THERMAL ENGINEERING LAB-II

(2025408)

4th SEMESTER

LAB MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING

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LIST OF PRACTICAL:

1. **Study of high-pressure boiler with model**
2. **Study of boiler mountings and accessories**
3. **Conduct performance test on VCR test rig to determine COP of the refrigerator**
4. **Conduct Performance test on 4-Stroke Spark Ignition engine.**
5. **Leak detection of refrigeration equipment.**

EXPERIMENT NO 1

AIM: Study of high-pressure boiler with model.

APPARATUS: Model of Babcock & Wilcox Boiler.

HIGH PRESSURE BOILER: A boiler which generates steam at a pressure higher then 80 bar is called high pressure boiler. The term boiler or steam generator is applies to device for Generating steam which may be used for power generation as in case of steam engines or turbines, for textile industries, for heating as in case of heating installation for building.

The demand for the high power output from the boiler and associated plants has increased in the last ten years. It is a common practice to use high pressure and temperature steam in power plants to increase the efficiency of the plant and to reduce the cost of electricity production. The high pressure boiler which is also known as modern boilers used for power generation are for steam capacities 30 to 650 tons/hr and above with a pressure up to 160 bar and maximum steam temperature of about 540°C.

Salient features of high pressure boilers:

Methods of circulation of water and steam. 2. Arrangement of tubing and boiler drum. 3. Methods of superheating the steam. 4. Water softening plant.

Types of High Pressure Boiler:

1. La Mont boiler

2. Benson boiler

3. Loeffler boiler

4. Schmidt-Hartmann boiler

5. Velox boiler

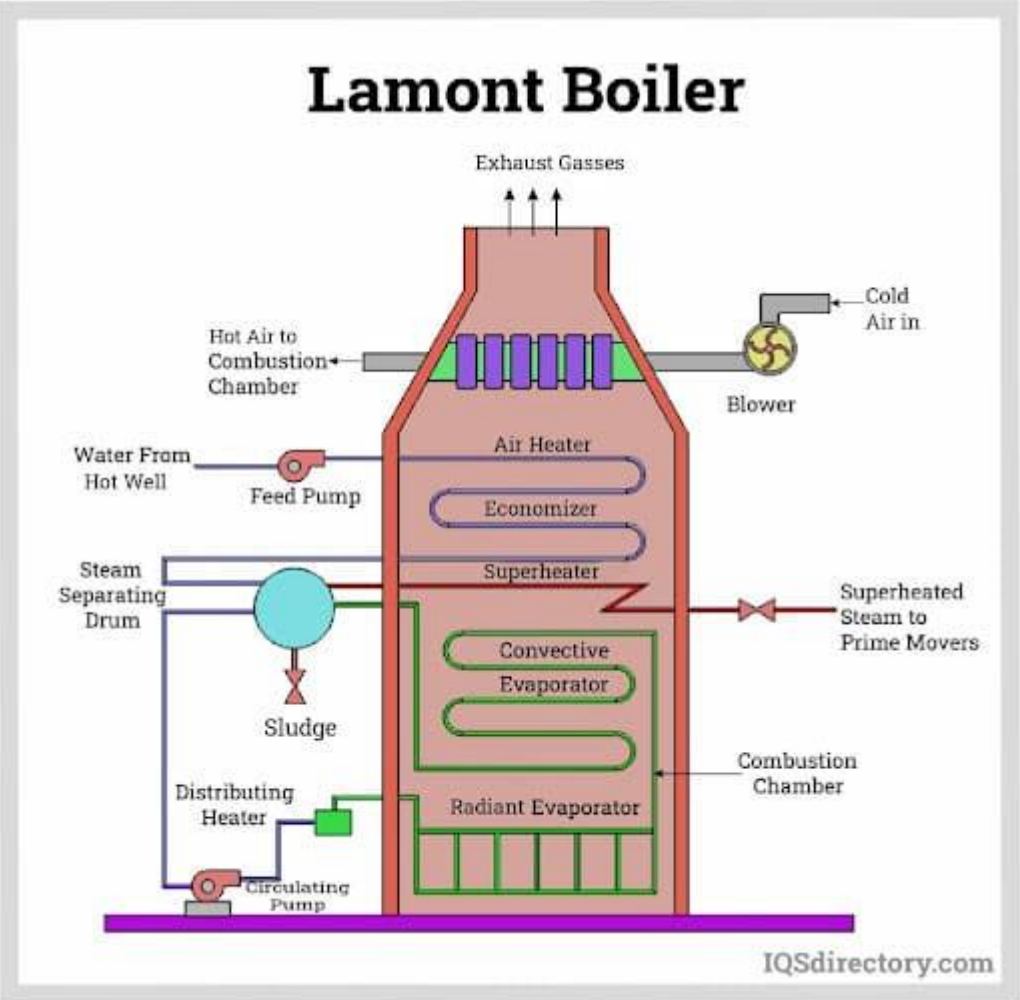
6. Supercharged boiler

1. La Mont Boiler:

The Lamont boiler is a forced convection water tube boiler that uses a pump to circulate water. It has an economizer to save on energy and increase efficiency, a boiler drum, superheater, evaporator, and air preheater. The combustion chamber for a La Mont Boiler has water pumped through the economizer and preheater into the boiler drum.

The boiler drum serves as a steam separator. The pump pushes the water to a distributor header that has nozzles to send the feed water into the evaporator tubes located in the walls of the boiler to increase surface heating.

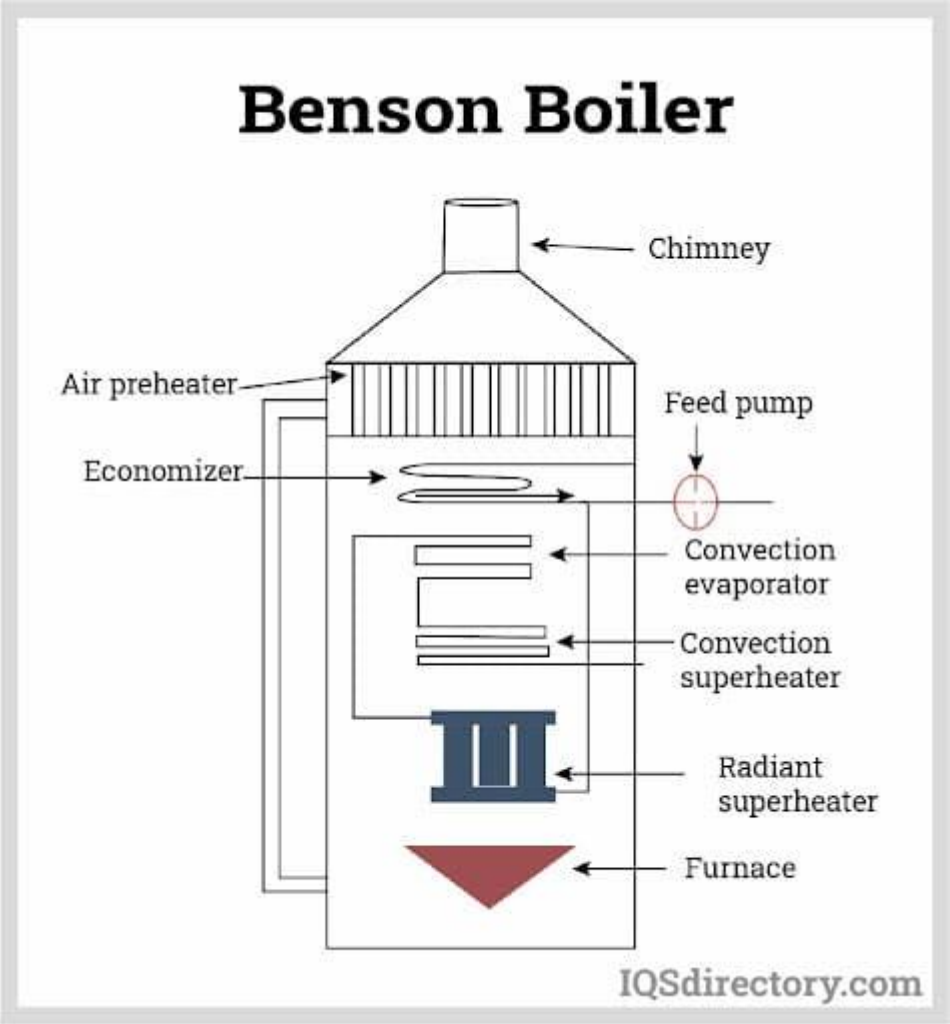
The water and steam go into the boiler drum, where the steam is separated and passed to the superheater and on to the turbine. The superheater increases the temperature of the saturated steam to prevent water droplets from entering the turbine.



2. Benson Boiler

The Benson boiler has some of the same features as the La Mont boiler without a steam separator and it works under critical pressure. It is a water tube, forced circulation boiler, where the feed water is compressed to supercritical pressure to prevent the formation of bubbles in the water tube. The compressed water feed increases the density of the water such that its density and that of the steam become the same, which reduces the latent heat in the water to zero making it easier to convert to steam.

The function of the air preheater, economizer, superheater, evaporator, and combustion chamber are the same. Unlike the La Mont boiler, the combustion chamber can be mounted horizontally.

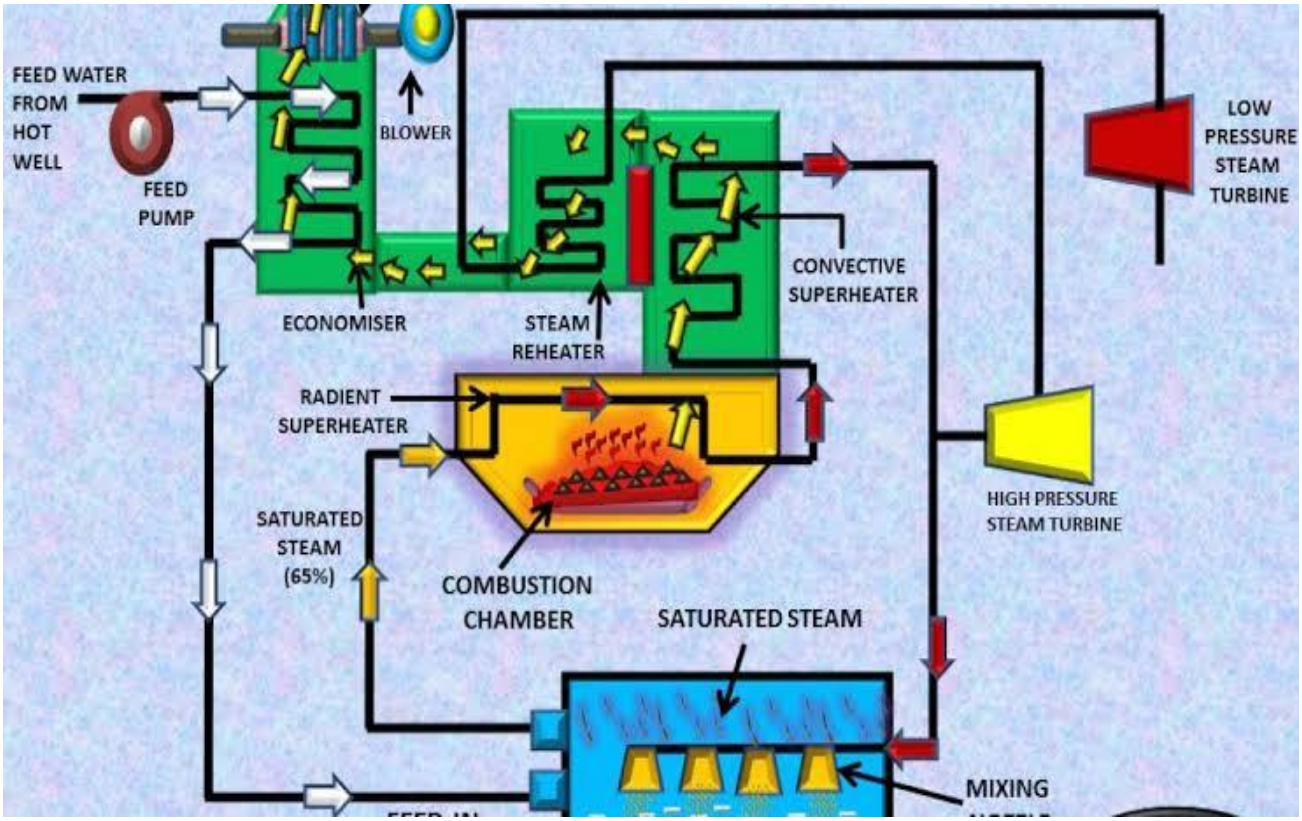


3. Loeffler boiler :

The Loeffler boiler was developed to resolve a problem with the La Mont boiler, which was salt and sediment buildup on the surface of the water tube and reduced heat transfer. Like the Benson boiler, water is circulated under high pressure in the water tube.

The Loeffler boiler has radiant and convective superheaters that work together to distribute the steam to the turbine. The radiant superheater heats the saturated steam using radiant energy produced by the burning fuel and is where heat transfer takes place. The steam then passes through the convective superheater that is heated by the flue gases, which further heats the steam before it passes on to the turbine.

Diagram of Leoffer Boiler

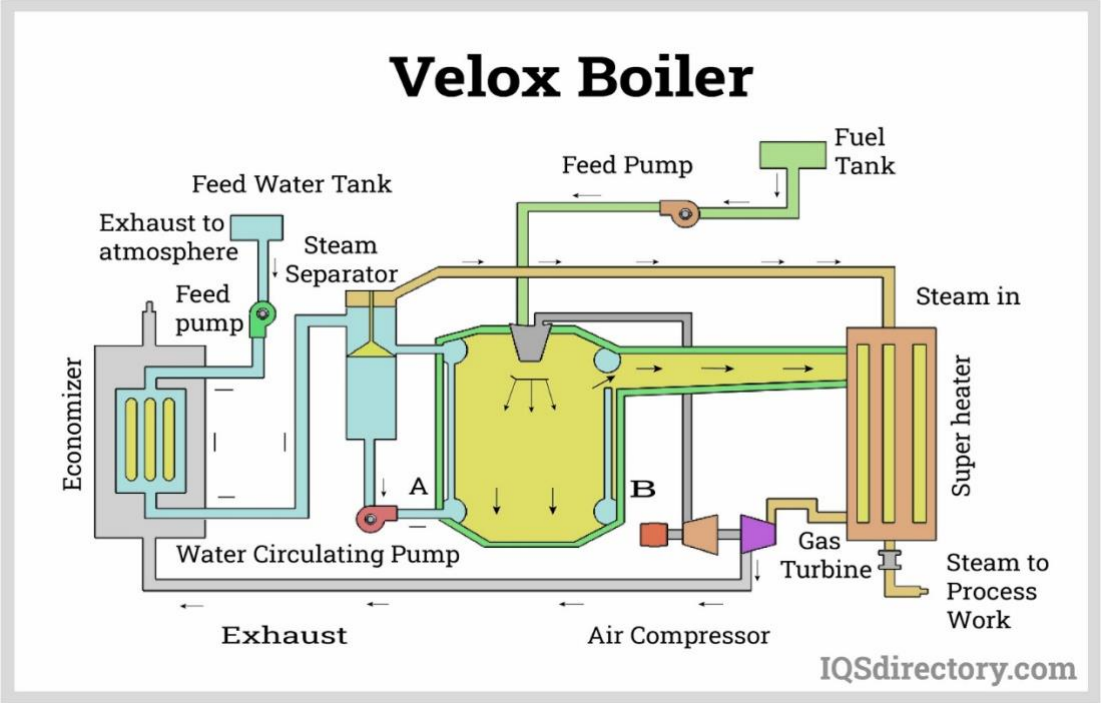


4. Velox Boiler:

The Velox boiler is a forced circulation water tube boiler that uses high velocity to rapidly produce steam. The principle of the Velox boiler is built on the velocity of the gas, which moves faster than the speed of sound and increases the rate of heat transfer.

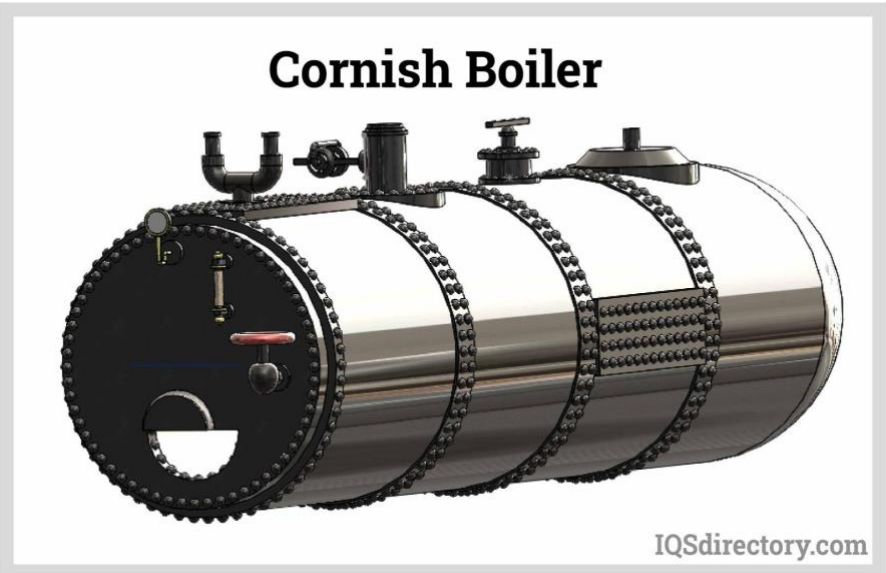
The Velox boiler has a gas turbine compressor that sends compressed air into the combustion chamber, where more heat is released. The increased rate of heat release enhances the flue gases velocity to the speed of sound. The flue gases pass from the fire tubes at the bottom of the combustion chamber and surround water filled tubes.

Water is forced from the economizer to the circulating pump at high speed causing the heat to transfer from the gases to the water very rapidly. The water and steam move to the water separator and on to the superheater. As with the Loeffler boiler, the flue gasses are used to heat the superheater.



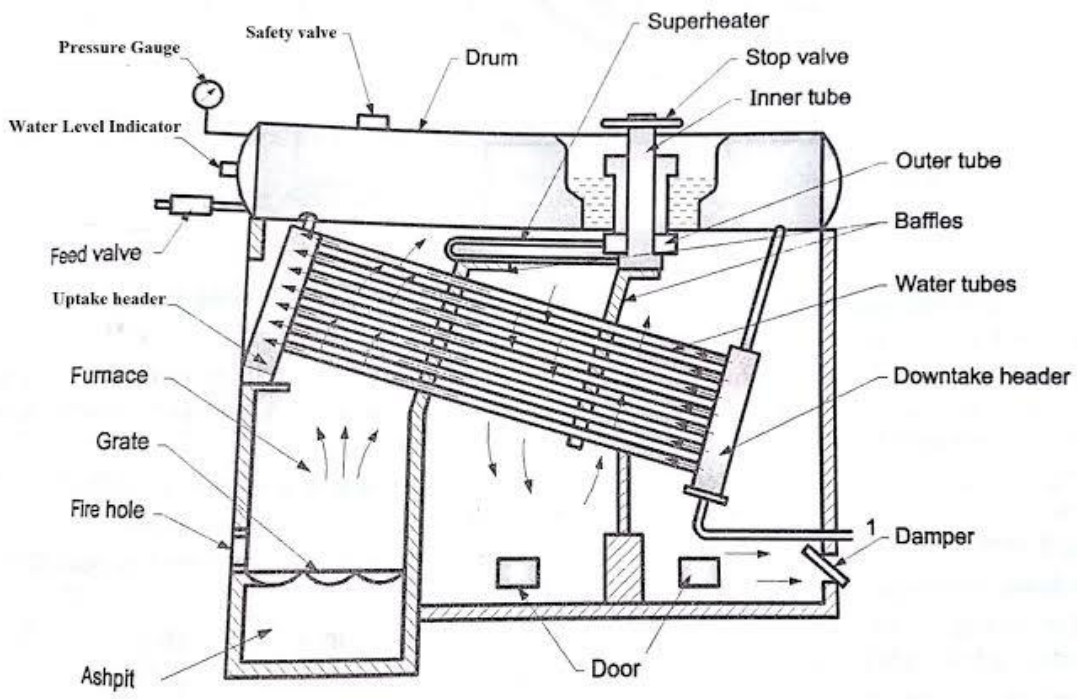
5.Cornish Boiler:

The Cornish boiler is the simplest form of boiler. It is a fire tube boiler that has a long horizontal tube with a single flue that contains the fire. The cylindrical shell of a Cornish boiler is one to two meters in diameter and can be four to seven meters long.The fuel for a Cornish boil is loaded into a grate through a door, where it burns to produce hot gases that move into the fire tube that is surrounded by water, where the water is heated to produce steam.



6.Babcock and Wilcox Boiler:

The Babcock and Wilcox boiler is a water tube horizontal boiler with natural draft circulation and multiple tubing. Water enters the tubes by a down take header, is heated by hot flue gases and moves in a zigzag fashion forced by baffle plates. The steam in the tubes moves to an uptake header, where it is collected in a boiler drum. An anti-priming pump filters the steam to remove any water droplets so that only steam is sent to the superheater, which increases the temperature of the steam. The steam from the superheater is collected or sent on to the turbine.



EXPERIMENT NO 2

AIM: Study of boiler mountings and accessories.

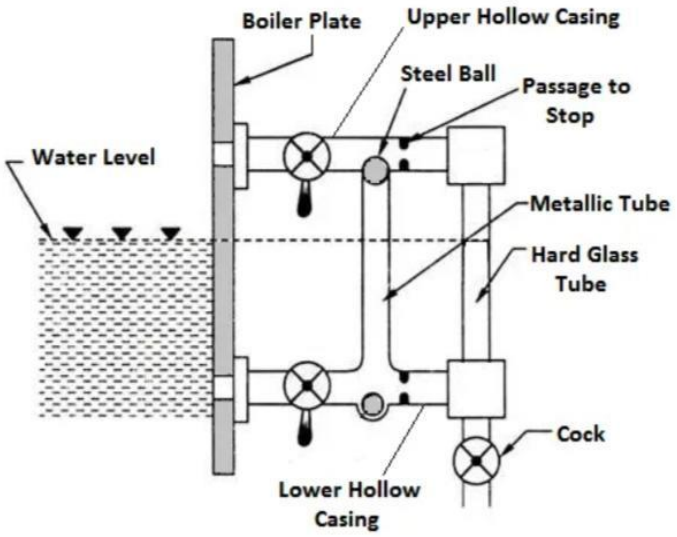
THEORY:

BOILER MOUNTING: The boiler mountings are fittings which are mounted on the boiler for its proper functioning. Mountings are water level indicator, safety valve, pressure gauge, etc. It may be noted that a boiler cannot function safely without the mountings.

Following are the important boiler mountings:

1. Water level indicator
2. Pressure gauge
3. Safety valve
4. Stop valve
5. Blow off
6. Feed check valve
7. Fusible plug

1.WATER LEVEL INDICATOR: It is an main fitting in the boiler, Water level indicator indicates the water level inside the boiler. It is a safety device upon which safe working of the boiler depends.



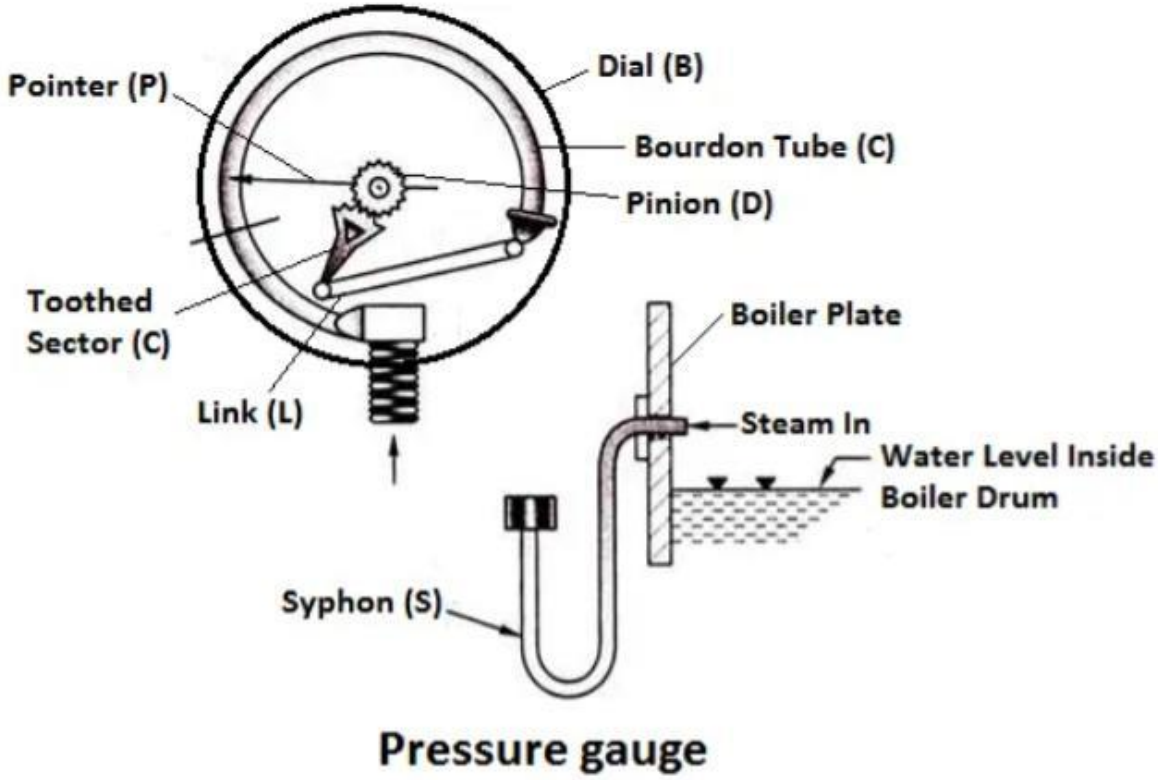
Water level Indicator

Working Principle: Water-tube indicator the water consists of a vertical hard glass tube G which is fitted with two gunmetal tubes A and B. The tubes A connects the steam space of the boiler with the glass tube and the tube B connects the water space of the boiler with the glass tube.

The tube A is provided with a valve 'S', called a steam valve, and tube B is fitted with another valve 'W', called a water valve. In addition to these valves, a third valve D, called

drain valve, is fitted to the water level indicator through which water together with condensed steam from the gunmetal tube A is drained from time to time.

2.PRESSURE GAUGE: Pressure gauges are used to measure the pressure of steam inside a steam boiler. The pressure gauge is fixed in front of a steam boiler.



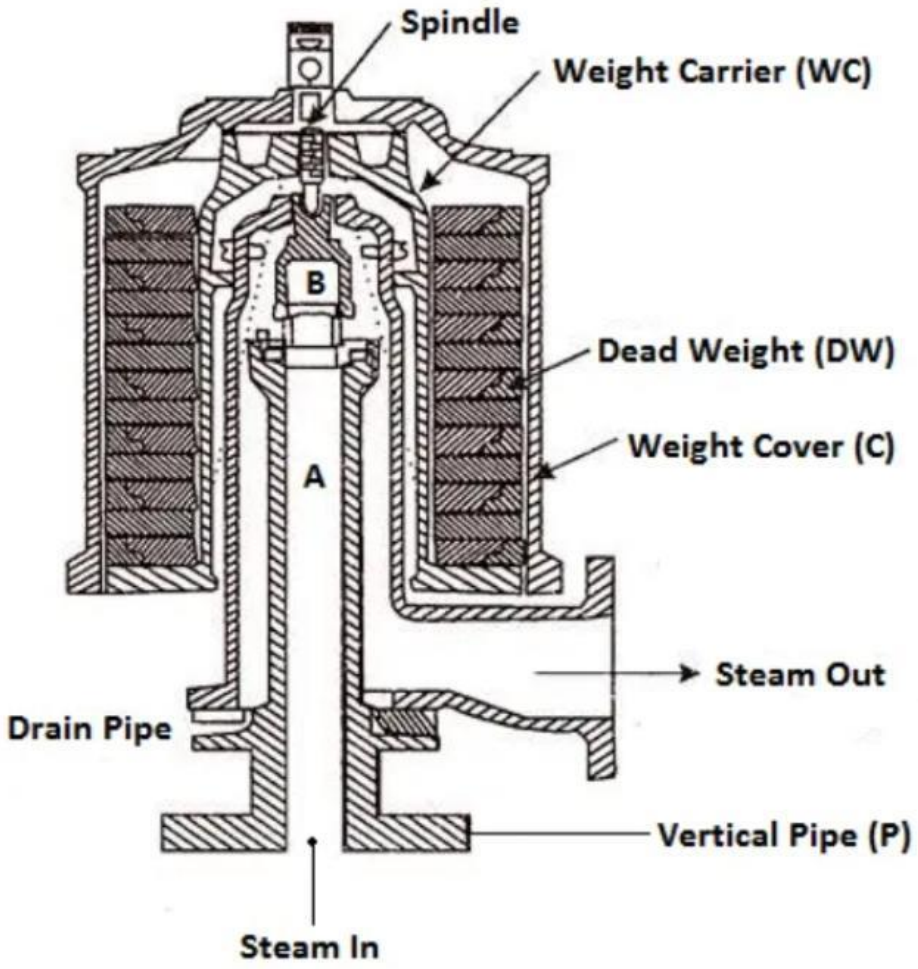
Pressure gauge

Working Principle:

The pressure gauge shown in fig is bourdon pressure gauge. It consists of a circular spring tube A. One end of the bourdon tube is closed and connected to a link L and the other end is sequared to a Hollow block B. The link L connects the closed end of the tube to the toothed sector C which is hinged at O. The toothed sector gears with pinion D which carries a pointer P. The pointer moves on a dial graduated in pressure units.

3. SAFETY VALVE:

These are the devices attached in the steam boiler for preventing explosions due to excessive internal pressure of steam. The safety valve is an instrument which prevents the boiler pressure from rising above its normal working pressure by automatically opening when the boiler pressure exceeds the normal working pressure, thus allowing excess steam to escape into the atmosphere until the pressure comes down to its normal valve. Thus, a safety valve ensures safety to a boiler from being damaged due to excessive steam pressure.



Safety Valve

The safety valves commonly used are:

(I)Deadweight safety valve,

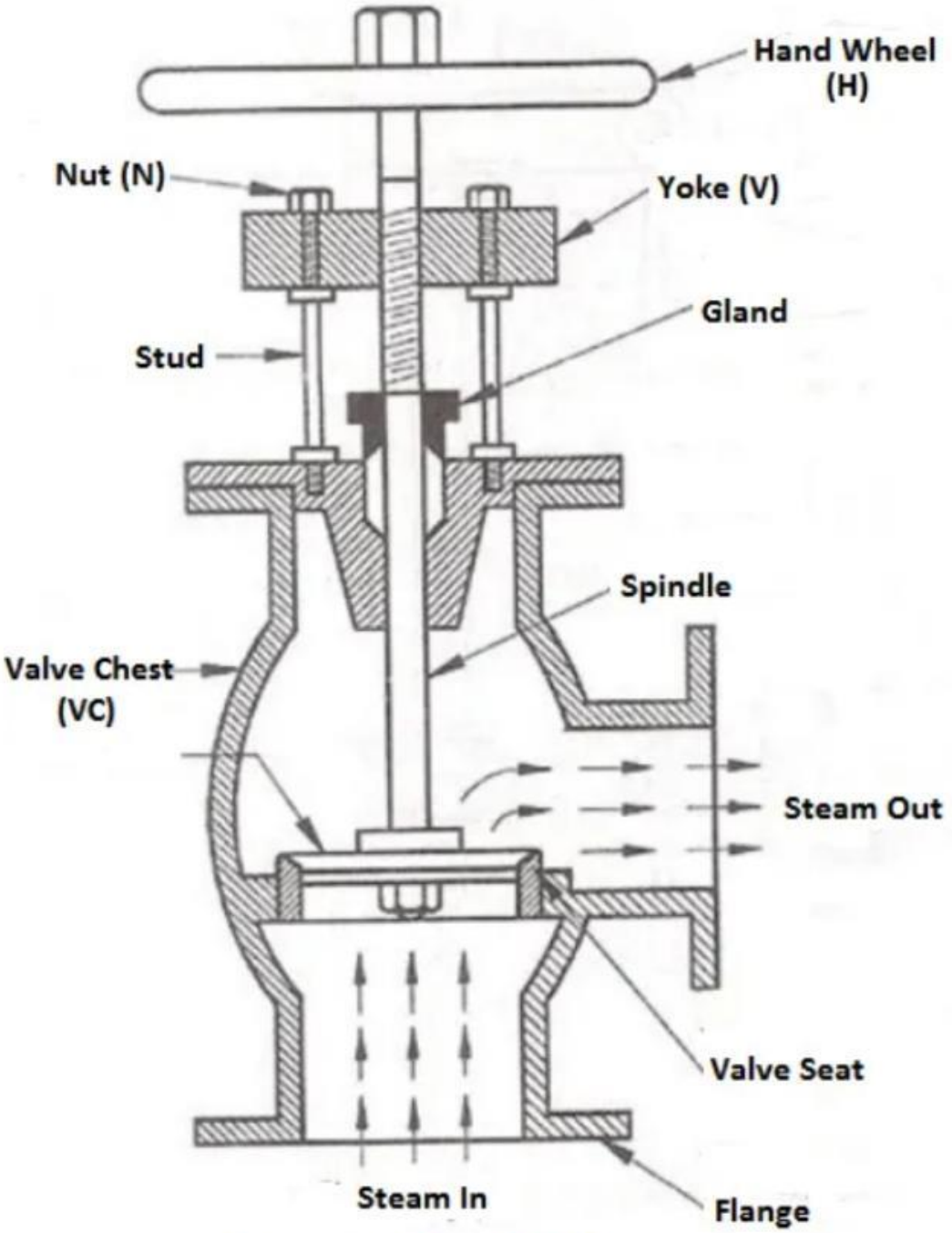
(II) Lever safety valve,

(III) Spring-loaded safety valve

4. STEAM STOP VALVE:

The function of a stop valve is to control the flow of the steam from within the boiler and to stop it completely when required. A stop valve or junction valve is used to regulate the flow of steam from the boiler.

The valves mounted on the boilers, which change the direction of flow of steam by 90° are called junction valves, while valves fitted in pipelines which allowing the steam in the same direction are called stop valve.

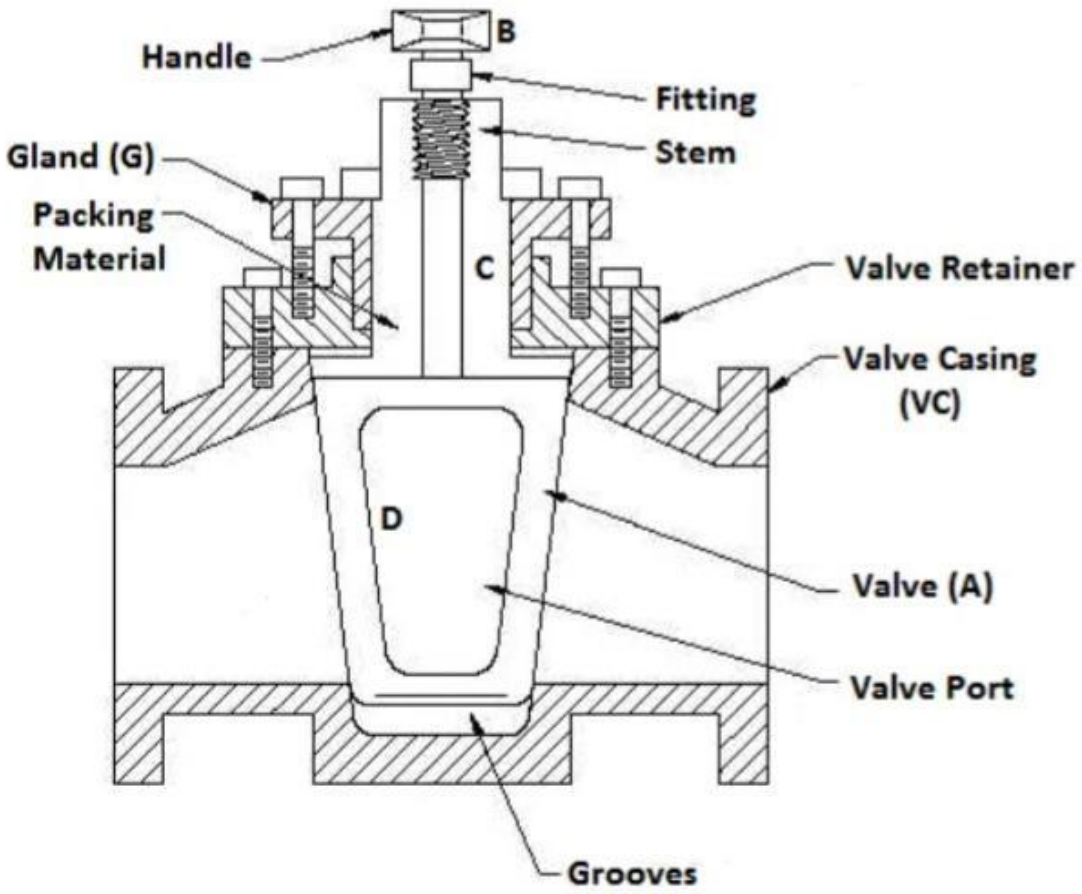


Steam Stop Valve

5.BLOW OFF VALVE OR COCK:

The function of a blow-off valve is to remove periodically the sediments deposited at the bottom of the boiler while the boiler is in operation and to empty the boiler while it is being cleaned or inspected. When the blow-off valve is opened the water which is under the

pressure of steam, rushes out with tremendous velocity thus carrying out the sediments along with it.

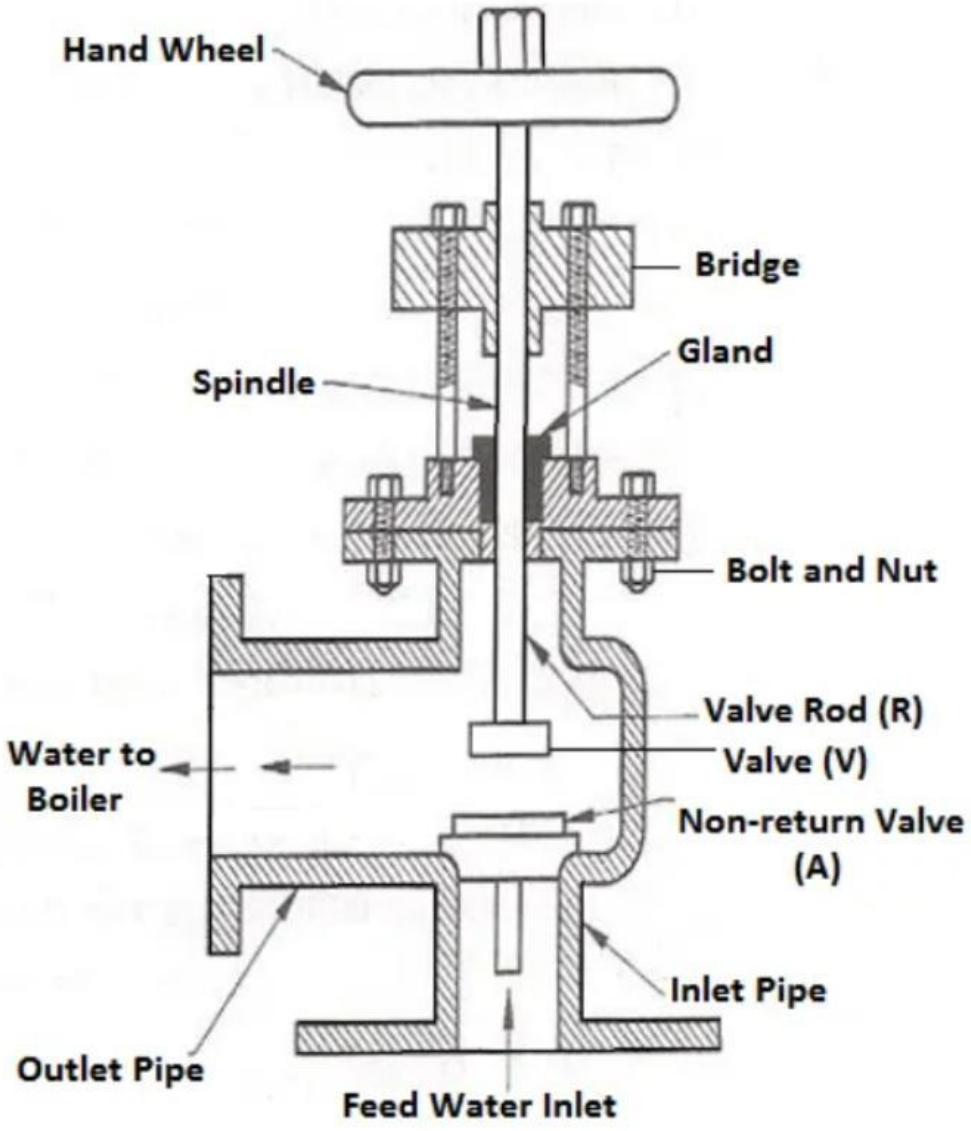


Blow off Valve or Cock

6.FEED CHECK VALVE:

When the level of water in the boiler falls, it is brought back to the specified level by supplying the additional water called feed water. The pressure inside the boiler will be high therefore the pressure of the feed water has to be raised by a pump before it is fed into the boiler. The feed water under high pressure is fed into the boiler through the feed check valve.

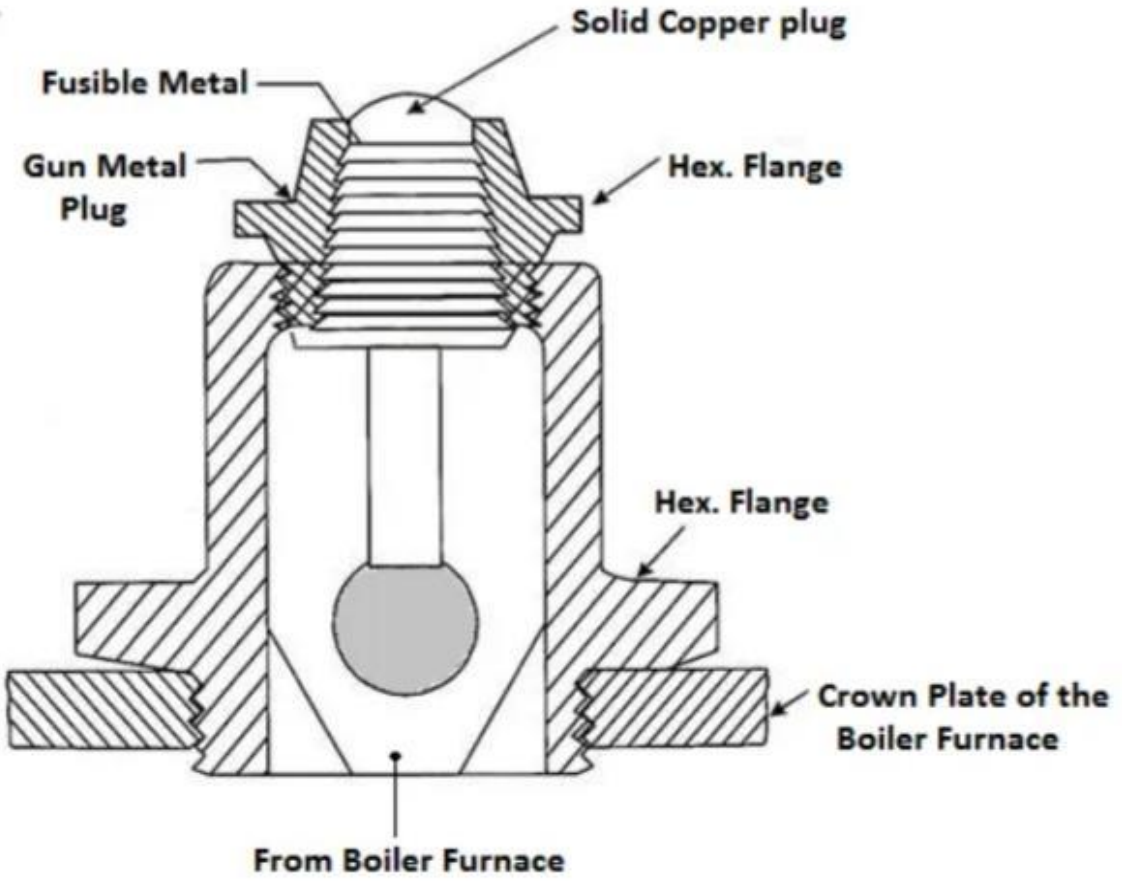
The function of a feed check valve is to control the flow of water from the feed pump to the boiler and to prevent the backflow of water from the boiler to the pump when the pump pressure is less than the pressure or when the feed pump ceases to work. Evidently feed check valve is placed at the boiler end of the delivery pipe of the feed pump.



Feed Check Valve

7.FUSIBLE PLUG:

The plug is made up of tin or leads alloy, which has a low melting point. The function of the fusible plug is to put-off the fire in the furnace of the boiler when the water level falls below an unsafe level and thus avoids the explosion, which may take place due to overheating of the tubes and the shell. It is fitted over the crown of the furnace or the combustion chamber.



Fusible Plug

Boiler Accessories

The boiler accessories are required to improve the efficiency of the steam power plant and to enable for the proper working of the boiler. The boiler accessories aren't mounted directly on the boiler.

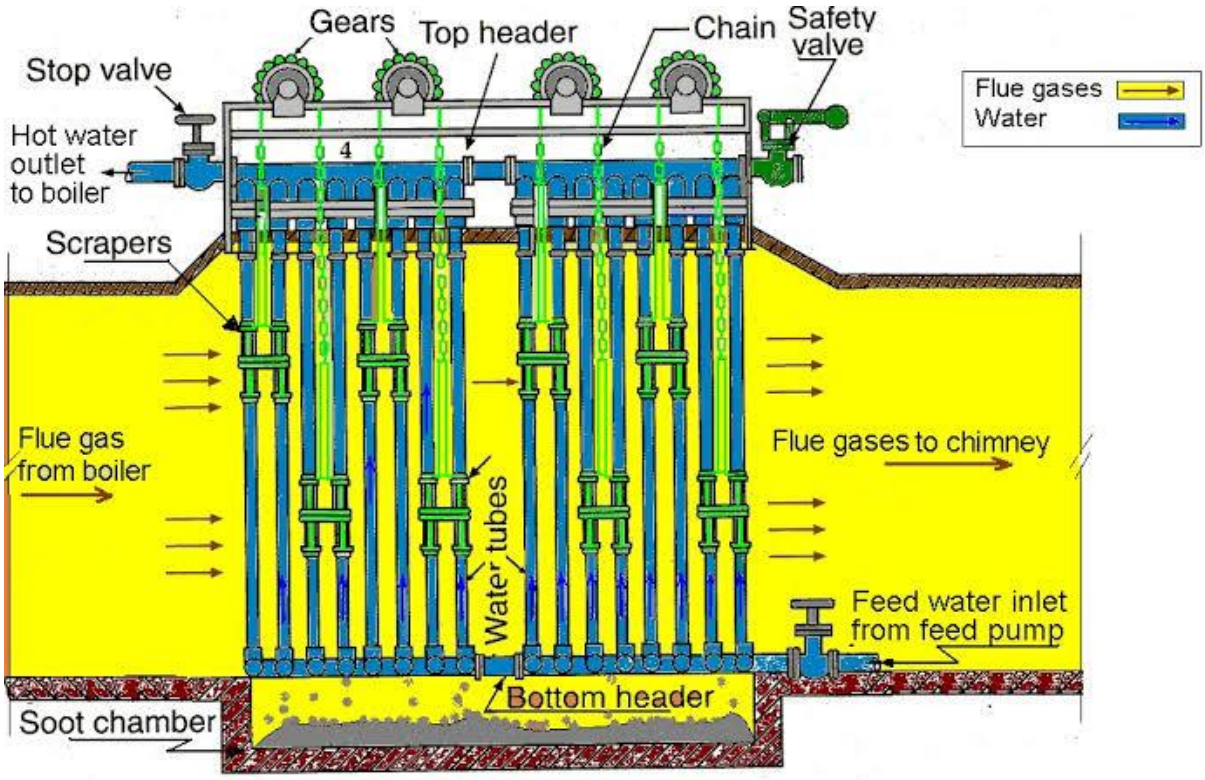
The essential boiler accessories are:

1. Economiser
2. Air pre-heater
3. Superheater
4. Feed pump
5. Steam Separator
6. Steam trap

ECONOMISER: The combustion gases coming out of the boiler contain a large quantity of heat. Therefore the maximum amount of heat from the gases should be recovered before it escapes to the chimney.

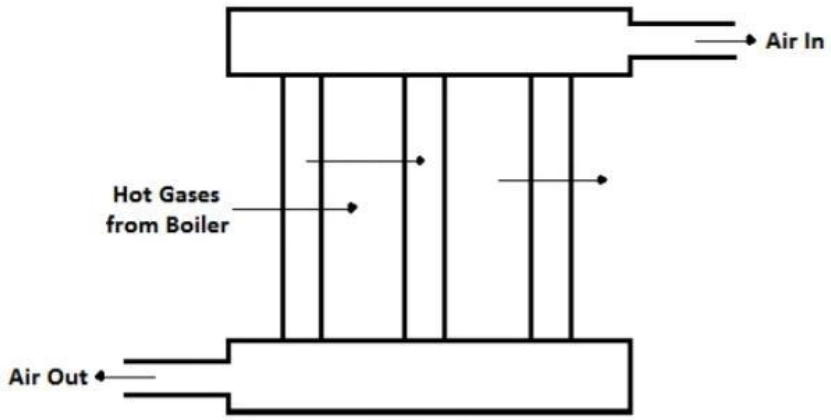
In the economiser, heating the feed water does the recovery of heat in the flue gases. The economiser is placed in the path of the gases. They improve the overall efficiency of the boiler by reducing fuel consumption.

Diagram of Economiser



2. Air Pre-heater:

The air preheater is an accessory that recovers the heat in the exhaust gas by heating the air supplied to the furnace of the boiler. Supplying preheated air into the furnace produces a high furnace temperature and accelerates the combustion of the fuel. Thus the thermal efficiency of the plant will be increased.

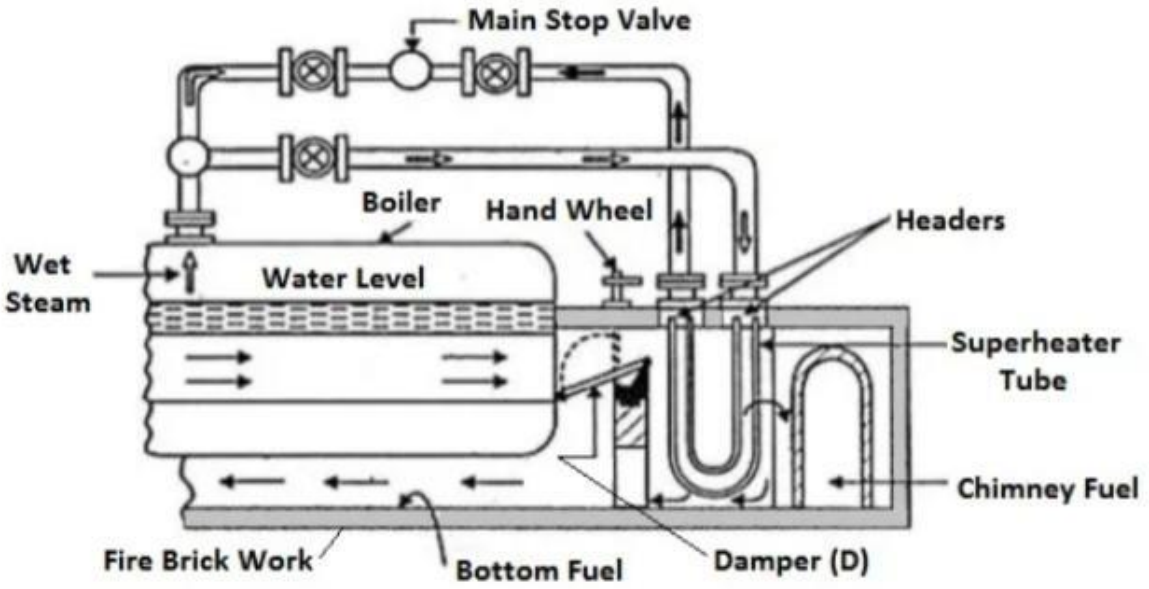


Air Pre-heater

The advantages of air pre-heater are,

- in the steam generation rate.
- Better combustion with less soot, smoke and ash, and
- Low-grade fuels can be used.

3. SUPERHEATER: The superheater is used in boilers to increase the temperature of the steam above the saturation temperature. The dry saturated steam generated in the boiler is passed through a set of tubes placed in the path of the flue gases, in which it will be heated further by the hot gas to increase its temperature about the saturation temperature.



Superheater

4. Feed Pump

A feed pump is a boiler accessory required to force the feed water at high pressure into the boiler. Commonly used pumps are,

- Reciprocating pumps
- Rotary pumps

The reciprocating pumps are driven directly by coupling them to the steam engine. The rotary pumps are driven by the steam turbines or by electric motors.

EXPERIMENT NO 3

AIM: Conduct performance test on VCR test rig to determine COP of the refrigerator.

APPARATUS: R-134a, Refrigerator, thermocouple, COP, Refrigerator Test Rig.

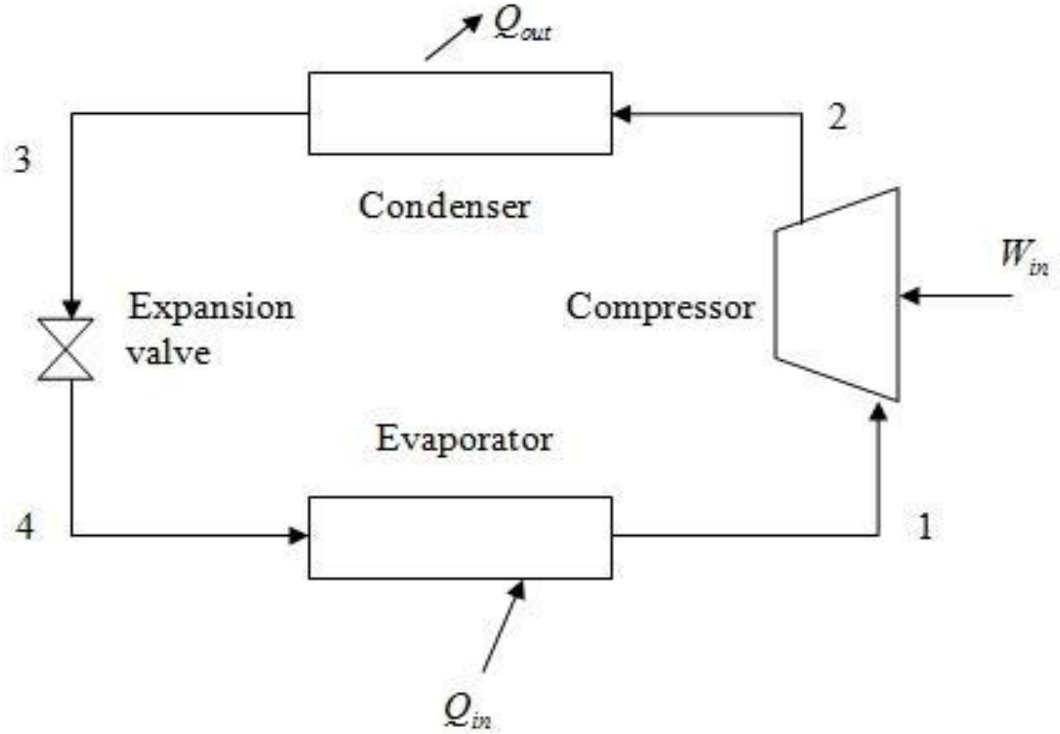
THEORY: Refrigeration is used to produced cooling in combining of all Compartment together and cooling effect produced by Vapour compression cycle. Refrigeration is used to preserve The food and storage to spoilage of food . Refrigeration are Used to remove heat from body at lower temperature to Transfer the heat at high temperature body on expense External work supplied. Vapour Compression Refrigeration Cycle working substance is known as refrigerator R-143a is Used to remove the heat and *cooling* substance. The Refrigerator is employing the isentropic compression at Lower pressure by Refrigeration. Compressor is a mechanical Device used to compress the Refrigeration from leveling the Evaporator at low pressure temp region and discharge to High pressure. Condenser is rejecting the heat to atmosphere From a Refrigeration process. Then expansion valve is Throttle to control refrigerant flow to condenser to Evaporator or in closed space. Expansion valve is called Capillary tube. Then evaporation process is absorbing the Heat from a refrigerated space and refrigerant against Convent liquid to vapour and process completed and recycle.

- Actual COP is defined as amount of heat absorbed by unit Mass of refrigerant in the Evaporator.
- Work of compression is defined as the amount of Refrigeration occurred in Evaporator, required to Compressor work.
  Then,
  COP = Qact / Wact
  Again, theoretical COP we get,
  COP th = m(h1-h4) / m(h2-h1)
  COP th = (h1-h4)/(h2-h1)

EXPERMENTAL SETUP

The experiment was conducted sequenced by ranking all of Data manually given. The all four temperatures of point of Thermocouple wire are connected to j-and k type Thermocouple scanner. The thermocouple is temperature is Measured at particular point such a vapour compression Cycle . The temperature is measured between point is time Increase is object that stable the reading on temperature Indicator. Backside of test rig panel is connected pressure gauge on suction side and discharge side of Compressor to measure the pressure at vaccume and Discharge .The data was recorded at time interval that load is Provided in the domestic refrigerator by heater.


RAC-01: VAPOUR COMPRESSION REFRIGERATION CYCLE TEST RIG
XEEPL
XEEPL
XEEPL


Q_{out}
2
3
Condenser
W_{in}
Expansion
valve
Compressor
Evaporator
4
1
Q_{in}

PROCEDURE:

- Put the machine proper position where it level is Vertical well leveled and ventilared and machine Must have at least 1.5m clearance from all sides.
- Apply 230v,50Hz of 1 phase supply to switch.
- Put the main switch ON.
- Start the refrigerator ny putting switch ON.
- Put heater switch ON. However it willnot give Supply to heater on the thermometer will cut out.
- Run the system minimum 1 Hr.
- Record all reading according to as per observation Table.
- Not down reading after regular interval of time as 5min.
- Calculate the result as per the procedure Mentioned.
- Repeat the same procedure.

OBSERVATION TABLE:

SAMPLE CALCULATION

T1=After Evaporation

T2=After Compration

T3=After Condantion

T4=After Expansion

The load varies from 25.2 watt

Suction pressure = 11psi =0.7586 bar

Discharge pressure = 325psi = 22.41 bar

Time for 10 blings = 90 sec

V = 120

I = 0.21

Q = V × I = 25.2 watt

Work of compressor

Wc = (10/3200)*(3600/time required for 10 blings In sec)

Wc = 125 watt

Actual COP

COP_{act} = Q/Wc = 0.2.2

Therotical COP = (h1-h4/h2-h1)

COP_{th} = Qact/Wact = 2.2777

RESULTS: Actual COP is less than Theoritical COP.

EXPERIMENT NO 4

AIM: Conduct Performance test on 4-Stroke Spark Ignition engine.

INTRODUCTION:

The Test Rig is multicylinder petrol engine coupled to a hydraulic brake And complete with all measurement systems, auto electrical panel , self-Starter assembly, Morse test setup,battery etc., Engine is with 4 cylinder Water cooled radiator is provided. Engine cooling is done by through Continuous flowing water.

SPECIFICATIONS:

1 Engine coupled to hydraulic brake

2.Clutch arrangement

3.Morse test setup

4.Stand,Panel with all measurements

5.Air tank, fuel tank

6.Auto electrical with battery

DESCRIPTION OF THE APPARATUS:

Engine: Either PREMIERE / AMBASSODAR four cylinder four stroke Water cooled automotive (reclaim) spark ignited with all accessories.

Make: PREMIERE

Speed: max 5000rpm

Power: 23 HP at max speed

No of cylinders: FOUR

Firing order: 1-3-4-2

Cylinder bore: 73mm

Stroke length: 70mm

Spark plug gap: 0.64mm

Other components include battery, starter motor, alternator/DC

Dynamo, ignition switch, solenoid, cables, accelerator assembly, radiator, Valves etc.

HYDRAULIC BRAKE:

It is a reaction type hydraulic dynamometer; a stator body can swing in its Axis, depending upon the torque on the shaft. The shaft is extended at both Ends and supported between two bearings. Rotor is coupled at one end to the Engine shaft. Water is allowed inside

through stator and flows inside pockets Of rotor and comes out of rotor. Any closure of valve or any restriction Flowing water, created breaking effect on the shaft, and which is reflected Inopposition force of stator. Stator while reacting to proportional force pulls A spring balance, which is calibrated in kgs. Controlling all three valves Enables to increase or decrease the load on the engine.

CLUTCH ARRANGEMENT:

A long lever with locking facility is provided. It helps to either couple engine To hydraulic brake or decouple both. Initially for no load do not couple these Two and after increasing engine speed slowly engage same. Do not allow any Water to dynamometer when engine is started. This is no load reading.

OBSERVATIONS:

1. Orifice diameter d0 =25mm
2. Density of water ρw =1000kg/m3
3. Density of air ρa =1.2kg/m3
4. Density of Petrol ρf =0.7kg/lit
5. Acceleration due to gravity g =9.81m/sec2
6. Torque on length R =0.3mt
7. Calorific value of Petrol Cv =43,210kJ/kg
8. Cd of orifice = 0.62
9. Cylinder bore D =73mm
10. Stroke length L =70mm

PROCEDURE:

1. Check the lubricating oil level.
2. Check the fuel level.
3. Check and Release the load on the dynamometer if loaded.
4. Check the necessary electrical connections and switch on the Panel.
5. Provide the Battery Connections.
6. Open water valve for engine cooling and adjust flow rate , say 4to 6 LPM

TABULAR COLUMN:

CALCULATION:

EXPERIMENT NO 5

AIM: Leak detection of refrigeration equipment.

THEORY: Refrigerants leak detection can be done using simple methods such as listening to using more advanced tools such as electronic leak detectors. Leakage of refrigerant in a HVAC system is inevitable as there are many imperfect joints fitting or welding points. Some of the leaks are as low as 1 oz every decade and are not critical to the operation of the system. Others may leak more due to the harsh temperature, environment and vibration that cause these joints to leak. If not rectified, these defects will cause a drop in efficiency to the heating or the cooling system.

The methods that are used depends on the types of refrigerant in the system. Proper safety precaution such as wearing goggles and gloves must be taken while dealing with refrigerants. If the refrigerant is corrosive such as ammonia, make sure you handle it carefully by using proper tool to test and handle the leak.

1.Halide Leak Detector: This detector is the most traditional way of detecting refrigerants with chlorine as part of the components. Therefore CFCs and HCFCs can be easily detected but HFCs cannot be detected using this method. It is able to detect leakage down to 1 to 1.5 oz per year. It has a sample tube, an end for the flame and the other end powered by propane or acetylene gas.

The draft created by the propane will draw the sample of gas near the sample tube. It will then pass over a heated copper element and causes the flame to change color.

Hence, checking it under a bright sunlight is not as effective. When methyl chloride is detected, the flame will turn to green and blue if higher concentrations of the gas is sampled.

2. **Electronic Leak Detector:** This refrigerants leak detection is the most favorable used device these days due to its accuracy and ease of use. Higher end models use infrared sensor to accurately detect a leak of less than 0.1 oz per year. HFCs, CFCs, HCFCs and HCFC-based refrigerant blends can be detected easily by using this advanced technology state of the art tool. This detector has a filter that prevent contaminants and water from entering it. It is

also able to work in an environment contaminated by refrigerants by using the re-calibration feature.

3**. Ultraviolet Fluorescent Dye Leak Detector:** This refrigerants leak detection method is more messy and was developed to find leaks in the automatic transmissions of the automobile industry. Here, a special fluorescent dye is charged into the system that is suspected to be leaking. This dye will mix with the oil and the mixture is circulated by the refrigerant in the system. Once it escapes through the leak, you will see glows under the ultraviolet lamp.

4. Ultrasonic Leak Detector: The system must be highly pressurized for this detector to work. This refrigerants leak detector uses an electronic amplification system that is able to detect the high frequency sound of the leak. A microphone and earphones are used as input and output of the system.

5. Detecting Ammonia: Ammonia can be detected by the use of phenolphthalein paper where the moistened paper will turn pink (small amount) or scarlet (bigger amount) when in contact with this gas. The other method is by using a lighted sulfur candle which will give a thick white smoke when it encounters the ammonia gas.

6. Detecting Carbon Dioxide: In system that uses carbon dioxide as its refrigerant, detection can be done easily by using a soap solution added with bromothymol blue. The solution will turn to yellow when this gas is detected.