EXPERIMENTS IN ELEMENTS OF MECHANICAL

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DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT : ELEMENTS OF MECHANICAL ENGINEERING

SUBJECT CODE: 110006

INDEX

EXPERIMENT NO. 1

Introduction to Steam Boilers

AIM: To introduce the types of steam boilers.

OBJECTIVE: To study different types and classification of steam boilers.

THEORY:

Boiler: It is a closed vessel in which the heat produced by the combustion of fuel is transferred to water for its conversion into steam at the desired temperature and pressure.

Broadly speaking, boiler is a device used for generating,

- Steam for power generation
- Hot water for heating purpose

Classification of Boilers:

The boilers may be classified as under:

- **<u>According to the direction of the axis of the boiler shell:</u>**
  1) **Horizontal Boiler:** If the axis of the boiler is horizontal, it is called the horizontal boiler.
     Example: Lancashire boiler, Locomotive boiler.
  2) **Vertical Boiler:** If the axis of the boiler is vertical, it is called the vertical boiler.
     Example: Cochran boiler.
  3) **Inclined Boiler:** If the axis of the boiler is inclined, it is known as inclined boiler.
     Example: Babcock & Wilcox boiler.
- **<u>According to the tube content:</u>**
  1) **Fire Tube Boiler:** The boilers in which the hot gases are inside the tubes and the water is surrounding the tubes is called fire tube boiler.
     Example: Lancashire boiler, Locomotive boiler, Cochran boiler.
  2) **Water Tube Boiler:** The boiler in which the water is inside the tubes and the hot gases surround them is called water tube boilers.
     Example: Babcock & Wilcox boiler, Sterling boiler.
- **<u>According to the furnace position:</u>**
  1) **Externally Fired Boiler:** In the boiler if the fire is outside the shell, that boiler is known as externally fired boiler.
     Example: Babcock & Wilcox boiler.
  2) **Internally Fired Boiler:** In the boiler in which the furnace is located inside the boiler shell, it is known as internally fired boiler.
     Example: Cochran boiler, Lancashire Boiler.
- **<u>According to the circulation of water:</u>**
  1) **Forced Circulation Boiler:** In the boilers if the circulation of water is done by a pump, then they are known as forced circulation boilers.
     Example: Velox boiler, La-Mont boiler.
  2) **Natural Circulation Boiler:** In the boiler if the circulation of water takes place due to difference in density resulting from difference in temperature, it is known as natural circulation boiler.
     Example: Babcock & Wilcox boiler, Lancashire boiler.

- **According to the working pressure:**
  1) **High pressure Steam Boiler:** If the working pressure of the boiler is more than 25 bar, the boiler is known as high-pressure steam boiler.
     Example: Babcock & Wilcox boiler.
  2) **Low Pressure Steam Boiler:** If the working pressure of the boiler is between 3.5 to 10 bar, the boiler is known as low-pressure steam boiler.
     Example: Cochran boiler, Cornish boiler.
  3) **Medium Pressure Steam Boiler:** If the working pressure of the boiler is between 10 to 25 bar, the boiler is known as medium pressure steam boiler.
     Example: Lancashire boiler, Locomotive boiler.
- **According to the use:**
  1) **Stationary Boilers:** The boilers, which cannot be transported easily from one place to another, are called stationary boilers.
     Example: Lancashire boiler, Babcock & Wilcox boiler.
  2) **Portable boilers:** The boilers which can be easily transported (moved) from one place to another are called portable boilers.
     Example: Locomotive boiler.
- **According to the number of tubes:**
  1. **Single Tube Boiler:** The boiler having only one fire tube or water tube is called single tube boiler.
     Example: Cornish boiler.
  2. **Multi Tube Boiler:** The boiler having two or more fire or water tubes for the circulation of hot gases or water are called multi tube boiler.
     Example: Lancashire boiler, Locomotive boiler, Babcock & Wilcox boiler, Cochran boiler.

REFERENCES:

- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
- Elements of Mechanical engineering by Prof.S.M.Bhatt,Shri H.G.Kataria,Shri J.P.Hadiya Books India Publication
- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. Define boiler & give the classification of boilers.(Just Name & Example)

2. State the applications of steam boilers.

3. State the differences between boilers used for power generation and for process heating.

4. Give the merits & demerits of fire tube boiler & water tube boiler.

5. List the specification criteria for a typical boiler.

6. What are the primary requirements of boiler for it's functioning?

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 2
Study of various types of boilers

AIM: To study various types of boilers like Cochran boiler, Lancashire boiler, Locomotive boiler, Babcock and Wilcox boiler.

OBJECTIVE: To study the working and constructional features of Cochran boiler, Lancashire boiler, Locomotive boiler, Babcock and Wilcox boiler.

COCHRAN BOILER

Specifications:

- Shell Dia =2.75 m
- Height = 5.75 m
- Working pressure=6.5 bar (max=15bar)
- Steam capacity=3500 kg/hr (max=4000kg)
- Heating section area=120 m^2
- Efficiency=70-75%

Characteristics:

- Vertical
- Portable
- Fire-tube
- Multi-tube
- Internally fired
- Natural circulation
- Solid as well as liquid fuel can be burnt

Working:

- The water is feed into boiler through feed check valve.
- Level is adjusted to help of water level indicator.
- Coal is added trough a fire hole to grate and then burnt.
- The hot gases produced are collect in firebox.
- From fire box the gas passes on to the combustion chamber through short flue pipes are to considerable velocity.
- The firebrick lining in the combustion chamber deflects the hot gases to pass through horizontal tubes.
- From here the hot gases through smoke box enter the chimney.
- Water is evaporated and steam is collected at top.
- Steam is then taken out through steam stop valve.

LANCASHIRE BOILER

Specifications:

- Shell diameter = 2 to 3 m (generally 2.74 m)
- Length of shell = 7 to 9 m (generally 9 m)
- Max ^{m} working pr. =16 bar.
- Steam generating capacity = 8000 to 9000 kg/hr.
- Efficiency = 50 to 70 %

Characteristics:

- Horizontal
- Stationary
- Fire – tube
- Internally – fired
- Multi – tube (Two flue tubes)
- Natural circulation of hot gores
- Medium pr.
- Stationary boiler
- It burns solid fuel

Working:

- Water is fed in to shell through feed check valve.
- Water level is adjusted with help of water level indicator.
- Coal is added to grate through fire hole.
- Coal is then burnt.
- Position of damper is adjusted in such a way that necessary air required for combustion of coal be supplied.
- Combustion will produce hot gases, then these hot gases will move along flue tubes.
- They are deflected by firebrick arch.
- They are made to pass all along the length of main flue tubes (MFT).
- At end of MFT they are deflected again and made to pass through bottom flue tubes (BFT).
- At front of shell, the gases in bottom flue tubes (BFT) are divided into two side flue tubes (SFT) and are sent back.
- From side flue tubes (SFT) gases enter into smoke box and finally go to the chimney.
- Gases pass through MFT heats water centrally, from below (BFT) and from sides (SFT) and thus transfer maximum heat to the water.
- Water is then converted into steam.
- Steam is collected in steam collector pipes from where it can be taken out for further use with help of steam stop valve.

LOCOMOTIVE BOILER

Specifications:

- Length of barrel = 5210mm
- Dia. of barrel=2100mm
- Dia of super heater tubes=140mm
- No. of super heater tubes=38
- Dia. of ordinary (fire tubes)=57.2mm
- No. of ordinary fire tubes=116
- Working pressure=14 bar
- Grate area=4.3m^2
- Steaming capacity=9000 kg/hr
- Coal burnt=1600kg/hr
- Efficiency =70%

Characteristics:

- Horizontal
- Fire – tube
- Internally fired
- Forced- circulation
- Medium pressure
- Portable
- Multi-tube boiler

Working:

- H_2O is fed into shall through feed check valve.
- Water level is adjustable with the help of water Level indicator.
- Through fire hole coal is added on grate and coal is burnt.
- Hot gases, then produced by combustion of coal firstly heats water surrounding firebox.
- These gases then passes though horizontal tubes placed in barrel.
- These gases then goes to smoke box.
- Hot gases transfers heat to water surrounding the tubes.
- Due to this heat water is converted in to steam.
- A regulator is provided inside cylindrical dome. This is operated by regulator shaft from engine room by driver.
- This steam is now entering in to header.

- Header is dividing into one is inlet header or saturated steam chamber and second is superheated steam chamber.
- S.P. leads the steam from regulator to the sat. steam chamber. It then leads steam to super heater tubes.
- After passing through these tubes steam returns back to superheated steam chamber.
- Superheat steam now flows into cylinder.
- The draught is due to exhaust steam from cylinder, which is discharged through exhaust pipe.

Since chimney is short, artificial draught is produced to drive out the burnt gases.
The methods used for this are

a) Motion of locomotive on rails.
b) Periodic rush of spent steam, from engine cylinder into firebox to blast pipe, vacuum thus created sucks hot gases and helps their discharge into atmosphere.
c) Blower is mounted at the inlet of chimney, which is run by steam supplied directly by boiler the blower is operated only when the supply of steam to engine is cut off.

BABCOCK & WILCOX BOILER
Specifications:

- Diameter of the drum = 2000 to 4000 mm
- Length = 6000 to 9000 mm
- Size of water tubes = 76.2 to 101.6 mm
- Size of upper header tubes = 38.4 to 57.1 mm
- Maximum working pressure = 42 bar
- Maximum steaming capacity = 40,000 kg/hr.
- Efficiency = 60 to 80%

Characteristics:

- Horizontal
- Stationary
- Water – tube type
- Multi-tube boiler
- Externally fired
- Having natural circulation of water
- Having forced- circulation of air & hot gases
- Solid as well as liquid fuel fired
- High pressure

Working:

- Water is fed in to shell through feed check value.
- Due to gravity water passes through the vertical tubes, headers & fills up the inclined tube first. The water then collects in boiler shell.
- Water level is adjusted with help of water level indicator.
- Coal is added to trolley grate.
- Coal is then burnt.
- The trolley is then pushed into the fire space.
- In order to provide air for combustion of coal & circulation of hot gases, damper is lowered to the furnace level.
- The baffle plates do not allow hot gases to pass to the right side.

- These gases heat the super heater & then move down. These gases travel in the sine wave form and then move to the smoke-box fitted with a long chimney.
- Water in the upper portion of the tubes is heated and rises up. The cold water from the down take header rises to take its place & water from the boiler drum flows down. Thus the natural circulation of water takes place by placing the water tubes at inclined.
- Till the temperature of water in the tube & in the drum becomes uniform, the circulation of water continues. Finally the water in the upper portion of the tubes is converted into steam.
- It is then collected in the boiler shell.
- The steam collected above the surface of the water in the drum is wet steam. The super heater is used to convert this wet steam into superheated steam.
- The superheated steam is then taken out through the steam stop valve fitted on the top of the boiler for different uses.

REFERENCES:

- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
- Elements of Mechanical engineering by Prof.S.M.Bhatt,Shri H.G.Kataria,Shri J.P.Hadiya Books India Publication
- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS

1. Write the characteristics of a Cochran boiler.

2. Explain the working of Cochran boiler with neat sketch.

3. Write general specifications & characteristics of Babcock & Wilcox boiler.

4. State the mountings & its functions of a Lancashire boiler.

5. Write general specifications & characteristics of locomotive boiler.

6. Why fire grate is inclined in locomotive boiler.

7. Why super heater is used in locomotive boiler.

8. Explain the working of Lancashire boiler with neat sketch of three views.

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 3
To Study of Boiler Mountings & Accessories

AIM: To study different types of boiler mountings & boiler accessories.

OBJECTIVE: To study the function, working and constructional features of boiler mountings & boiler accessories.

THEORY:
The fittings and devices, which are necessary for the safety and control of a boiler, are called Mountings.

According to I.B.R., the following mountings should be fitted to the boilers:

1. Two safety valves.
2. Two water level indicators.
2. A pressure gauge**.**
3. A steam stop valve.
3. A feed check valve.
4. A blow of cock.
5. A manhole.
4. Mud holes or sight holes.
3. Fusible plug.

Water Gauge
It indicates water level in the boiler. It consists of a glass tube, two gunmetal tubes & three cocks. The ends of the glass tube that passes through the stuffing boxes are connected with two metal tubes having flanges at their ends for bolting to the boiler. The water of the boiler comes into the glass tube through the lower tube and the steam through the upper tube. The water then stands in the glass tube at the same level as in the boiler. Two cocks are used to control the passage of between the boiler and the glass tube while the third cock is in used to discharge some of the water from inside the boiler to see whether the gauge is in proper order or not. The glass tube is protected by means of a cover, made of specially toughened glass, which will prevent any accident that may happen due to breaking of glass tube. It is used for ordinary boilers.

Pressure Gauge
Function: The function of the pressure gauge is to measure the pressure exerted inside the vessel. Construction: This gauge is generally fitted on the front side of the boiler shell. It is fitted to the steam space with the help of an inverted siphon.
It consists of a Bourdon's spring tube ABC. It is made of copper and bent into circular shape. This tube has an elliptical section. The end A of the tube is plugged. The other end C is connected to the hollow block E. The block E has a small opening for the entrance of steam or water from the boiler. The end A is connected to the link R. This is pivoted at H. This carries a toothed sector. This can swing about H. The small pinion meshes with this sector. Pinion carries a pointer P fitted on its spindle. To indicate pressure of steam inside the boiler, this pointer moves on a graduated dial or scale. The pressure gauge components are enclosed in a circular dial casing.
Working: The pressure gauge is connected with the boiler's steam space through a U-tube siphon. The U-shaped pipe contains water, which fills the Bourdon tube. The pressure of the steam acting through the water on the inside of the tube tries to make the tube circular. One end is fixed, the free end moves. Because of pinion & gear arrangement, the slight movement

of the Bourdon tube is magnified considerably and the point gives a maximum deflection, which can be read on the scale.

Steam stop valve

Function: The function of the steam stop valve is to regulate the flow of steam from one steam pipe to the other or from the boiler to the steam pipe. The steam stop valve when directly mounted on the steam space of the boiler shell & connected to the steam pipeline which supplies steam to the prime mover is called a junction valve.

Working: When the hand wheel is turned in anticlockwise direction, the spindle is raised up. This will raise the valve from its seat. Thus a passage for the steam from the clearance between the valve and the valve seat is formed. In order to lower the valve, the hand wheel is rotated in clockwise direction. This rotation will close the passage for steam. Adjusting the position of the valve based on the requirements can regulate this. Under the normal working condition, the valve is open and the steam flows from the boiler to the steam pipe.

Feed check valve

Function: It is used to control the supply of water to the boiler & to prevent the escaping of water from the boiler when the pump pressure is less or pump is stopped.

Working: Under normal working condition, the pressure on the feed pump side (connected to elbow) is more than the boiler side pressure. This pressure difference lifts the check valve. To allow the feed water to enter the boiler, the feed valve is lifted manually. Hence, the feed water may enter the boiler. In order to control the supply of feed water to the boiler, the position of the feed valve is controlled. In the event of failure of feed pump, the pressure on the water sump side reduces. The check valve will be closed because of higher steam pressure. This will prevent the back flow of water from the boiler to the water sump. The check valve is to be replaced if it does not give satisfactory results. The stuffing box is provided in the valve to stop the leakage at the spindle.

Blow off cock valve

Functions:

- To discharge a portion of water when the boiler is in operation to blowout mud, scale or sediment periodically.
- To empty the boiler, when necessary for cleaning, inspection & repair.

It is fitted on the boiler shell directly or to a short branch at the lowest part of the water space. This pipe is known as blow-down pipe.

Working: In order to operate the valve, the rectangular slot is brought in line with the passage of the body. This is possible by rotating the plug with the help of wheel. When the slot is placed in this position, the cock is opened and all the impurities, mud, sediments etc. Start flowing out of the boiler and they are removed. When the slot is brought at right angles to the passage of the body, the cock is closed.

Fusible Plug

Function: Its function is to protect the boiler against damage due to over heating for low water level. It is fitted in the crown of the furnace or firebox at appropriate place.

Construction: It consists of a hollow gunmetal body. This body is screwed into the firebox crown. The body has a hexagonal flange. This is used to tighten the body into the shell. A gunmetal plug having a hexagonal flange is screwed into the gunmetal body. The hollow gunmetal plug is fitted in another gunmetal plug. These two plugs are separated by an annulus of fusible metal.

Working: In the normal working conditions of the boiler, the fusible plug is fully submerged under water. This is so because under normal condition, proper water level is maintained & can be checked by water level indicator. Under the circumstances, the heat from the fusible plug is being conducted to water. This keeps the fusible metal at an almost constant temperature, much below its melting point. When the water level falls below the fusible plug, the plug gets uncovered from water. The upper portion of the plug gets exposed to the steam space. The steam cannot keep the plug cool. This will over heat the fusible metal. The plug falls down along with the fusible metal making a hole. The steam and water, being under pressure immediately reach the firebox and extinguish the fire.

Safety valves

Function: It is a device, attached to the steam space of the boiler shell, which opens automatically to discharge some steam & prevent the steam pressure inside the boiler to exceed.

There are **four types** of safety valves generally fitted on a boiler.

Dead weight safety valve, Lever loaded safety valve, Spring-loaded safety valve, High steam & low water safety valve.

(1) Dead weight safety valve

A valve V is placed upon a valve seat S that is fixed upon a long vertical pipe P having a flange at the bottom for fixing at the top of the boiler. Suspended at the top of the valve is the weight carrier D that carries cast iron rings W. The total weight must be sufficient to keep the valve on its seat against the normal working pressure. When the steam pressure exceeds the normal limit**,** it lifts the valve V with its weight & the excess steam escape through the pipe to the outside. This valve is used only with stationary type of boilers. It is the most elementary type of safety valve. The objection to dead weight safety valve is the heavy weight that has to be carried.

(2) Lever safety valve

The disadvantages of using a heavy weight in a dead weight safety valve are eliminated in a lever safety valve by the use of a lever. The valve rests over the gunmetal seat, which is secured to a block fixed upon the boiler. One end of the lever is hinged while the other end carries a weight. The thrust of the lever with its weight is transmitted to the valve by a short strut. When the steam pressure exceeds the normal limit, it lifts the valve & the lever with its weight. The excess steam will thus come out of the boiler. It is suitable for stationary boilers.

(3) Spring loaded safety valve

There are various types of spring-loaded safety valves in use of which a locomotive safety valve is described here. This is also called a Rams bottom safety valve. It consists of a cast iron body with 2 branch pipes. Two separate valves are placed over the valve sittings, which are secured to the top of the branch pipes. A lever is placed over the valves by means of two pivots. The lever is held tight at its proper position by means of a spring, one end of which is

connected with the lever while the other end with the body of the valve. When the steam pressure exceeds the normal limit, the valve rises up against the action of the spring & the steam escapes out. For testing, the valve may be opened by pulling the lever in the downward direction. Spring-loaded safety valves are now widely used for stationary & non-stationary boilers.

(4) High steam and low water safety valve

The valve is generally used at the Cornish or Lancashire boiler. It allows the steam to escape when the steam pressure exceeds the working pressure or when the water level falls below the normal level. So this is a combination of 2 valves used for 2 purposes. The valve V rests on a valve seat & the valve U loaded with the weight W_2 rests on the valve V. When the steam pressure exceeds me normal limit, the valve along with the valve U raises up against the thrust of the lever, & excess steam escapes out. Inside the boiler, a lever L is hinged at Ac point F. One end of the lever carries a weight W_1 while the other end has a large earthenware float E. The lever is balanced when the weight E is under the water. But when the water level falls below the normal limit, it is unbalanced & its knife-edge K pushes the collar C that is fixed to the valve U having a weight W_2. The valve U raises with the weight W_2 & the steam escapes through a specially constructed passage causing a loud noise.

Boiler accessories: These are the appliances, which are installed with a boiler in its neighboring area. The function of boiler accessories is to increase the efficiency of the boiler. The following boiler accessories are generally used.

- Economizer
- Super heater
- Air preheater
- Steam separator
- Steam trap
- Boiler Feed Pump
- Injector

Economizer

A device, which utilizes the waste heat, carried by the exhaust gases before leaving the boiler through chimney or exhaust steam or utilized steam for heating feed water is called feed water heater or economizer. It is generally used for stationary boilers.

It consists of a large no. of vertical cast iron pipes which are connected with 2 horizontal pipes, one at the top & the other at the bottom. The feed water is pumped into the economizer through the bottom pipe. From the bottom pipe the water comes into the top pipe through the vertical pipes & finally comes into the boiler. The water is allowed to pass in a direction opposite to that of the furnace gas.

At the rear end of the vertical pipes, a blow-off valve is fitted through which any mud or sediment deposited in the bottom boxes may be discharged. The soot of the flue gases deposits on the outer surface of the vertical pipes & this reduces the efficiency of the boiler. A system of scrapers is, therefore, adopted to clean the outer surface of vertical pipes. Each vertical pipe is fitted with a scraper which moves up & down automatically & continuously by means of a gear & belt arrangement. A safety valve is also provided at the end of the pipe for the safety of the pipes.

Super heater

The function of a super heater is to increase the temperature of steam with the supply of additional heat. They are located in the path of the furnace gases so that heat is recovered by the super heater from the exhaust gases.

It consists of 2 mild steel boxes or headers. Group of solid drawn steel tubes bent to U form is hanged from the headers. The ends of these tubes are expanded into the headers. C & D are external & internal covers. For inspection & cleaning, the space is provided between the headers. The covers close this space. Any tube may be taken out & replaced without disturbing the super heater the branches on the headers for the inlet & outlet of the steam are forged on the headers. The steel flanges have been screwed on to the header. A balanced damper is provided in the super heater to prevent the overheating of the super heater tubes. The handle operates this damper. By turning the damper upwards into the vertical position the gases pass directly into the bottom flue without passing over the super heater tubes. By placing the damper in intermediate position, part of the gases will go over the super heater tubes & the remaining will pass directly to the bottom flue. Varying degrees of superheat may be thus, possible to obtain.

Air preheater

The air preheater heats the air before it enters in to the boiler by using the heat of flue gases, which are coming out from the economizer. Now as we suppose supply this preheated air to the boiler it saves some amount of fuel. As we need some amount of heat in removing the moisture from the fuel, the preheated air will supply this heat. Thus that much amount of the heat we have to supply less in to the boiler in form of fuel.

Steam Separator

The steam separators separate the steam and water before the steam enters in to the steam turbine. There is a typical requirement of the steam turbine that the steam, which is entering to it, it should be dry. There should not be any water particles in it.

Steam trap

The steam traps are used in the steam power plant in order to remove the water particles from the steam.

Feed pump

The feed pump increases the pressure of feed water, which is coming out from the condenser. As we all knows the pressure inside the boiler is higher than the atmospheric pressure and the condenser pressure, so the water will not flow from condenser or from atmosphere automatically.
So Because of this we are forced to use the feed pump.

Injector

The injector injects the water in to the boiler. Injectors can be used alternatively in place of feed pumps. As the function of both is same, which is to increase the pressure of feed water in order to enter it in to the boiler.

REFERENCES:

- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
- Elements of Mechanical engineering by Prof.S.M.Bhatt,Shri H.G.Kataria,Shri J.P.Hadiya Books India Publication
- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. What is boiler mounting? Give the examples of boiler mountings.

2. Why accessories are used in boiler? Give the examples of boiler accessories.

3. Write the location & functions of following mountings.
    1. Steam stop valve.

    2. Blow of cock.

    3. Feed check valve.

4. Write the location & functions of following mountings & explain their working with a neat sketch.
   1. Water level indicator.

5. Fusible plug.

6. Bourdon tube pressure gauge.

7. Comment on the location of fusible plug in a boiler.

8. Dead weight safety valve.

9. Differentiate boiler mountings & accessories. Give examples of each.

10. Write the location & functions of following accessories.
    1. Feed pump.

    2. Steam separator.

    3. Steam trap.

    4. Steam injector.

11. Why scrappers are used in economizer?

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 4
To study the working of two stroke I.C. Engine

AIM: To study the working of two stroke I.C. Engine.

OBJECTIVE: To get acquainted with two stroke I.C. Engine.

THEORY:

Working principle of two stroke I.C. Engine

In these engines, the cycle of operations, i.e. suction, compression, ignition, expansion and exhaust, is completed in two strokes of the piston or one complete revolution of the crankshaft. These engines have one working stroke per revolution of the crankshaft. Here, there is no value gear mechanism. The valves are replaced by the ports are opened and closed by reciprocating motion of the piston in the cylinder. The two ports are inlet port and exhaust port. Two stroke cycle engines are widely used in scooters, motorcycles and small power engines.

Two stoke cycle

As the name implies, all the events in the two-stroke cycle are completed in two strokes. In two strokes, the crankshaft makes one revolution. Hence the two-stroke cycle is completed in one revolution. Control of admission of and exhaust in this engine is by means of ports provided into the side of the cylinder and also by means of the piston. The piston in this type of engine is also the engine valve. The crankcase is made gas tight. This is because the incoming air-fuel mixture passes through the crankcase on its way into the cylinder. The air-fuel mixture passes into the crankcase through an inlet port, provided in the bottom of the cylinder. A transfer port is led from the crankcase into the cylinder through which air-fuel mixture is transferred from crankcase to cylinder. The exhaust port connects cylinder to atmosphere. Through this port, the product of combustion is exhausted to atmosphere.

REFERENCES:

- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
- Elements of Mechanical engineering by Prof.S.M.Bhatt,Shri H.G.Kataria,Shri J.P.Hadiya Books India Publication

QUESTIONS:

1. Explain the working of a two-stroke cycle with supporting diagrams:
    1. S.I. engine

2. C.I. engine

2. List merits & demerits of two stroke cycle I.C. engines compared to four stroke cycle engines.

3. Give comparison between two-stroke cycle and four-stroke cycle I.C. engine.

4. State the application of two stroke cycle I.C. engines.

5. What is scavenging? How is it accomplished?

6. Why deflector is provided on the top of the piston head in two strokes I.C. engine?

7. State the methods of cooling in the I.C. engines.

8. State the functions of crankcase in two stroke cycle I.C. engines.

9. Why 2 stroke engines are lighter than 4-stroke engine for a given power?

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 5
Study of the working of four stroke I.C. Engine

AIM: To study the working of four stroke Petrol and four stroke Diesel Engine.

OBJECTIVE: To get acquainted with four stroke Petrol and four stroke Diesel Engine.

Working of four stroke Petrol Engine

1) Suction stroke
During this stroke, inlet valve remains open and exhaust valve remains closed. The piston moves from TDC/IDC (Top dead center / Inner dead center) position to BDC/ODC (Bottom dead center / Outer dead center) position. This creates suction and supplies the charge (Air + Fuel mixture) into the engine cylinder. As the piston reaches BDC/ODC, the inlet valve is closes.

2) Compression stroke
During this stroke, both inlet and exhaust valve remains closed. Piston moves from BDC to TDC. The movement of piston compresses the charge in the clearance volume. The pressure and temperature of the charge increases continuously during this stroke. As the piston reaches to the TDC the charge is ignited by spark plug producing instantaneous combustion. This occurs nearly at constant volume.

3) Power or Working or Expansion stroke
During this stroke, both inlet and exhaust valve remains closed. The piston moves from TDC to BDC. The charge ignited at the end of compression stroke gets sudden increases in pressure and temperature and expands due to heat of combustion. It puts propulsive force on piston and useful work is done during this stroke. And hence it is known as working stroke. As the piston reaches to BDC, exhaust valve opens.

4) Exhaust stroke
During this stroke, the piston moves from BDC to TDC. Inlet valve remains closed and exhaust valve is open. The exhaust gases are driven out through the exhaust valve into the atmosphere at constant pressure. At the end of exhaust stroke, the exhaust valve is closes and inlet valve opens. Then there will be again a suction stroke and same cycle will be repeated.
Otto cycle is also known as constant volume cycle.

Working of four stroke Diesel Engine

1) Suction stroke
During this stroke, the inlet valve remains open and exhaust valve remains closed. The piston moves from T.D.C. to B.D.C. Air from atmosphere is drawn (supplied) into the cylinder as piston moves.

2) Compression stroke
During this stroke, both inlet and exhaust valve remains closed. Piston moves from B.D.C. to T.D.C. The air is compressed to high temperature and pressure sufficient to ignite the fuel. At the end of stroke, fuel is injected into the cylinder.

3) Power or Expansion or Working stroke

During this stroke, both the inlet and exhaust valve remains closed. Piston moves from T.D.C. to B.D.C. Fuel is injected into cylinder and ignited just before this stroke causes the combustion of fuel and continues at nearly constant pressure. The high pressure and temperature Gases expends and pushes piston down words. The useful work in done during this store's the piston reaches BDC position, exhaust valve opens and the Pr. suddenly falls near to the atmospheric pressure.

4) Exhaust stroke

During this stroke, the exhaust valve remains opened and inlet valve and fuel injector remains closed. Piston moves from B.D.C. to T.D.C. The products of combustion are swept out through the exhaust valve opening at nearly constant pressure. At the end of exhaust stroke, inlet valve will just open and exhaust valve is closed. Thus the cycle is completed and it will repeat again.

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- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. Differentiate I.C. engine & E.C. engine by giving examples.

2. Classify the I.C. engine in various ways.

3. Why flywheel is provided in I.C. engine?

4. Discuss the difference between S.I. & C.I. engine. Also give the applications.

5. Explain valve-timing diagram in 4-stroke engine.

6. Write the function of following parts:
    1. Flywheel
    2. Crankshaft
    3. Connecting rod
    4. Piston
    5. Valve mechanism
    6. Fuel injector
    7. Spark plug
    8. Carburetor
    9. Piston rings

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 6
Study of Pumps And Air Compressors

AIM: To study the different types of Pumps & Air Compressor

OBJECTIVE: To study the working, construction and function of various pumps & Air Compressor.

PUMPS

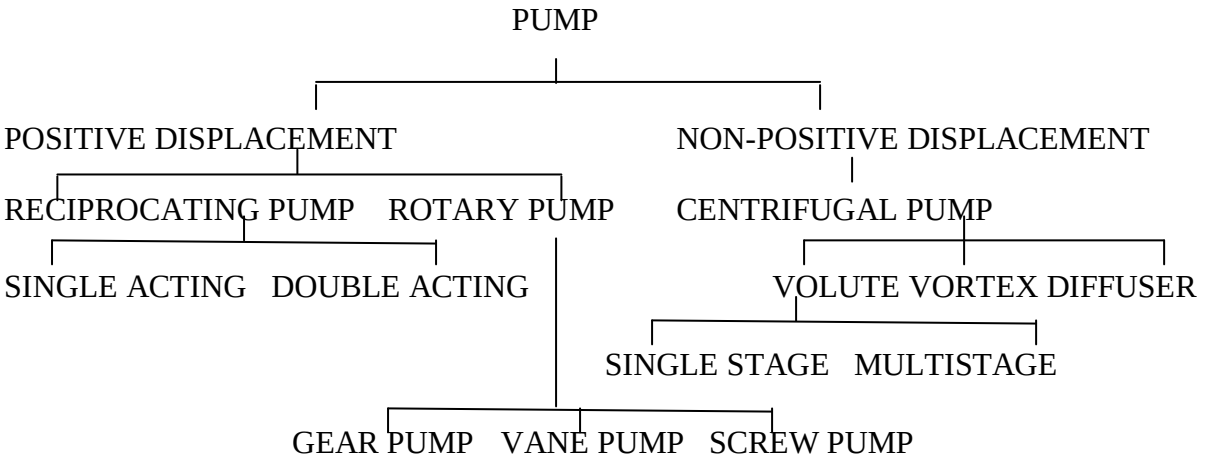
Introduction

The pump is one of the most important accessories of prime movers like heat engines.
It is used,

- To feed the water into the boiler.
- To circulate the water in the condenser for condensing the steam.
- To remove the condensed steam from the condenser.
- To transfer the fuel oil from the reservoir to its proper place.
- To force the lubricating oil in the proper place of lubrication.

The pump is a mechanical device by means of which liquid may be conveyed from one place to the other. The nature of the liquids that are pumped varies from the most volatile fluid a to the thick mud and sludge, from the water to the most corrosive acids and alkalis, from fluids at low temperature to many types of molten metals. Pumping means addition of energy to liquid to move it from one place to the other, and this is done by means of piston, plunger, impeller, propeller, gears, screws etc.

The pumps may be classified, according to the principle of operations into four general classes such as



Reciprocating Pumps

A reciprocating pump consists of a cylinder or barrel, a piston and suction and delivery valves. Inside the cylinder a piston reciprocates in the same way as in a steam engine. During the suction stroke, a volume of liquid almost equal to the volume swept through by the piston is drawn into the cylinder through the suction valve, and during the delivery stroke, the same

volume of liquid is discharged through the delivery valve under positive pressure. This is why it is called the positive displacement pump.

Types of Reciprocating Pumps

The reciprocating pumps may be classified:

- According to the types of pistons such as piston pump and plunger pump.
- According to the action of liquid upon the piston ends such as single acting and double acting.
- According to the methods of drive such as direct acting pump a and power pump.

In a single acting pump, the liquid is discharged at alternates strokes, whereas in double acting pump it is discharged at every stroke. A direct acting pump is a reciprocating pump, which is driven by a steam engine, and the piston rod of the pump is directly connected with the piston rod of the steam engine. A power pump is also a reciprocating pump, which may be driven by an electric motor, internal combustion engine or steam turbine, through a rotating crank or eccentric.

Operation / Working of Reciprocating Pumps

Operation of a single acting pump:
During the upward stroke of the plunger, the pressure inside the pump chamber decreases and the water enters into it through the suction value VI is closed and the water is forced through the delivery valve V2 into the delivery pipe. The water is discharged at every alternate stroke.

Operation of a double acting pump:
In a double acting pump, the water is delivered at every stroke and there is a continuous discharge of water. VI, V2 are suction valves and V3, V4 are delivery valves of the pump. When the piston moves towards the cylinder head, the water in the pump chamber is forced by the piston to move through the valve V3 into the delivery pipe. In this time the pressure falls on the other side of the piston as the volume increases. The water from the reservoir enters into the pump chamber due to the atmospheric pressure through the valve V2. The other valves V 1 and V4 are closed in this time due to the pressure of water.

On the second stroke, i.e. when the piston moves away from the cylinder head, the water is forced by the piston to move through the valve v4 and the water enters into the pump chamber through the valve Vl. Thus in every stroke the water is discharged and a continuous flow of water is maintained. This type of pump, where water is lifted by the positive pressure of the piston, is called a force pump.

Centrifugal Pumps
A pump which employs centrifugal force for conveying liquids from one place to the other is called a centrifugal pump. It is similar to a reversed water turbine in action. Here kinetic energy of the leaving water from the impeller is converted in to potential energy, which is utilized to increase the delivery head of the pump. It consists of a rotating element called impeller is; rotated inside the casing, the liquid is discharged by the centrifugal force from its center. So a vacuum is produced at the suction eye, which is connected with the suction pipe and the liquid from the reservoir flows to the impeller.

Types of Centrifugal Pumps

The centrifugal pumps may be classified, according to the type of casing, as volute and diffuser type centrifugal pumps.

VOLUTE TYPE

It is one of the most common types of centrifugal pump where the impeller is surrounded by a spiral casing known as volute chamber. The pretty large velocity of water leaving the impeller is greatly diminished on entering the volute space and thus a slight pressure head is gained at the cost of the large velocity head of water leaving the impeller. In the volute space the water flows circumferentially. As the volute has to collect water coming out of the different parts of the. Circumference of the impeller, it has to handle gradually increasing quantity of water from the start of the spiral to the discharge end. To avoid loss due to shock arising out of water particles moving with different velocities striking each other, the velocity of flow in the volute chamber is kept a& constant as possible by gradually increasing the cross sectional area of the volute.

VORTEX TYPE

The action of volute chamber for converting the velocity head of water into the pressure head is very much improved if a parallel walled circular chamber is inserted between this impeller and the volute chamber. This chamber is known as vortex or whirlpool chamber. The water leaving the impeller moves freely in this vortex chamber and its velocity head is gradually transformed into pressure head and afterwards the water is collected in the volute chamber is discharged through the discharge pipe.

DIFFUSER TYPE

When guide vanes are provided in the whirlpool chamber the pump is called a diffuser type of pump. By the use of guide vanes the effectiveness of the whirlpool chamber is greatly improved. The impeller of this pump is surrounded by fixed guide vanes within the casing. This ring of guide vanes is known as diffuser. The water leaving the impeller flows though the fixed guide vanes and as passage between the guide vanes is of gradually increasing area, the velocity of water fails and the pressure increases. Thus in a diffuser pump the amount of conversion of velocity head into pressure head is greater than with simple whirlpool chamber and much greater than in the case of a pump with simple volute chamber. The diffuser type of pump has therefore the highest efficiency. This type of pump is also called the turbine pump.

MULTISTAGE

When a pump consists of a single impeller it is called a single stage pump. A single stage pump cannot produce sufficient high-pressure head efficiently, and multistage pumps are therefore, used. In a multistage pump two or more impellers are guided into the inlet of the second, and so on. Thus the pressure of the liquid gradually increases as it passes through successive stages of the impeller.

PRIMING

Priming in centrifugal pump, means removal of air, gas or vapour from the pump casing and from its suction line by filling it with the liquid to be pump. It is required to produce a vacuum by the action of the pump so that the atmospheric pressure may push the liquid to

move in the upward direction to fill the evacuated pump chamber. In centrifugal pump, priming must be done before starting and this may be done by hand or by some other means.

Rotary Pumps

Centrifugal and rotary pumps work on the principle of rotation. They operate entirely on different principles. A centrifugal pump operates on the principle of centrifugal action of rotation, but a rotary pump is a positive displacement pump. Rotary pumps are suitable for pumping thick and viscous liquids such as vegetable oil, grease, tar, heavy lubricating oil, etc. It is also used for pumping lighter liquids having high vapour pressure such as gasoline, alcohol, benzene, etc. and for general pumping.

Types of Rotary Pumps

GEAR PUMP

Different types of gears such as spur gear, spiral gear, herringbone gear, etc. may be used. A rotary pump of spur gear type is described here. Two spur gears one and two are in mesh inside the casing. The gear one is the driving gear while two is the driven gear. When the pump is primed, the liquid fills the space between the teeth of the gears at the suction side. The entrapped liquid between the teeth and is discharged into the delivery pipe.

VANE PUMP

It consists of a casing in the form of an eccentric and cylindrical rotor, which contains the sliding vanes at the grooves. The rotor will touch the upper portion of the casing and there will be a gap between the rotor and the casing at the lower portion. The vanes are free to move away from the center of the rotor due to the spring action or due to gravity and centrifugal force of rotation. When the rotor moves, the liquid is entrapped between the vanes and the casing. This liquid is carried on by the vanes and finally discharged through the delivery pipe.

SCREW PUMP

Screw pumps are special type of rotary positive displacement pumps in which the flow is through the pair of screws. Here, the flow is truly axial. The liquid is carried between screw threads in pair of screws in mesh and is displaced axially as the screws rotate.

COMPRESSOR

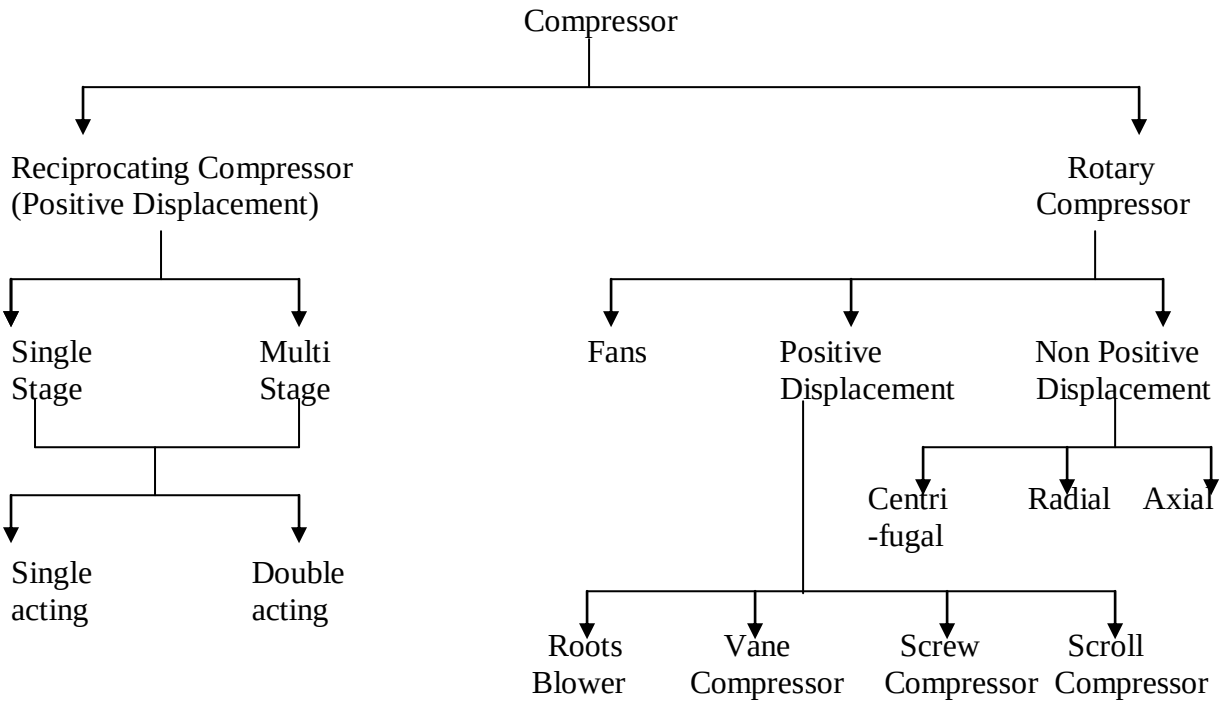
Introduction

An Air Compressor is a machine which takes in air at low pressure and compresses it to high pressure with the help of some suitable arrangement i.e. a reciprocating piston and cylinder arrangement or a rotary arrangement.

Working

An Air Compressor takes in air at atmospheric pressure. It is compressed to high pressure and then delivered it to a storage tank. From the storage tank it is taken out for different uses through the pipe lines. The compressor is driven with the help of some prime-mover.

Classification of compressor



The air compressor can be classified in number of ways:

a) According to the method of carrying out compression:

1. Reciprocating
2. Rotary
3. Centrifugal

b) According to the principle of operation
   1. Positive displacement
   2. Non positive displacement compressor or Dynamic compressor or steady flow compressor

c) According to the number of stages employed
   1. Single stage- delivery pressure up to 5 bar
   2. Two(Double)-stage – delivery pressure 5 to 35 bar
   3. Three stage – delivery pressure 35 to 85 bar
   4. Four stage – delivery pressure above 85 bar

d) According to the delivery pressure developed
   1. Low pressure – delivery pressure up to 1 bar
   2. medium pressure – delivery pressure 1 to 8 bar
   3. High pressure – delivery pressure 8 to 10 bar
   4. Super high pressure – delivery pressure above 10 bar

e) According to the action of piston for carrying out compression of air
   1. Single acting
   2. Double acting

f) According to the number of cylinders used
   1. Single cylinder
   2. Double cylinder
   3. Multi cylinder

g) According to the pressure rise limit
   1. Fans – pressure ratio 1 to 1.1

2. Blowers – pressure ratio 1.1 to 2.5
3. Compressor – pressure ratio above 2.5

h) According to method of cooling used
1. Air cooled
2. Water cooled

i) According to the volume of air delivered
1. Low capacity – volume delivered is 0.15 m^3/sec or less
2. Medium capacity – volume delivered is 0.15 m^3/sec to 5 m^3/sec
3. High capacity – volume delivered is more than 5 m^3/sec

j) According to the nature of installation
1. Stationary or fixed
2. Semi stationary
3. Portable

k) According to the method of power drive used
1. Direct drive
2. Belt drive
3. Chain drive

l) According to the field of application
1. Spray painting
2. Sand blasting
3. Quarrying
4. Mine
5. Road building
6. Rock drill
7. Pneumatic hand tool

m) According to the medium to be compressed
1. Air
2. O_2, H_2 etc
3. Refrigerant gas

n) According to the arrangement of cylinders
1. Vertical
2. Horizontal
3. V type
4. W type
5. Radial

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- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. Define pump and classify different types of pumps.

2. What is priming in centrifugal pump? State the various method of priming.

3. What do you understand a self-priming pump? State the advantage of self Priming pump

4. What is meant by positive displacement pump?

5. Explain working of following pumps with neat sketches.
   a) Plunger pump

   b) Centrifugal pump

   c) Volute pump

d) Diffuser pump

6. Differentiate between reciprocating and rotary air compressor.

7. Explain with the neat sketch the construction and working of single acting air compressor.

8. Explain the working of two stage compressor with P-V diagram.

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 7
Study of Steam Calorimeters

AIM: To study the various types of steam calorimeters.

OBJECTIVE: To find out dryness fraction with the help of steam calorimeter.

THEORY:

Introduction

A vapour is an intermediate stage between a liquid & gas. The liquid, which is used to generate vapour, should not decompose at high temperature and should posses a good thermal capacity. It should the cheap non-poisonous non-corrosive and odorless. Since water possesses all these properties it is used as working fluid in steam engines and steam turbines.

Steam formation

When water is heated at constant pressure Its volume gradually increases with increase of temperature Until it reaches at a point where steam begins to form. On further heating water is converted into steam without any further riser of temperature The constant temperature at which steam forms is called the saturation temperature And corresponding pressure is called saturation pressure At saturated temperature If steam contains no water particles it is called only a saturated steams otherwise it is called wet steam.

Throttling

Throttling is a type of expansion where steam passes through narrow passages & expands with a fall of pressure without doing any external work. It is also called wire drawing. In this case there is no interchange of heat similar to adiabatic process. The enthalpy remains constant during this process.

Measurement of dryness fraction

The dryness fraction of steam may be determined by means of steam calorimeters. There are different types of steam calorimeter such as throttling calorimeter; separating calorimeter etc.

Throttling calorimeter

It is known that at the time of throttling the steam begins drier & nearly saturated steam becomes superheated. The throttling type of expansion is used in this calorimeter.

The calorimeter Consists of a sampling tube **T** that is inserted into the steam pipe **P.** The steam from the steam pipe is allowed to expand in the vessel **S** after passing through narrow orifice **O**. The temperature of steam(t_s) after expansion will be known by thermometer **R** & the pressure will be known by manometer **M**. This type of calorimeter fails when the steam is not superheated after expansion. The pressure if the steam pipe should be known before hand.

Enthalpy before throttling = Enthalpy after throttling

OR

$$h_{f1} + x_1 (h_{fg1}) = h_{g2} + cp (t_s - t_f)$$

Separating calorimeter

If the steam is very wet; the dryness fraction will be measured using a separating calorimeter. The function of this calorimeter is to separate the water particles from the steam. The steam

enters into the sampling tube **T** from the steam pipe **P**. Then the steam flows in the reverse direction and the water particles come in contact with the perforated cup **D** due to its heavier momentum the water collects in the chamber **S** whose mass is known from the graduation in the glass gauge **L**. The steam will be discharge through an orifice at the bottom. The gauge **C** has two scales; one indicates the steam pressure & the other the quantity of steam flows per ten minutes. The discharged steam may also be condensed in a bucket its mass may be known without gauge **C**.

Let m be the mass of the apparently dry steam discharged in a given time & m' be the mass of water particles deposited at the same time. So the initial mass of wet steam is (m+m').

Dryness fraction x = m/(m+m')

This calorimeter gives only an approximate dryness fraction because the steam discharged from the calorimeter is not absolutely dry.

Combined calorimeter

Separating calorimeter does not give an accurate result and the throttling calorimeter fails if steam is not superheated after throttling. A combination of separating & throttling calorimeter is hence found most suitable for accurate measurement of dryness fraction of steam. The steam first passes through a separating calorimeter & then through a throttling calorimeter.

Let,

m' = mass of water collected in the separating calorimeter

m = mass of steam passes from the separating g calorimeter into the throttling calorimeter

It is then finally condensed in a condenser.

So, m+m' = total mass of steam entered into the separating calorimeter from the steam main.

Let x2 be the apparent dryness fraction determined by the separating calorimeter,

So, x2 = m / (m+m')

Let, x1 be the dryness fraction of wet steam, which enters into the throttling calorimeter. This dryness fraction x1 can be determined with the help of following equation.

$$hf1 + x1\ (hfg1) = hg2 + cp(ts-tf)$$

So the actual amount of dry steam passes from the steam main is x1 (m).

Now if x be the actual dryness fraction at the steam main, then

x = x1(m) / (m+m') = x1 (m / (m+m')) = x1(x2)

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- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
- Elements of Mechanical engineering by Prof.S.M.Bhatt,Shri H.G.Kataria,Shri J.P.Hadiya Books India Publication
- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. Explain the working of following calorimeter with neat sketch.
    1) Barrel / Tank calorimeter.

    2) Separating calorimeter.

3) Combined- Separating & Throttling calorimeter.

2. State the limitations of Separating & Throttling calorimeter.

3. Explain the Throttling process used for finding dryness fraction.

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 8
Study of Refrigeration & Air conditioning Systems

AIM: To Study The Refrigeration & Air-Conditioning System.

OBJECTIVE: To know the basics about Refrigeration & Air-Conditioning System.

REFRIGERATION SYSTEM

The principal parts of the system and their functions are as under:

Evaporator: To provide a heat transfer surface through which heat can pass from the refrigerated space or product into the vaporizing refrigerant.
Suction line: To convey the low-pressure vapour from the evaporator to the suction inlet of the compressor.
Compressor: To remove the vapour from the evaporator and to raise the temp. and pr. of the vapour to appoint such that the vapour can be condensed with normally available condensing media.
Discharge line or Hot gas line: To deliver high pressure, high temperature vapour from the discharge valve of the compressor to the condenser.
Condenser: To provide a heat transfer surface through which heat passes from the refrigerant to the atmospheric air.
Receiver: To provide storage for the condensed liquid so that a constant supply of liquid is available to the evaporator as needed.
Liquid line: To carry the liquid refrigerant from the receiver to the refrigerator flow control.
Refrigerant flow control: To meter proper amount of refrigerant to the evaporator and to reduce the pre. of liquid entering the evaporator so that liquid will vaporize in the evaporator at the desired low temp.

AIR-CONDITIONING SYSTEM
An air conditioner is a mechanical device that transfers heat from inside your home to the outside air. Heat is removed by first passing indoor air through an evaporator coil where refrigeration lines containing R-22 absorb the heat. The heat is then carried outside to the condenser coil where it is released into the outside air. This process continues until the air inside your home is at the desired temperature. An air conditioner doesn't just cool the air. There are other functions that can have an equally important role in your comfort.

The four functions of an air conditioner are:
- Cools the air - removes the heat.
- Dehumidifies the air - removes the moisture.
- Filters the air - removes the dust.
- Circulates the air - evenly distributes the air.

If any one of these four functions is not operating properly, you will not feel comfortable.
To accomplish the four functions above, every air conditioner must have these basic components:
- Compressor - compresses and pumps the refrigerant through the system.
- Evaporator coil - absorbs heat and moisture from your home.

- Condenser coil - releases the heat into the outside air.
- Fan motor - circulates the air inside your home and also blows hot air outside.
- Refrigerant expansion device - cools the refrigerant so that it can absorb heat.
- Operating controls - turns unit on/off, sets desired temperature, controls fan speed, etc.

Air Conditioning Systems

The system by which air conditioners provide cooling is called the Refrigerant Cycle. This system has four major components common to all air conditioning systems (see figure). These components and their basic functions are listed below.

1. *Compressor* - Refrigerant is drawn from the evaporator and pumped to the condenser by the compressor. The compressor also pressurizes the refrigerant vapor so that it will change state (condense) readily.
2. *Condenser* - The high-pressure refrigerant vapor releases heat through the condenser coils as it condenses into liquid refrigerant.
3. *Metering Device* (capillary tube, expansion valve) - The metering device restricts the flow of liquid refrigerant from the condenser to the evaporator. As refrigerant passes through the metering device, its pressure decreases making it easier to vaporize.
4. *Evaporator* - The low-pressure liquid refrigerant absorbs heat as it vaporizes in the evaporator coils.

Split system (Central Air Conditioning)

The components of this system are separated in two different locations. The evaporator is located inside and provides cooling through a central air duct. The compressor and condenser are located outside. This system is most commonly used for residential applications, small office buildings and commercial buildings.

Window Air Conditioner

This is a small packaged unit designed to fit in a window, primarily residential use.Room air or ambient air is drawn in through the evaporator intake in front. The air is cooled as it passes over the evaporator coils and leaves through the cool air nozzle(s). The condenser intake on the side of the unit draws in air to cool the condenser coils. This warm air is then discharged out the condenser exhaust on top.

REFERENCES:

- Elements of Mechanical engineering by Desai P S & Soni S B, Atul Prakashan
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- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

1. Define following terms with respect to refrigeration.
   - Refrigeration
   - Ton of Refrigeration
   - Refrigerant
   - Refrigerating effect
   - COP
   - Heat pump
2. Explain the working of Vapour absorption refrigeration system with neat sketches. (Name the major components.)

3. Define air conditioning.

5. Differentiate between refrigeration and air conditioning.

6. What is split A/C unit? Why it is required?

7. Which are the fields of application of window air conditioner?

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 9
Study of motion and power transmission Systems

AIM: To study the power and motion transmission systems.

OBJECTIVES:

1. To under stand the different types of power transmission elements, their features and their suitability with respect to given constraint.
2. To known the different types of power transmission drives, their selecting criteria as well as merits and demerits.

THEORY:

The power is transmitted by different modes. One of these modes is mechanical drive. It comprises different elements depending on the requirements which are as under:

1) Shaft or Shafting.
2) Belt.
3) Pulley.
4) Gear.
5) Chain.
6) Bearings and bearing blocks.

Shaft

It is a one of the most essential element for power transmission. It is supported and runs in bearings the other elements like pulleys, gears are mounted on shaft for transmit the motion.
The power transmitted by shaft can be given by,

$$P = \frac{2 \pi N T}{60,000}$$

Where P = power (in kW)
N = rpm of shaft
T = Torque on shaft. (N.m)

Belt

A belt is a flexible element running over pulleys. Which are used mostly in belt drives. They are made with different cross section and from different materials depending on amount of torque which is going to be transmit, the center distance between the driving and driven shaft.

Types of Belt

a) Flat belt

They are rectangular in cross section with standard width and thickness. They are available in the form of long strap which can be join by suitable type of joint with require length. Mostly used when distance between two shafts as large as 10 meters. Through this type of belts we can get the clutch action by shifting it from loose to tight pulley.
The materials for flat belt are leather, rubber, canvas etc.

b) V-belt

They are trapezoidal in cross section with standard dimensions and available in endless form in standard length. They are run in v-grooves made pulleys. The number of belts used is depends on the amount of torque, which is to be transmitting. By using this types of belts slip can be reduce. They are mostly used to connect shafts, which have center distance less than or equal to 5 meters. By this types of belts speed ratio can be achieve up to 7.
The material for v-belts is fabric-vulcanized rubber with cotton or nylon cord tension element.

c) Timing belt

These belts are basically flat belt with teeth molded on inner side. They are available in standard endless length, pitch and width. They are also known as positive drive belts. Mostly used for short center distance arid for higher power transmission. They are comparatively costlier.

The material used for these types of belts is high quality rubber reinforced with the high tensile fabric cords.

d) Rope

It is also one kind of circular belt which is used mostly in factories and workshops, when the distance between shafts is running from 8mtrs. to 30 meters.

The materials used for these are leather, cotton, fabric and rubber and metal Wires. The fiber ropes are used when the pulleys are about 60 meters. Apart, while wire ropes are used when the pulleys are up to 150 meters apart.

Pulleys

The function of this element is to transmit the power from one shaft to the belt which running over it, by giving motion in virtue of friction. They are generally made from C.I, Cast steel, wrought iron and aluminum alloys, wood, nylon, plastics, fibers etc.

Constructional Details:

The main parts of pulleys are as under:

a) Rim: Is an outer most part of pulley. It may flat or grooved or convex on which belt is runs. The convex feature preventing the slipping of belt and it keep in tension to the belt.

b) Hub or Boss: A Central hollow cylindrical portion of pulley called hub, in which shaft is inserted and to prevent relative motion between them by different methods.

c) Arm: It joining the hub and the rim. They may be straight or curved have various cross section like circular or elliptical etc.

d) Rib: It is a circular disc like portion of pulley joining the hub and the rim. Smaller diameter's pulley provided with it.

Types of Pulley

a) Cone pulley (Stepped pulley)

Mostly made from C.I., having several steps of different diameters, it used to get varying velocity ration of power transmission between parallel shafts by simple shifting the belt from one step to other. The driving and driven pulley are placed opposite manner and diameter of the corresponding steps are such that same belt can be used.

b) Guide pulley

Used to guide the belts connecting nonparallel intersecting or nonintersecting shafts. It is also keeps the belt in proper plane.

c) Jockey (Rider) pulley

It increases the arc of contact and also keeps the belt in tension. It mounted near the smaller of the two-transmission pulleys in a belt drive and always positioned to ride on the slack side of the belt.

d) Grooved pulley

It has a groove at rim and cross section of it depends on the cross section of belt or rope. Generally made from C.I. Because of groove, comparative friction is higher so can be used for transmitting higher torque.

e) Fast and loose pulley

Pair of pulley mounted on the shaft out of which one is provided with brass or gunmetal bush and it rotates freely where as other is keyed to shaft. The arrangement enable a machine shaft to be started or stopped at will without stopping the running of the belt by shifting the belt from loose pulley to fast pulley or fast pulley to loose pulley by a suitable belt shifter.

Chain

It consists of several rigid links hinged together to provide on endless flexible loop passing over the driving and driven wheel called sprockets. Sprockets have projecting teeth, which fit into recesses in the link of chain enabling a positive drive.

The pitch can be given by following formula,

$$P = d \cdot \sin\left(\frac{180°}{Z}\right)$$

where, d = Diameter

Z = Number of teeth on sprocket

Roller chain commonly used for power transmission. In bicycles, motor cycles, textile machineries and agricultural equipment the roller chains are frequently used. In context of stands they can be classified like simplex, duplex or triplex chain.

Gear

Gear is a toothed member (link), which is used to transmitting the motion by means of successively engaging teeth from a rotating shaft to another, which rotates, or from a rotating shaft to a body which translates. They are used to transmit power between shafts that are parallel, intersecting or neither parallel nor intersecting by the use of various types of tooth gears.

Types of Gears

a) Spur gear

Used where the power is transmitted between parallel shafts. The teeth may be internal or external. These gears have very wide applications like in watches, measuring instruments, machine tools, automobiles etc. In this types teeth are parallel to shaft axis.

b) Helical gear

These are similar to spur gear except that their teeth are not straight to the shaft axis but follows a helical path, with either left hand helix or right hand helix. They are used to connect parallel shaft as well as nonparallel shaft, nonintersecting shaft. Properly designed helical gears run more smoothly and quietly at high speeds. In this types of gears teeth are gradually engaged with each other because of this, the noise pollution and impact load is low compare to spur gears. The draw back of these gears is axial thrust experience during motion. The solution of this problem can be solved by double helical (Herringbone) gear.

c) Spiral gear

Skewed gears are used to connect two nonparallel, nonintersecting shafts. Their teeth are like helical gear cut along helical path on the wheel periphery. The teeth have point contact. Suitable for small power transmission.

d) Bevel gear

They have their blanks conical in shape and having varying in cross section along the tooth width. They are mostly used where two axis of shaft intersecting in a plane, they may be at right angle or may not be. The bevel gears having angle between shafts at 90° are called miter gears and other then 90° is called bevel gears. Depending on their shape of teeth they may be classified as straight tooth type, spiral or skew or hypoid bevel gears. Spiral has smoother running action. Hypoid bevel gears are used in automobile differential gear box.

e) Worm gear

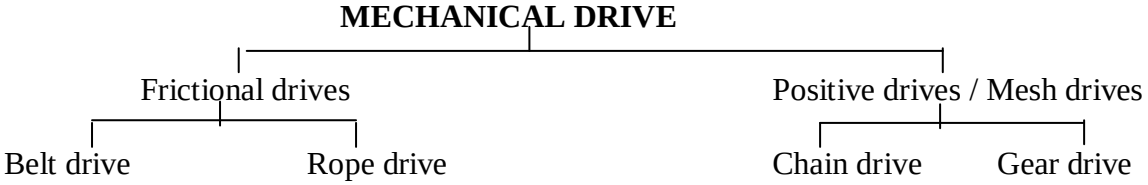
These are special forms of helical gear in which teeth have line contact and axes of driving and driven shaft are at right angle and nonintersecting. A smaller gear is called worm and large one called worm wheel. This combination use for very large velocity ratio and for law space. The noise and vibration are cooperative low. Their common application are in lath, drilling, milling etc. They are also used in reduction gearbox.

f) Rake and pinion

This may consider as a pair of spur gear having one of the gear having infinite pitch circle diameter (PCD) is called rack. Where as other small gear is known as pinion. These are used to transmit circular motion into rectilinear motion and vice- versa. They are fitted in lathe, drill, planner etc. to convert rotary motion into transitory motion.

Power transmission drives

As we know power is transmitted by different type of drives which are framed in following tree diagram.



Frictional drive

In this type the power is transmitted by the virtue of friction. If the distance between source and utilization place is small than direct drive is used other wise flexible drive is used.

BELT AND ROPE DRIVE

To transmit the power from one shaft to another shaft, pulleys are mounted on two shafts. Which are connected by belt or a rope depends upon the requirement. The belt /rope should be in tension so that motion of one pulley is transmitted to other. Through this system constant velocity ratio can not be maintained because of slipping and straining of belt/rope. Diameters of driving and driven pulley are the controlling parameter for the velocity ratio and their relation can be written as under,

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

Where, N_1, N_2 = speed of pulleys.

D_1 , D_2 = respective diameter of pulleys.

With respect to belt position and relation between axes of the shaft, belt drive can be classified.

a) Open belt drive

When shaft axes are parallel and rotates in same direction. In this case driver pulls the belt from one side and delivers it to other side. Thus the tension in the lower side will be more than that in upper side. The lower side known as tight side where as upper side called slack side.

b) Cross belt drive

Used where the shaft axes are parallel but direction of rotation of two shafts is in opposite direction. In this case driver pulls the belt from one side and delivers to other side.

c) Quarter turn drve

Used for nonparallel non-intersecting shafts. Provided that the center line of the belt when approaches a pulleys lies in the mid plane of that pulley.

d) Right angle drive

Used when axes of shaft are at right angle. In this one additional suitable guide pulley used. Which is directing and can be connect to belt.

POSITIVE DRIVE

To avoid slipping and for getting constant velocity ratio this type is used. In this projecting portions (tooth) are mash with corresponding recesses. This constrained to move together without slipping and ensure perfect velocity ratio (V.R). Under this class chain drive and gear drives are falling which are discuss as under:

Gear trains

An assembly of gear wheels by means of which motion is transmitted from one shaft to another shaft is called gear train. It may include any or all kinds of gears, depends on the relative axial relationship between the shafts and the require V.R .The ratio of rpm of driver (1^{st}) gear to rpm of the driven (last) gear is known as speed ratio or V.R of gear train. It will be positive if direction of rotation 1^{st} and last is same and negative in case of opposite. As we have seen that depending on the gear arrangement different type of gear train can be framed as under,

a) Simple gear train

A series of gears, capable of receiving and transmitting motion from one gear to another is called simple gear train. In it, all the gear axes remain fixed relative to the frame and each gear is on separate shaft. In this type,

1) A pair of mating external gear always moves in opposite direction and move in same direction in case of one internal gear (annular) and one external pair.

2) All odd number gears are move in one direction and all even number gear move in the opposite direction.

3) Shaft axes are parallel to each other.

4) Intermediate gear does not effect on V.R and therefore they called as idlers. Some time idler may use to change the direction of driven gear. Their formulas are as under,

$$\text{Train value} = \frac{\text{Rpm of driven}}{\text{Rpm of driving}} = \frac{\text{Number of teeth of driving}}{\text{Number of teeth of driven}}$$

$$\text{V.R.} = \frac{1}{\text{Train value}}$$

b) Compound gear train

When two or more than two gear are mounted on common shaft it is known as compound gear. It gives compact layout. The train value of type can be denoted as under,

$$\text{Train value} = \frac{\text{Product of number of teeth of driving gears}}{\text{Product of number of teeth of driven gears}}$$

c) Reverted gear train

First and last gears run at same axis, it is also one kind of compound train. Very large reduction ratio can be achieve in compact place by this type. The speed ratio and their pitch circle radius relation can be written as under,

$$\text{Train value} = \frac{\text{Product of number of teeth of driving gears}}{\text{Product of number of teeth of driven gears}}$$

$$R_1 + R_2 = R_3 + R_4$$

Where, R_1 = radius of driving gear

R_4 = radius of driven gear

R_2, R_3 = Intermediate gears

d) Epicyclic gear train

When there exists a relative motion of axis in gear train, it is called a planetary or epicyclic gear train, thus in an epicyclic train the axis of at least one of the gear also moves relative to the frame. If the arm is fixed, the gear train becomes a simple gear train. Large speed reduction is possible with this type and if the fixed wheel is annular a more compact unit could be obtained. Important applications of epicyclic gear train are in transmission, computing devices etc.

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QUESTIONS:

1. What are the basic methods for transmitting power from one shaft to another?

2. State the advantages of individual drive over group drive.

3. What is function of pulley? Why jockey pulley is used? Explain its working with neat diagram.

4. State the difference between belt drive, chain drive and gear drive.

5. Define the slip of the drive. What is function of guide pulley?

6. What is function of bearing? Give its classification with neat sketches.

Marks obtained: **Date:** **Signature of faculty:**

EXPERIMENT NO. 10
Study of Couplings, Clutches & Brakes

AIM: To study the different types of couplings, clutches & brakes.

OBJECTIVES:
1. To know the working principle of couplings, clutches and brakes.
2. To know the constructional features and their functional importance in particular items.
3. Their applications in industrial field.

THEORY:
In practice it is rare that power generation and power utilization at the same place. It is transformed in different mode. Here we are limiting our discussion up to mechanical mode. Transmission nature is a preferential and with respect to this different elements are used.
When mechanical power transmitted by continues rotating motion and input & out put members require acting as same unit in that situation members are join t couplings. Where as requirement is discontinue / continue and with limiting extremity (power flow. In that constrains mostly clutches are used and for control over power value on input or output member brakes are used, They are used to slow down, stop or hold a load or release a load and control its speed.

Couplings
Most common power transmitting member is shaft, which limited by manufacturing and shipping requirements. The elements which joint two shifts are know as couplings, which transmit power one to another. On the bases of axial relationship between two shafts, different types of couplings are developed which are as under:

1. SLEEVE COUPLING
It consist of sleeve or hollow cylinder normally made from cast iron, which receives end of two shafts made to butt together inside the sleeve. Sleeve and shaft are keyed by sunk key, which normally made from same shaft material. Some time two keys may be a used. Torque is transmitted from driver shaft to sleeve and from sleeve to driven shaft. It has no projected parts and simple constructional features still require careful fitting.

2. SPLIT MUFF COUPLING
It is a improved form of sleeve coupling. In this sleeve is split into two halves and connected by bolts. Here key also used as in sleeve coupling to create a pressure between the surface of shaft and the sleeve there is some clearance at joining of to sleeve halves. So tightening of the bolts causes frictional force between the surfaces. Because of this it can be used for heavy-duty work.

3. FLANGE COUPLING
It is most widely used from medium to heavy duty. It consists of two coupling halves keyed to two shafts, which are coupled by bolts. When bolt heads and nuts protrude beyond the flat surfaces of flanges, the coupling called as unprotected type, which is dangerous. To over come this flange is provided with a shroud or an annular projection, which shelter the bolt

heads and nuts. To ensure true alignment, one shaft may entered into other flange or projected portion of one flange fit into the corresponding recess of other flange.

4. BUSH PIN TYPE FLANGE COUPLING

It is a modified form of protected type flange coupling. There is a cushioning effect due to leather/rubber bush in one of the flange. In which enlarged diameter of pins are inserted and other end of bolt is fastened by nut in other flange. This feature is offering a small axial movement and takes care of shock and slight misalignment. It is mostly used for direct connection of electric motor.

5. OLDHAM COUPLING

It is used in connecting two parallel shafts whose axes are at small offset. It consist of three members, two flanges and one intermediate disc, both flange have diametrical slot at right angle to each other, where as intermediate disc has replica of that slots on respective either sides. The rotation of drive shafts causes the rotation and sliding of circular disc, which transmit the power to the driven shaft.

6. UNIVERSAL COUPLING

It is used where the axes of shafts are intersecting to each other and during operation; angle between the axes may slightly very. It consists of forks keyed to the ends of either shaft and they are pin joined to a center block, which has two arms at right angles to each other. This is widely used in automobiles to connect propeller shaft and also in machine tools.

Clutches

Element which used to connect the one rotational part to another stationary, which later is to be set into motion and transmit as well as control the limit of flow of mechanical power, where the power at driven may be required to start or stop frequently. There are four categories: 1) mechanical type 2) electromagnetic type 3) pneumatic type 4) hydraulic type.
We will study here mechanical type clutches.

JAW AND TOOTHED TYPE CLUTCH

Positive clutches used to connect driven shaft to prime mover when it is not objectionable to start the driven suddenly and where the connected load (including inertia resistance) is not so great, which is also not so harmful to the prime mover it self. It consists of segmental projection or dogs on one side flange and corresponding recesses on other side flange on the driven shaft. In this driving flange is rigidly attached where as driven flange is keyed by feather key so it can slide on that shaft. Some time involute teeth also provided.

FRICTIONAL CLUTCH

Power transmitted by virtue of friction between the surfaces. These are important when engagement must be made under load and prime mover is to be protected against sudden load. Apart from this, shafts running at different speed are to connect, without stopping. These features make them suitable for vehicles, process machineries, machine tool and where the frequently power cut-off either partial or completely required. Frictional surfaces may be flat, conical or cylindrical and they are named with respect to that.

a) Disc clutch: In this type, one flange is rigidly keyed to driving shaft. Where as other is fitted on driven by splines or feather key so it can move along the axis of shaft. During

working movable flange is pressed by mechanism so the torque is transmitted by friction through the disc, which is between two flanges. In this type of clutches the amount of transmitted torque will be depends on axial pressure, contact area of surfaces and coefficient of friction. On the bases of number of disc frictional clutches can be classified like single disc clutches, multi disc clutches. When large torque is to be transmitted at that time multi disc clutches is preferable, because of higher number of contact surfaces.

b) Cone clutch: In this contact surfaces of flange are in conical shape. The slop of cone is varying from 8° to 15°, the clutch parts (cones) are held together by springs, which produce axial force. In this type of clutches the excessive axial pressure is not required.

c) Centrifugal clutch: They are used in a wide variety of application to connect drives (electric motor, I.C.engines etc.) In this type of clutches power flow is possible only after reaching certain amount of speed of driving shaft. The engagement of shoes with the inner lining of drum will take place when centrifugal force becomes greater than spring force. This engagement will cause the transmission of torque from driving to driven.

BRAKES

It is a element whose primary purpose is to absorb a kinetic energy by way of frictional resistance. Which are generally used for slow or stopping the moving parts, there are some brakes which are used to with hold conversion from potential to kinetic energy of the object as they are lowered by hoists elevators etc. Other main function is to hold a body in rest of uniform motion against accelerating forces/ couples and preventing unwanted reversal of the direction of rotation. The major functional different between clutch and brake is that unlike a brake, which connects a moving member to a stationary frame, a clutch connects a rotating member to another rotating member. In brakes absorbed energy dissipate in form of heat.

They are used in automobile, trains, vehicles, hoists elevators, press and in machines.

Their different classes are:
Mechanical type brakes, electrical type brakes, hydraulic type brakes and some other types.
Here our discussion is limited up to **mechanical** types.

Types of Brakes

a) Block brake: This brake consists of block, which are pressed against the rim of revolving brake wheel or drum, which faced with frictional material. The block are made of soft material compare to drum or wheel, like wood or soft metal.

These types of brakes are mostly used in railway trains, tram cars etc. Prony brake is also belongs to this class.

b) Band brake: It consists of flexible bend of leather of steel lined with friction material, which embraces a part of the circumference of brake drum. In context of interrelated position between band ends and fulcrum, band brake may be simple or differential type band brake. When force is applied at lever end the friction is generated between band and drum surfaces, which cause speed reduction or stopping of wheel.

The band and block type brake is improved type of band brake, which consists of number of wooden blocks fixed to a steel band.

Properties required for brake linings

1) High mechanical strength.

2) High coefficient of friction.

3) Law wear rate.

4) High heat dissipation capacity.

5) Should not affect by moisture or oils.

Examples: wood, leather, asbestos and ferrodo.

d) **Internal expanding shoe brake:** Widely used in automobiles. Which may be operated by mechanically or hydraulically. It consists of two shoes lined with some friction material, pivoted at one ends about a fixed fulcrum. The shoes are housed inside the rotating drum. Under release condition there is a gap between shoes and inner surface of the drum by spring, when shoes are expanded by mechanically /hydraulically. The friction between shoes and the drum produce a braking torque and hence reduces the speed of the drum. These types of brakes are mostly used in automobiles.

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- Elements of Mechanical engineering By Dr.Sadhu Singh,S.Chand Publication

QUESTIONS:

(1) State the functions of couplings, clutches and brakes.

(2) Classify couplings, clutches and brakes. (Just Name)

(3) Distinguish between a clutch and coupling and brake and clutch.

(4) Writes short notes on followings with neat diagrams:
1. Internal expanding shoe brake.

2. Band brake.

3. Centrifugal clutch.

4. Oldham coupling.

Marks obtained: **Date:** **Signature of faculty:**