Lab Manual_2022-23
Basic Mechanical engineering
3110006

Department of Mechanical Engineering
L.E.College, Morbi.

L.E.College, Morbi

Certificate

*This is to certify that Mr./Ms.*____________________________________

*Enrollment No.*_________________*Branch*_____________________________

***Semester 1st** has satisfactory completed the course in the subject Basic **Mechanical Engineering** in this institute.*

Date of Submission: -___/____/ _______

Vision:
To deliver quality engineering education for mechanical engineers with professional competency, human values and acceptability in the society.
Mission:

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

L.E.COLLEGE MORBI
Department of Mechanical Engineering
B.E. Semester – I
Basic Mechanical Engineering(3110006)
List of Experiments

Sr. No.	Title	Mapped CO	Mapped PO	Date of completion	Sign	Marks
1	To understand construction and working of various types of boilers.	CO-4	PO-1			
2	To understand construction and working of different boiler mountings and accessories	CO-4	PO-1			
3	To determine brake thermal efficiency of computerized four stroke single cylinder diesel engine test rig.	CO-3	PO-1			
4	To understand construction and working of different types of air compressors	CO-3	PO-1			
5	To understand vapor compression refrigeration cycle of domestic refrigerator	CO-4	PO-1			
6	To understand different arrangement and application of various power transmission drives.	CO-5	PO-1			
7	To understand different types of engineering materials.	CO-5	PO-1			
8	To understand construction, working and application of clutches, coupling and brakes	CO-5	PO-1			
9	To understand different types of Pumps.	CO-4	PO-1			
10	To do Case Study on any one Energy conversion system.	CO-4	PO-1			

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B.E. Semester – I

Basic Mechanical Engineering(3110006)

List of Assignments

Sr. No.	Title	Mapped CO	Mapped PO	Date of completion	Sign	Remarks
1	Introduction, Fuels and Combustion	CO-1	PO-1			
2	Properties of Gases, Properties of Steam	CO-2	PO-1& 2			
3	Heat Engine, I C Engine	CO-3	PO-1			
4	Steam Boilers, Pumps, Air Compressors, Refrigeration and Air Conditioning, Coulpling , Clutches, Brakes	CO-4	PO-1			
5	Transmission of Motion and Power, Engineering Materials	CO-5	PO-1			

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EXPERIMENT-1

Aim: To understand construction and working of various types of boilers.

Introduction

Steam boiler is a closed vessel in which heat produced by the combustion of fuel is utilized to generate steam from water, at desired temperature and pressure.

According to IBR (Indian Boiler Regulation) boiler is defined as ***"Boiler is a closed pressure vessel with capacity exceeding 22.75 liters used for generating steam under pressure."***

The steam produced may be supplied:

a. For generating power in steam Engine or steam turbines.
b. At low pressures for industrial process work in cotton mills, sugar factories, etc., and
c. For producing hot water for supply of hot water and for heating the buildings in cold weather.

Classification of Steam Boilers

1. **According to relative position of water and hot gases**
   a. Fire Tube boiler - hot gases pass through fire tubes which are surrounded by water.
   b. Water tube - water flows inside the tubes and the hot flue gases flow outside the tubes.
2. **According to the axis of the shell**
   a. Vertical boiler – the axis of the shell is vertical.
   b. Horizontal boiler – the axis of the shell is horizontal.
   c. Inclined boiler – the axis of the boilers is inclined.
3. **According to the method of firing**
   a. Externally fired boilers – furnace is located outside the shell.
   b. Internally fired boilers – furnace is located inside the shell, means combustion takes place inside the boiler shell.
4. **According to the method of water circulation**
   a. Forced Circulation boilers - water is circulated by pumps which is driven by motor.
   b. Natural Circulation boilers - water is circulated by natural convection currents which are set up due to the temperature difference produced by the application of heat.
5. **According to the pressure of steam**
   a. High pressure – boilers working pressure is less than 10 bars. Example: Babcock and Wilcox boiler
   b. Medium pressure boilers – working pressure is 10 to 70 bars. Example: Lancashire and locomotive boiler
   c. Low pressure boilers – working pressure is above 70 bars. Example: Cochran and Cornish boiler.
6. **According to the mobility of boiler**
   a. Stationary boilers – it is used for stationary plants.
   b. Mobile boilers – it can move from one place to another.
7. **According to the number of tubes in the boiler**
   a. Single tube boilers – they have only one fire or water tube.
   b. Multi tube boilers – they have more than one fire or water tubes.

Comparison between Fire tube and Water tube boiler

Sr. No.	Particular	Fire Tube boiler	Water tube boiler
1	Position of water and hot gases	Hot gases inside the tubes and water outside the tubes	Water inside the tubes and hot gases outside the tubes
2	Operating pressure	Limited to 25 bar	More than 125 bars
3	Rate of steam generation	Lower	Higher
4	Suitability	Not suitable for large power plant	Suitable for large power plant
5	Chance of explosion	Less due to low pressure	More due to low pressure
6	Floor space requirement	More	Less
7	Cost	Less	More
8	Requirement of skill	Required less skill for efficient and economic working	Required more skill and careful attention efficient and economic working
9	Use	For producing process steam	For producing steam for power generation as well as process heating.
10	Scale deposition & over heating	There is no water tubes, no problem of scale deposition and less problem of overheating & bursting	Small deposition of scale will cause overheating and bursting of the tubes.

Cochran Boiler (Vertical multi-tubes boiler)

It is one of the best type of vertical multi-tubular boiler. It is fire tube boiler and used for steam generation at lower rate.

Specification

Shell diameter = 2.75

m Height = 5.75 m

Working pressure = 6.5

bar Heating surface area

120 m^2

Steam capacity = 3500 kg/hr (Max. = 4000

kg/hr) Efficiency = 70 to 75 %

Characteristics of boiler

It is a vertical, multi tubes, fire tube, internally fired, natural circulation boiler.

Construction

The boiler consists of a cylindrical shell, hemispherical fire box, fire tubes and chimney. The top of the shell having hemispherical shaped crown as shown in fig 1.1.

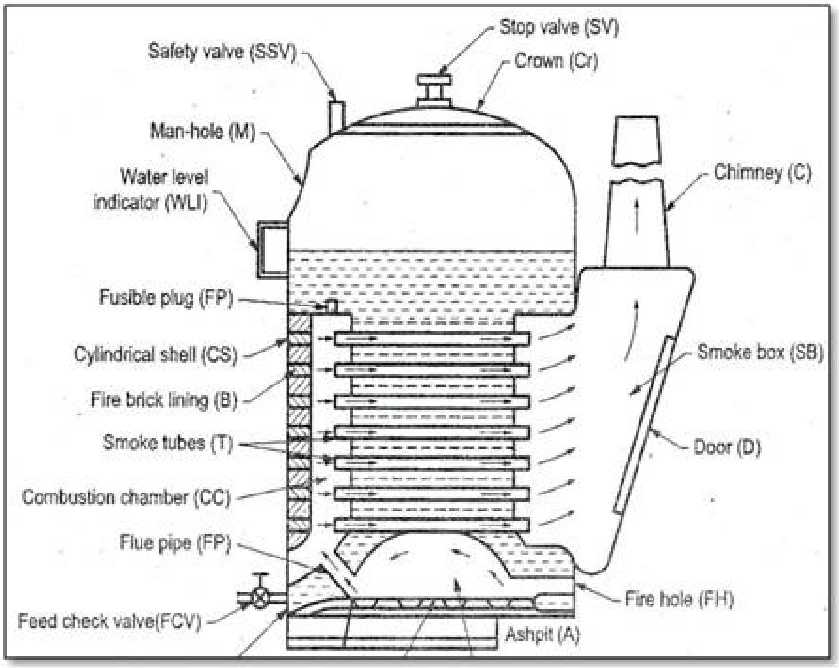

Fig. 1.1 Cochran Boiler

The hemispherical crown of boiler gives good strength to withstand pressure of steam inside the boiler. The hemispherical shape of furnace can withstand high heat and it is also useful to increase radiant heat transfer.

The grate is placed at the bottom of furnace and ash pit is located below the grate. The furnace and the combustion chamber are connected by short flue pipe. The wall of the combustion chamber is lined with the fire bricks.

Working

The water is supplied to the boiler through feed check valve. The level is adjusted with the help of water level indicator. Coal is added through the fire-hole or door to the grate and burnt. The hot gases produced are collected in the fir box.

These hot gases enter into horizontal fire tubes. Heat transfer takes place from flue gases passing inside the tubes to water surrounded the tubes. The flue gas coming from the fire tubes enter into smoke box. Finally they discharged to atmosphere through a chimney. The ash formed is collected in ash pit. The steam is collected through anti priming pipe on the top of the shell.

Advantages

1. It is compact and portable boiler therefore minimum floor area is required.
2. Initial cost of boiler is less

3. It can be moved and set up readily in different locations.
4. Quick and easy installation.
5. Any type of fuel can be used. (Coal or Oil)

Disadvantages

1. Steam raising capacity is less due to vertical design.
2. Water along with steam may enter the steam pipe under heavy loads sue to small steam space.
3. Efficiency is poor in smaller sizes.

Lancashire Boiler

It is simple in design, easy to operate and less operating and maintenance cost. It is one of the most commonly used stationary boilers. It is normally used in sugar mills, textile industries where power generation as well as process heating is required.

Specification

Shell diameter = 2 to 3 m

Length of the shell = 7 TO

9 m Working pressure = 16

bar

Steam capacity = 8000-9000 kg/hr
Efficiency = 50 to 70 %

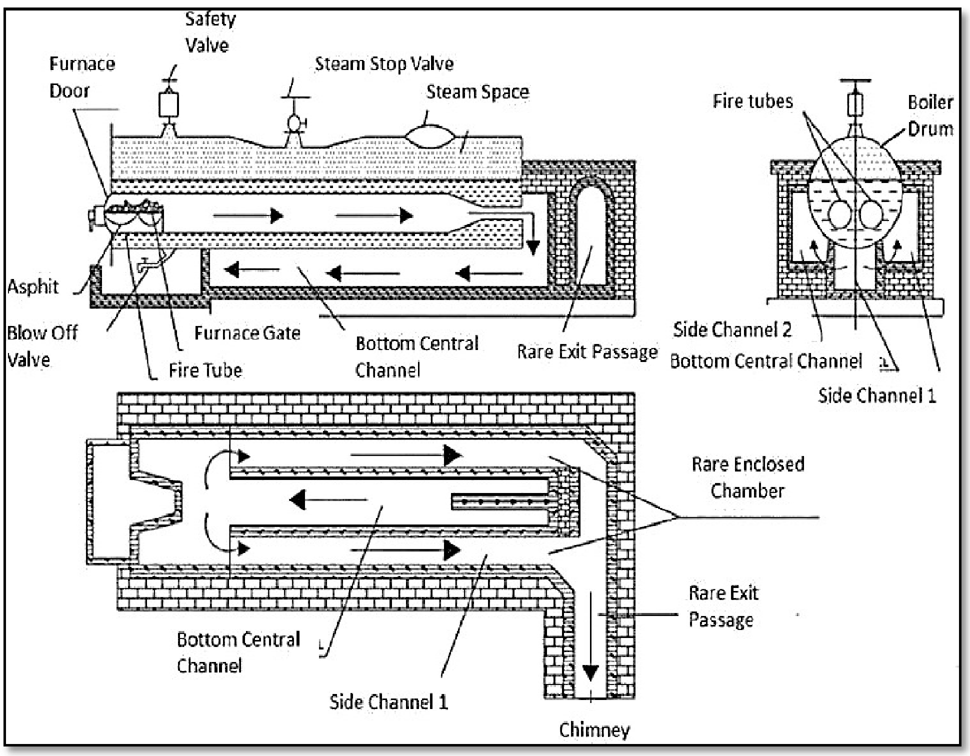

Fig. 1.2 Lancashire Boiler

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Characteristics

Horizontal, stationary, fire tube, internally fired multi-tube (two fire tube), natural circulation of hot gases, medium pressure boiler.

Construction

It consists of a cylindrical shell and two fire tubes as shown in fig. 6.2. The cylindrical shell is placed over the brick structure.

The boiler has three passes for flow of gases. One flue passes from inside of boiler and through fire tubes, is called main flue (MF). Second flue passes froth below the shell is called bottom flue (BF) and third from the side of boiler is called side flue (SF). The side flue and bottom flue passes are formed by brick work.

The fuel grates are provided at the front end and inside of two main fire tubes. A fire bridge is provided at the end of the grate to prevent coal and ash particles entering into the interior of the furnace tubes.

Superheater is provided at the end of the main flue tubes in passage of flue gases. While an economiser is at the end of the side flues, before exhausting the gases to chimney. Dampers (sliding doors) are placed at the end of the side flues to control the flow of gases.

The pressure gauge and water level indicator and feed check valve are provided at front of the boiler. On the front side, the blow off cock is provided at the bottom. The fusible plugs are mounted on the top of the main flues just over the grate. The antipriming pipe, safety valve, low water and high steam safety valve and manhole are provided on the top of boiler shell.

Working

The coal is introduced to the grate through fire holes. The combustion of coal takes place in presence of air which is regulated by damper. The combustion will produce hot gases.

Path of flue gases: The hot gases from the grate pass upto back end of the tubes and then in the downward direction (MF to BF). They move by the bottom flue to the front of the boiler where they are divided into two streams and pass into the side flues (BF to SF). They move along two side flues and enter the chimney and discharged to atmosphere.

Path of flue gases is as under

Grate → Fire tube (MF) → BF → SF → Chimney → Atm

Due to this flue gas path, the water in the shell is heated from bottom by the bottom flue, from sides by side flue and from center by fire tubes.

Damper regulates mass flow rate of flue gases. Ultimately it regulates fuel combustion rate as well as steam generation rate. Dampers are opened by chain passing over a pulley outside the boiler.

Advantages

Response of pressure build up is less.

1. The furnace is inside the tubes therefore the grate area is restricted.
2. Due to three passes of flue gases, the heating surface area per unit volume of boiler is large.
3. The fluctuations in load can be easily met by this boiler due to large reservoir.
4. Easy operation, low maintenance costs, easy to clean and inspect.
5. By use of economiser and superheater, maximum heat of flue gases is utilized, so efficiency of boiler can be increased.

Disadvantages

1. Maximum working pressure is limited to 16 bar.
2. Due to brick work, more floor area is required.

Babcock and Wilcox boiler

It is a water tube boiler and used in stationary and marine engine. The efficiency of this boiler is much greater than that of the fire tube boiler. This boiler is exclusively used when pressure is above 10 bar and steam generating capacity is required higher than 7000 kg/hr.

Specification

Diameter of the drum = 2000 to

4000. Length = 6000 to 9000 mm.

Size of the water tube = 76.2 to 101.6 mm

Size of upper header tube = 38.4 to 57.1

mm

Maximum working pressure = 42 bar

Maximum steam capacity = 40,000

kg/hr Efficiency = 60 to 80 %

Characteristics of boiler

Horizontal, multi-water tube, externally fired, natural circulation of water, forced circulation of air and hot gases, solid as well as liquid fuel can be fired.

Construction

Fig. 3 shows a Babcock and Wilcox boiler. It consists of inclined water tubes, a steam and water drum, a mud box and super heater.

The drum is connected with uptake and downtake header by short riser tubes. These headers are connected to series of inclined water tubes.

The water tubes are inclined to horizontal about 15° or above to bring natural circulation of water. The hand hole is provided in header in front of each tube for cleaning and inspection of tubes.

The baffles plates are provided in order to make the circulation of hot gases in sine wave form. A damper is fitted at back of the boiler to regulate the draught and chain grate stoker is used to feed the coal to furnace.

Soot doors are provided to clean the outside of water tubes and to remove the soot. Soot doors are also helpful to access the interior of the boiler.

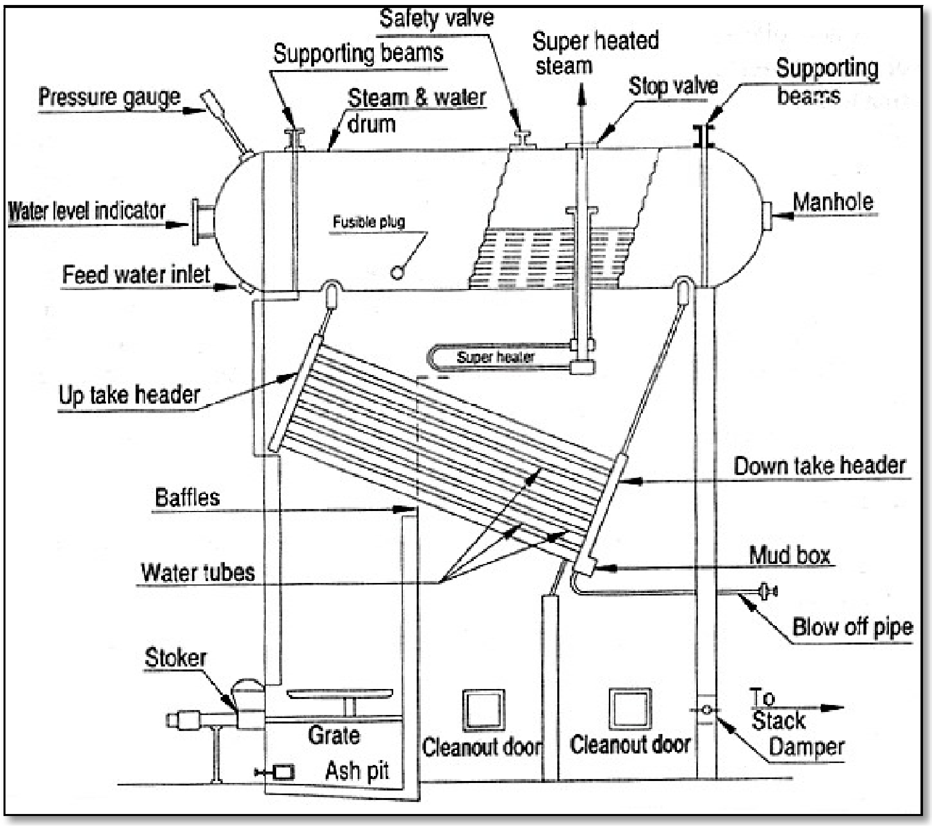

Fig. 1.3 Babcock Wilcox Boiler

Working

The water fed into the boiler shell through the feed check valve. Due to gravity water passes through the vertical tubes, headers and fills up the inclined tubes first. Then the water collects in the drum. Initially one half of drum is filled up with water.

The coal is introduced to furnace grate by help of stoker. The coal is fired, hot gases produced is first forced to move upward through passage between tubes. The baffles plates make flow of hot gases in sine wave, as move down and then move upward over the water tubes. The damper controls the flow of air into the furnace.

Advantages

1. The steam generation capacity of the boiler is very high, about 2000 to 40000 kg/hr.
2. Replacement of defective tubes is easy.

3. The draught losses as compared to other boilers are minimum.
4. It is used in power station for generating large quantity of steam.
5. Boiler is required less space area compared to fire tube boilers, and offers greater operational safety.

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EXPERIMENT-2

Aim: To understand construction and working of different boiler mountings and accessories.

Boiler Mountings

These are different fittings and devices which are necessary for the operation and safety of a boiler. Normally these devices are mounted on boiler shell.

According to IBR the following are the list of mountings should be fitted to the boilers.

1. Two water level indicators
2. A pressure gauge
3. Safety valves
4. A Steam stop valve
5. A feed check valve
6. A blow off cock
7. Fusible plug
8. A man hole, Mud holes or sight holes

Water level indicator

Function

It is an important fitting, which indicates the water level inside the boiler to an observer. It is a safety device, upon which correct working of boiler depends. This fitting may be seen in front of boiler, and are generally two in number.

Construction

It consists of three cocks and a glass tube. Stem Cock 1 keeps the glass tube in connection with the steam space. Water cock 2 puts the glass tube in connection with the water in the boiler. Drain cock 3 is used at frequent intervals to ascertain that the steam and water cocks are clear.

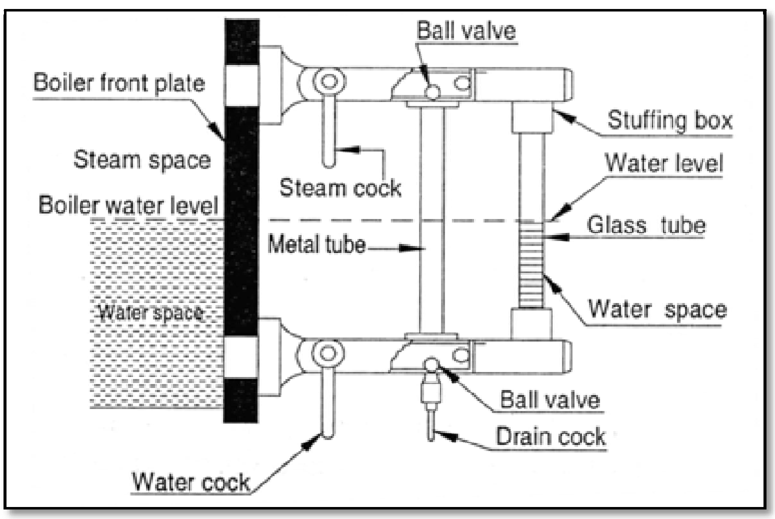

Fig. 2.1 Water Level Indicator

Working

In the working of a steam boiler and for the proper functioning of the water level indicator, the steam and water cocks are opened and the drain cock is closed. In this case handles are placed in a vertical position. The rectangular passage at the ends of the glass tube contains two balls. In case the glass tube is broken, the two balls are carried along its passages to the ends of the glass tube. It is thus obvious, that water and steam will not escape out. The glass tube can be easily replaced by closing the steam and water cocks and opening the drain cock.

Pressure Gauge
Function

It is used to measure the pressure of the steam inside the steam boiler. The pressure gauges generally used are of Bourdon tube type.

Construction

It consists of an elliptical elastic tube XYZ bent into an arc of a circle, as shown in fig. 6.5. This bent up tube is called Bourdon's tube. One end of the gauge is fixed and connected to the steam space in boiler .The other end is attached by links and pins to a toothed quadrant. This quadrant meshes with a small pinion on the central spindle.

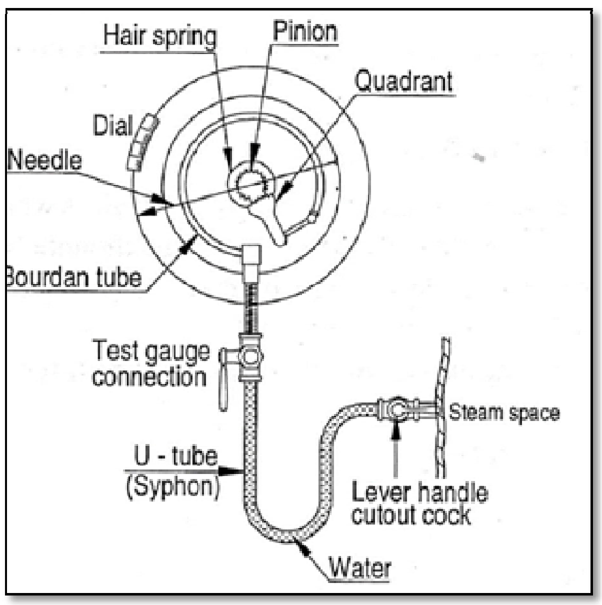

Fig. 2.2 Pressure Gauge

Working

The steam under pressure flows into tube. As a result of this increased pressure, tube tends to straighten itself. Since the tube is encased in a circular curve, therefore it tends to become circular instead of straight. With the help of simple pinion and sector arrangement, the elastic deformation of the Bourdon tube rotates the pointer. This pointer moves over a calibrated scale, which directly gives the gauge pressure.

Safety Valves

It is the device attached to the steam chest for preventing explosions due to excessive internal pressure of steam. A steam boiler is usually, provided with two safety valves. These are directly placed on the boiler. Following are the four types of safety valves are used.

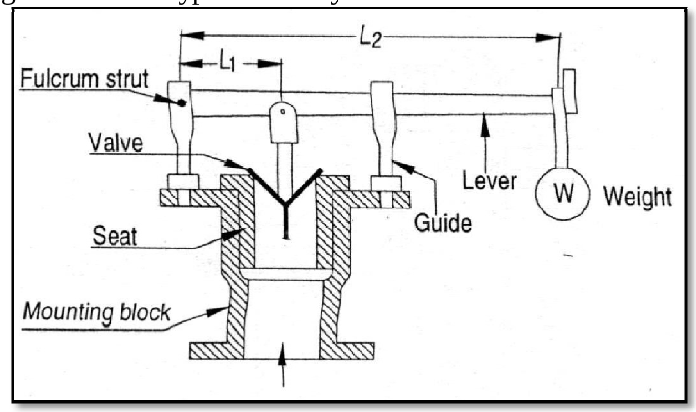

Fig. 2.3 Lever Safety Valve

Lever Safety Valve

A lever safety valve used on steam boilers is shown in fig. 6.6. A lever safety valve consists of a valve body with a flange fixed to the steam boiler. The bronze valve seat is screwed to the body, and the valve is also made of bronze. The thrust on the valve is transmitted by the strut. The guide keeps the lever in a vertical plane.When the pressure of steam exceeds the safe limit, the upward thrust of steam raises the valve from its seat. This allows the steam to escape till the pressure falls back to its normal value. The valve then returns back to its original position.

Dead Weight Safety Valve

When the steam pressure exceeds the normal limits, this high pressure steam creates upward force on valve, thus valve V lift with its weights and the excess steam escapes through the pipe to he outside.

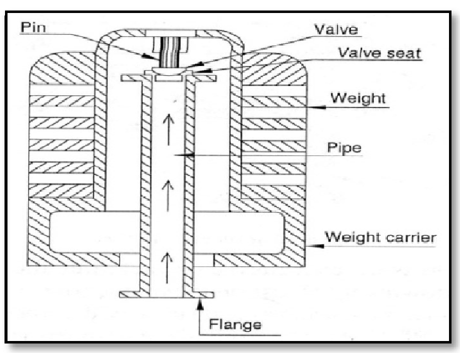

Fig. 2.4 Dead Weight Safety Valve

High Steam Low Water Safety Valve

It allows the steam to escape out of boiler when steam pressure exceeds normal value or water lever in the boiler falls below the normal level.

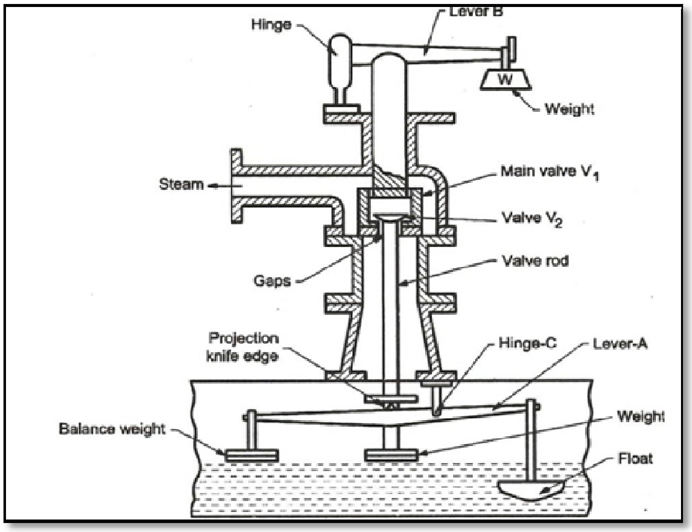

Fig. 2.5 High stem low water safety valve

It consists of lever A which is hung inside the boiler shell and it is hinged at point C. One end of the lever carries a balance weight and the other end carries an earthen float immersed in water. The balance weights are kept in such a way that the knife edge of the lever just touches the projection when the float just dips into water. It also consists of two valves. One is main valve V1 which rests on its seat. The edge of the central opening in the valve V1 forms the seat for the hemispherical valve V2 and the end of valve rod carries a weight.

When the water level falls and floats is sufficiently uncovered from water, the weight of the float increases and no longer. It is balanced by the balance weights. Consequently, the float end of the lever will descend and causes a swing in the lever A. When the lever swings, the valve rod is pushed up. It also pushes up the hemispherical valve V2 and the steam leaks through the gaps provided with a loud noise. This acts as a warning to the boiler attendant. When the hemispherical valve is closed, the main valve V1 acts as an ordinary lever safety valve and it guards against the high pressure in the boiler. The valve V1 is held in position partly by the weight on the rod of valve V2 and partly by the loaded lever above the valve casing. When the steam pressure exceeds the limiting working pressure, the main valve V1 along with valve V2 lifts up and the steam leaks out through the discharge duct.

Spring Loaded Safety Valve

A Ramsbottom spring loaded safety valve is shown in Fig. 2.6. It is usually, fitted to locomotives. This valve consists of a cast iron body having two branch pipes. Two valves sit on corresponding valve seats at the end of the pipes.

The lever is placed over the valves by means of two pivots. The lever is held tight at its position by means of a compression spring. One end of this spring is connected with the lever while the other ends with the body of the valve.

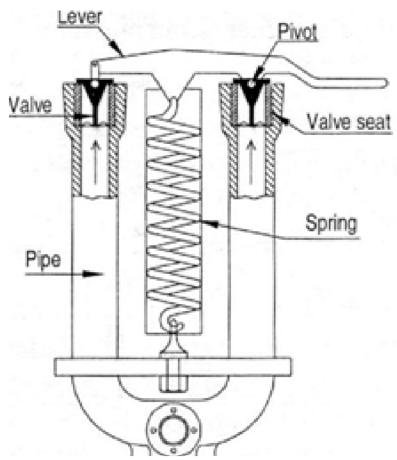

Fig. 2.6 High stem low water safety valve

Under the normal conditions, the spring pulls the lever down. This applies downward force on valves which is greater than the upward force applied by steam. When steam pressure exceeds normal value, upward force become, larger than the downward force on the valve due to spring. Thus the valves are lifted from their seats, opening the passage for steam to release out. The valve closes due to spring force when the pressure in the boiler becomes normal.

Steam Stop Valve

<u>Function</u>To control the flow of steam from the boiler to the main steam pipe. To shut off the steam completely when required.

Construction

The body of the stop valve is made of cast iron or cast steel. The valve, valve seat and the nut through which the valve spindle works, are made of brass or gun metal. The spindle passes through a gland and stuffing box. The spindle is rotated by means of a hand wheel. The rotation of the spindle causes the valve to move up and down.

Working When the valve sits over the valve seat, the passage of steam is completely closed. The passage may be partially or fully opened for the flow of steam by moving the valve up, rotating the hand wheel.

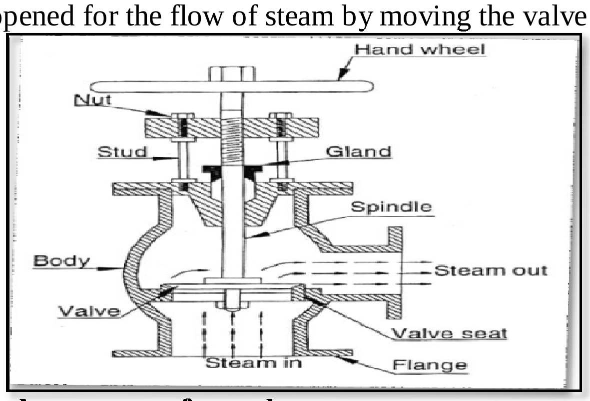

Fig. 2.7 High stem low water safety valve

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Feed Check Valve

Function

Its function is to regulate the supply of water, which is pumped into the boiler, by the feed pump.

Construction

It is a non-return valve, fitted to a screwed spindle to regulate the lift. This valve must have its spindle lifted before the pump is started.

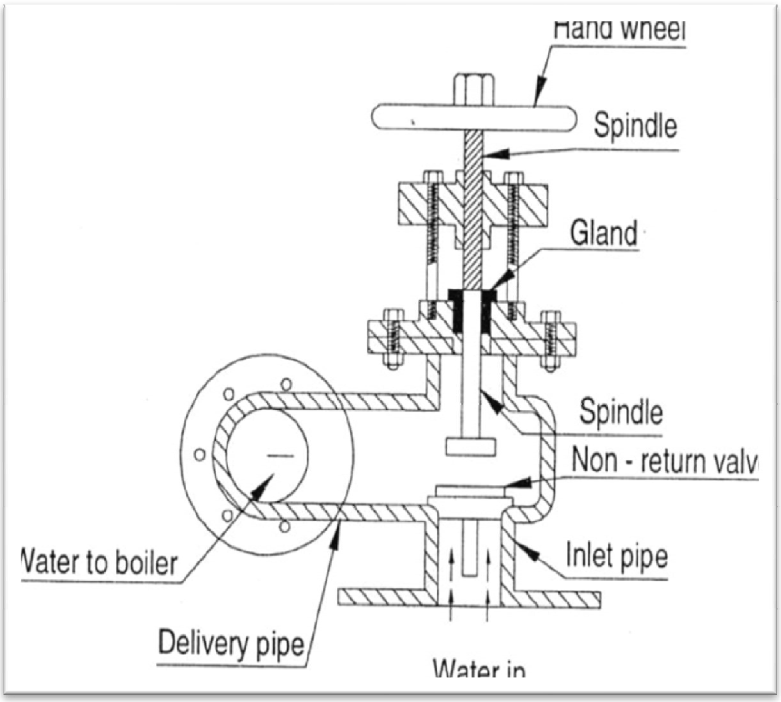

Fig. 2.8 Feed Check Valve

Pump pressure acts from below the non-return valve and boiler pressure acts from above it. Under normal working conditions, the pump delivery pressure is higher than the boiler pressure. So the valve is lifted from it seat and allows the water to flow to boiler. The lift of the valve is controlled by moving the spindle up and down with the help of the hand wheel. Thus, the flow of water can be controlled.

Working

If the boiler pressure is higher than pump pressure or the pump is stopped, the upward force on non-return valve is higher. So it sits on its seat and closes the passage. Thus water from boiler is not allowed to flow backward.

Blow Off Cock

<u>Function</u>

It may discharge a portion of water when the boiler is in operation to blow out mud, scale or sediments periodically. It may empty the boiler when necessary for cleaning and repair.

<u>Construction</u>

A common type of blow-off cock is shown in fig. 2.9. A conical plug is fitted accurately into a similar casing. The plug has a rectangular opening. The plug slot is perpendicular to the flow passage.

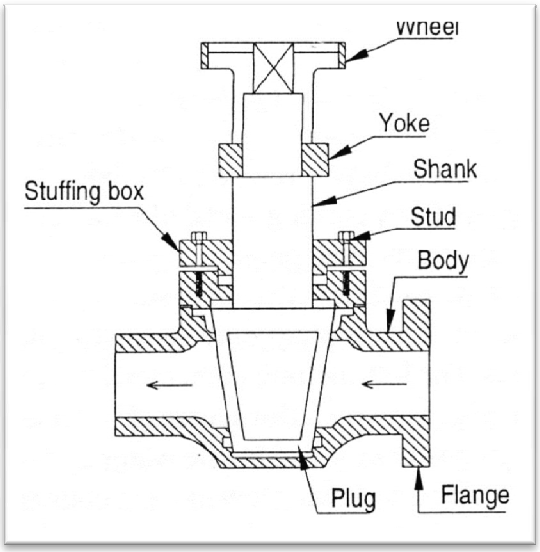

Fig. 2.9 Blow-off Cock

<u>Working</u>

When the plug slot is brought in line with the flow passage of body by rotating the plug, the water from boiler comes out with a great force. If sediments are to be removed, the blow- off cock is operated when the boiler is on. This forces the sediments quickly out of boiler.

Fusible Plug

Function

The main function of the fusible plug is to extinguish fire when water level in the boiler falls below an unsafe level.

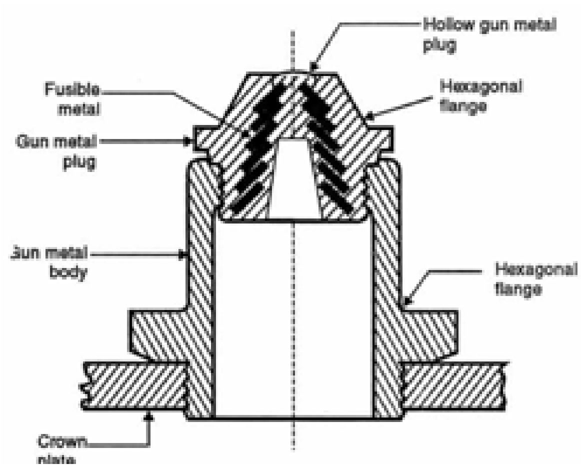

Fig.2.10 Fusible plug

Construction

The construction of the fusible plug is shown in fig. 2.10 which consists of three plugs. The hollow plug A having hexagonal flanges is screwed to the fire box crown plate. The plug B gunmetal plug is screwed to the body A. The third plug C is made up of copper is locked with metal like tin or lead which has a low melting point.

Working

In normal working condition, water covers the fusible plug remains cool. In case the water level falls below the danger levels, the fusible plug gets exposed to steam. This overheats the plug and fusible metal having low melting point melts quickly. Due to this plug S falls. The opening so made allows the steam to rush on to the furnaces and extinguishes the fire or it gives warning to the boiler attendant that the crown of furnace is in danger of being overheated.

Boiler Accessories

These are auxiliary plants or parts required for steam boilers for their proper operation and to increase the efficiency of the boiler.

Commonly used boiler accessories are as:

1. Feed pumps
2. Injector
3. Economiser
4. Air preheater
5. Superheater
6. Steam separator
7. Steam trap

Economizer

Function

An economizer is a device in which the waste heat of the flue gases is utilized for heating the feed water.

Construction and working

Fig. 2.11 shows an independent type vertical tube economiser. It is employed for boilers of medium pressure range unto about 25 bar. It consists of a large number of vertical cast iron pipes P which are connected two horizontal pipes, one at the top and other at the bottom. A is the bottom pipe through which the feed water is pumped into the economizer. The water comes into the top pipe B from the bottom pipe and finally flows into the boiler.
The flue gases flows around the pipes in the direction opposite to the flow of water. Consequently, heat transfer to the surface of the pipes takes place and water is thereby heated.

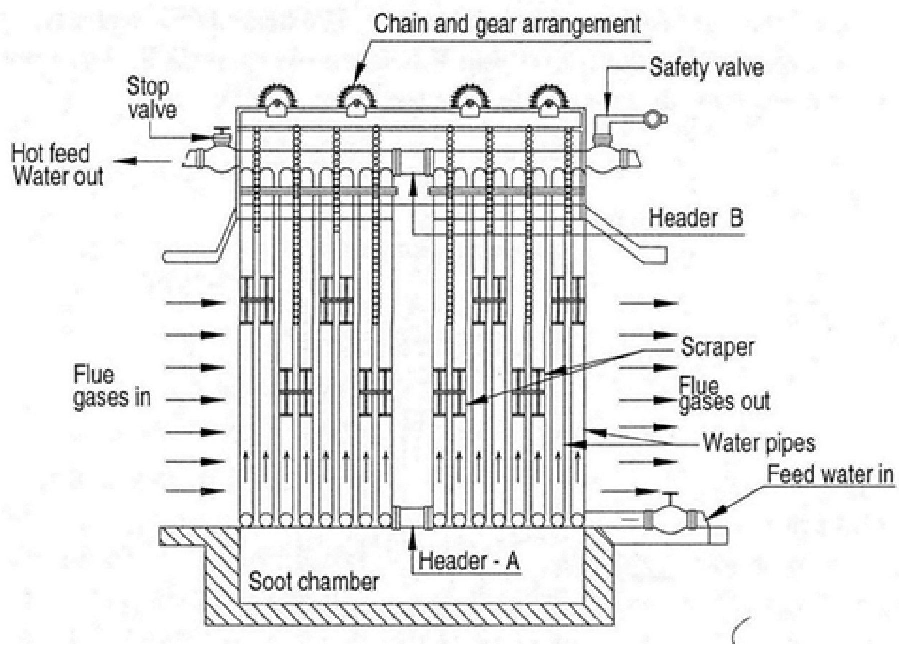

Fig. 2.11 Economizer

A blow off cock is provided at the back end of vertical pipes to remove sediments deposited in the bottom boxes. The soot of flue gases deposited on the pipes reduces the efficiency of economizer. To prevent the soot deposit, the scrapers move up and down to keep the external surface of pipe clean. By-pass arrangement of flue gases enables to isolate or include the economizer in the path of flue gases.

Super Heater

Fig. 2.12 Shows Sugden's superheater installed in a Lancashire boiler. It consists of two steel headers to which are attached solid drawn 'U' tubes of steel. These tubes are arranged in groups of four and one pair of the headers generally carries ten of these groups or total of forty tubes.

Function

Superheater increases the temperature of the steam above its saturation temperature by utilizing exhaust gases.

Construction and working

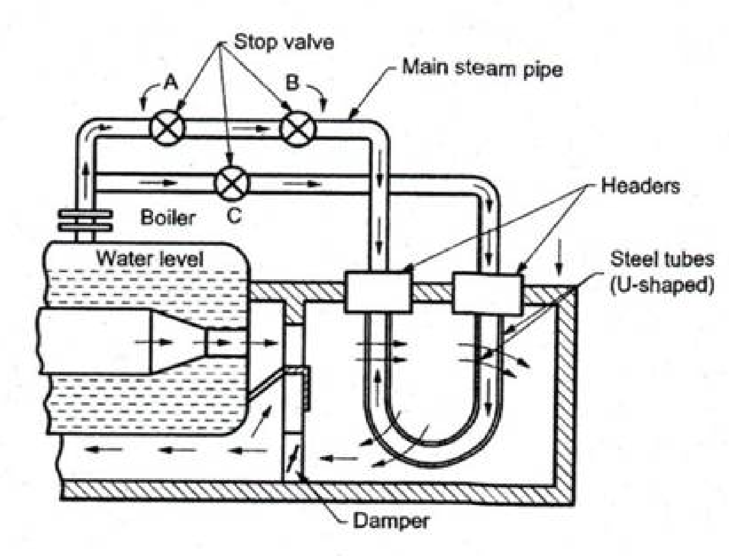

Fig. 2.12 Superheater

The stop valve A is closed and stop valves B and C are in open position. The wet steam from boiler flows into right hand header via stop valve C. After superheating of steam in the tubes, it flows into the left hand header, from where it is withdrawn through the stop valve B. If the superheated steam is not needed, the stop valves B and C are closed and the wet steam is directly taken out from the boiler through stop valve A.

Air Preheater

Function

Air preheater increase the temperature of air before it supply to the furnace using heat from flue gases passing through the chimney.

Construction and working

Air preheater is installed between economiser and the chimney. It consists of large numbers of tubes which arranged in path of flue gases shell as shown in Fig. 2.13 Hot flue gases enters into tubes from top of shell and leave from the bottom to the chimney. The inlet air at room temperature is admitted into shell at lower end with the help of the fan. The air passes upward around the tubes in the opposite direction to the flow of hot flue gases. The soot hopper provided at the bottom is used to collect soot during cleaning operation of the tubes.

Advantages

1. Preheated air increases combustion rate and then increases steam generator rate of boiler.
2. Due to higher temperature of air furnace temperature of air, furnace temperature increases, so low grade coal can be burnt efficiently.
3. Air heated by heat of exhaust gases. It reduces fuel consumption. Therefor thermal efficiency of boiler increased.

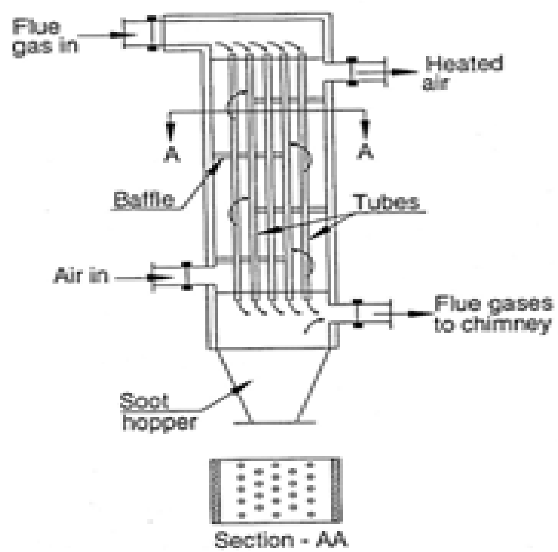

Fig. 2.13 Air Preheater

Disadvantages

1. There are formations of clinker, on the grate due to higher combustion temperature.
2. Natural draught is not possible with air preheater because of temperature of the gases is reduced, also pressure drop take place in the flow of flue gases. Thus forced draught is required.

****

EXPERIMENT-3

Aim: To determine brake thermal efficiency of computerized four stroke single cylinder diesel engine test rig.

Standard Accessories:

- Fuel Measurement consumption by volumetric method and also provide fuel measurement by load cell on fuel tank.
- Air intake measurement by using orifice plate U tube manometer of proper height & Air box with size of 300X300X500 mm.
- Digital RPM meter (Except Mechanical loading)
- Digital Electronic torque controller for Eddy current dynamometer
- Digital temperature gauges (Air IN, Exhaust OUT, Cooling Water IN and OUT)
- fuel tank 10 lit capacity,
- Water flow Measurement through Rota-meter with 2400 LPH capacity
- Clean and soft water supply tank of capacity 300 lit with ISI certified motor pump set.
- Combustion pressure sensor, crank angle sensor ,
- Exhaust gas calorimeter,
- Engine interfaces, computer system with i3 processor or equivalent AMD processor, window 8 OS and MS office 2014, 1 PCI slot and PC card, data logger with suitable software & LED colour monitor.
-

Test Rig Is Capable Of Find Out Different Parameters Like:

1. Brake Power
2. Fuel Consumption
3. Brake Thermal Efficiency
4. BMEP
5. Volumetric Efficiency
6. Air-fuel ratio
7. Indicated Power
8. Friction Power
9. IMEP
10. Indicated thermal efficiency
11. Mech. Efficiency
12. Indicated Torque
13. Diagrams of Combustion pressure versus crank angle, Combustion pressure versus volume, Heat Release Curve.

Safety Precautions:

Vision:
To deliver quality engineering education for mechanical engineers with professional competency, human values and acceptability in the society.
Mission:

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

1. Use this test rig with permission of lab in charge/ subject teacher/ competent authority only.
2. Testing and performance on this test rig must be done under able supervision only.
3. Before starting engine start cooling water circulation pump without fail. Never run the test rig without cooling water supply, this may damage pressure measuring sensors.
4. Immediately turn OFF the engine if water supply is interrupted, or temperature sensor is showing higher temperature then permissible value.
5. Make sure for proper quantity of fuel and cooling water supply is available in respective tanks for the duration of performance.
6. After starting engine wait of steady state before taking results for batter accuracy of reading.
7. In the computer, save all reading and performance report in a proper directory with proper name to have hassled-free reporting and filing.
8. Do not uses USB drive to take the data / report etc. from computer, concern lab in-charge shall provide that.
9. After copulation of performance / testing shut off all equipment and peripherals properly.
10. Without fail make an entry of using this test rig in UTILIZATION REGISTER of test rig.

<u>Operating Procedure (S.O.P.):</u>

1. Select start – all programs – engine_9ch_new, the main window computerized test bench tester opens.
2. Before starting test set all the engine parameters and initial values through initial settings which are necessary for calculating various engine parameters.
3. To open initial setting window select file DUT info - initial settings.
4. All the channels have to be calibrated before starting the test for the first time.
5. "Load & Heat balance test" window displays load applied on the engine along with torque and speed.
6. Following 4 tab windows : a) observation data, b) load and efficiency, c) heat balance, d) heat balance credit and debit will appear enter data recorded.
7. File path shows where the data are stored when SAVE button is pressed.
8. Time taken for fuel consumption for last test will show in sec taken for the engine to consume the quantity of fuel between high sense and low sense sensors for the last set of readings taken.
9. Clicking on start test button "Datalog10CH" window will appear.
10. Data logger will test the engine automatically and "PV-Pθ Diagram" window will appear.

Observations and Calculations:

Testing Parameters of Engine:

- Note it down from the test data sheet developed from test rig software

Sr. No.	Particulars	Value as available	**Value** with Unit conversion (if Required)
1.	Engine Type as per classification:		
2.	Bore Diameter:		
3.	Stroke Length:		
4.	Engine speed(Rated):		
5.	Fuel used:		
6.	C. V. of Fuel used:		

OBSERVATIONS FOR EFFICIENCY CALCULATIONS:

- Note it down from the test data sheet developed from test rig Software

Sr. No	Particulars	Test 1	Test 2	Test 3	Test 4	Test 5
1	Pressure indicated:					
2	Engine Speed:					
3	Rate of Fuel supply:					
4	Load on Dynamometer:					
5	Load Arm Length:					
6	Break Power:					
7	Indicated Power:					
8	Mechanical Efficiency:					
9	Break Thermal Efficiency:					
10	Indicated Thermal Efficiency:					
11	Specific Fuel Consumption:					

Sample Calculations: (For test no. ____)

1) **Indicated Power:**

$$I.P. = \frac{P_m \times L \times A \times N}{60 \times 10^3} \quad kW$$

Here ***N*** = the number of working stroke per minuts

= ***Engine Speed/2*** for Four Stroke Engine

2) **Break Power:**

$$B.P. = \frac{2 \times \pi \times N \times T}{60 \times 10^3} \quad kW$$

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- To create ethical engineers who can contribute for sustainable development of society

Here N= thespeed of Engine in r.p.m.

3) **Mechanical Efficiency:**

$$\eta_{mech} = \frac{I.P.}{B.P.} \times 100 \quad \%$$

4) **Indicated Thermal Efficiency:**

$$i\ \eta_{th} = \frac{I.P}{\dot{m}_f \times C.V.} \times 100 \quad \%$$

5) **Break Thermal Efficiency:**

$$Break\ \eta_{th} = \frac{B.P.}{\dot{m}_f \times C.V.} \times 100 \quad \%$$

Calculated Result for each Test and % error							
Sr. No	**Particulars**		**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
1	Break Power:	Result					
		% error					
2	Indicated Power:	Result					
		% error					
3	Mechanical Efficiency:	Result					
		% error					
4	Break Thermal Efficiency:	Result					
		% error					
5	Indicated Thermal Efficiency:	Result					
		% error					

CONCLUSION:

EXPERIMENT-4

Aim: To understand construction and working of different types of air compressors

Vision:
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Mission:

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

Introduction

A machine which takes in air at low pressure and compress it to high pressure with the help of some suitable arrangement i.e. a reciprocating piston and cylinder arrangement or a rotary arrangement, is called an air compressor.

Uses of Compressed air

1. The compressed air has number of application in different industries. They are listed as under:
2. Operating pneumatic drill, hammers for the formation of rivet heads.
3. For filling air in automobile tyres.
4. For spray painting.
5. Increasing inlet pressure of I.C. Engine.
6. To operate air motor in mines where fire risks are more.
7. Pumping of water.
8. Gas turbine power plant.
9. Conveying the materials like sand and concrete along a pipe line.
10. For sand blasting.
11. Operating blast furnaces.
12. Operating air brakes used in buses, trucks, trains etc.

Classification of compressors

The air compressor can be classified in number of ways.

1. **According to method of compression**
   a. ***Reciprocating compressor***
   This type of compressor compresses air by reciprocating action of piston inside a cylinder. It is suitable for producing high pressure.
   b. ***Rotary Compressor***
   In a rotary compressor, air or gas is compressed due to the rotation of impeller or blades inside a casing similar to a rotary pump.
   c. ***Centrifugal compressor***
   A machine in which compression of air to desired pressure is carried out by a rotating impeller as well as centrifugal action of air.

2. **According to method delivery pressure**
   a. Low pressure - up to 1.1 bar
   b. Medium pressure - 1.1. to 8 bar
   c. High pressure – 8 to 10 bar
   d. Very high pressure - above 10 bar

3. **According to principle of operation**
   a. ***Positive displacement***
   In this type, pressure of air is increased by reducing the volume of it. Here air is compressed by positive displacement of air with piston or with rotating element. These are capable with

low volume flow rate. Examples: Reciprocating compressor, Roots Blower etc.

b. Roto dynamic or steady flow compressor

In this type, compression of air is carried out by a rotating element imparting velocity to the flowing air and developed desired pressure. Here compression is achieved by dynamic action of rotor.

Examples: Centrifugal, Axial flow, etc.

4. **According to the number of stages**
   a. Single stage compressor - pressure up to 5 bar
   b. Multistage compressor - pressure above 5 bar

5. **According to method the number of cylinder**
   a. Single cylinder
   b. Multi cylinder

6. **According to method the pressure limit**
   a. Fans - pressure ratio 1 to 1.1
   b. Blowers - pressure ratio 1.1 to 2.5
   c. Compressor - pressure ratio above 2.5

7. **According to volume of air delivered**
   a. Low capacity - volume flow rate up to 9 m^3/min
   b. Medium capacity - volume flow rate 10 m^3/min to 300 m^3/min
   c. High capacity: Volume flow rate above 300 m^3/min

8. **According to fluid to be compressed**
   a) Air compressor
   b) Gas compressor
   c) Vapour compressor

Reciprocating air compressor

Construction

It consists of the cylinder in which a piston reciprocates. The piston is driven by crank through connecting rod. The crank is mounted in a crankcase.

There are two valves, i.e. intake valve and delivery valve. The valves are generally pressure differential type. Thus they operate automatically by the difference of pressure across the valve.

Operation of a compressor

Case-(1) Operation without clearance

It is assumed that in an ideal compressor there is no clearance volume at the end of the stroke. In this type of compressor, when piston is moving away from TDC, pressure inside cylinder will decrease and volume will increase. Hence pressure difference across the valve is created. The spring operated inlet valve will be opened automatically for intake of air. Therefore the atmospheric air enters into the cylinder at constant pressure P1 with increase in volume. This process is shown by (4-1) on p- V diagram.

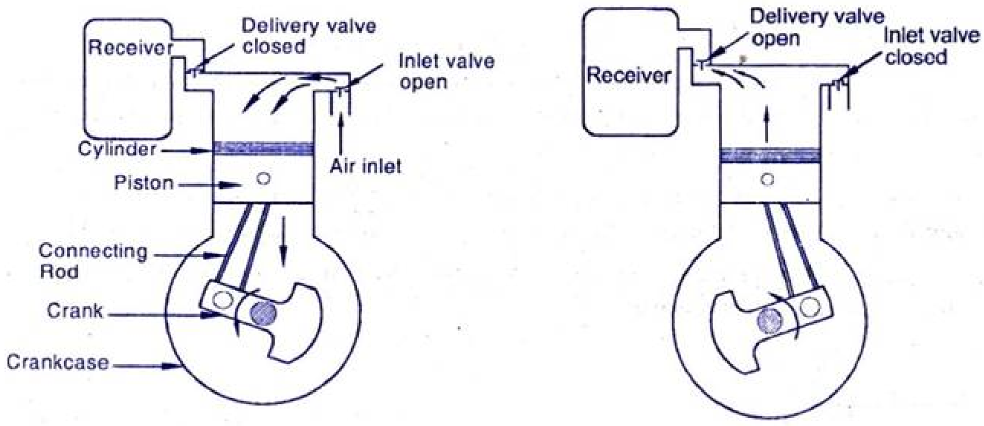

Fig. 4.1 Reciprocating air compressor

The piston moves towards the TDC from BDC during the second stroke. The air is compressed adiabatically with increase of pressure. This is shown by the curve (1-2). When the pressure of compressed air becomes equal to the pressure of receiver in which the air is delivered, the spring operated delivery valve opens automatically and the air is forced into the receiver at constant pressure P_2 from the cylinder. This process is shown by horizontal line 2-3.

Again piston moves away from TDC. Thus the cycle is completed and the same cycle will be repeated. Area of the diagram (1-2-3-4) represents the work required to compress air from pressure P_1 to P_2 for adiabatic compression.

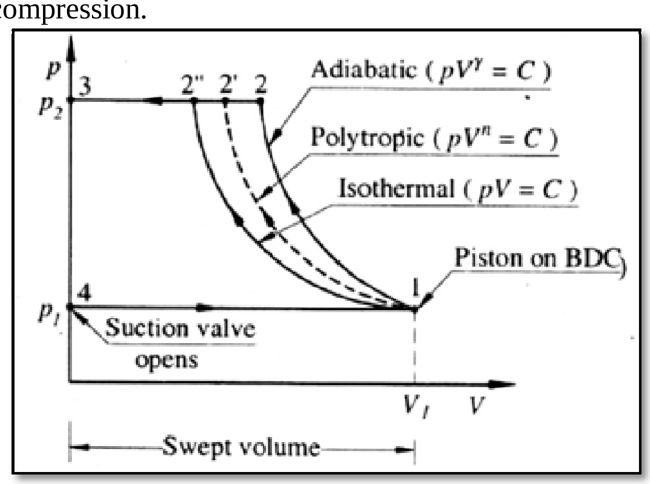

Fig. 4.2 P-V diagram without clearance

Case- (2) Operation with clearance

In actual compressor always there is clearance volume at the end of stroke. The small clearance is required because of,

(1) Preventing striking of piston at cylinder head,

(2) Thermal expansion due to high temperature at the end of compression,

(3) Maintaining machine tolerance.

(A) If the compression follows $PV^n = C$

The clearance volume is denoted by V_C or V_3.The residual compressed air at a pressure $P_2 = P_3$ is filled in clearance volume at the end of upward stroke of piston. So during the suction stroke this residual compressed air expands and denoted by the curve (3-4) on p-V diagram in fig.

This expansion will reduce pressure from $P_2 = P_3$ to intake pressure $P_4 = P_1$. Due to this reduction in pressure the in valve will begin to open. This will permit the intake of a fresh air. The volume (V_1 - V_4) known as suction volume, effective swept volume or free air delivery at suction condition.

The work required to drive compressor per cycle is represented by area (4-1-2-3). At point 4 suction valve opens, at point 2.

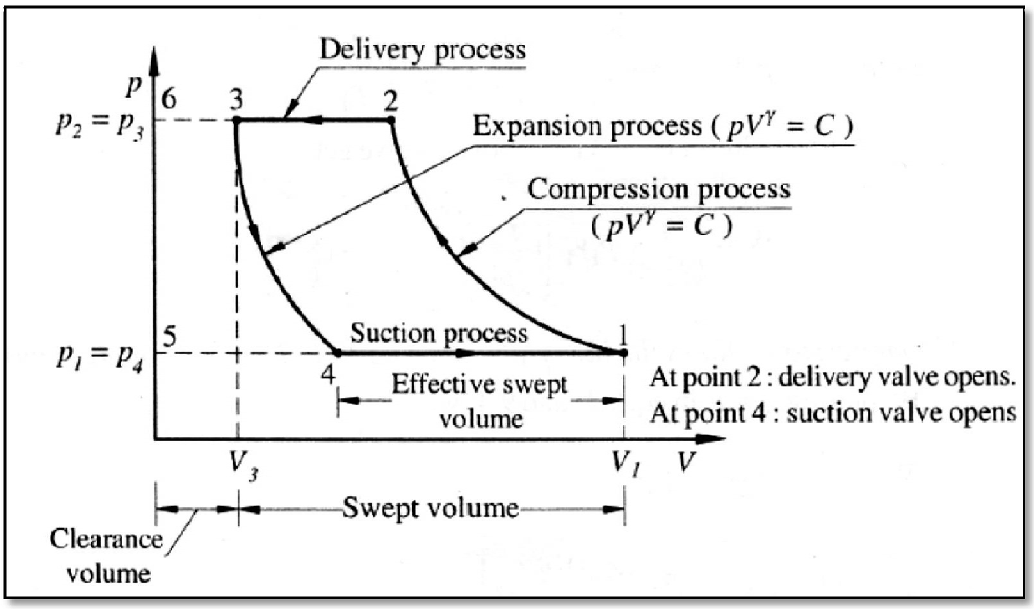

Fig 4.3 P-V diagram with clearance

Multistage reciprocating compressors

In a single stage compressor, if the pressure ratio is increased, the volumetric efficiency decreases.

When the pressure ratio is increase maximum, the volumetric efficiency becomes zero, thus multistage compression is needed.

Problems with single stage compression are,

The higher the delivery pressure, the higher will be delivery temperature. This increase in temperature causes increase in specific volume and energy loss. So compressor has to handle more volume of air at higher temperature.

The increase in temperature of air causes reduction in density of air, hence the mass flow through compressor decreases.

The operation at high pressure and temperature will need heavy working parts.

Working

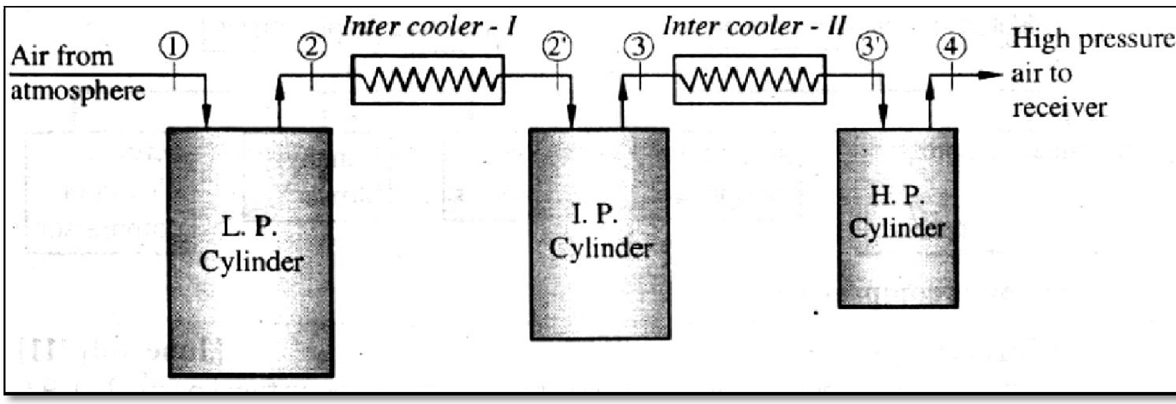

Fig. 4.4 Concept of multistage compressor

In low pressure (L.P.) cylinder, air is compressed adiabatically from point 1 to 2. This compressed air is passed through intercooler-l where it is cooled from 2 to 2'. The air coming from intercooler-l is then admitted into the intermediate pressure (I.P.) cylinder where it is compressed adiabatically from 2' to 3. The compressed air from I.P. cylinder is cooled from 3 to 3' in the intercooler-2. Finally air enters into high pressure (H.P.) cylinder for getting higher pressure.

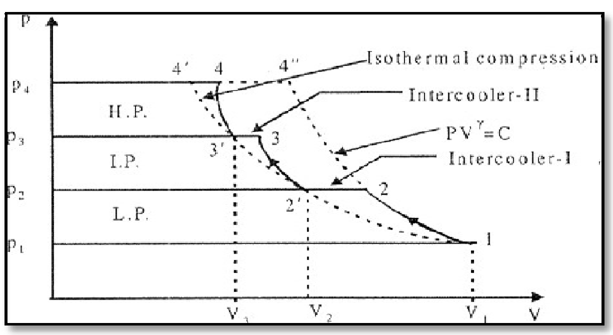

Fig. 4.5 P-V diagram of multistage compressor

Advantages

1. Without inter-cooling, the curve of compression will follow the path (1- 4”), hence the saving in work input due to inter-cooling.
2. Volumetric efficiency is increased due to the smaller pressure range, as the effect of expansion of air in the clearance volume is less.
3. Less shaft power is required for a given pressure ratio due to the saving in work input.
4. Due to smaller working temperature, better lubricating effect is provided.
5. Better mechanical balance and smoother torque-angle diagram is obtained.
6. In a multistage compressor, the low pressure cylinder is lighter.
7. There is less leakage problems due to less pressure difference for each stage.

Rotary air compressor

In rotary air compressor, the air is entrapped between two sets of engaging surface and the pressure of air is increased by squeezing action or back flow or the air.

Types of Rotary air compressor

1. **Positive Displacement Compressor**
   a) Roots blower
   b) Vane compressor

2. **Dynamic Compressor**
   a) Centrifugal compressor
   b) Axial-flow compressor

Roots Blowers

Construction

The two lobe type roots blower is shown in fig. 4.6. For higher pressure ratios, three and four lobes versions are used.

One of the rotor is connected to the drive. The second rotor is gear driven from the first. Thus both the rotors, rotate in phase. In order to seal delivery side from the inlet side, the profile of the lobs is of cycloidal or involute. This sealing continues until delivery commences.

To reduce wear, there must be some clearance between the lobes and between the casing and the lobes. Although this clearance will form a leakage path for compressed air and will have an adverse effect on efficiency when pressure ratio increases.

In order to achieve the acceptable efficiency of the blower a very small clearance of about 0.2 to 0.5 mm is provided. The pressure at the delivery is not constant. Single acting blower can develop the pressure up to twice the inlet pressure.

Principle of operation

The operation can be considered as taking place in two distinct phases suction and discharge as describe below

Suction phase : The rotation of the rotors produces space, which increases the volume as rotation continues.

The gas therefore flows into the machine to fill the space. The flow of gas into the blower continues involving both the rotors.

A quantity of gas is trapped between one rotor and the casing for a very brief interval. This part of the blower is not open to the suction. No gas flows into it. The gas continues to flow into the space produced by the rotation of the other rotor. This rotor is carrying out the same cycle as the first but 90^0 behind it.

Discharge Phase

The trapped volume is at suction pressure as it has simply been drawn in by the movement of the rotors. There is no internal compression of gas as there is no meshing of rotors prior to the release to discharge. Continued rotation of rotors, opens \ the trapped space to the discharge port.

As the Pressure in the discharge port is higher than suction pressure, the movement that the trapped volume opens to the discharge Port, a back flow of gas from discharge takes Place. This will increase its Pressure up to discharge level. The continued rotation then pushes out the gas into the chamber (Receiver).

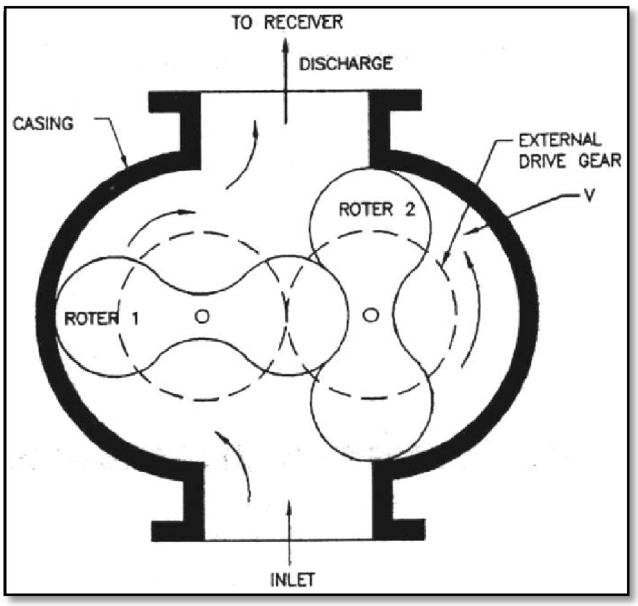

Fig. 4.6 Roots blower

Vane compressor

Construction

It consists of a rotor mounted eccentrically in the body. This rotor is supported by ball and roller bearings in the end cover of the body. The rotor is slotted to take the blades. These blades are made from non-metallic material usually fiber. The casing of the compressor is circular in which the drum rotates during rotation.

The vanes remain in contact with the cylinder. The slots in which the blades are fixed are cut radially into the rotor. The blades or vanes can slide in and out due to the centrifugal forces setup by the rotary motion of the rotor. The circular casing is provided with one inlet and one outlet port. The space between the rotor and its casing is sub-divided into a number of compartments by these, vanes. Two consecutive vanes form one compartment. Due to eccentric motion of the rotor the volume of each compartment keeps on changing. It can develop the pressure up to 9 bar and delivered 15 m^3/min of air.

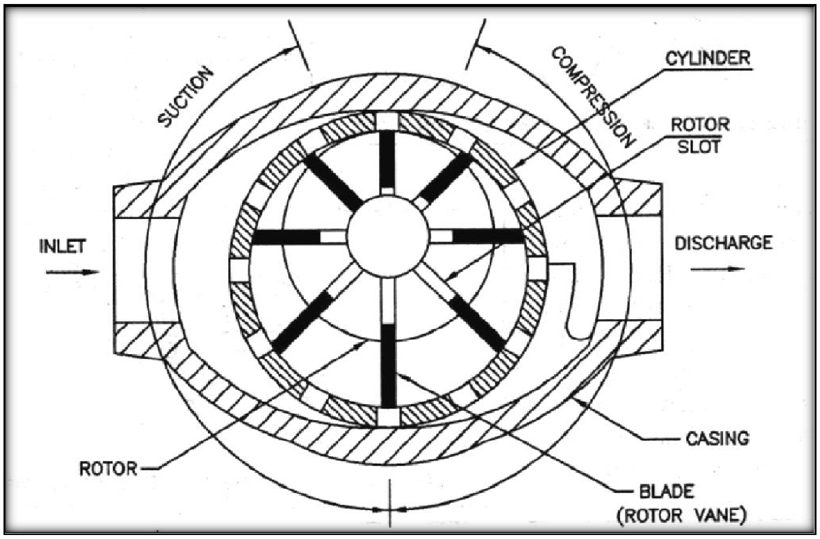

Fig. 4.7 Vane compressor

Principle of operation

The operation can be considered to take place in three phases. Suction, internal compression and discharge.

Suction phase

The relative position of the rotor and casing is clearly shown in fig. The start of the suction phase is indicated for one space between two of the vanes. The rotation of the rotor causes space to be formed between the vanes, the rotor and casing. This space is connected to the suction port so that gas from the suction passes into the space to fill it.

The continued rotation of the rotor increases the space open to the suction. Hence more gas flows in, to fill it. This process continues until the space into which the gas is flowing stops increasing. This will depends on the numbers of vanes in the compressor.

After this point the enclosed volume starts to reduce if it is still connected to the compressor suction gas will be dispelled. The suction port is positioned to be cut off as soon as the vanes move beyond this point.

Internal Compression Phase

The reduction in volume which occurs due to continued rotation, thus causes internal compression to take place. This will continue until the leading vane moves over discharge port. This will allow , the trapped gas to be released. The positioning of the discharge port determines the amount of internal compression.

Discharge phase

It is the final phase of operation. When the leading vane passes the discharge port , the gas is open to discharge and is expelled.

Centrifugal Compressor

A centrifugal compressor is used to supply large quantities of air at low pressures. The main features of the compressor are shown in Fig..

Construction

It consists of an impeller I. It carries a disc D. On this disc D, a large number of radial vanes or blades B are mounted. The impeller is mounted on the compressor shaft S. This shaft is usually rotates at high speed (20.000 to 30,000 RPM). C is a volute casing, it is known as diffuser. The impeller is shrouded by means of the casing. It surrounds the impeller in such a way that it forms the diverging passages for the air. Air coming out of the diffuser is collected in the casing of the compressor. It is then taken out from the out let O.

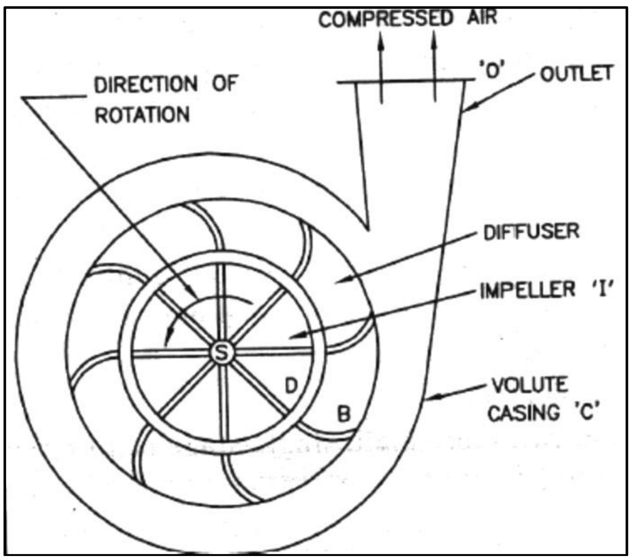

Fig. 4.8 Centrifugal compressor

Working

Air at low velocity and atmospheric pressure enters the compressor through eye E. It flows radially outward through the impeller blades. This air is subjected to a centrifugal force while passing through the impeller. The pressure and velocity increases in the impeller. The high-velocity air passes through the convergent passages formed by diffuser blades. The velocity is reduced. This decrease in velocity (K.E) of the air increases its pressure. It is found that, nearly half the pressure of the air is developed in the impeller and the remaining half in the diffuser. The compressor shown in fig. 4.8 is a single stage centrifugal compressor. The pressure ratios of 4 to 6 are common. For higher pressure ratios, multi-stage compressors are used

Axial Flow compressor

Construction

An axial flow compression stage consists of a row of moving blades arranged round the circumference of a rotor. A row of fixed blades arranged round the circumference of a stator.

The air is flowing axially through the moving and fixed blades in turn. At the entry, stationary guide vanes are provided at the entry to the first row of moving blades.

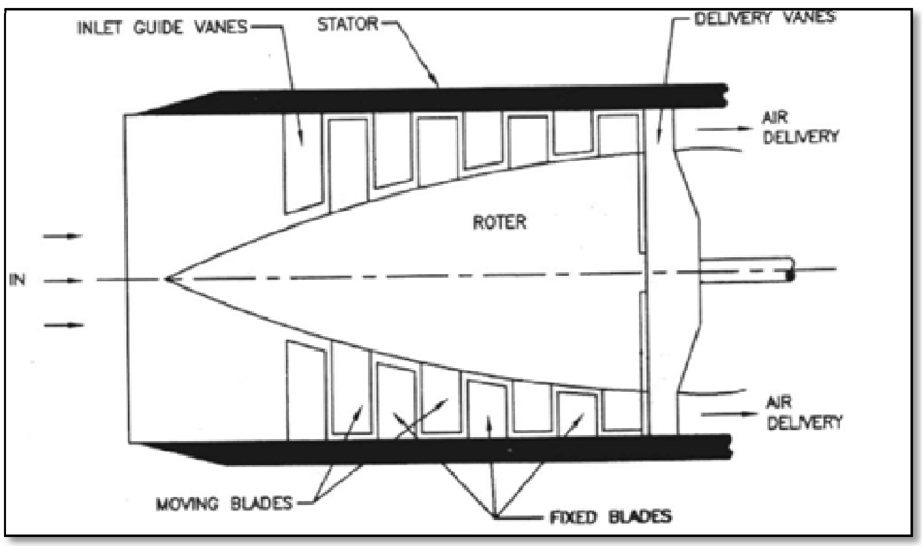

Fig. 4.9 Axial flow compressor

Working

The compression is performed in a similar manner to that of the centrifugal type. The work input to the rotor shaft to the air is by the moving blades. This will accelerate the air. The velocity of the air relative to the blades is decreased as the air passes through them because of the space provided between blades. This reduction in velocity increases the pressure. The air is then further diffused in the stator blades.

The stator blades are also arranged to form diffuser passages. The fixed stator blades guides the air by changing its angle in order to enter the second row of moving rotor blades. The number of stages are usually large.

These compressors are capable of developing pressure ratios of 1.2 to 1.3 per stage. These compressors can develop pressures up to 8 bar and deliver 1 to 50 m^3/s of air. Thus in order to achieve above pressure ratio of 8, about 6 stages is required.

****

EXEPERIMENT-5

Aim:To demonstrate vapor compression refrigeration cycle of domestic refrigeration

Introduction

In heat engine, heat flow from hot body to cold body and produce useful work. If it operates in the reverse direction, it takes heat from a cold body and rejects it to a hot body by the external mechanical work known as reversed heat engine. This principle is used in heat pump and refrigerator.

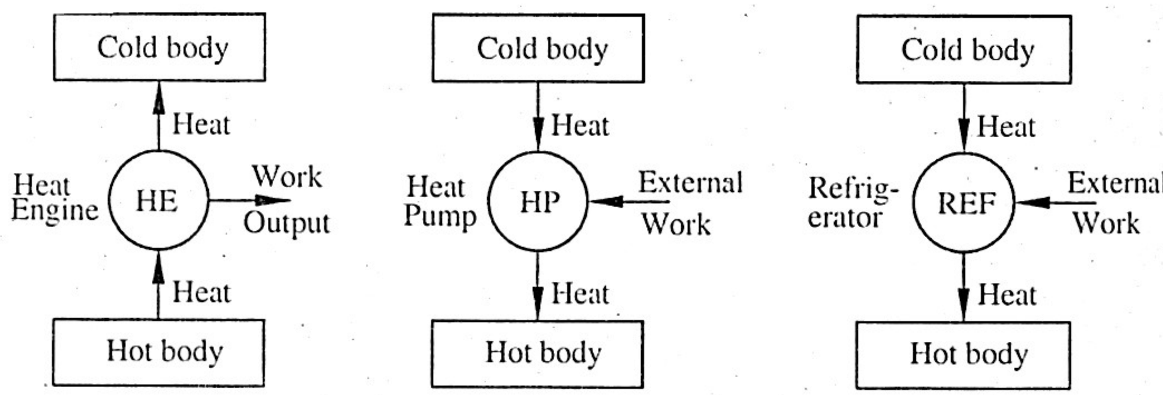

Figure 5.1 Heat Engine, Heat Pump and Refrigerator

Heat pump

It is device which absorbs the heat from cold body (surrounding) and deliver to hot body as shown in fig. and maintain constant temperature of hot body for useful purpose. In this devise, external work required to convey heat from cold body to hot body.

Refrigerator

It is a device which removes heat from cold body and reject to hot body (surrounding) and maintains low temperature for useful purpose. In this device, external work is required to convey heat from cold body to hot body.

It is a device or system used to maintain the low temperature below the atmosphere temperature within required space.

Principle of refrigeration

In refrigeration, the heat is to be removed continuously from a system or space at a lower temperature and transfer to the surrounding at a higher temperature. In this process, according to second law of thermodynamics external work is required to convey heat from cold body to hot body. Therefore in refrigeration, power is required to cool the space below the atmospheric temperature.

Refrigeration is defined as the method of reducing the temperature of a system below surrounding temperature and maintains it at the lower temperature by continuously abstracting the heat from it. In simple, refrigeration means the cooling or removal of heat from a system.

Refrigerants

The refrigerant is a heat carrying medium which absorbs heat from space (desired to cool) and rejects heat to outside the refrigerator (in atmosphere). The refrigerant is working medium under goes various processes of refrigeration cycles which are used to produce refrigeration.

Properties of a good refrigerant

a) It should have high latent heat of evaporation and low specific volume.
b) It should have good thermal conductivity for rapid heat transfer.
c) It should be non-toxic, non-flammable and non-corrosive.
d) It should have low specific heat in liquid state and high specific heat in vapour state.
e) It should have high co-efficient of performance.
f) It should be economical in initial cost and maintenance cost.

Application of refrigeration

a) Storage and transportation of food stuffs as dairy products, fruits, vegetables, meat, fishes etc.
b) Preservation of medicines and syrups.
c) Manufacturing of ice, photographic films, rubber products.
d) Processing of petroleum and other chemical products.
e) Liquification of gases like N_2, O_2, H_2 etc.
f) Cooling water.
g) Comfort air conditioning of auditoriums, hospitals, residence, offices, factories, hotels, computer rooms etc.

Refrigerants commonly used in practice

1) **NH_3 (Ammonia)**

Properties

Highly toxic, flammable, good thermal properties, highest refrigerating effect per kg of refrigerant.

Uses

It is widely used in large industrial and commercial refrigeration system. It is mostly used with Vapour absorption refrigeration cycle like ice plants, cold storage, packing plants etc.

2) **CO_2 (Carbon dioxide)**

Properties

Colorless, non-toxic, non-flammable and non-corrosive gas. It gives low refrigeration effect.

Uses

It is used in marine refrigeration system.

3) **Air**

Properties

Easily available without cost, non-toxic, completely safe refrigerant, low COP.

Uses

It is used in aircraft air-conditioning system.

4) **R-11 (Trichloro monofluoro methane) or Freon-11**

Properties

Non-toxic, Non-flammable and Non-corrosive.

Uses

It is used in Small office buildings and factories for refrigeration.

5) **R-12 (Dichlaro - difluro methane) or Freon -12**

Properties

Non -toxic, Non-flammable, Non-explosive, high COP and most suitable refrigerant.

Uses

It is used in domestic vapour compression refrigeration.

6) **R-22 (Monochloro - difluro methane) or Freon -22**

Properties

Non-toxic, Non-flammable, Non-explosive Required less compressor displacement.

Uses

It is used in commercial and industrial low temperature applications (in air conditioning).

Refrigeration effect and unit of refrigeration

Refrigeration effect

It is define as the amount of heat absorbed by refrigerant from the space to be cooled.

The capacity of refrigeration system is expressed in tons of refrigeration which is unit of refrigeration.

1 ton of refrigeration

It is defined as refrigerating effect produced by melting of 1 ton of ice from and at 0°C in 24 hours.

OR

Amount of heat required to remove in order to form one ton of ice in 24 hours from water at temperature $0\ ^0C$.

The latent heat of ice is 335 kJ/kg, the refrigeration effect produced by 1 ton ice in 24 hours is, In actual practice, 1 ton = 900 kg considered for calculation of 1 ton of refrigeration,

1 ton of refrigeration= 210** $\frac{KJ}{min}$ **= 3.5KW

Co-efficient of performance

It is defined as the ratio of refrigerating effect to work required compressing the refrigerant in the compressor. It is the reciprocal of the efficiency of a heat engine. Thus the value of COP is greater than unity.

Mathematically,

$$COP = \frac{\text{Refrigerating effect}}{\text{Work of compressor}}$$

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Types of refrigerators

The refrigerator can be classified as follows.

1. Natural refrigerator

In natural refrigerator, the cooling effect produced by evaporation of liquid or sublimation of solids. When liquid evaporate, it absorbs heat from surrounding and produces cooling. Similarly, in sublimation (melting) of solid, it absorbs heat from surrounding and produces cooling effect.

2. Mechanical refrigerator

In mechanical refrigerator, refrigeration effect produced by, external source of mechanical energy or heat energy.It is further classified as,

1. Vapour compression refrigerator
2. Vapour absorption refrigerator
3. Air refrigerator

Vapour Compression Refrigeration system (VCRS)

Construction

This system consist of (l) Evaporator (2) compressor (3) condenser and (4) expansion device. In vapour compression refrigerator, vapour used as the refrigerant. It is circulated in system in which it alternately evaporates (liquid to vapour) and condenses (vapour to liquid) thus it undergoes a change of phase. In the evaporation it absorbs the latent heat from the space to be cooled. In the condensing or cooling, it rejects heat to atmosphere.

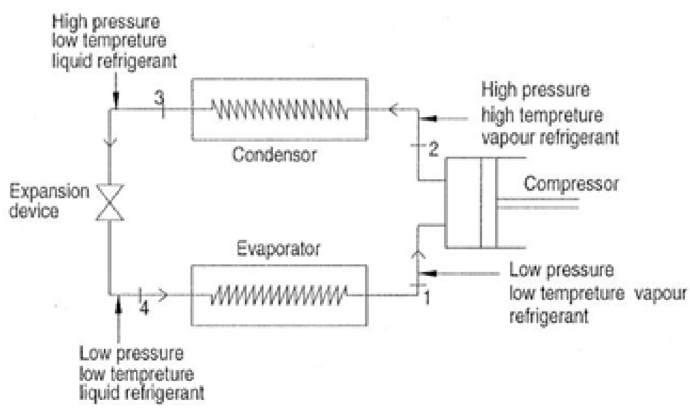

Fig. 5.2 Vapour compression refrigeration system

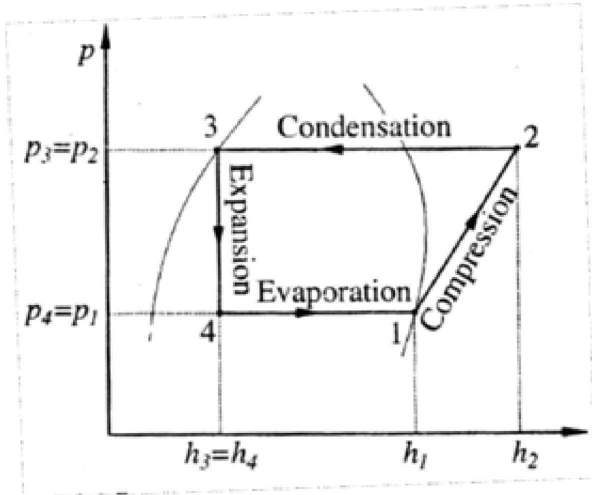

Fig. 5.3 P-h diagram

Functions of main parts of vapour compression system are,

Compressor

Function of compressor is to remove the vapour from the evaporator and increases its pressure and temperature up to it can be condensed in the condenser. Pressure of refrigerant coming from compressor should be such that the saturation temperature of vapour (corresponding to this pressure of vapour) is higher than the temperature of cooling medium in condenser. So that high pressure vapour can reject heat to cooling medium in the condenser.

Condenser

The function of condenser is to facilitate a heat transfer surface through which heat transfer takes place from the hot refrigerant vapour to the condensing medium. In domestic refrigerator condensing medium is atmospheric air.

Expansion valve or device

The function of expansion valve is to meter the proper amount of liquid refrigerant and reduces pressure of liquid refrigerant entering the evaporator. Hence liquid will vaporize in the evaporator at the desired low temperature and absorb heat from the space.

Evaporator

An evaporator provides a heat transfer surface through which low temperature liquid refrigerant can absorb heat from space and it vaporized.

Working

Process 1-2: Inlet of compressor (at point 1), low pressure and low temperature vapour enters the compressor. Compressor compresses the vapour at high temperature and pressure. The condition of refrigerant at exit to compressor (at point 2) is high pressure and high temperature vapour. *Process 2-3:* High pressure, high temperature vapour coming from compressor condenses in the condenser by the rejecting heat to cooling medium. Cooling medium is usually air or water. The condition of refrigerant at exit to condenser (at point 3) is low temperature saturated liquid.

Process 3-4: The saturated liquid coming from condenser passes through expansion device (throttling valve) where pressure of saturated liquid decreases from condenser pressure to evaporator pressure. The condition of refrigerant after throttling is low temperature and low pressure liquid.

Process 4-1: Liquid refrigerant coming from expansion device enters into evaporator where it absorbs latent heat of evaporation from space to be cooled (refrigerator compartment). Due to absorption of heat liquid refrigerant converted into saturated vapor or superheated vapour at low pressure and low temperature. Again this vapour enters into compressor and the cycle is repeated.

Domestic vapour compression refrigerator

Construction

It consists of an evaporator installed in the freezing compartment of the refrigerator. One end of evaporator connected to the suction side of the compressor and other end connected to condenser through throttle valve. Normally condenser installed at the backside of refrigerator. The delivery side of compressor is connected to a condenser.

Examples available in capacities of 65 liters, 100 liters, 165 liters, 275Iitres,1000 liters.

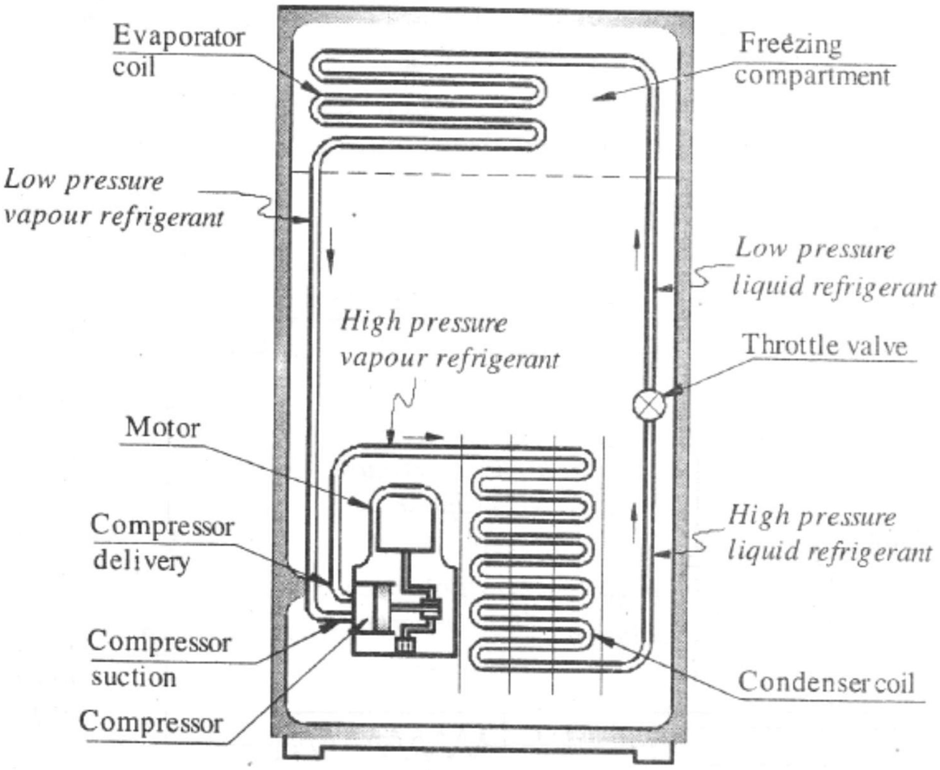

Fig. 5.4 Domestic vapour compression refrigerator

Vapour Absorption Refrigeration System (VARS)

Construction

This system is shown in figure consists of (i) evaporator, (ii) condenser, (iii) generator, (iv) absorber, (v) pump and (vi) expansion device. In this system the refrigerant coming from evaporator is absorbed by absorber.

The absorbing medium may be solid or liquid. In VAR system, the compressor is replaced by an absorber and generator.

Ammonia is refrigerant has characteristic as it is easily absorbed by water at low pressure and temperature, but at high pressure and temperature, the solubility of ammonia in water is reduced. Therefore when mixture of water and ammonia is heated by generator, the ammonia vapour is separated from water.

This principle is used in the vapour absorption refrigeration system. Here the ammonia is refrigerant and water is absorbent.

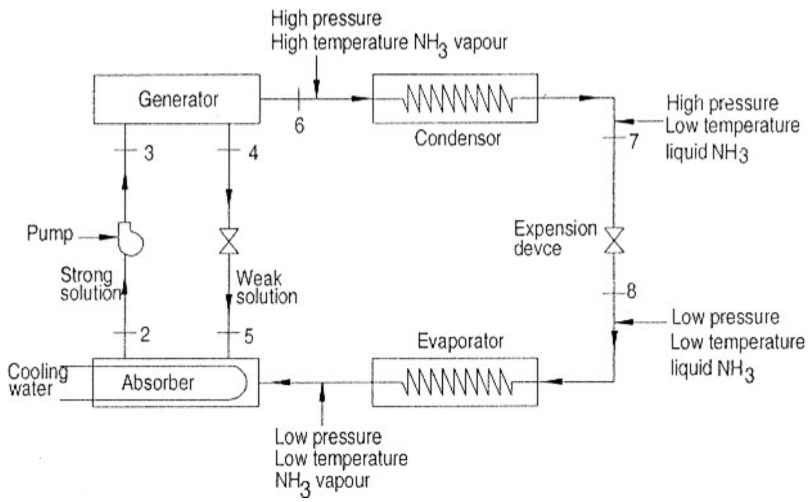

Fig. 5.5 vapour absorption refrigeration system

Working

Low pressure and low temperature vapour ammonia coming from evaporator enters in the absorber where ammonia is absorbed by weak solution coming from generator through throttle valve at point 5. Due to absorption of NH_3 in water, solution becomes strong. [In the mixture of NH_3 and water, if amount of NH_3 is less than water is called weak solution and if amount of NH_3 is more than the water is called strong solution.] During absorption process heat is released and rejected to cooling water.

The strong solution from absorber is pumped into generator, where it is heated and NH_3 vapour separated from solution. In generator is supplied from external source. The weak solution at point 4 is flowing back to absorber through throttle valve. Again weak solution in absorber absorbs NH_3

vapour coming from evaporator.

NH_3 vapour coming from generator (at point 6) passes through condenser and condensed in condenser and reject heat to cooling medium. Then liquid NH_3 (at point 7) throttled through expansion device and it enters into evaporator (point 8). In the evaporator NH_3 evaporates by absorbing latent heat of evaporation to produce refrigerating effect. Thus the cycle is completed.

Comparison between vapour compression and vapour absorption systems

Table 5.1 Comparison between VCR and VAR

Sr. No	Particulars	Vapour compression system (VCR)	Vapour Absorption system (VAR)
1.	Working method	Refrigerant vapour is compressed	Refrigerant is absorbed and heated
2.	Type of the energy Supplied	Mechanical work supply to compressor	Heat energy supply to generator
3.	Input work required	More compression work is required	Less mechanical energy is required to run pump
4.	COP	High (Approx. 3)	Low (Approx. 0.6)
5.	Capacity	Limited up to 1000 tons for single compressor	It may be above 1000 tons
6.	Noise	More	Quiet operation
7.	Leakage	More leakage due to high pressure	Almost there is no Leakage
8.	Operating cost	High because of compressor consumes more work	Less because of less heat energy is required
9.	Suitable refrigerant	R-12	Ammonia

****

EXPERIMENT-6

Aim: To understand different arrangement and application of various power transmission drives

Introduction

The power is required in various workshop operations. The electricity is main source of power for machinery. The electricity is converted into mechanical energy by means of an electric motor. The machine uses this mechanical energy to perform various operations.

Drive is an intermediate mechanism which transmits power and motion from the prime mover (or electric motor) to the machine. The mechanisms which are used to transmit the required motion and power from one shaft to another shaft are called Mechanical drives. These drives are extensively used in automobiles, workshops, processing and transport industry.

Mechanical Drives

Why to use drives?

- To vary the speed and torque.
- To run several machines by single prime mover. To avoid thrust, shocks etc.
- For convenience and safety purposes.

Methods of drive

There are two methods of Drive

1 Individual Drive
2 Group Drive

Individual Drive

In this system, each machine tool has its own electric motor which drives the machine through belt, chain, gearing or by direct coupling. The system is also called as self-contained drive.

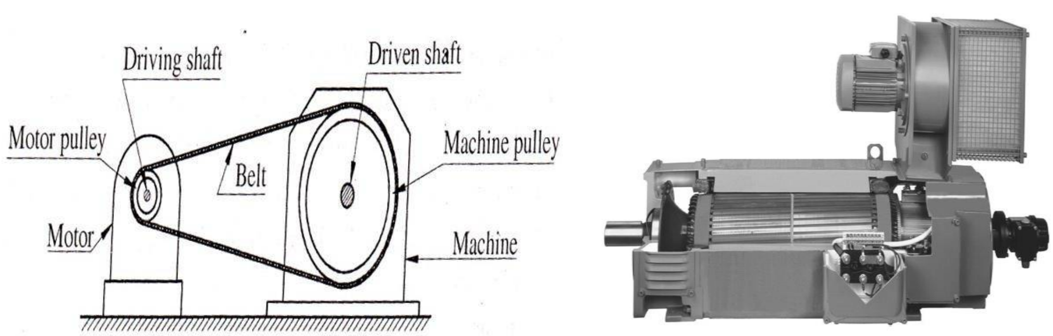

Fig. 6.1 Individual drive

Group Drive

This system uses a high powered motor which drives an overhead shaft called main shaft by means of chain or belt. The main shaft runs across the workshop from one end to other end. The main shaft drives another shaft called counter shaft. Finally the countershaft drives the group of machines through belting and pulleys.

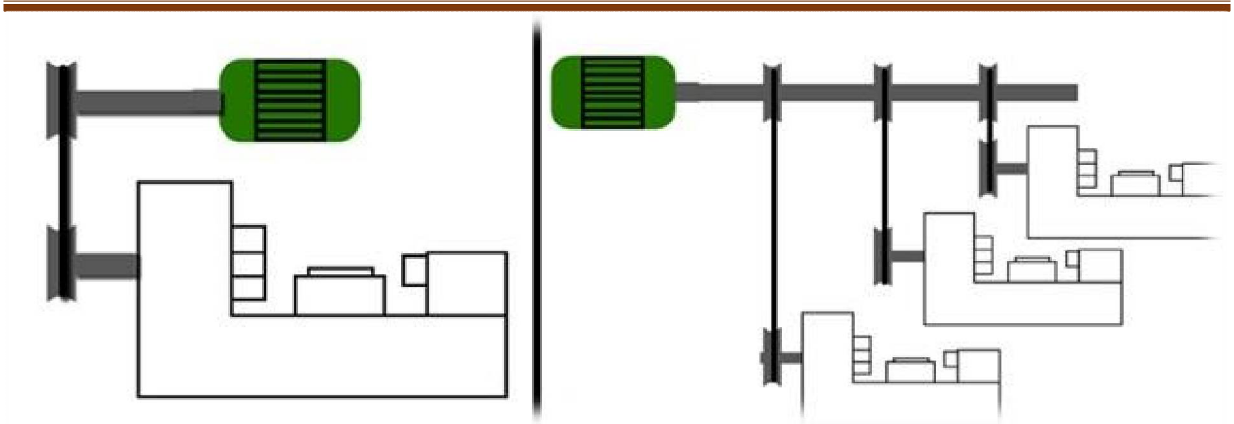

Fig. 6.2 Individual drive and Group Drive

Comparison between individual drive and Group drive

Table 12.0.1 Comparison between Individual and Group drive

Sr. No.	Individual drive	Group drive
1	It is suitable for small size workshop where machines may be moved frequently and machines are scattered over large area.	It is suitable for medium and large size workshop where machines are not scattered over large area.
2	Speed of a machine can be controlled separately.	Cone pulleys required to obtain wide range of speed.
3	Machine shaft can be rotated in any direction.	Difficult to change the direction of main shaft.
4	Individual machine does not affect other machines when failure of a motor occurs.	Failure of main motor will stop entire group of machines.
5	Less power is wasted if less machines are working.	More power is wasted if less machines are running but more economical when all machines are working in full load.
6	High initial capital investment.	Less initial capital investment.

Elements of power transmission

The main elements of power transmission system are **Nuts, bolts, pins, keys and couplings**, etc. which are provided to hold the two components of machine elements together.

Driving and driven shafts for transmit motion and power from one place to another place.

Belts, chains, gears are as connectors for transmission of motion and power from driving shaft to driven shaft.

Axles, bearings, brackets etc. to provide support to other elements of a machine.

Shaft, spindle and axle

Shaft

A shaft is a rotating machine element which transmits power. The power is delivered to the shaft by the application of tangential force and the resulting turning moment set up in the shaft allows the power to be transmitted from one point to another point.

Generally shafts of cylindrical shape are used but shafts with square and hexagonal cross section are also used in practice. Hollow shafts are preferred since these are 50 % lighter in weight compared to solid shafts for the same rigidity and stiffness. Hollow shafts also used whenever it is required to pass through components of a machine.-

Fig. 6.3 Shaft

Fig. 6.4 Spindle

Spindle

A spindle is a short revolving shaft that transmits motion either to a cutting tool or a work piece.

Axle

An axle is a machine element which is used for transmitting bending moment and carries such rotating parts as wheels and gears. An axle gives support to the rotating body.

Fig. 6.4 Axle

Fig. 6.5 Axle of Truck

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Types of mechanical drives

There are mainly three types of mechanical drives

1. Belt drive
2. Chain drive
3. Gear drive

Belt drive

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds. The amount of power transmitted depends upon the following factors

1. The velocity of belt.
2. The tension under which belt is placed on pulleys.
3. The arc of contact between the belt and the smaller pulley.

Belt drives are one of the common methods used whenever power or rotary motion is required to transmit between two parallel shafts.

Fig. 6.7 Belt drive

Belt Drive

- Open belt drive
- Cross belt drive
- Quarter turn belt drive
- Belt drive with idler pulley
- Fast and loose pulley drive
- Cone pulley drive
- Compound belt drive

1. Open belt drive

This type of belt drive is used to transmit power when two parallel shaft rotating is same direction. The portion of belt having high tension called tight side and portion of belt having less tension will be slack side.

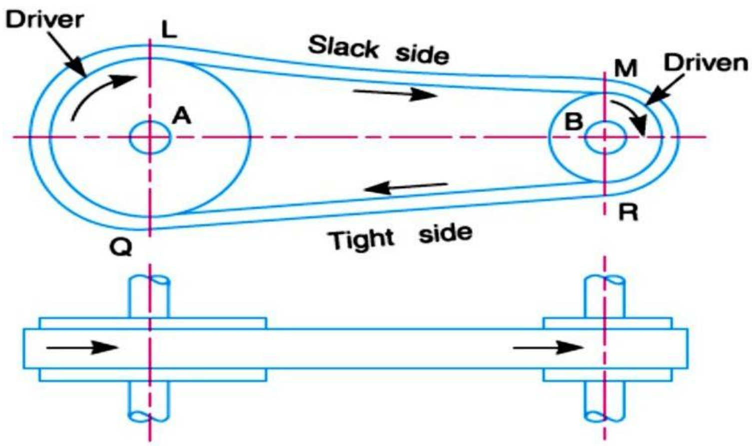


Fig. 6.9 Open belt drive

2. Cross belt drive

This drive transmits power when shafts are parallel but rotate in opposite direction. This type of drive should be used for large distance between two shafts and for lower speed.

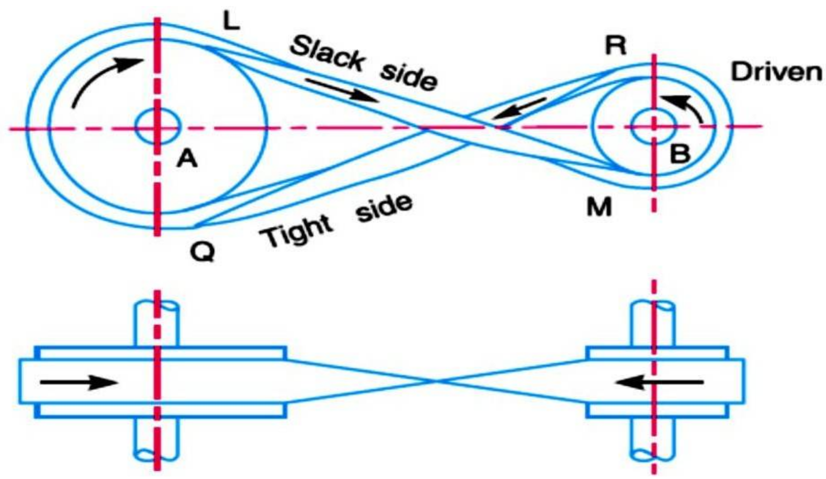


Fig. 6.10 Cross belt drive

3. Quarter turn belt drive

The quarter turn belt drive is also known as right angle belt drive. It is used to transmit power between two shafts at right angle. When the reverse motion is desired this arrangement is not suitable.

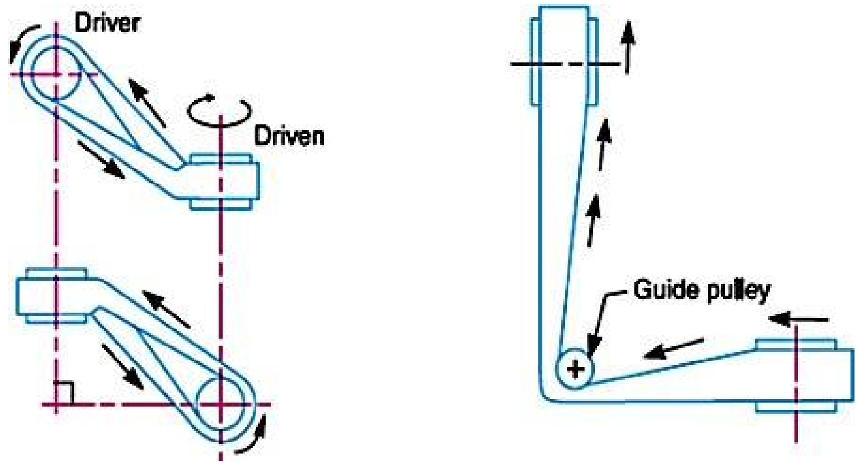


Fig. 6.11 Quarter turn belt drive

1. Belt drive with Idler pulley

After long time of running the length of belt may be increases, so angle of contact decreased. To increase it, it is required to increase tension. To increase tension in belt, Idler pulley is used.

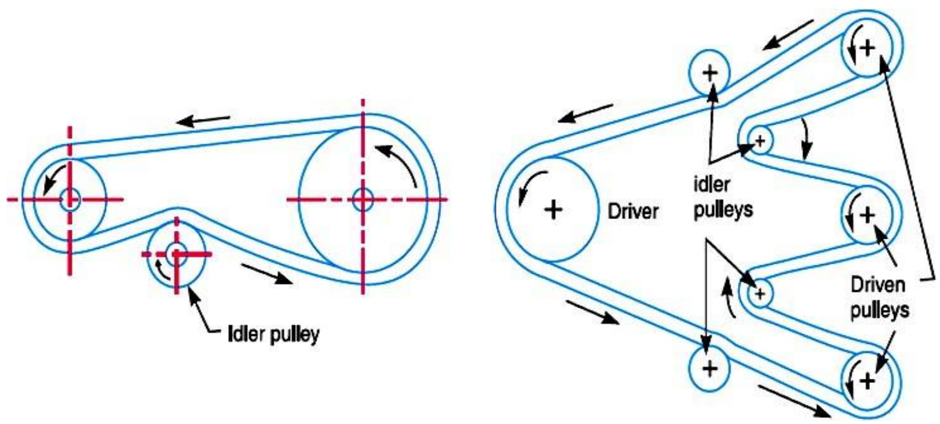


Fig. 6.12 Belt drive with idler pulley

2. Fast and Loose pulley drive

This drive is used when it is need to start or stop driven shaft without stopping driver shaft.

The pulley which is keyed to driven shaft is called fast pulley and a loose pulley runs freely over the machine shaft and not transmitting any power.

When the driven shaft is required to be stopped, belt is pushed on loose pulley by sliding bar.

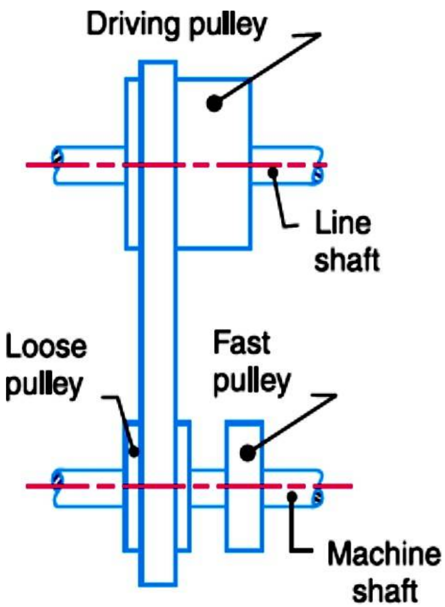


Fig. 6.13 Fast and loose pulley drive

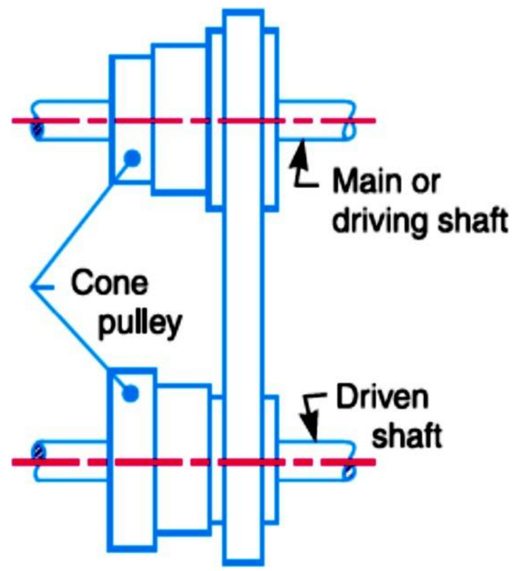


Fig. 6.14 Stepped or cone pulley drive

3. Stepped or Cone pulley drive

A stepped or cone pulley drive used where different speed are required at driven shaft while driving shaft runs at constant speed.

4. Compound belt drive

A compound belt drive is used when large speed ratio required and there is large center distance between two shafts. As shown in fig. 12.15 power is transmitted from pulley 1 to pulley 4 through intermediate pulley 2 and 3.

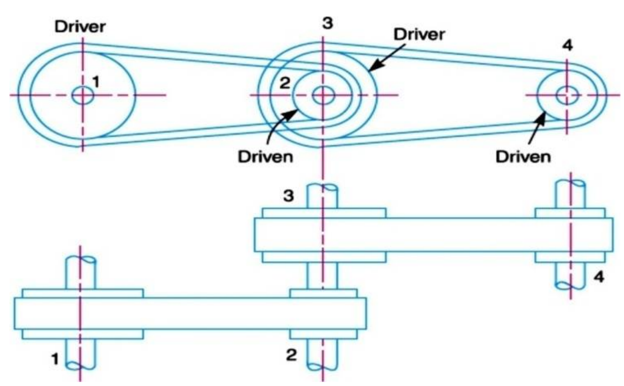


Figure 6.15 Compound belt drive

Types of Belt

1. Flat belt

The flat belt is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another when the two pulleys are not more than 8 meters apart.

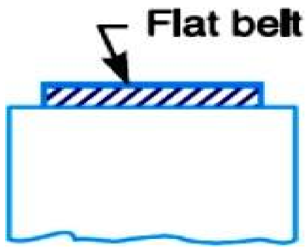


Figure 6.16 Flat belt

Figure 6.17 Flat belt

2. V belt

The V-belt is mostly used in the factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulleys are very near to each other.

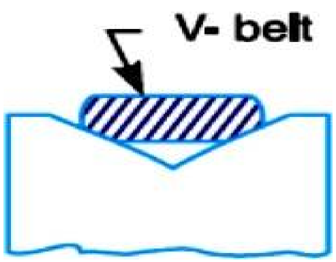


Fig. 6.18 V belt

Fig. 6.19 V belt

3. Circular belt or Rope

The circular belt or rope is mostly used in the factories and workshops, where a great amount of power is to be transmitted, from one pulley to another, when the two pulleys are more than 8 meters apart**.**

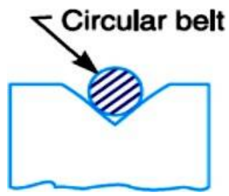


Fig. 6.20 Circular belt

Fig. 6.21 Timing belt

4. Timing belt

Timing belts are modification of flat belts. On the flat belt teeth mounted on underside face. They are made from high quality rubber. Timing belts are used for relatively small distance. It is costlier than flat belt and v belt.

Difference between Flat belt and V-belt drive

Table 6.2 Difference between Flat belt and V-belt

Sr. No.	Flat Belt	V-Belt
1	It is suitable for moderate power transmission when distance between the shafts is large.	It is suitable for large power transmission when distance between the shafts is small.
2	There is chance of slip due to frictional grip between pulley and belt. Hence it is not a positive drive.	There is less chance of slip due to more frictional grip between belt and pulley.
3	It requires large space.	Due to compactness, required less space.
4	High velocity ratio may not obtain.	High velocity ratio may be obtained.
5	For same value of co-efficient of friction, angle of lap and allowable tension the power transmission by flat belt is less than that of V - belt drive.	For same value of co-efficient of friction, angle of lap and allowable tension the power transmission by V-belt is higher than that of flat belt.

Chain drive

Construction of chain drive

Slipping occurs in belt and rope drives. In order to avoid this slipping phenomenon chain drives are used. A chain drive consists of three elements

1. Driving sprocket
2. Driven sprocket
3. An endless chain which is wrapped around two sprockets.

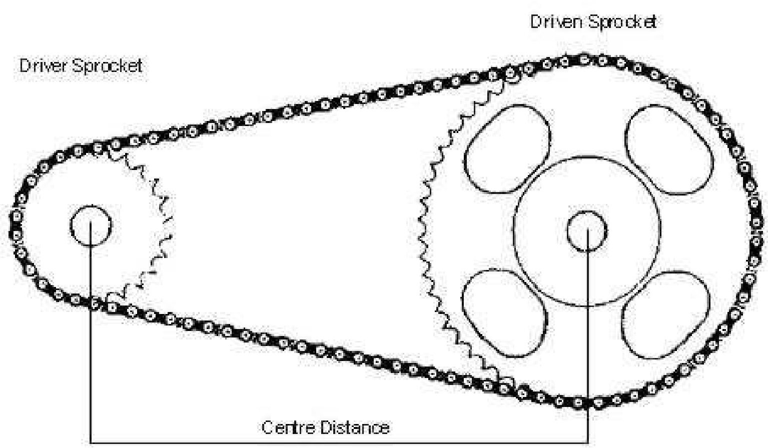


Fig. 6.22 Chain drive

Advantages of chain drive
It provides a positive transmission and no chances of slip are here. It gives a constant velocity ratio.

Applications
It is used in bicycle, motorcycles, agricultural machinery and textile machinery, material handling equipment etc.

Types of Chain
1. Hoisting and Hauling chains
2. Conveyor chains
3. Power transmission chains

Hosting and Hauling chain
It used for hoisting and hauling purposes. These are further classified as,
a) Chain with oval links
b) Chain with square links

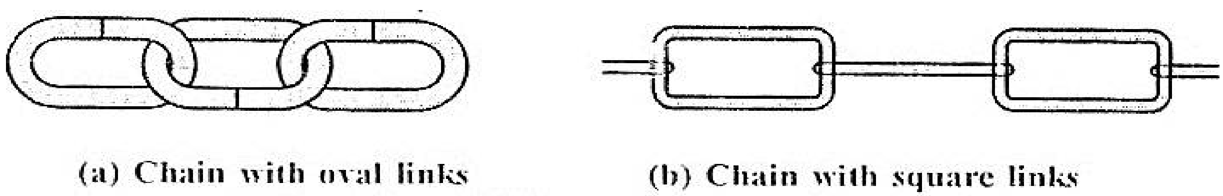


Fig. 6.23 Hosting and hauling chain

Conveyor Chain
It used for elevating and conveying the material continuously and they run at low speeds. These are further classified as,

a) Detachable or hook joint type chain
b) Closed joint type chain

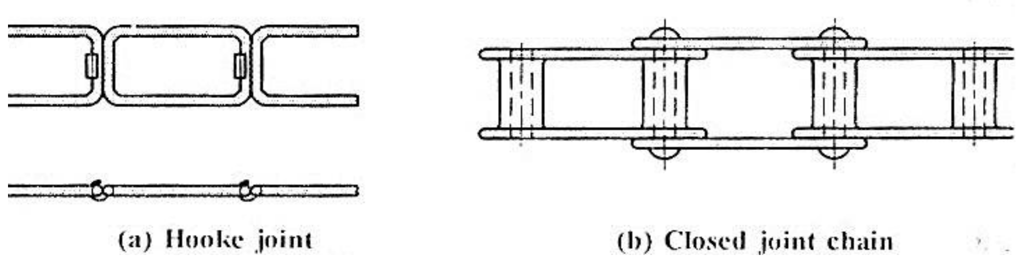


Figure 6.24 Conveyor chain

Power transmission chain
It is used for transmitting motion from one shaft to another shaft. These chains operate at maximum speed of 15 m/sec.

These are further classified as,

a) Roller chains
b) Silent chain or inverted tooth chain
c) Bush or Block chain

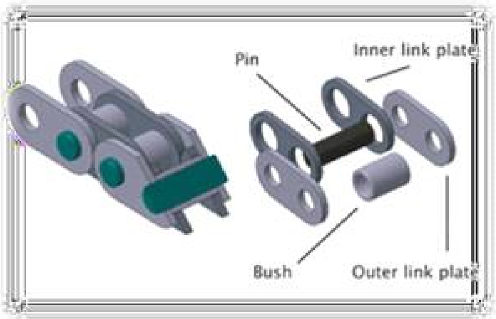


Fig. 6.25 Roller Chain

Fig. 6.26 Bush chain

Fig. 6.28 Silent Chain

Gear drive and Friction drive

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit toque and power.

In order to transmit a definite power from one shaft to another shaft to the projection on one disc and recesses on another disc can be made which can mesh with each other.

In early days, friction discs as shown in figure were used for transmitting the power from one shaft to another shaft. In such a case, the power transmission capacity depends on friction between surfaces of two discs. Therefore, this method is not suitable for transmitting higher power as slip occurs between the discs.

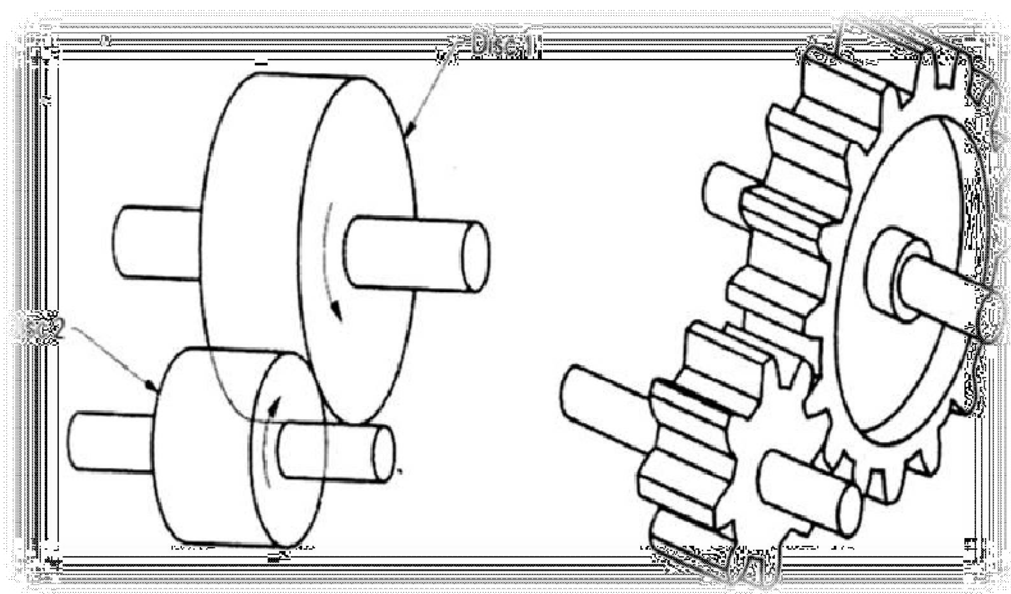


Figure 6.29 Friction drive and Gear drive

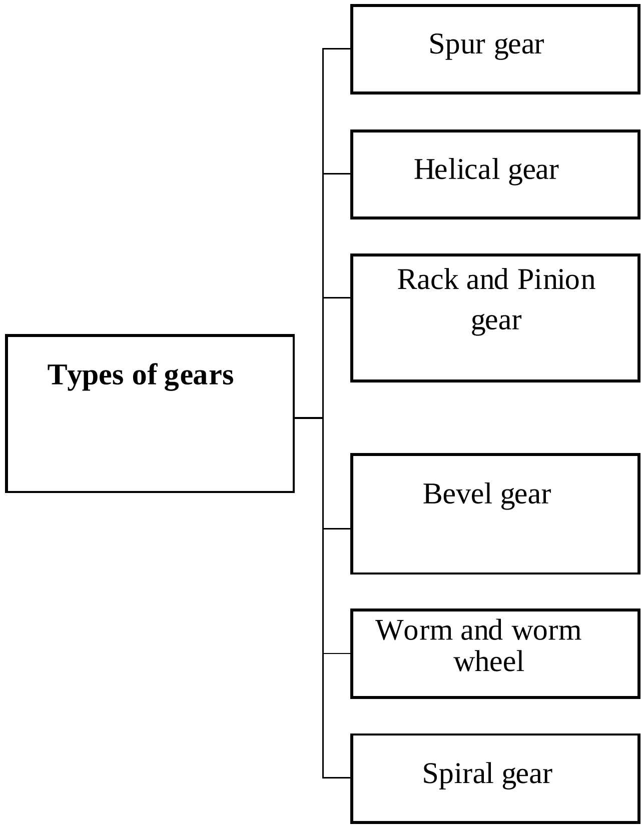
Advantages of gear drive

1. It is a positive drive (no slip) i.e. it transmits exact velocity ratio from one shaft to another shaft.
2. It can transmit very large power.
3. High transmission efficiency.
4. It requires less space.
5. This drive is more reliable.

Disadvantages of gear drive

1. Manufacturing cost is high.
2. Maintenance cost is also high due to lubrication requirements.
3. The error in cutting teeth may cause vibrations and noise during operation.
4. It requires precise alignment of shafts.

Types of gears



Spur gear

In spur gears, teeth are parallel to axis of rotation.It transmit power from one shaft to another parallel shaft. It uses in Electric screwdriver, oscillating sprinkler, windup alarm clock, washing machine, clothes dryer etc.

Fig. 6.30 Spur gear

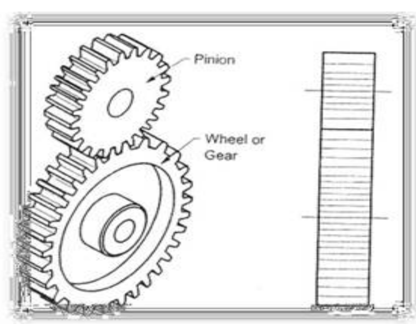


Fig. 6.31 Spur gear

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Helical gear

The teeth on helical gears are cut at an angle with axis of gear.

In helical gears engagement of gear teeth is gradual. This gradual engagement makes helical gears operate much more smoothly and quietly than spur gears. In helical gears transmission of load is gradual which results in low impact stresses and reduction in noise. Thus they are used for high speed transmission.

Only disadvantage in helical gear is that, it induces axial thrust in one direction on the bearings. To overcome this disadvantage double helical gear or herringbone gear is used as shown in figure. Herringbone gears are mostly used in heavy machinery.

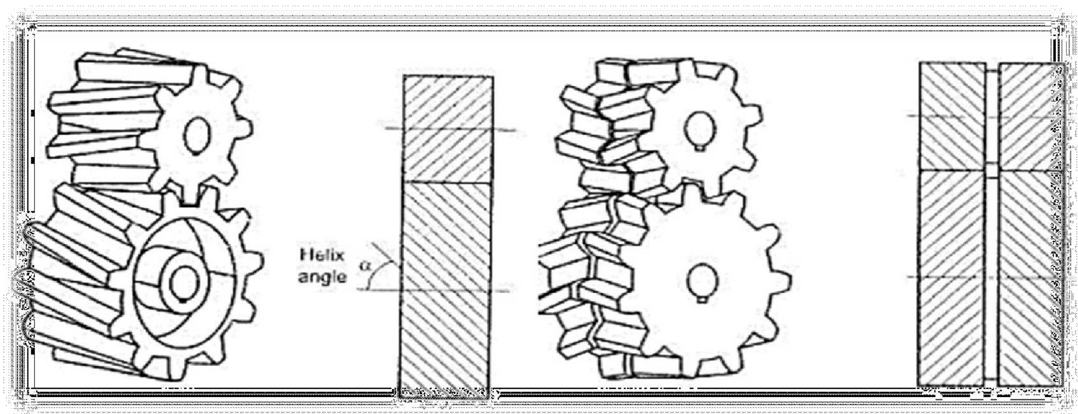
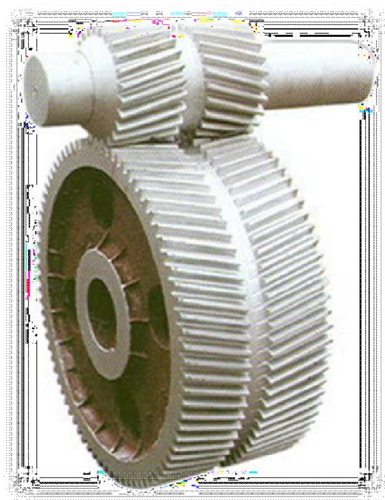


Fig. 6.32 Helical gear and double helical gear



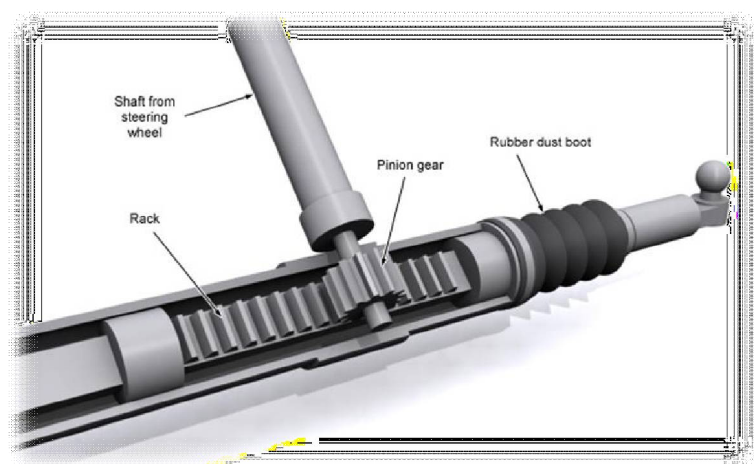


Fig. 6.33 Double helical gear

Fig. 6.34 Steering Mechanism

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Mission:

- To nurture engineers with basic and advance mechanical engineering concepts
- To impart Techno-Managerial skill in students to meet global engineering challenges
- To create ethical engineers who can contribute for sustainable development of society

Rack and Pinion gear

Rack and pinion gears are used to convert rotary motion into linear motion. It is a special case of spur gear in which one gear is having infinite diameter called "Rack". A perfect example of this is the steering system of car. It is also widely used in measuring instruments.

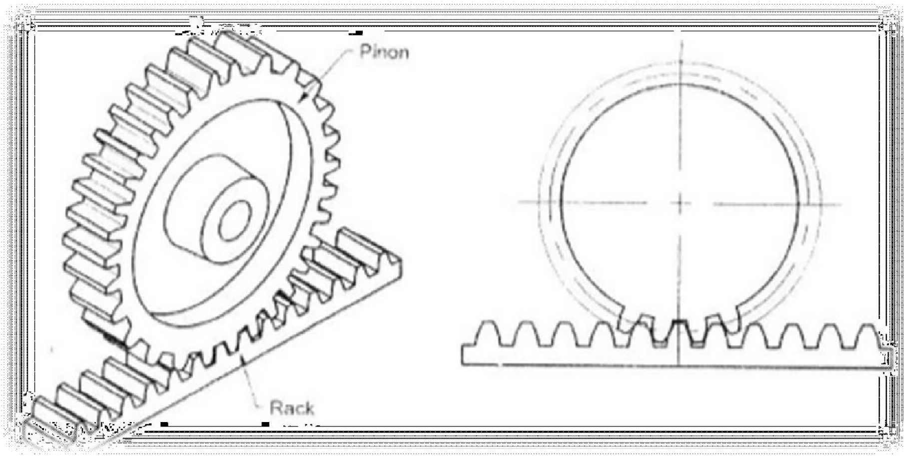

Fig. 6.35 Rack and Pinion

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Bevel gear

When power is required to be transmitted from one shaft to another shaft which are intersecting to each other, bevel gears are used. Generally, the angle between two shafts is 90°. It is used in locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc. The bevel gears are of two types,

1. Straight bevel gear
2. Spiral bevel gear

Fig. 6.36 Straight bevel gear

Fig. 6.37 Spiral bevel gear

Worm and Worm wheel

Worm gears are used when large gear reductions are needed.

It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater.

Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc.

It is used to transmit power from one shaft to another shaft which are non-intersecting and their axes are normally at right angles to each other.

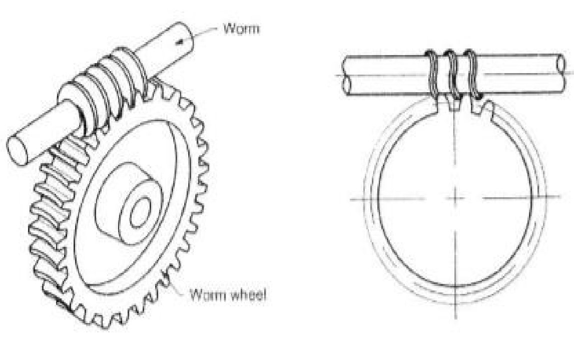

Fig. 6.38 Worm and worm wheel

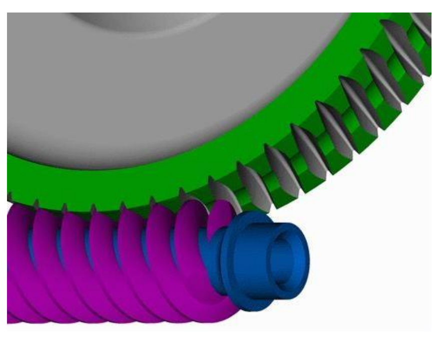

Fig. 6.39 Worm and worm wheel

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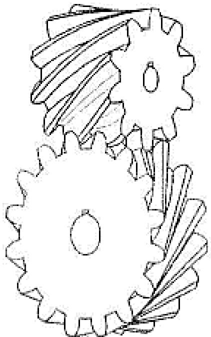
Spiral gear

It is used to transmit power from one shaft to another shaft which are non-parallel and non-intersecting. It is suitable for low load transmission due to having point contact between mating teeth.



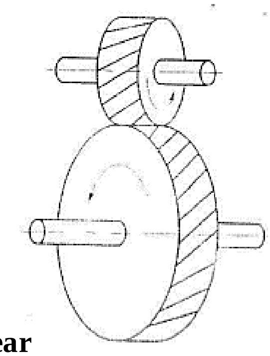


Fig. 6.40 Spiral gear

Fig. 6.41 Spiral gear

Comparison between Belt drive, Chain drive and Gear drive

Table 12.3 Comparison of Belt, Chain and Gear drive

Sr. No.	Particulars	Belt drive	Chain drive	Gear drive
1	Main element	Pulleys, belt	Sprockets, chain	Gears
2	Slip	Slip may occurs	No slip (Positive drive)	No slip (Positive drive)
3	Suitability	For large center distance	For moderate center distance	For short center distance
4	Space requires	Large	Moderate	Less
5	Design, manufacturing, complexity	Simplest	Simplest	Complicated
6	Failure	Failure of belt does not cause the further damage of machine.	Failure of chain may not seriously damage the machine.	Failure of gear may cause serious break down in the machine.
7	Life	Less	Moderate	Long
8	Lubrication	Not required	Required	Requires proper lubrication
9	Installation cost	Less	Moderate	More
10	Use	For low velocity ratio	For moderate velocity ratio	For high velocity ratio

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EXPERIMENT-7

Aim: To study about different engineering materials

Introduction to Engineering Materials

Since the earliest days of the evolution of mankind, the main distinguishing features between human beings and other animals has been the ability to use and develop materials to satisfy our human requirements.

Nowadays we use many types of materials, fashioned in many different ways, to satisfy our requirements for housing, heating, furniture, clothes, transportation, entertainment, medical care, defense and all the other trappings of a modern, civilized society.

Most materials doesn't exist in its pure shape, it is always exist as an ores. During the present century scope of metallurgical science has expanded enormously. In the recent years studying the metallurgy science gave humanity an ever growing range of useful alloys.

Appropriate understanding of the materials resources and nature enable the engineers to select the most appropriate materials and to use them with greatest efficiency in minimum quantities while causing minimum pollution in their extraction, refinement and manufacturing.

Classification of Engineering Materials

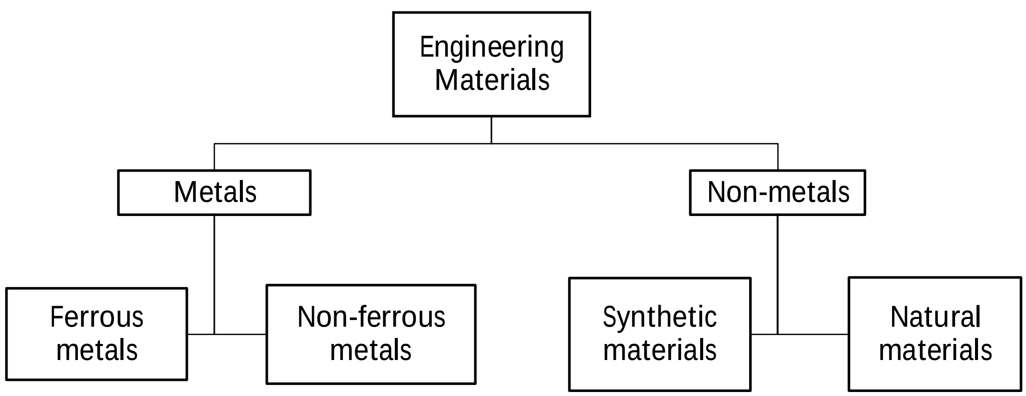


Fig. 7.1 Classification of Engineering Materials

Metals

1. **Ferrous metals**

These are metals and alloys containing a high proportion of the element iron.

They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.

As an example of ferrous metals such as: bridge building, the structure of large buildings, railway lines, locomotives and rolling stock and the bodies and highly stressed engine parts of road vehicles.

2. Non – ferrous metals

These materials refer to the remaining metals known to mankind. The pure metals are rarely used as structural materials as they lack mechanical strength.

They are used where their special properties such as corrosion resistance, electrical conductivity and thermal conductivity are required. Copper and aluminum are used as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials. They are mainly used with other metals to improve their strength.

Non – metallic materials

1. Synthetic materials

These are non – metallic materials that do not exist in nature, although they are manufactured from natural substances such as oil, coal and clay.

They combine good corrosion resistance with ease of manufacture by moulding to shape and relatively low cost.

Synthetic adhesives are also being used for the joining of metallic components even in highly stressed applications.

2. Natural materials

Such materials are so diverse that only a few can be listed here to give a basic introduction to some typical applications.

Wood

This is naturally occurring fibrous composite material used for the manufacture of casting patterns.

Rubber

This is used for hydraulic and compressed air hoses and oil seals. Naturally occurring latex is too soft for most engineering uses but it is used widely for vehicle tyres when it is compounded with carbon black.

Glass

This is a hardwearing, abrasion-resistant material with excellent weathering properties. It is used for electrical insulators, laboratory equipment, and optical components in measuring instruments and, in the form of fibers, is used to reinforce plastics. It is made by melting together the naturally occurring materials: silica (sand), limestone (calcium carbonate) and soda (sodium carbonate).

Emery

This is a widely used abrasive and is a naturally occurring aluminum oxide. Nowadays it is produced synthetically to maintain uniform quality and performance.

Ceramic

These are produced by baking naturally occurring clays at high temperatures after moulding to shape. They are used for high – voltage insulators and high – temperature – resistant cutting tool tips.

Diamonds

These can be used for cutting tools for operation at high speeds for metal finishing where surface finish is greater importance. For example, internal combustion engine pistons and bearings. They are also used for dressing grinding wheels. Oils: Are used as bearing lubricants, cutting fluids and fuels.

Silicon

This is used as an alloying element and also for the manufacture of semiconductor devices.

Composite materials

These are materials made up from, or composed of, a combination of different materials to take overall advantage of their different properties.

In man-made composites, the advantages of deliberately combining materials in order to obtain improved or modified properties were understood by ancient civilizations. An example of this was the reinforcement of air- dried bricks by mixing the clay with straw. This helped to reduce cracking caused by shrinkage stresses as the clay dried out. In more recent times, horse hair was used to reinforce the plaster used on the walls and ceiling of buildings. Again this was to reduce the onset of drying cracks.

Nowadays, especially with the growth of the plastics industry and the development of high- strength fibers, a vast range combination of materials is available for use in composites. For example, carbon fiber reinforced frames for tennis rackets and shafts for golf clubs have revolutionized these sports.

Types of Common Composite materials

Laminar or layer composites

Plywood, coated tools, insulated wires.

Particulate composite

Concrete (cement sand and gravel)
Abrasive particles and matrix in grinding wheels
Cemented carbides- particle of WC uniformly distributed used as a
cutting tool Properties are uniform in all direction.

Fiber reinforced composite

Thin fibers of one material are embedded (fixed) in matrix of another material.
Glass is most widely used fiber with polymer as matrix. Other fibers are carbon, boron etc.
Properties depend upon the fibred material volume fraction of fiber, orientation of fiber, properties of matrix, degree of bonding between fiber & matrix etc.

General Properties of Engineering Materials

1. **Tensile strength**

Strength is the ability of a material to resist applied forces without fracturing.

It is the ability of a material to withstand tensile (stretching) loads without breaking.

2. **Toughness**

Toughness is the ability of a material to absorb energy without rupturing. The rubbers and most plastic materials do not shatter (break), therefore they are tough. For example, if a rod is made of high-carbon steel then it will be bend without breaking under the impact of the hammer, while if a rod is made of glass then it will broke by impact loading.

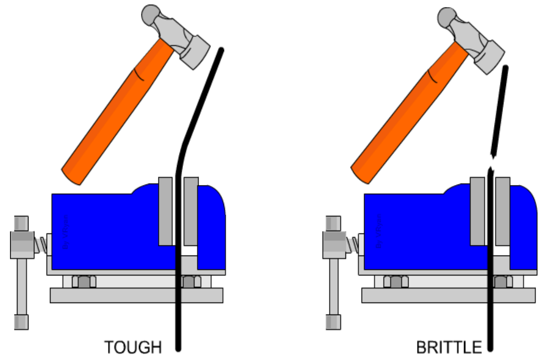


Figure 7.3 Toughness and Brittleness

3. Brittleness

It is the property of a material that shows little or no plastic deformation before fracture when a force is applied. Also it is usually said as the opposite of ductility and malleability.

4. Hardness

It is the ability of a material to withstand scratching (abrasion) or indentation by another hard body, it is an indication of the wear resistance of the material.

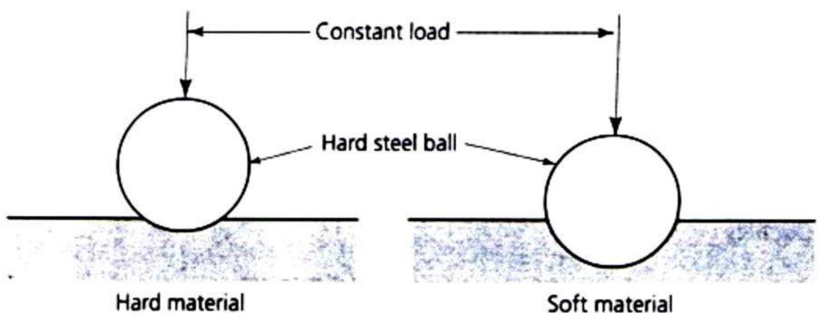


Fig. 7.4 Hardness

5. Ductility

It refer to the capacity of substance to undergo deformation under tension without rupture as in wire drawing tube drawing operation.

6. Stiffness

Stiffness is the resistance of a material to elastic deformation or deflection. A material which suffers only a slight deformation under load has a high degree of stiffness.

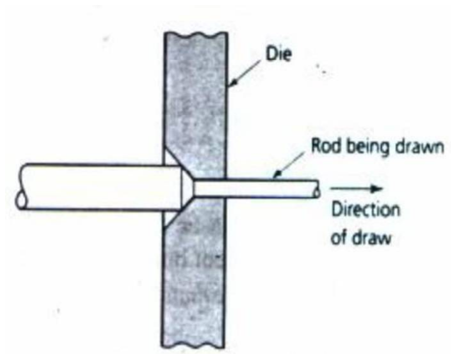


Fig. 7.5 Ductility

7. Malleability

It is the capacity of substance to withstand deformation under compression without rupture or the malleable material allows a useful amount of plastic deformation to occur under compressive loading before fracture occurs. Such a material is required for handling by such processes as forging, rolling and rivet heading.

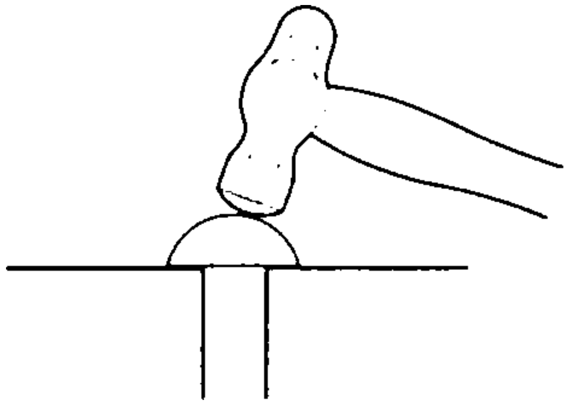


Fig. 7.6 Malleability

8. Elasticity

It is the ability of a material to deform under load and return to its original size and shape when the load is removed. If it is made from an elastic material it will be the same length before and after the load is applied, despite the fact that it will be longer whilst the load is being applied. All materials possess elasticity to some degree and each has its own elastic limits.

Fig. 7.7 Elasticity

9. Plasticity

This property is the exact opposite to elasticity. It is the state of a material which has been loaded beyond its elastic limit so as to cause the material to deform permanently. Under such conditions the material takes a permanent set and will not return to its original size and shape when the load is removed. When a piece of mild steel is bent at right angles into the shape of a bracket, it shows the property of plasticity since it does not spring back strength again.

Some metals such as lead have a good plastic range at room temperature and can be extensively worked (where working of metal means squeezing, stretching or beating it to shape).

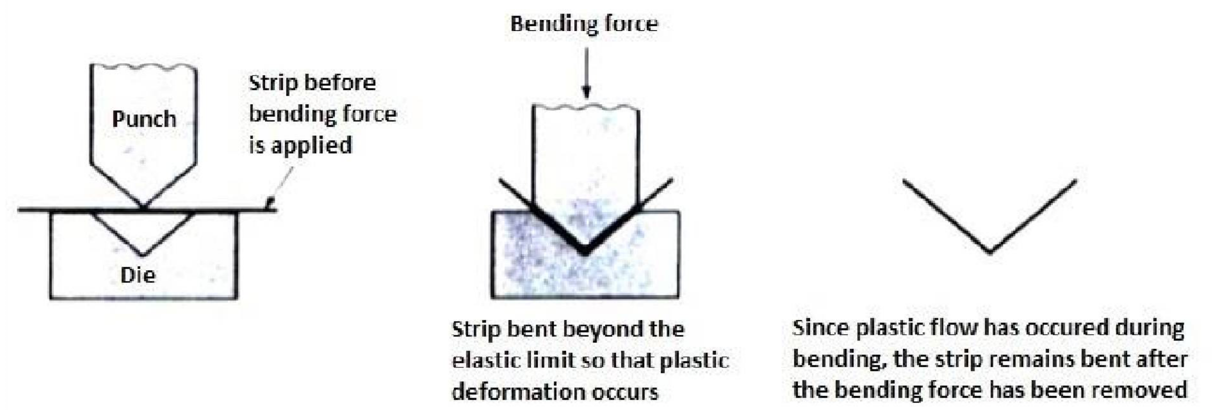


Fig. 7.8 Plasticity

10. Creep

When part is subjected to a constant stress at high temperature for a long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing internal combustion engines, boilers and turbines.

11. Resilience

It is the property of a material to absorb energy and to resist shock and impact loads. It is measure by amount of energy absorbed per unit volume within elastic limit. This property is essential for spring materials.

12. Thermal conductivity

This is the ability of the material to transmit heat energy by conduction.

13. Fatigue

A material fails at stresses below the yield point stresses when it is subjected to repeated tensile and compressive stresses. This type of failure of material is known as fatigue. This property is considered in designing shafts, connecting rods, gears, springs etc.

14. Electrical resistivity

It is the property of a material due to which it resists the flow of electricity through it.

15. Electrical conductivity

It is the property of a material due to which it allows the flow of electricity through it.

****

EXPERIMENT-8

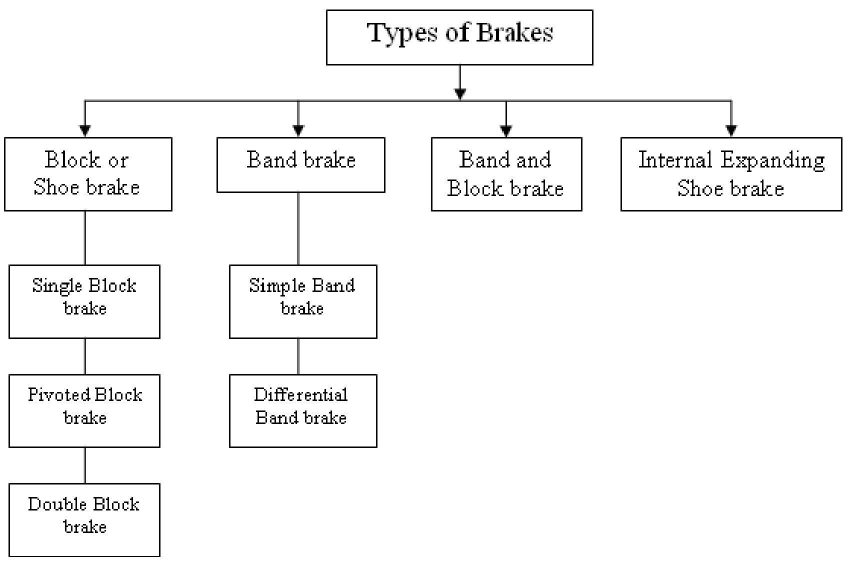
AIm: To understand construction and working of different Types of Brakes.

Introduction:

A brake is a device by means of which an artificial Frictional resistance is applied to a moving body in order to retard or stop the Motion of a body. The Function of brake is to control the Motion of a Machine or Machine element. Brake may be used to Slow down, stop or hold the load or to release a load and control its Speed. IN process of performing its function the brake is required to absorb the kinetic energy of Moving parts or the potential energy of the objects being lowered.

Types Of Brakes:

In general the brakes are classified as follows:



1. **Block or Shoe Brakes:**

These brakes consist of blocks which are pressed against the surface of a rotating drum.

Block or shoe brakes are again classified as follows:

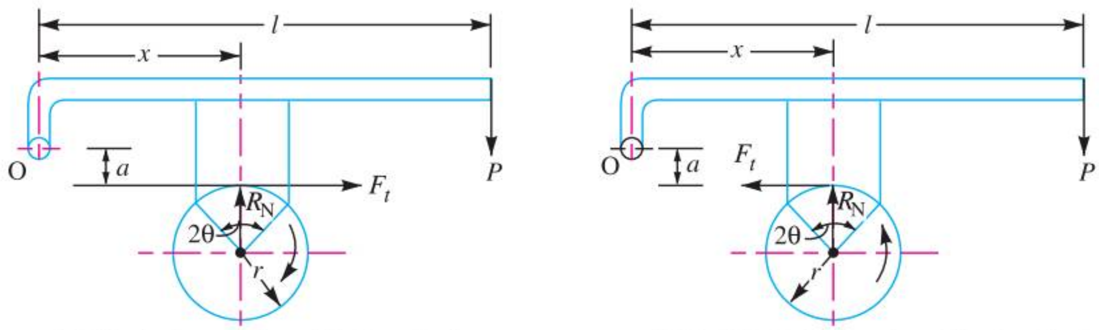
I. Single block or shoe brake

II. Pivoted block brake

III. Double block or shoe brake

Single Block or Shoe Brake:

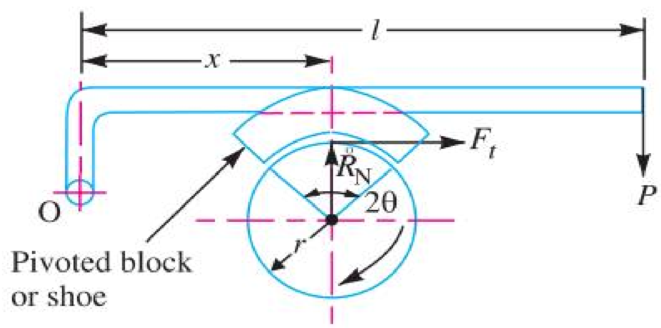
Single block or shoe brake consists of block or shoe which is pressed against a rotating drum by means of lever as shown in Fig. The block which is rigidly attached or pivoted to the lever is lined with friction material. The friction between friction lining on the block and drum retards the rotation of the drum. The block or shoe is made up of softer material than the rim of the drum. The material of the block for light and slow vehicles is wood and rubber and for heavy and fast vehicles it is cast steel.



(*a*) Clockwise rotation of brake wheel. (*b*) Anticlockwise rotation of brake wheel.

- **Pivoted Block Brake:**

A pivoted block brake is shown in Fig-2. Unlike single block brake in this the shoe is pivoted to lever to get uniform wear when 2 is more than 60°. These brakes have more life and provided higher braking torque.



- **Double Block or Shoe Brake:**

When a single block brake is pressed against the rotating drum, an unbalanced load on the bearing of the shaft supporting the drum will act. This load produces the bending of the shaft. It can be prevented by using a double block or shoe brake having two blocks on the two sides of the drum. Upper ends of brake arms are held together by using spring as shown in Fig-3. When effort P is applied to bell crank lever, then spring gets compressed and brake released. When there is no force P on bell crank lever, the brake is engaged automatically. In this case braking torque becomes two times. Double block or shoe brake is used in electric cranes.

2. Band Brakes:

Band brake consists of a rope, belt or flexible steel band lined with frictional material which is wrapped partly round the drum. When band is pressed against the external surface of drum, the frictional force between drum and band will induce braking torque on the drum.

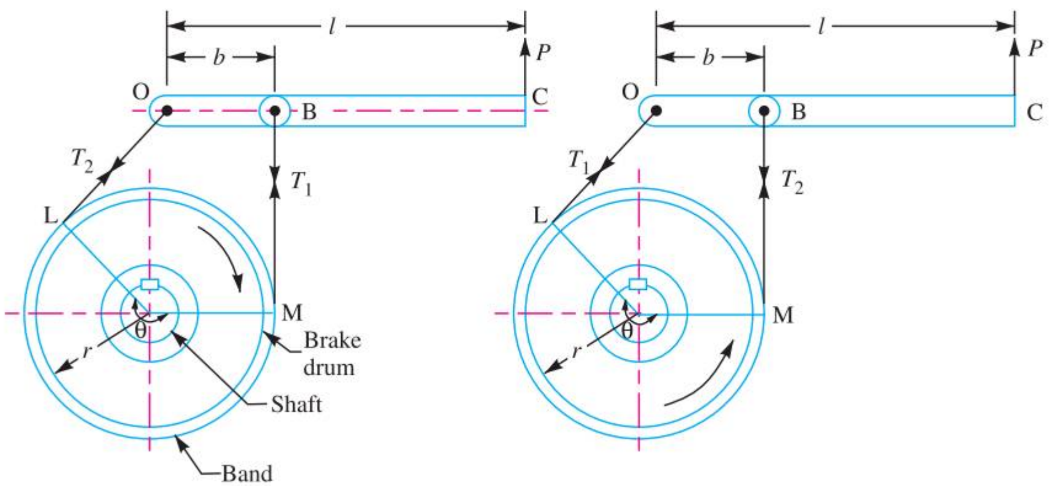
There are two types of band brake:

(a) Simple band brake

(b) Differential band brake

- **Simple Band Brake:**

A simple band brake is shown in Fig. In this one end of the band is attached at the fulcrum of the lever while the other end is at a distance 'b' from fulcrum. When the force P is applied at the free end of the lever, it turns about the fulcrum O. It tightens the band on the drum and brakes are applied. The braking force is provided by the friction between the band and the drum.



(*a*) Clockwise rotation of drum. (*b*) Anticlockwise rotation of drum.

- **Differential Band Brake:**

In a differential band brake, neither end of the band is attached to the fulcrum of the lever. The two ends of band are attached to the two points on opposite side of the fulcrum as shown in Fig-5. The lever AOC is pivoted at fulcrum 'O' and two ends of band are attached at points A and B. Differential band brakes can provided higher braking torque compared to simple band brake for the same amount of effort, P.

3. Band and Block Brake:

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A band and block brake consist of number of wooden blocks fixed inside a flexible steel band. When the brake is applied, the blocks are pressed against the drum. The friction between block and drum provides the braking action. It is shown in Fig-6.

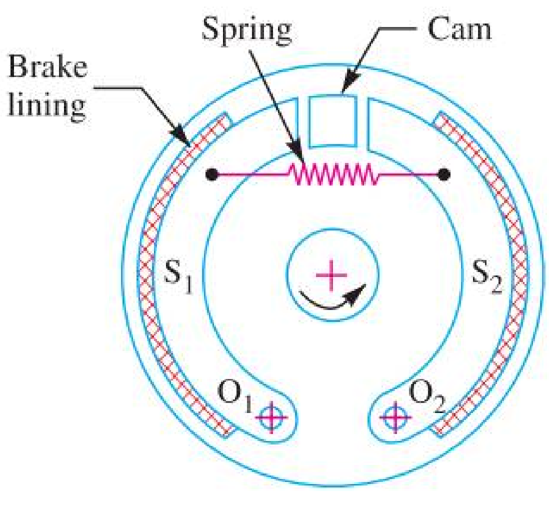
The advantage of providing wooden blocks is that it provides a higher co-efficient of friction and they can be easily replaced after being worn out. Because of higher co efficient of friction of wooden block. Effectiveness of this brake increases.

4. Internal Expanding Shoe Brake:

An internal expanding shoe brake is shown in Fig-7. Internal expanding shoe brake consists of two semicircular shoes S_1 and S_2 pivoted at the fixed fulcrum O_1 and O_2 respectively. The outer surfaces of the shoes are lined with friction material like Ferodo.

One end of the shoe is pivoted at fulcrum while the other end is subjected to the actuating force. The actuating force on both the shoes is applied by hydraulic cylinder or cam mechanism.

When the cam rotates the shoes are pushed outward against the rim of the drum. Friction between shoes and the drum produces braking torque causing the drum to retard or stop completely. When this actuating force through the rotation of cam is released, the helical tension spring retracts the shoes to the original position.



(*a*) Internal expanding brake.

The internal expanding shoe brakes are having at least one self- energizing or self- actuating shoe per wheel. The drum encloses the entire system to keep out of dust and moisture.

For anticlockwise rotation of drum, the left shoe is known as leading or forward or primary shoe and right shoe as trailing or rear or secondary shoe. Internal expanding shoe brake is used in motor cars and light trucks.

EXPERIMENT-9

Aim:To understand working of Pumps.

Introduction

A pump is a machine used to move liquid through a piping system and to raise the pressure of he liquid (US-DOE, 2006; Ksrassik et al 2011). It is a hydraulic machine which converts mechanical energy into hydraulic energy. Pump can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement and gravity pump.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid.

Pump can be classified into two categories:

1. Positive displacement pumps and
2. Non-positive displacement pumps.

Positive Displacement Pump

Positive-displacement pump can operate by forcing a fixed volume of fluid from inlet pressure section of the pump into the discharge zone of the pump. It can be classified into two types:

- Rotary-type positive displacement pump:
- Internal gear pump
- Screw pump
- Reciprocating-type positive displacement pump:
- Piston pump
- Diaphragm Pump

Rotary-Type Positive Displacement Pump

Positive displacement rotary pump can move the fluid by using rotating mechanism that creates a vacuum that captures and draws in the liquid. Rotary positive displacement pump can be classified into two main types:

Gear pumps - a simple type of rotary pump where the liquid is pushed between two gears.

Rotary vane pumps - similar to scroll compressors, these pump have a cylindrical rotor encased in a similar shaped housing. As the rotor orbits, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

Reciprocating-Type Positive Displacement Pump

Reciprocating pump move the fluid using one or more oscillating pistons, plungers or membranes (diaphragms), while valves restrict fluid motion to the desired direction. Pump in this category are simple with one cylinder or more. They can be either single-acting with suction during one direction of the piston motion and discharge on the other or double-acting with suction and discharge in both directions.

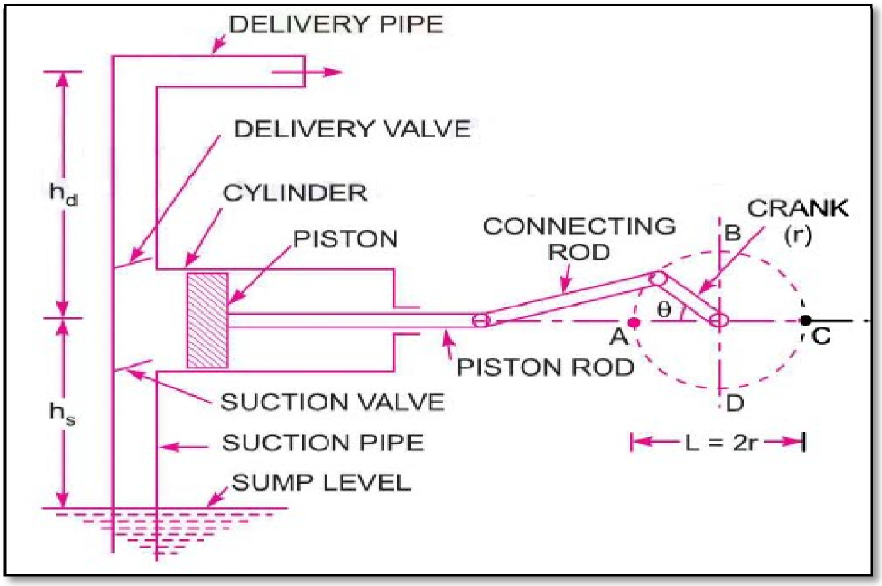


Fig. 9.1 Reciprocating pump

Typical reciprocating pumps are:

Plunger pumps - a reciprocating plunger pushes the fluidthrough one or two open valves, closed by suction on the wayback.

Diaphragm pumps - similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.

Piston displacement pumps - usually simple devices for pumping small amounts of liquid or gel manually.

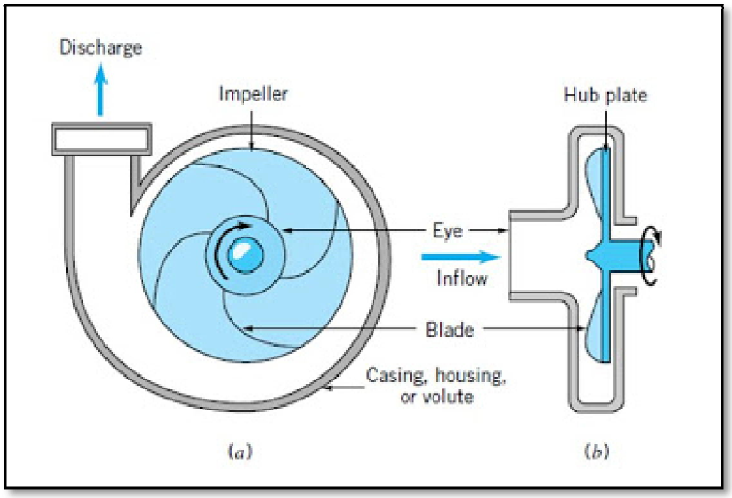
Non - Positive Displacement Pump

With this pump, the volume of the liquid delivered for each cycle depends on the resistance offered to flow. A pump produces a force on the liquid that is constant for each particular speed of the pump. Resistance in a discharge line produces a force in the opposite direction. When these forces are equal, a liquid is in a state of equilibrium and does not flow. If the outlet of a non positive-displacement pump is completely closed, the discharge pressure will rise to maximum for a pump operating at a maximum speed. A non-positive displacement pump can be classified as follows:

Centrifugal Pump

A centrifugal pump is a rotodynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid (Friedrichs and Kosyn 2000; Gulich 2008). Centrifugal pump are most common type of pump used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and it is accelerated by the impeller, flowing radially outward or axially into a diffuser or volute chamber, from where it exits into the downstream piping system. Centrifugal pump are typically used for large discharge through smaller heads.

Centrifugal pump are often associated with the radial-flow type However, the term "centrifugal pump" can be used to describe all impeller type rotodynamic pumps including the radial, axial and mixed-flow variations.



Types Of Rotodynamic Flow Pump

Radial, mixed and axial-flow pump belongs to a class of machines known as rotodynamic. As a class, are suitable for most of the liquid pumping applications but notable exceptions include metering, handling of highly viscous liquids and very high pressure or low flow rate requirement. For these applications normally, positive displacement pumps are used.

Types of Flow in the Pump

The categories of pump deal with single and multi-stage versions of radial-flow, mixed-flow and axial-flow pump. These three categories of pumps are identified by the nature of the flow through the impeller as shown in Figure 3.1. Radial-flow and mixed-flow pumps are commonly known as Centrifugal pumps.

Axial-Flow Pump

Axial-flow pump differ from radial-flow pump in that the fluid enters and exits along the same direction parallel to the rotating shaft. The fluid is not accelerated but instead "lifted" by the action of the impeller. Axial-flow pump operate at lower pressure and higher flow rates than radial flow pump.

Mixed-Flow Pump

Mixed-flow pump function as a compromise between radial and axial-flow pump. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction.

As a consequence mixed-flow pump operate at higher pressures than axial-flow pump while delivering higher discharge than radial-flow pump.

Radial-Flow Pump

The fluid that enters along the axial plane is accelerated by the impeller and exits at right angles to the shaft (radially). Radial-flow pump operate at higher pressures and lower flow rates than axial and mixed-flow pumps.

Characteristics of positive displacement and non-positive displacement pump

Positive- displacement pump Non positive- displacement pump

1.For every stroke pumping chamber opens to an outlet port. It provides a smooth and continuous flow. Pressure affects the output only to extent that it increases internal leakage.

2..These are self-priming when started Pressure can reduce the delivery due to high pressure the liquid simply recirculates inside the pump. properly. It cannot create a vacuum sufficient for self-priming.

Submersible Pump

A submersible pump assembly is shown in Figure 3.2 is a devicewhich has a hermetically sealed motor close-coupled to the pump body. Themain advantage of this type of pump is that it prevents pump cavitation, aproblem associated with a high elevation difference between the pump andthe fluid surface. Submersible pump are more efficient than jet pumps.

Working Principle of Submersible Pump

The submersible pump used in ESP installations are multistagecentrifugal pump operating in a vertical position. Produced liquids, after beingsubjected to great centrifugal forces caused by the high rotational speed of theimpeller, lose their kinetic energy in the diffuser where a conversion ofkinetic to pressure energy takes place. This is the main operationalmechanism of radial and mixed flow pumps. The pump shaft is connected to the gas separator or the protector bya mechanical coupling at the bottom of the pump. The fluid enter the pumpthrough an intake screen and are lifted by the pump stages. Other partsinclude the radial bearing (bushings) distributed along the length of the shaftproviding radial support to the pump shaft running at high rotational speeds.

The mixed flow pump are mainly composed of four subassemblies. These subassemblies are the driver, discharge head, column assembly and thepump assembly. The power is transmitted from the electric motor or any other type of driver such as diesel engine to the pump. There are different types of electric motors used in different applications. If the pump is driven from the top, the discharge head is used and the column pipe and the intermediate shaft are adjusted for the different installations. If the length of the installation is increased, the number of the bearings used to hold the intermediate shaft is also increased. In the applications where the driver is located on the top of the discharge head, the power is transmitted to the pump by means of several shaft connections. The reason why several shafts are used to transmit the power is the flexibility of the installation.

The head shaft going through the discharge head is placed between the intermediate shaft and motor. The stuffing box is placed in the discharge head which is preventing the water coming from the column assembly leak into the motor side. The column
assembly is composed of pipes which are connected to each other and the bottom end of the column assembly in the vertical direction is connected to the discharge part of the pump. The intermediate shaft is located in the column assembly and connected to the head shaft and pump shaft by means of coupling connections. However the intermediate shaft is centered in the column assembly by means of journal bearings. The distance between the bearings are adjusted according to the rotational speed of the pump. The pump shaft holding the impeller is connected to the intermediate shaft. The impellers are locked on the shafts by means of impeller lock collets or key connections.

The bowls are connected to each other by means of bolt and nut. The impeller is located inside the bowl in vertical turbine pump and the bearing inside the bowl is used to align the shaft inside the pump assembly. The manufacturing tolerances are important while producing the bearing inside the bowl from the mechanical efficiency point. Nevertheless, the balance occurring depends upon the manufacturing of the impeller is also checked before the impeller is connected to the pump shaft. At the lower end, the suction intake is located where the journal bearing inside it allows the shaft to be aligned from the bottom end of the pump assembly.

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