, so no liquid will be lifted up by the pump. This makes the priming an essential step before starting pump.

The second step is the revolution of the pump impeller inside a casing full of water to produce a forced vortex which is responsible for imparting a centrifugal head to water. For this purpose the delivery valve is still kept closed to reduce starting torque and the electric motor is started to rotate the impeller. The delivery valve is opened when the pressure of the liquid surrounding the impeller is considerably increased. The rotation of the impeller also cause a reduction of pressure at the center, due to which the water in suction pipe rushes into the eye to replace the liquid which is being discharged from the entire circumference of the impeller.

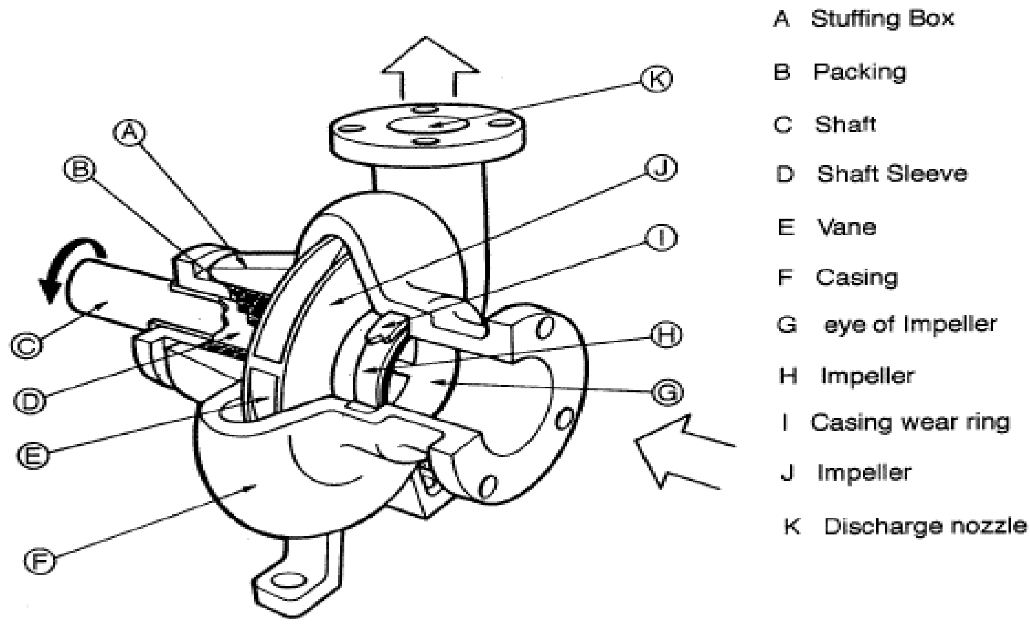


Figure: Cut-away view of a centrifugal pump.

Experiment No: 9

AIM: - To study the working of single plate clutch.

Apparatus: - Model of single plate clutch.

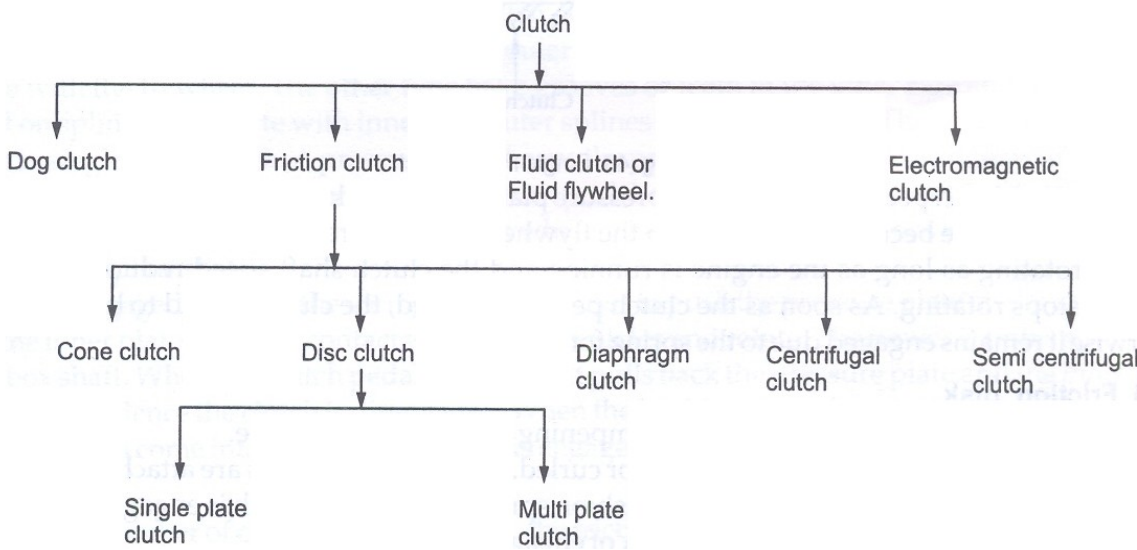
THEORY:-

Clutch:-

It is a device which disconnects the engine from the rest of the transmission and enables the engine to run without moving the vehicle.

Types of clutch:-

Clutch can be classified bellows:



SINGLE PLATE CLUTCH:-

It is the most common type of clutch used in motor vehicles. Basically, it consists of only one clutch plate, mounted on the splines of the clutch shaft, as shown in Figure. The flywheel is mounted on the engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs, and is free to slide on the clutch shaft when the clutch pedal is operated. When the clutch is engaged, the clutch plate is gripped between the flywheel and the pressure plate. The friction linings are on both the sides of the clutch plate. Due to the friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As the clutch plate revolves, the clutch shaft also revolves. Clutch shaft is connected to the transmission (i.e. Gear box). Thus the engine power is transmitted to the crankshaft to the clutch shaft.

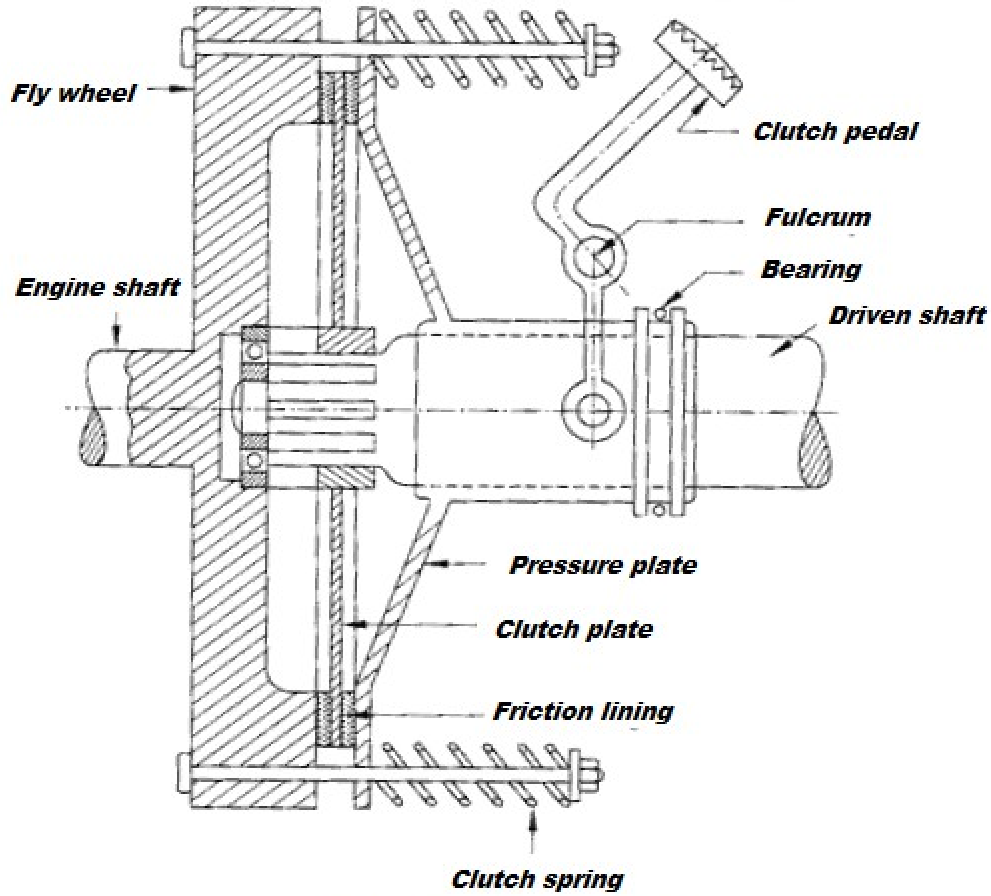


Figure- Single Plate Clutch

When the clutch pedal is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus, the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces.

Experiment No: 10

AIM: - **To study different type of gears used for power transmission.**

Apparatus: - Model of different types of gears.

THEORY:-

GEAR: - The gear is defined as a toothed element which is used for transmitting rotary motion from one shaft to another. When teethes are provided on its internal surface, known as internal gear or annular wheel. When teethes are provided on its external surface, known as external gear.

TYPES OF GEAR AND THEIR APPLICATIONS:

The gear can be classified in the following ways:

1. According to the position of axes of the shafts:

a) Parallel shafts

b) Intersecting shafts

c) Neither parallel nor intersecting shafts

a) Gear for connecting parallel shafts: The gear used to connect the shaft in which their axes of rotation are parallel to each other are-

I. ***Spur gears:*** The gear used to connect two parallel shafts and having straight teeth which are parallel to the axis of the wheel are known as spur gears. They impose only radial loads. These are slow speed gears. If noise is not a problem, these can be used for any speed. The most usual arrangement is an external gear and pinion combination. If centre distance is to be reduced, the internal gear with external pinion combination is also used. Gears rotate in opposite direction in case of external gearing and in same direction in case of internal gearing. Figure show the spur gears. These are generally used in lathes for speed change mechanism.

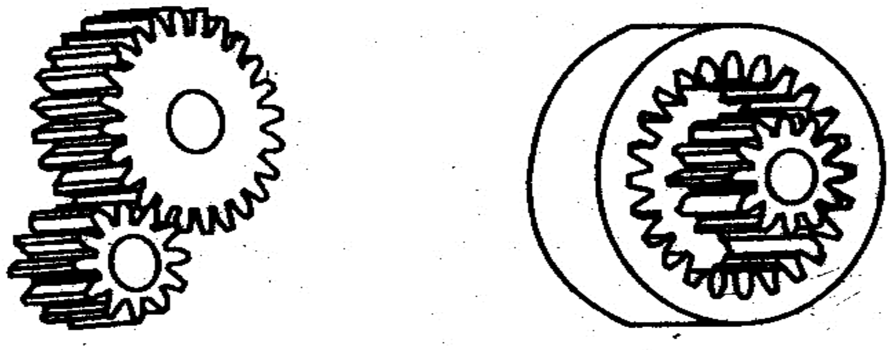


Fig. Spur gears

II. ***Spur Rack and pinion:*** Spur Rack is a special case of a spur gear. It has infinitely large pitch diameter. The spur rack and pinion combination converts rotary motion into translator motion or vice-versa. Figure shows the rack and pinion.

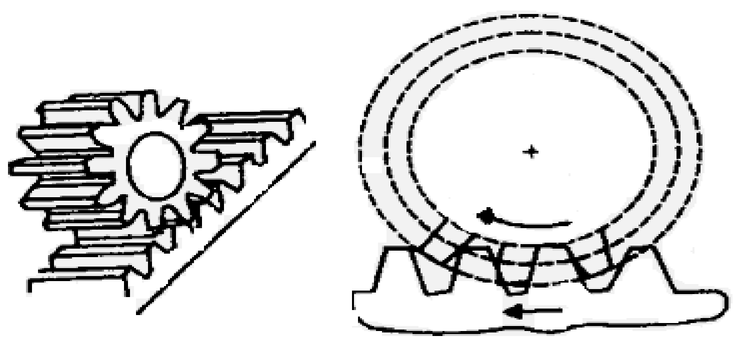


Figure- Rack And Pinion

III. ***Helical gears:*** Figure shows the helical gear. In helical gears, teeth are inclined to the axis of the shaft and are in form of helix. Two meshing gears have the same helix angle but have teeth of opposite hands i.e. a right hand pinion meshes with a left hand gear and a left hand pinion meshes with a right hand gear. These gears are considered for high speed and can take higher loads as compared to equal size spur gear.

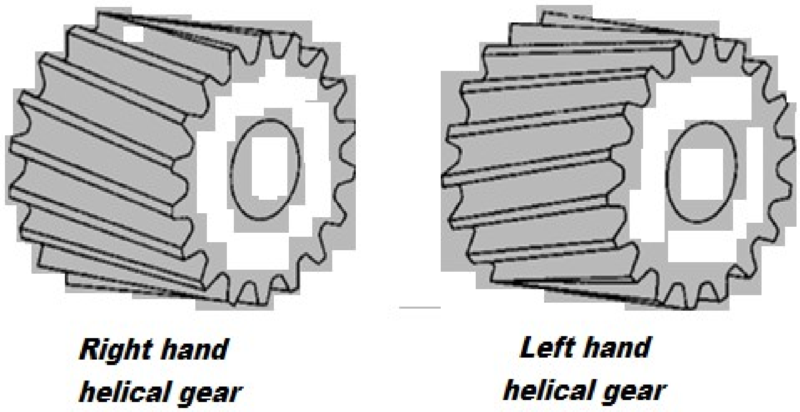


Figure- Helical Gear

Single helical gears impose both radial and thrust loads on their bearings.

IV. ***Double helical gears:*** These gears have two sets of opposite helical teeth i.e. one has right handed helix and other a left handed helix. The teeth of two rows are separated by a groove used for tool run-out. These can be run at higher speeds without noise and vibrations. There is no axial thrust on the bearing. Double helical gear is shown in figure.

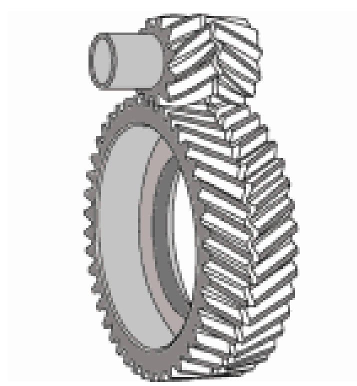


Figure- Double Helical Gear

V. ***Herring bone gears:*** These gears are shown in figure. These are essentially the same as the double helical gears but in these gears, there is no space separating the two opposed sets of helical teeth. These are used in turbines.

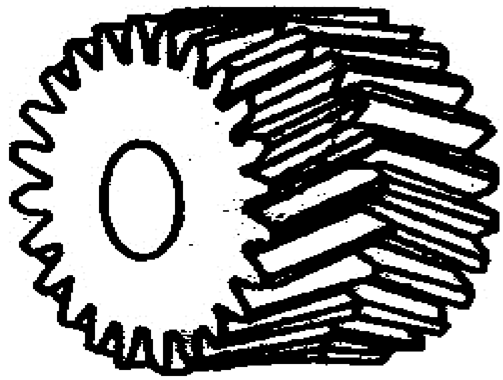


Figure- Herringbone Gears

b) Gears for connecting intersecting shafts: The gears used to connect two intersecting shafts are known as bevel gears.

If the teeth on the gears are straight radial to the point of intersection of shaft axes then gears are known as straight bevel. But if teeth are inclined then gears are known as helical bevel (or spiral bevel).

I. ***Straight bevel gears:*** Figure shows the straight bevel gears. In straight bevel gears, teeth are straight, radial to the point of intersection of the shaft axis. There is variation in cross-section throughout their length. Although they are made for a shaft angle of 90°, can be produced for almost any angle. Straight bevel gears make the line contact similar to spur gears. These can be internal bevel gears also similar to internal spur gears. Two such gears of the same size with shaft angle of 90° are known as mitre gears.

II. ***Spiral bevel gears:*** In these bevel gears, the teeth are inclined. These are most suitable for high speeds. These can run more quietly and can take up more load than straight bevel gears, but the thrust loads are greater. These are used for the drive to the differential of an automobile. Spiral bevel gear is shown in figure.

Figure- Straight Bevel Gear ***Figure- Spiral Bevel Gear***

c) Neither parallel nor intersecting shafts: The axis of such shafts crosses in space. The shaft which lies in parallel may skewed at any angle between 0° and 90°. The following main types of gears are used between such shafts:

I. ***Spiral gears:*** These are also called crossed helical gears. There is no difference between these gears and helical gears until they are mounted in mesh with each other. A pair of meshed crossed helical gears usually has the same hand. The teeth of these gears have point contact with each other and are used for low loads.

II. ***Hypoid gears:*** these are similar to spiral bevel gears with the difference that the axes of the shafts do not intersect. The term 'offset' is the distance between a hypoid pinion axis and the axis of the hypoid gear. Hypoid gears become spiral bevel gears, if the offset is zero. The shafts angle is usually 90° but other angles are not possible. The tooth action between such gears is a combination of rolling a sliding along a straight line. Hypoid gear is shown in figure.

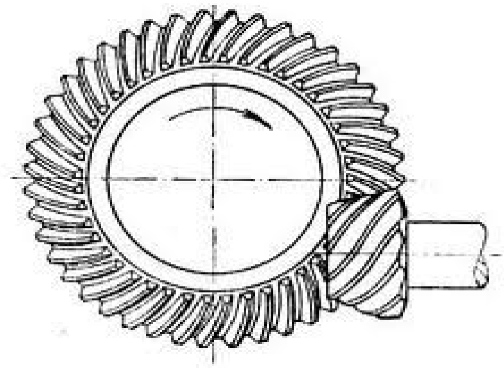


Figure- Hypoid Gear

III. ***Worm gears:*** in such gears one gear has screw threads. Due to this factor, they are quiet, vibration free and give a smooth run. These gears are used with shaft angles of 90°, but other angles are not possible.

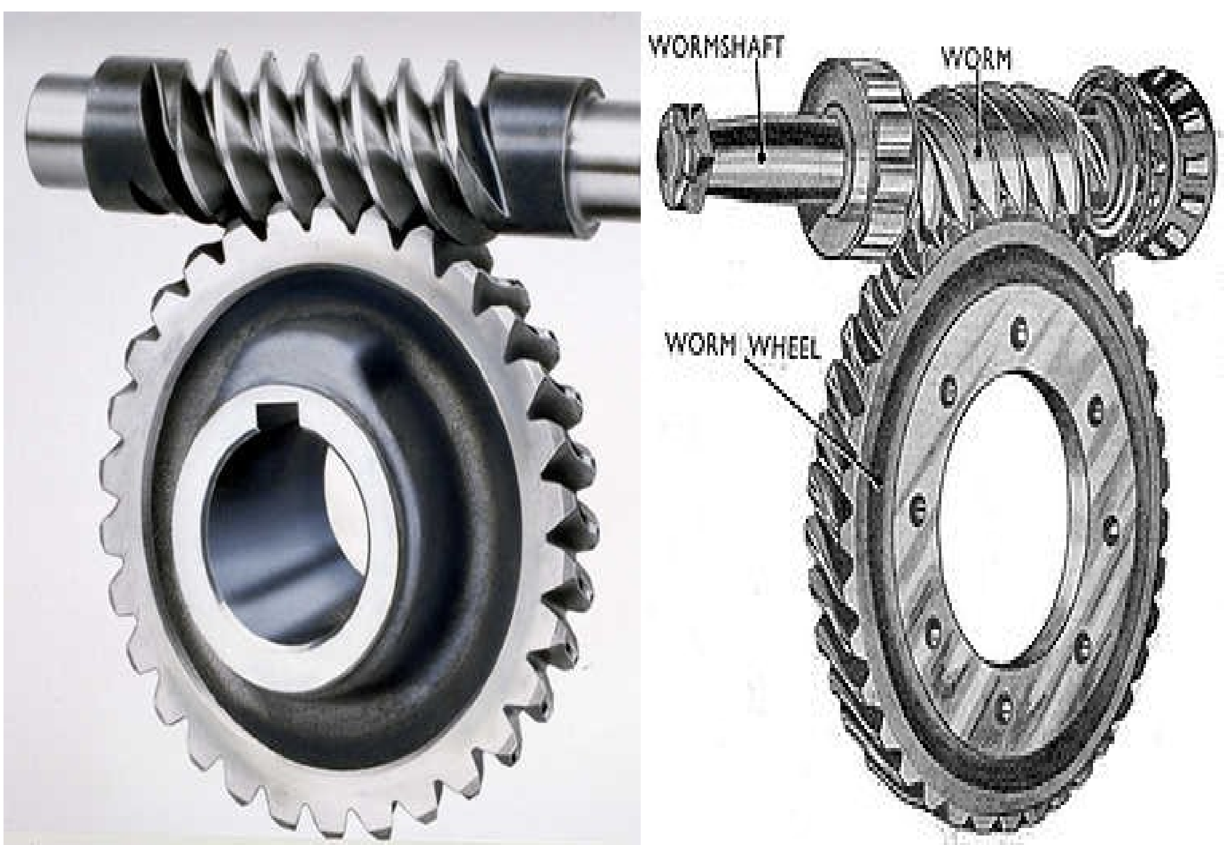


Figure- Worm and Worm wheel

2. According to the peripheral velocity of the gears: The gears may be classified on the basis of peripheral velocity as;

a) ***Low velocity***: The gears having velocity less than 3m/s are known as low velocity gears.

b) ***Medium velocity:*** The gears having velocity between 3m/s to 15 m/s are known as Medium velocity gears.

c) ***High velocity:*** The gears having velocity more than 15 m/s are known as High velocity gears.

3. According to the types of gearing: The gears, according to the type of gearing may be classified as:

a) ***External gearing:*** In this case the teeth are provided on the external surface. When the gears of the two shafts mesh externally with each other, it is known as external gearing. In this case the motion of the two gears is always opposite. The gear is known as spur wheel and smaller is known as pinion. External gearing shown in figure.

b) ***Internal gearing:*** In this case, the teeth are provided on its internal surface. Figure shows the internal gearing, in which the gears of two shafts mesh internally with each other. The larger wheel is known as annular wheel while the smaller wheel pinion. The motion of the two gears is always same.

c) ***Rack and pinion:*** Spur Rack is a special case of a spur gear. It has infinitely large pitch diameter. The spur rack and pinion combination converts rotary motion into translatory motion or vice-versa.

4. According to the shape of teeth of the gears: The gears may be classified as:

a) ***Straight teeth gears:*** Spur gears have straight teeth.

b) ***Inclined teeth gears:*** Helical gears have inclined teeth (which are inclined to the wheel rim surface).

c) ***Curved gears:*** Spiral gears have the curved teeth over the rim surface.