C.V RAMAN POLYTECHNIC, BHUBANESWAR
DEPARTMENT OF MECHANICAL ENGINEERING
POWER STATION ENGINEERING LAB

Power Station Engineering Laboratory (6th semester) Code-Pr-2 Full marks: 75

	Pr.2 POWER STATION ENGINEERING LAB	Levels
CO1	study about modern steam power plant and cooling tower models.	3
CO2	determine the various efficiencies of steam turbine.	3
CO3	learn jet condenser and De-Laval turbine.	3
CO4	gain knowledge about spring loaded safety valves.	3
CO5	Learn about different types of boiler models.	3

CO-PO Mapping

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	Average CO
CO1	3.00	-	-	2.00	-	-	-	2.50
CO2	3.00	-	-	2.00	-	-	-	2.50
CO3	3.00	1.00	-	2.00	-	-	-	2.00
CO4	3.00	-	-	2.00	-	-	-	2.50
CO5	3.00	1.00	-	2.00	-	-	-	2.00
Average PO	3.00	1.00	-	2.00	-	-	-	**2.30** / **2.00**

Sessional Rubrics (25)

	Attendance (3)			Record (5)			Experiment/Job (12)			Viva (5)		
	The student attends all the classes.			Presentation with good technical details and good communication skills, refers to the slides to explain the points and completely engaged with audience.			The seminar report is accroding to the specified format. The content is written with clarity and in organized manner. There is a logical flow in the text.			Defends all questions by providing clear and insightful answers to the questions.		
Rating/Performance criteria	12	11	10	9	8	7	6	5	4	3	2	1
Attendance (3)										Fulfills to 100% of set criteria	Fulfills to 70% of set criteria	Fulfills to 50% of set criteria
Record (5)								Fulfills to 100% of set criteria	Fulfills to 80% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 30% of set criteria
Experiment/ Job (12)	Fulfills to 100% of set criteria		Fulfills to 90% of set criteria	Fulfills to 80% of set criteria	Fulfills to 70% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 40% of set criteria	Fulfills to 30% of set criteria			
Viva (5)								Fulfills to 100% of set criteria	Fulfills to 80% of set criteria	Fulfills to 60% of set criteria	Fulfills to 50% of set criteria	Fulfills to 30% of set criteria

Sessional (25)

Sl. No.	Name of student	Registration number	Attendance (3)	Record (5)	Experiment (12)	Viva (5)	Total (25)

Practical Rubrics (50)

	Report (15)				Experiment/Job (25)				Viva (10)		
	Report is well written. The Contents are equipped with neat sketch, error free calculations and free from grammatical errors.				Identifying equipment, instruments and material and setting up of machine tool. Exhibits proper knowledge of the lab procedure. Runs the machine independently. Takes all the readings from machine/apparatus during experiment. The obtained result is calculated correctly to find the result. Analyses if any error occurred with the reason. The experiment is completed within the time limit with taking proper safety precautions. Discipline and ethics is maintained while performing the experiment.				A set of questions is asked relating to the experiment and subject.		
Rating/Performance criteria	25	24	21	18	15	12	10	8	6	4	2
Report (15)					Answers to 100% of questions asked	Answers to 75% of questions asked	Answers to 60% of questions asked	Answers to 50% of questions asked	Answers to 40% of questions asked	Answers to 30% of questions asked	
Experiment/Job (25)	Performs 100% of the criteria	Performs 90% of the criteria	Performs 80% of the criteria	Performs 70% of the criteria	Performs 60% of the criteria	Performs 50% of the criteria	Performs 40% of the criteria	Performs 30% of the criteria			
Viva (10)							Answers to 100% of questions asked	Answers to 90% of questions asked	Answers to 70% of questions asked	Answers to 50% of questions asked	Answers to 30% of questions asked

Practical (50)

Sl. No.	Name of student	Registration number	Report (15)	Experiment (25)	Viva (10)	Total (50)

Programme outcomes (POs) and Programme specific outcomes (PSOs) to be achieved through the practical of this course:-

1. **Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.
2. **Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.
3. **Design/development of solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.
4. **Engineering Tools, Experimentation and Testing:** Apply mode m engineering tools and appropriate technique to conduct standard tests and measurements.
5. **Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
6. **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
7. **Life-long learning:** Ability to analyses individual needs and engage in updating in the context of technological changes.

Program Specific Outcomes (PSOs)

PSO-1	Discipline knowledge	Demonstration and understanding of tools with advanced software for design specification and operation of Mechanical Engineering systems, components and processes.
PSO-2	Professional Skills	Apply contextual knowledge to analyze social, environmental, health, safety, legal, and cultural issues with professional ethics as part of the lifelong learning process. To be equipped to lead a team or operate successfully alone as an individual managing tasks in trans-disciplinary areas.

EXPERIMENT NO.01

Aim of the experiment:

Aim: To study of modern steam power plant with model.

Objectives:

1. Study about the layout of steam power plant.
2. Study about the Rankine cycle and different components steam power plant

Theory:

1. Modern Steam Power Plant and its Operating Cycle.

The general layout of the modern power plant consists of mainly four circuits which are

- Coal and ash circuit.
- Air and gas circuit.
- Feed water and steam flow circuit.
- Cooling water circuit.

A thermal power station using steam as working fluid works basically on the Rankine cycle. Steam is generated in a boiler, expanded in a prime mover and condensed in a condenser and fed into the boiler again with the help of pump. However, in practice, there are numerous modifications and improvements in this cycle with the aim of affecting heat economy and to increase the thermal efficiency of the plant.

1. Coal & Ash handling unit:

Before feeding the coil to the furnace. it to be converted into pulverized form and after the combustion the ash is in the ash handling unit.

2.Boiler:

The equipment asked for producing Steam is called boiler or steam generator Heating. The steam generator used for (i) heating (ii) Power generation iii) utilization is industries like sugar milk, chemical, Industries etc.

3 Super heaters:

The steam is taken out from the boiler and is superheater so that the steam be free from the water molecules.

4. Steam turbine:

The steam which is free from Water molecules are used to strike to the blades of turbine so that large amount of power can be generated.

5. Generator:

A generator that converts one form of energy another is attached to the rotor of the turbine and as the turbine rotates it also rotates with the speed of the turbine.

6. Condenser:

The steam striking on the blades of the turbine enter into the condenser where it is condensed with the help of cold water from cooling tower.

7. Economiser:

It added the feed water to extract a part of heat from the condenser by increasing the feed water temperature.

8. Feed pump:

This feed water is to be sent to the boiler using a feed pump.

9. Cooling tower:

The water that is used to condenser the steam in the condenser was supplied from the cooling tower.

10 Chimney:

It is the last stage where only the air particle into the atmosphere by reducing the heat from steam by the usage of the water sprinkle.

Working cycle Rankine:

Process 1-2

Steam is expanded inside the turbine isoentropically

Process 2-3

Heat transfer takes inside the condenser at constant pressure and temperature process.

Process 3-4

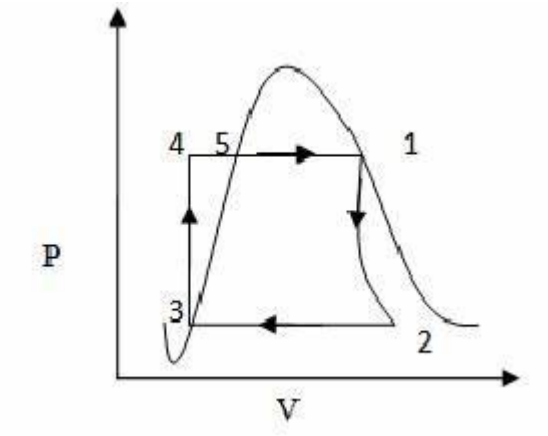
Pumping process takes place isoentropically.

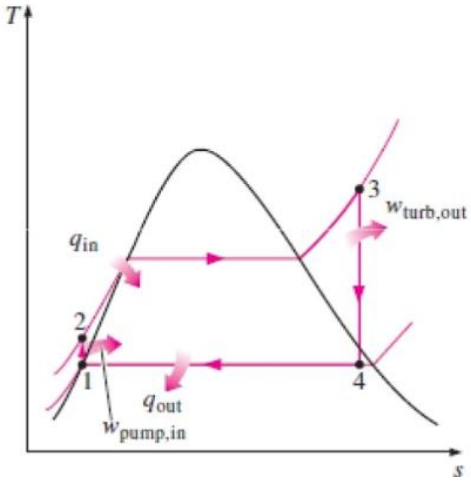
Process 4-1

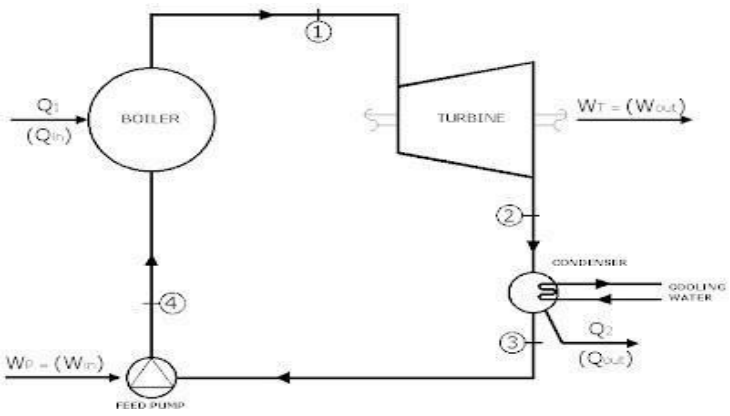
Heat transfer takes place inside the boiler at constant pressure process.

$$\eta_R = \frac{Work\,done}{Heat\,Absorbed} = \frac{h_2 - h_3}{h_2 - h_{f3}}$$

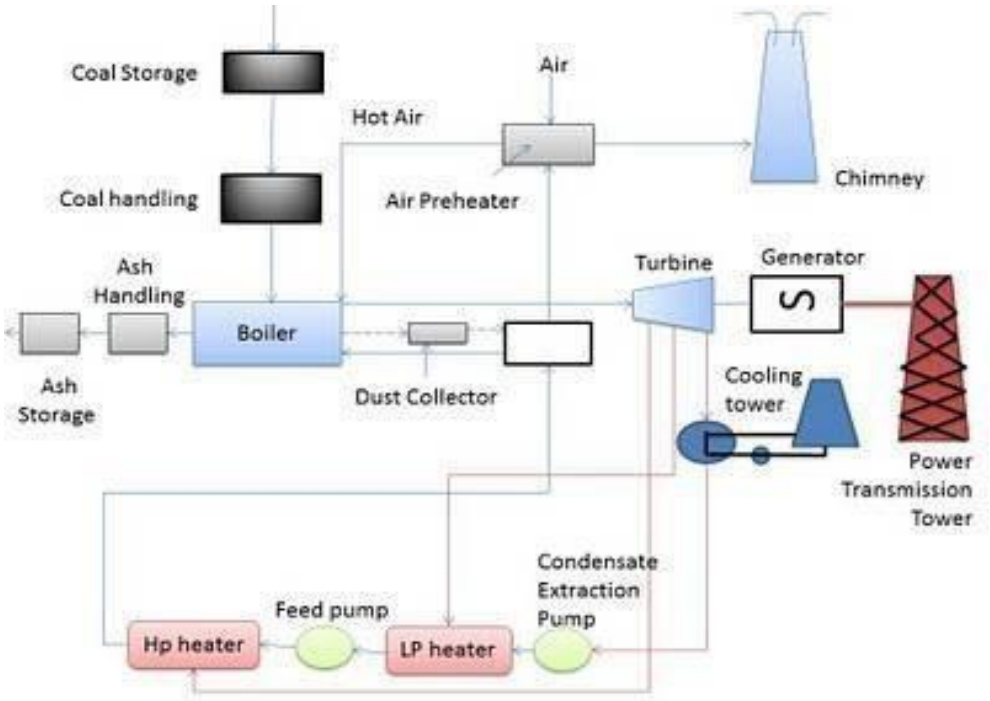
P-V, T-S and H-S diagram of simple Rankine cycle







Simple Rankine cycle



Steam power plant layout with its different circuits

Conclusion:

From the above experiment we studied steam power plant and its components working cycle successfully.

EXPERIMENT NO. 2

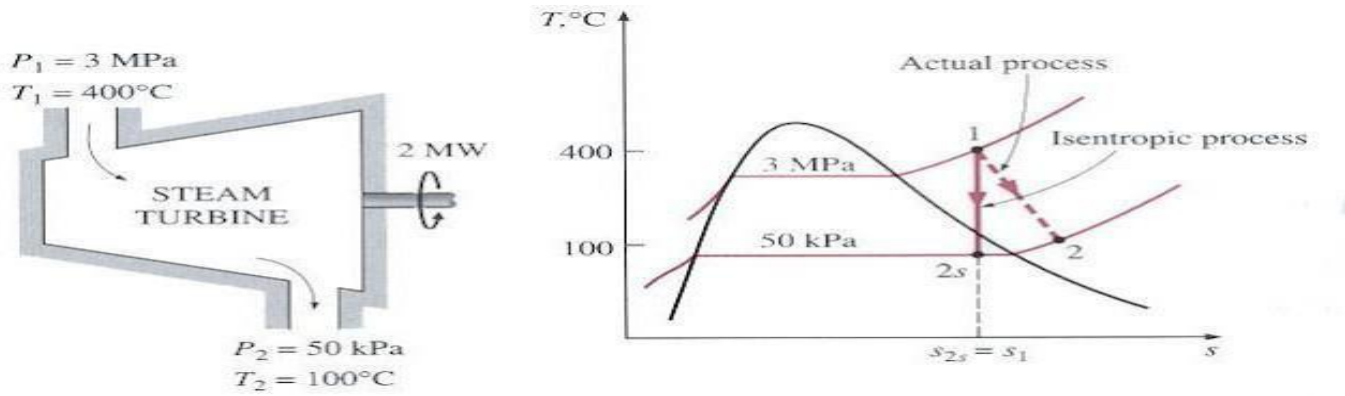
Aim of the experiment:

To determine the various efficiency of steam turbine.

Theory:

A steam turbine is a device that takes hot, high- pressure steam and extracts mechanical energy from it. This energy can then be used to do useful work that uses steam turbines is the steam power plant, which generates electricity used in everyday life.

An energy balance on the steam turbine tells us the relationship between the power output and the inlet and outlet states of the steam. A turbine is analyzed as an adiabatic (i.e., no heat transfer) device. The power output is then calculated as the mass flow rate of the steam multiplied by the difference in enthalpy between the inlet and outlet, or:



$$Wt=m(h1-h2)$$

Where Wt is the power output by the turbine ,*m* is the mass flow rate of the steam, and h1 and h2 are the specific enthalpies at the inlet and outlet, respectively The inlet and outlet states are indicated on the T-S diagram by the points 1 and 2. The point 2s on the T-5 diagram is the state that is used to calculate the isentropic efficiency of the steam turbine It is determined by the intersection of the outlet pressure and the inlet entropy Remember the second law of thermodynamics dictates that the outlet entropy cannot be less than the inlet entropy Therefore, if entropy stays the same this indicates that maximum possible energy has been extracted from the fluid at the two given pressures With this knowledge the isentropic efficiency can be defined as the following:

$$\eta_t \equiv \frac{\dot{W}_t}{\dot{W}_{t,s}} = \frac{h_1 - h_2}{h_1 - h_{2s}}$$

where is the maximum possible extracted power and he is the enthalpy associated with state 2s. The entropic efficiency, ½ must be between 0 and 1 by definition Efficiencies for steam turbines range from 0.3 to 0.9 but can vary widely depending on its design, size, and operating conditions

Conclusion:

The efficiency of steam turbine is----------

EXPERIMENT NO. 03

Aim of the experiment:

To study the cooling tower

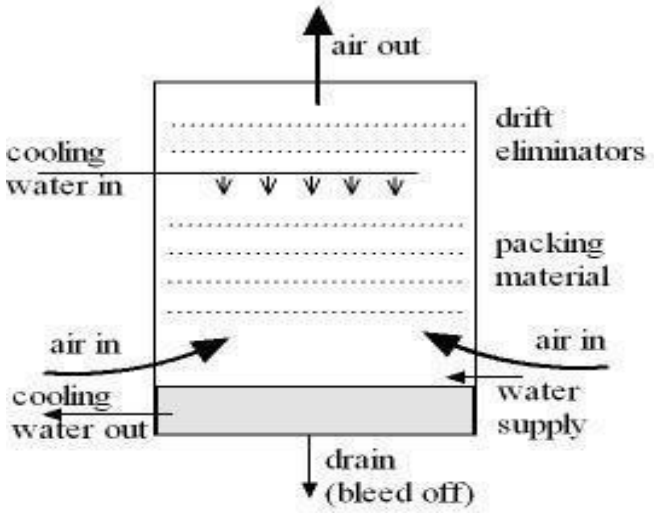
Apparatus:

Cooling Tower set up.

Theory:

Cooled water is needed for, for example, air conditioners, manufacturing processes or power generation. A cooling tower is equipment used to reduce the temperature of a water stream by extracting heat from water and emitting it to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly. Cooling towers are able to lower the water temperatures more than devices that use only air to reject heat, like the radiator in a car, and are therefore more cost-effective and energy efficient.

Cooling towers use the evaporative cooling principle to cool the circulated water, and they can achieve water temperatures below the dry bulb temperature – t_{db} - of the air cooling air and they are in general smaller and cheaper for the same cooling loads than other cooling systems.



Cooling towers are rated in terms of approach and range**,** where

- the **approach** is the difference in temperature between the cooled-water temperature and the entering-air wet bulb - t_{wb} -temperature
- the **range** is the temperature difference between the water inlet and exit states Since a cooling tower is based

  on evaporative cooling the maximum cooling tower **efficiency** is limited by the wet bulb temperature -t_{wb} - of the cooling air.

The water consumption - the make-up water of a cooling tower is about 0.2-0.3 liter per minute and ton of refrigeration. Compared with the use and waste of city water the water consumption can be reduced with about

90 - 95%.

There are two main types of cooling towers

1. Natural draught
2. Artificial draught (Mechanical type)

(i) Forced draught (Forced fan)

(ii) Induced draught (Suction fan)

1. Natural draught: When the circulation of air through the tower is by natural convection, it is known as a natural draught. In this, hot water from the condenser is pumped to top of tower where it is sprayed down through a series of spray nozzles. The hot water after giving its heat to air which circulates through the tower due to natural convection, gets cooled and is collected from bottom of tower.
2. Artificial draught: When the circulation of air through the tower is by artificial convection i.

e. Forced fan, Suction fan is known as artificial draught. It is of two type:

(i) Forced draught: The tower is completely encased with discharged opening at the top and fan at the bottom to produce flow of air.

(ii) Induced draught: Here fan is placed at the top which draws air through the tower. The warm water to be cooled introduce at the top of the tower through spray nozzles. It falls through a series of trays which are arranged to keep the falling water to be broken up into fins drops. The cooled water is collected at the bottom.

Procedure:

1. Make the initial setting as per equipment.
2. Start the experiment and take the temperature readings.
3. Complete the calculations.

Conclusion:

From the above experiment we studied cooling tower successfully.

EXPERIMENT NO. 04

Aim of the experiment:

Study of jet condenser.

Apparatus:

Model of jet condenser.

Steam Condenser:

It is a device or an appliance in which steam condenses and heat released by steam is absorbed by water.

Classification of Condensers

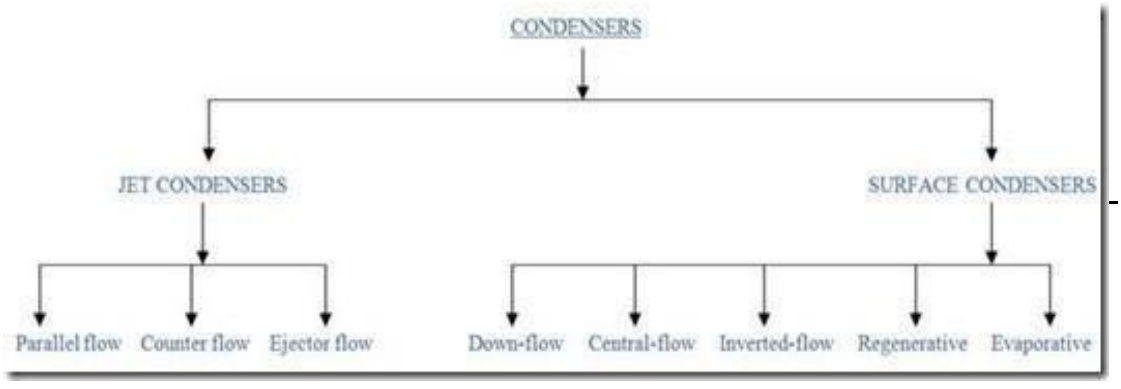
1. Jet condensers
2. Surface condenser

Jet Condensers:

The exhaust steam and water come in direct contact with each other and temperature of the condensate is the same as that of cooling water leaving the condenser. The cooling water is usually sprayed into the exhaust steam to cause, rapid condensation.

Surface Condensers:

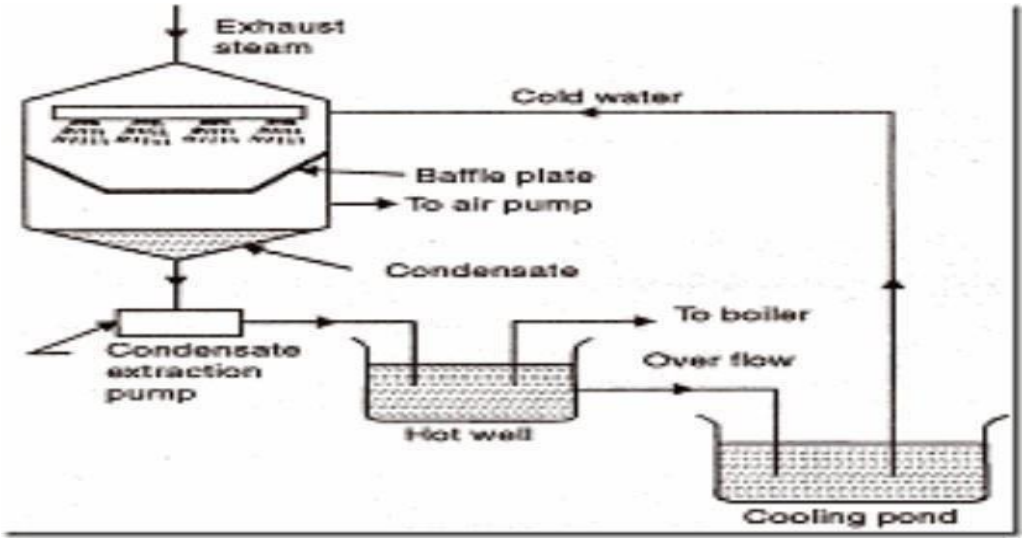
The exhaust steam and water do not come into direct contact. The steam passes over the outer surface of tubes through which a supply of cooling water is maintained.



Parallel-flow type of jet condenser:

The exhaust steam and cooling water find their entry at the top of the condenser and then flow downwards and condensate and water are finally collected at the bottom.

Fig. Parallel flow type condenser



Counter-flow type jet condenser

The steam and cooling water enter the condenser from opposite directions. Generally, the exhaust steam travels in upward direction and meets the cooling water which flows downwards.

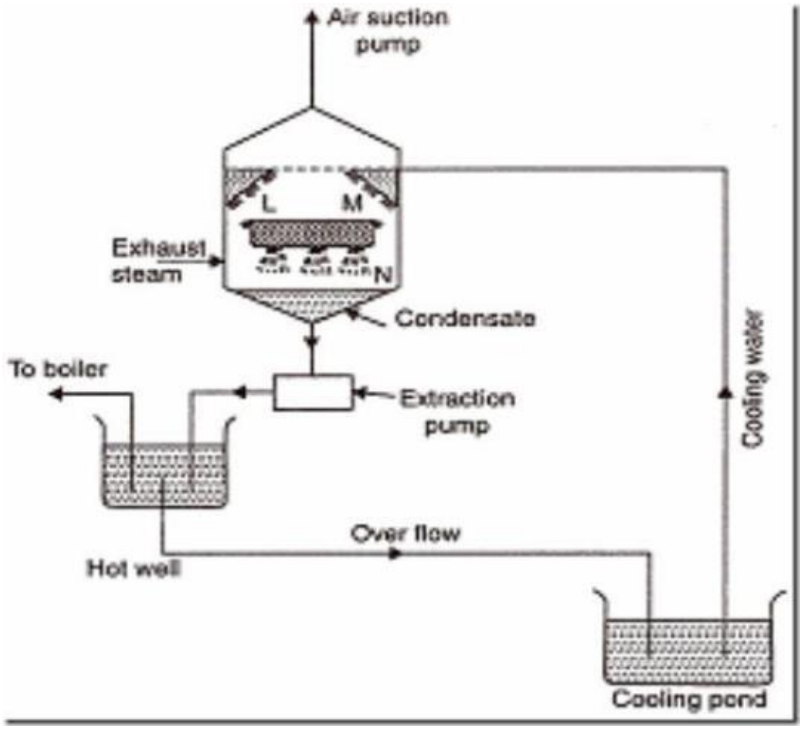


Fig. Low level counter flow type condenser

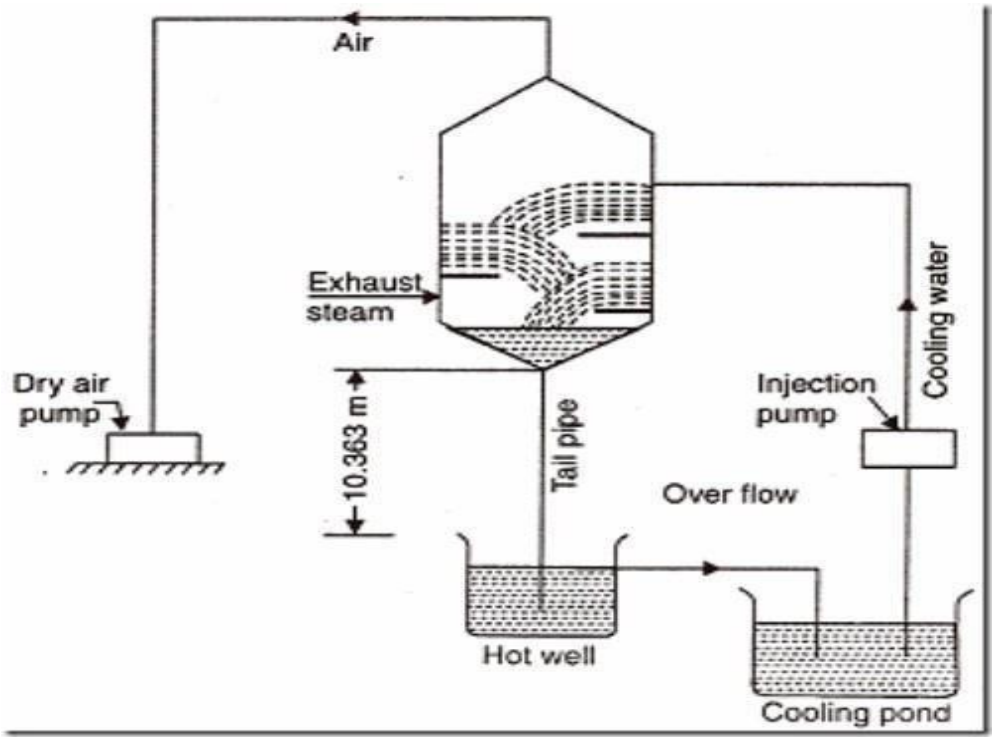
low level jet condenser (counter-flow type jet condenser

Figure Shows, L, M and N are the perforated trays which break up water into jets. The steam moving upwards comes in contact with water and gets condensed. The condensate and water mixture is sent to the hot well by means of an extraction pump and the air is removed by an air suction pump provided at the top of the condenser.

High level jet condenser (counter-flow type jet condenser)

It is also called barometric condenser. In this type the shell is placed at a height about 10.363 meters above hot well and thus the necessary of providing an extraction pump can be obviated. However provision of own injection pump has to be made if water under pressure is not available.

Fig. High level counter flow type condenser



Ejector condenser flow type jet condenser

Here the exhaust steam and cooling water mix in hollow truncated cones. Due to this decreased pressure exhaust steam along with associated air is drawn through the truncated cones and finally lead to diverging cone. In the diverging cone a portion of kinetic energy gets converted into pressure energy which is more than the atmospheric so that condensate consisting of condensed steam, cooling water and air is discharged into the hot well. The exhaust steam inlet is provided with an on- return valve which does not allow the water from hot well to rush back to the engine in case a failure of cooling water supply to condenser.

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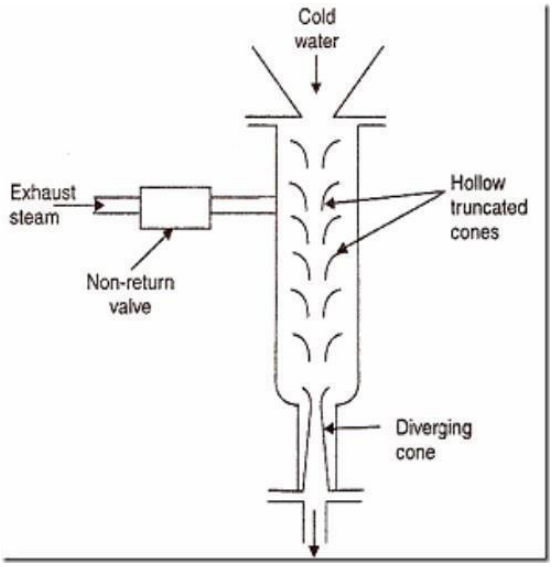
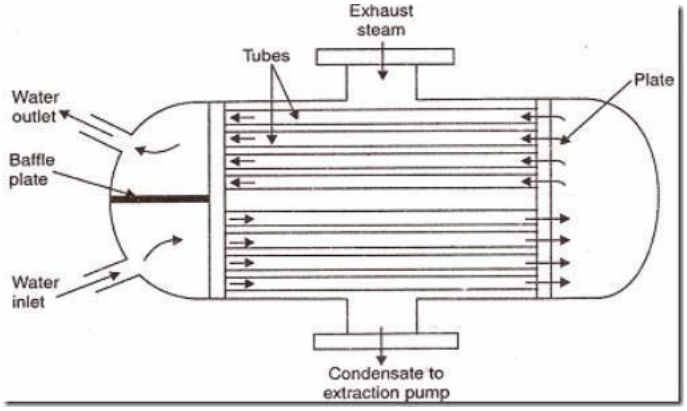


Surface condensers

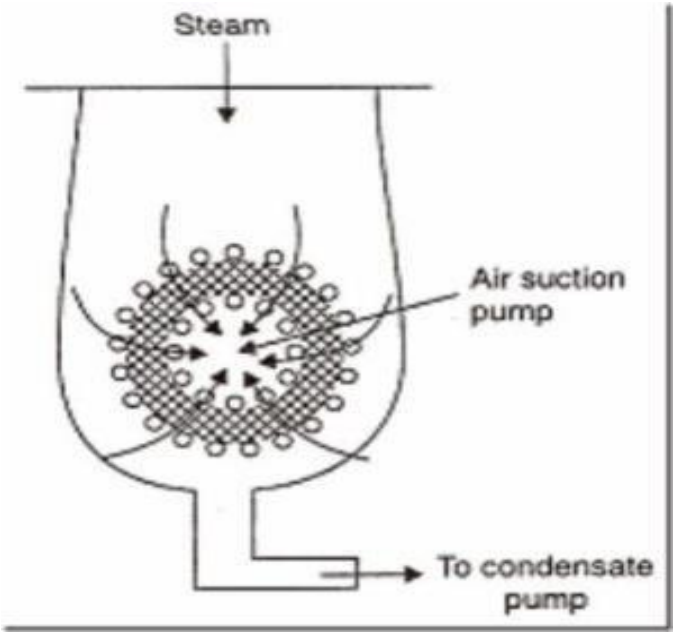
Down-flow type:

The cooling water enters the shell at the lower half section and a heat traveling through the upper half section comes out through the outlet. The exhaust steam entering shell from the top flows down over the tubes and gets condensed and is finally removed by an extraction pump. Due to the fact that steam flows in a direction right angle to the direction of flow of water, it is also called cross-surface condenser.



Central flow type:

In this type of condenser, the suction pipe of the air extraction pump is located in the center of the tubes which results in radial flow of the steam. The better contact between the outer surface of the tubes and steam is ensured, due to large passages the pressure drop of steam is reduced.



Inverted flow type:

This type of condenser has the air suction at the top, the steam entering at the bottom rises up and then again flows down to the bottom of the condenser, by following a path near the outer surface of the condenser. The condensate extraction pump is at the bottom.

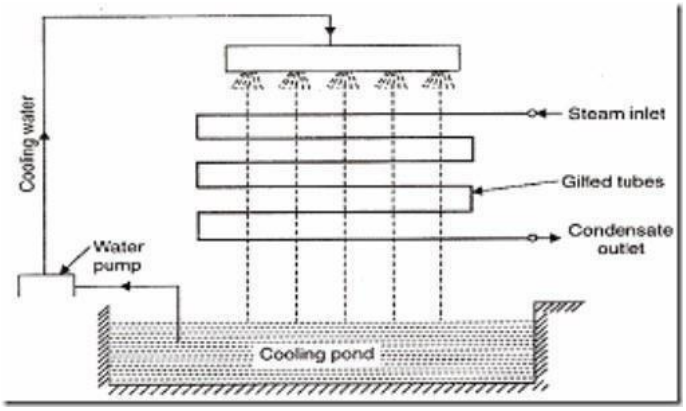
Regenerative type:

This type is applied to condensers adopting a regenerative method of heating of the condensate. After leaving the tube nest, the condensate is passed through the entering exhaust steam from the steam engine or turbine thus raising the temperature of the condensate, for use as feed water for the boiler.

Evaporative type:

The principle of this condenser is that when a limited quantity of water is available, its quantity needed to condense the steam can be reduced by causing the circulating water to evaporate under a small partial pressure.

The exhaust steam enters at the top through gilled pipes. The water pump sprays water on the pipes and descending water condenses the steam. The water which is not evaporated falls into the open tank (cooling pond) under the condenser from which it can be drawn by circulating water pump and used over again. The evaporative condenser is placed in open air and finds its application in small size plants.



Conclusion:

From the above experiment we studied jet condenser successfully.

EXPERIMENT NO. 05

Aim of the experiment:

To study about De-laval turbine

Apparatus:

Model of De laval turbine Impulse steam turbines)

Theory:

Steam turbines: The steam turbine is a prime mover in which the potential energy of steam is transformed into kinetic energy and latter in its turn is transformed into the mechanical energy of the rotation of the turbine shaft.

Classification of steam turbine: With respect to the action of steam, turbines are classified as:

- Impulse turbine
- Reaction turbine

1.Impulse turbine:

It is a turbine, which runs by the impulse of steam jet. In this turbine, the steam is first made to flow through a nozzle. Then the steam jet impinges on the turbine blades with are curved like bucket and are mounted on the circumference of the wheel. The steam jet after impinges glide over the concave surface of blades and finally leaves the turbine. The top portion of Impulse turbine exhibits a longitudinal section through the upper half, the middle portion shows one set of nozzles which is followed by a ring of moving blades, while lower part indicates changes in press and velocity during the flow of steam through the turbine. The principal equation of this turbine is the well-known "De Laval" turbine.

1.Reaction turbine:

In a Reaction turbine, the steam enters the wheel under pressure and flow over the blades. The steam while gliding proper the blades and then makes them to move. The turbine runner is rotated by the reactive forces of steam jets. In this, there is a gradual pressure drop takes place continuously over the fixed and moving blades. The fuel of fixed blades is that they after allow it expand to a larger velocity as the steam passes over the moving blades. Its K.E. is absorbed by them a three stage

Introduction:

In this article, we learn about the Impulse Turbine Principle and Working.

The steam turbines are widely used as prime mover in power plants, refineries, petrochemical industries, food processing industries

Steam Turbine Operation Principles

Impulse Turbine

In principle, the impulse steam turbine consists of a casing containing stationary steam nozzles and a rotor with moving or rotating buckets.

When the steam passes through the stationary nozzles and it's direct toward rotor buckets with high velocity. Thereby rotor buckets start to rotate at high speed.

Events take place in the nozzle

The following event takes place in the nozzles are

The steam pressure decreases.

- The enthalpy of the steam decreases.
- The steam velocity increases
- The volume of the steam increases.

In nozzles, the pressure energy of the steam converted into kinetic energy. They are two types of nozzles used in the steam turbine. They are

1. Convergent nozzles
2. Convergent -divergent nozzles

The Convergent Nozzles:

This type of nozzle used for smaller pressure drops, where the minimum exit pressure of the turbine equals **0.577 x the inlet pressure** (the critical pressure for nozzles). This type of nozzle is used for small steam turbines.

The main disadvantage of this nozzle, the exit pressure of the steam usually less than the calculated value of "0.577 x inlet pressure", due to the formation of eddy-currents. The eddy current losses are overcome in "Convergent-Divergent nozzles"

The Convergent-divergent Nozzles:

In convergent-divergent nozzles prevent eddy currents and the calculated velocity will be obtained even at large pressure drops.

The purpose of the bucket or moving blade on the rotor is to convert the kinetic energy of the steam into mechanical energy. If all kinetic energy converted into pressure energy, the steam exit velocity will be 0 m/s. practically it's not possible but it shows that the rotor blades must bring the steam exit velocity near 0 m/s.

Principle of Impulse Turbine:

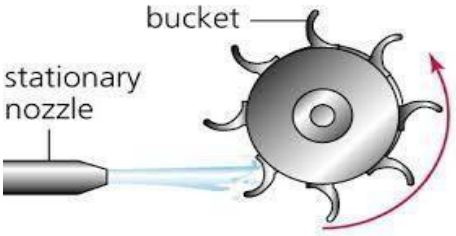
The steam at high pressure enters through a stationary nozzle of a steam turbine, as a result, the pressure of the steam decreases with an increase in steam velocity. As a result of increased steam velocity steam pass through the nozzle in the form of a high-speed jet. This high-velocity steam hit the properly shaped turbine blade, as a result, the steam flow direction changed. The effect of this

change in direction of the steam flow will produce an impulse force. This force causes the blade to move, thereby the rotor will start to rotate. As per Newton's 2nd Law of motion (change of momentum), The change of direction of steam flow in the blade produces the impulse force, this force tends to rotate the turbine rotor. Hence it's called "Impulse Turbine"

Impulse Turbine Working:

In an impulse turbine, the steam pressure drops and the velocity increases as the steam passes through the nozzles. When the steam passes through the moving blades the velocity drops but the pressure remains the same.

The fact that the pressure does not drop across the moving blades, hence the pressure at the inlet of the moving blade equals the pressure at the outlet of moving blades.



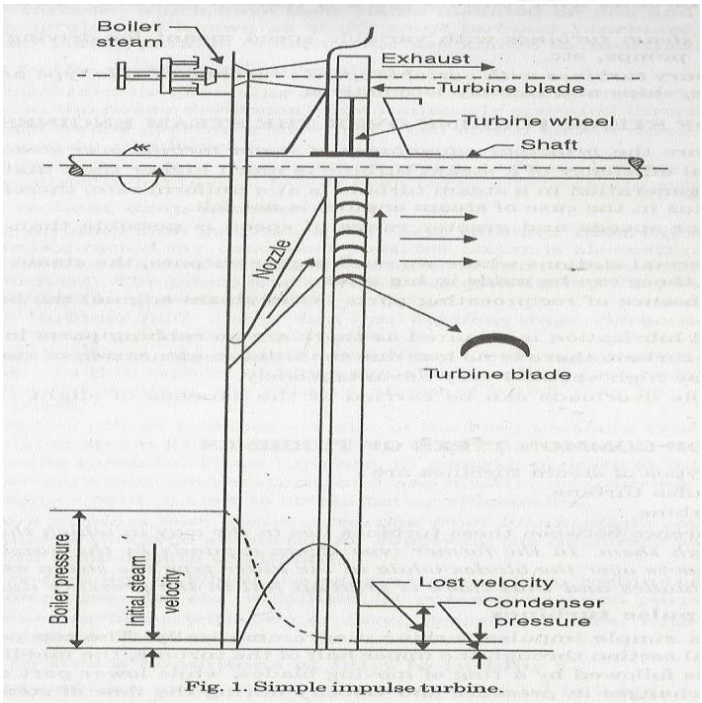


Fig. 1. Simple impulse turbine.

Conclusion:

From the above experiment we studied De lavel turbine successfully.

EXPERIMENT NO. 06

Aim of the experiment:

To study the spring-loaded safety valve

Apparatus:

Model of spring-loaded safety valve.

Boiler mountings: -

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

Safety Valves:

They are needed to blow off the steam when pressure of the steam in the boiler exceeds the working pressure. These are placed on the top of the boiler.

There are four types of safety valves:

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

Spring loaded safety valve:

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

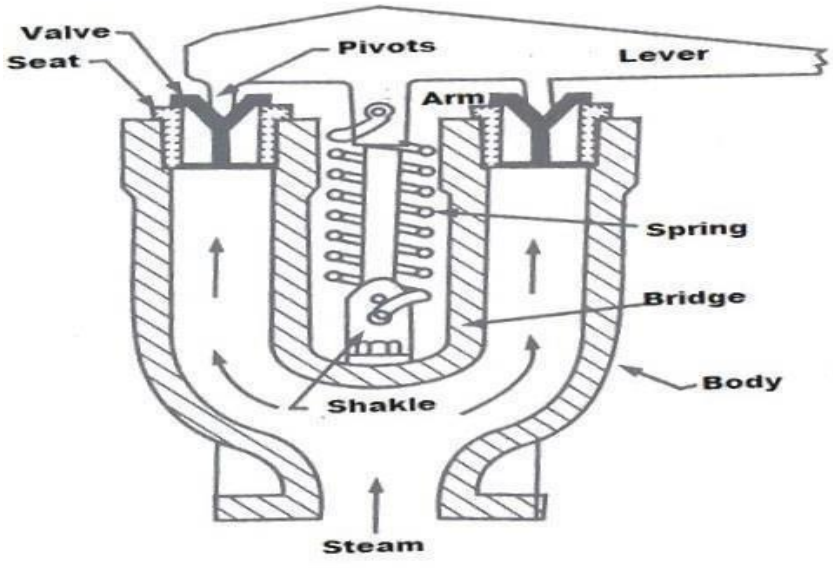


Figure- Spring Loaded Safety Valve

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

Conclusion:

From the above experiment we studied spring loaded safety valve successfully.

EXPERIMENT NO. 07

Aim of the experiment:

To Study the following steam generators (boilers) models.

Apparatus required:

SL.NO	NAME OF THE APPARATUS	SPECIFICATION	QUANTY
01	Fire tube boiler	Lancashire boiler, Cornish boiler	01
`02	Water tube boiler	Babcock and Wilcox boiler, Vertical water tube boiler	01

Theory:

Boiler:

A steam generator or boiler is, usually, a closed vessel made of steel. Its function is to transfer the heat produced by the combustion of fuel (solid, liquid or gaseous) to water, and ultimately to generate steam.

Fire tube boiler:

The boiler in which the hot gases form the furnace pass through the tubes which are surrounded by water is called fire tube boiler.

Example: Cochran Boiler, Lancashire boiler, Cornish boiler

Lancashire Boiler:

The Lancashire boiler is working on the principle of a heat exchanger. This is a shell and tube type heat exchanger where the exhaust gases flow through the tubes and water flows through shell.

Heat is a transfer from exhaust gases to water via convection. This is a natural circulation boiler where natural current flows the water inside the boiler.

Parts of Lancashire Boiler:

1. Water level indicator
2. Pressure gauge
3. Safety valve
4. Steam stop valve
5. Feed check valve
6. Blow off cock
7. Manhole
8. Fusible plug
9. Grate
10. Fire door
11. Ash pit

1. Water Level Indicator:

This indicates the level of water in the boiler and it is in front of the boiler. There are two water level indicators in the boilers.

2. Pressure Gauge:

The pressure gauge measures the pressure of steam inside the boiler and it is fixed in front of the boiler.

3. Safety Valve:

The safety valve is a very important device as it ensures the safety of the boiler from being damaged by excessive steam pressure.

4. Steam Stop Valve:

The purpose of the steam stop valve is to prevent and allow the flow of steam from the boiler to the steam pipe.

5. Feed Check Valve:

The function of the feed check valve is to control the flow of water from the feed pump to the boiler for preventing the backflow of water from boiler to the pump.

6. Blow off Cock:

Its function is to eliminate the sediments deposited at the bottom of the boiler when the boiler is in operation.

7. Man Hole:

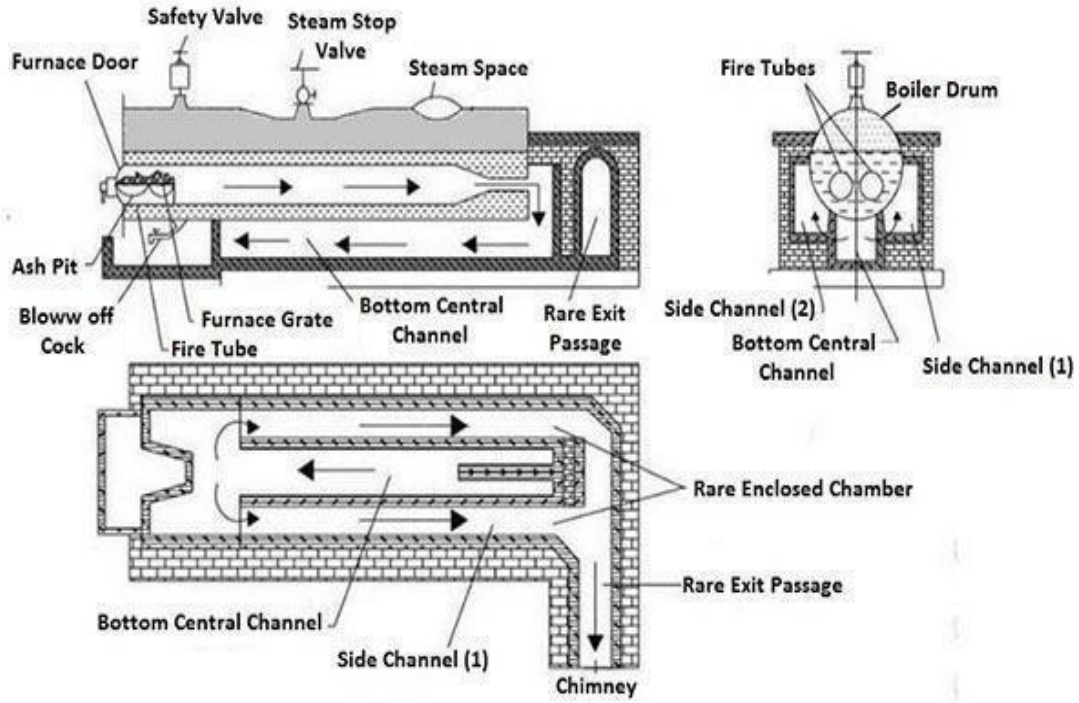
It is the place in the boiler where a man can enter into a boiler for cleaning or repairing.

8. Fusible Plug:

The function is to put-off the fire in the furnace of the boiler when water levels fall below the unsafe level.

9. Grate:

The grate is a floor used to burn the coal.



Lancashire Boiler

10. Fire Door:

A fire door is used to burn fuel inside or outside the boiler.

11. Ash Pit:

It is used to collect ash after burning the fuel.

Various Mountings and Accessories of Lancashire Boiler:

1. Economizer
2. Air pre-heater
3. Super heater
4. Feed pump

1. Economizer:

In the economizer, it is heating the feed water and is recover heat in flue gases. It is placed in the path of gases and it improves the overall efficiency of the boiler.

2. Air Pre-heater:

It is an accessory that recovers the heat in the exhaust gases by heating the air to the furnace of the boiler. This improves the thermal efficiency of the boiler.

3. Superheater:

It is used in superheating steam generated in the boiler. The main purpose is to raise the temperature of saturated steam without any change in pressure.

4.Feed Pump:

It is required to force the feed water at high pressure into the boiler.

Lancashire Boiler Construction:

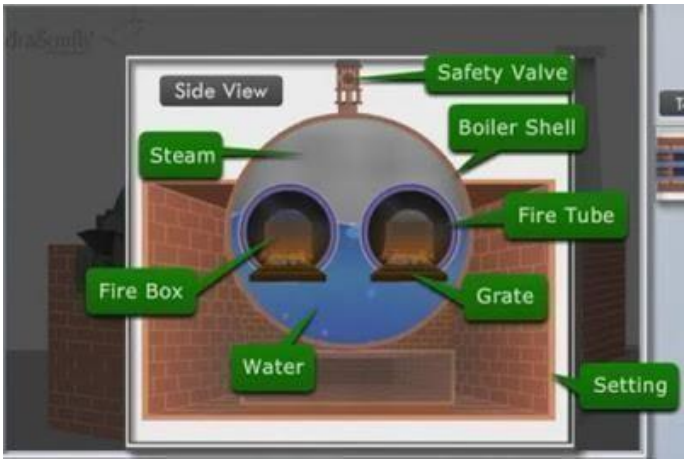
The Lancashire boiler is similar to the shell and tube type heat exchanger. This consists of a large drum having a diameter up to 4-6 meters and 9-10 meters in length. The drum has two fire tubes of a diameter of 40% of the diameter of the shell and the water drum is located over bricks.

There are three spaces between drum and bricks one is at the bottom and the other two are shown in the Lancashire boiler diagram. Flue gases are pass through fire tubes ad side and bottom space.

The water level inside the drum is always above the side channels of flue gases for more heat transfer to the water. The drum is filled with water and upper half-space for steam. A furnace is placed at one end of the fire tubes inside the boiler.

The low brick is at grates and it prevents unburned flue and ash to flow in the fire tubes. This boiler has necessary mountings and accessories like economizer, super heater, safety valve, pressure gauge, water gauge, etc.

Working of Lancashire Boiler



The Lancashire boiler has a horizontal cylindrical shell and it is filled with water surrounding with two large fire tubes.

There is a cylindrical shell and it is placed over brickwork and this creates several channels for the flow of hot flue gases.

The solid fuel is entered through a fire door and after that, it is burnt over grate at the front end of each fire tube.

There is a small arc shape brickwork that is there and at the end of the grate to deflect the flue gases upward and prevent the entry of burning coal and ashes into the interior part of fire tubes.

This fire tubes are slightly conical at the rear end for increasing the velocity of hot flue gases.

The hot flue gases are allowing to pass through the downward channel at the front end of the fire tubes. These gases pass-through side-channel towards the rear end of the fire tube and finally exit from a chimney.

The dampers are on each side for regulating airflow.

There is a feed check valve and it is used to feed the water uniformly to the boiler shell.

After starting the boiler, the water starts converts into steam by absorbing heat from flue gases. Steam is stored at the upper portion of the boiler where the anti priming pipe is separate the water from steam. So, the steam stop valve receives the dry steam for various purposes.

The manhole is at the top and bottom of the shell and it is to clean the boiler.

There is a bow-off valve and it is to remove the mud which is settled down and also used for cleaning the boiler.

Advantages

- This boiler has high thermal efficiency and it is about 80 to 90%.
- Has easy operating
- Has the ability to meet the load requirement
- Easy maintenance
- It generates a large amount of steam and more reliable
- Low electric consumption due to natural circulation

Disadvantages

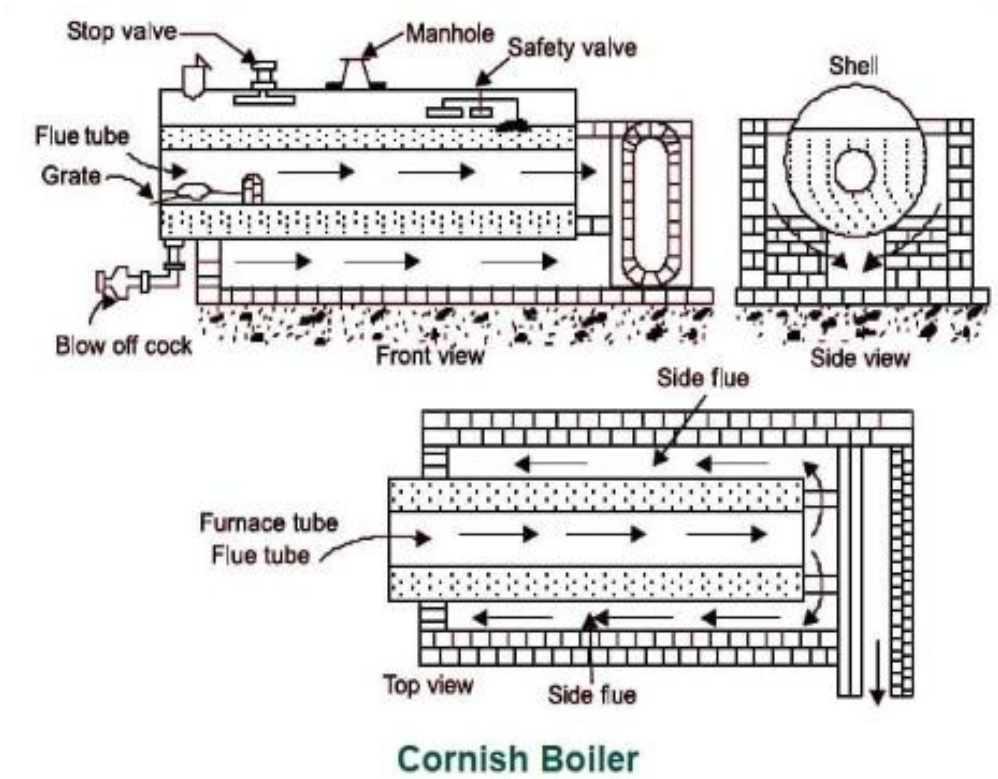
- This is a low-pressure type boiler so it cannot produce high-pressure steam
- Hard to maintenance in brickwork
- Has limited grate area due to small diameter of flue tubes
- Steam production rate is low about 9000 kg/hr
- Corrosion may occur in water legs

Applications

- The Lancashire boiler is used to drive steam turbines, locomotives, marines, etc.
- Lancashire boiler is also in various industries like the paper industry, textile industry, sugar industry, Tire industry, etc

Cornish boiler:

Cornish boiler is a simple horizontal boiler which belong to the shell and tube class of boilers. Cornish boiler is much like the Lancashire boiler. Cornish boiler has the ability to produce steam at the rate of 1350 kg/hr and can take the maximum pressure of about 1! Bar. "Dimensions of the Cornish boiler shell is # m to $ m in length and 1.! m to 1.% m in diameter. Cornish boiler is a & re tube type of boiler that is hot gases 'ow in tubes and water surround these tubes in shell.



Cornish Boiler

Parts of Cornish boiler:

Tubes (these are present inside the shell and hot gases flow through them)

Shell-which contain water inside it as well as tubes. Heat transfer between hot gases and water is take place here

Side flue

Flue are the tubes which take hot gases after they passes out from the & red tubes. Flue present at side of the horizontal shell are called side flues.

Bottom flue

Flue present at the bottom of the shell is called bottom flue. Bottom tube take the smoke toward the chimney

Grate-rate

Grate is the place where fuel is added for burning.

Ash pit

Ash pit the one which contain the ashes of fuel aster they are completely burn.

Chimney

Chimney take smoke from the bottom flue and take it out to the atmosphere.

Stop valve-is used to regulate the 'ow of steam from boiler

Safety valve

Purpose of this Valve is to stop the steam pressure from exceeding the maximum limit.

Working of the Cornish boiler

Fuel is added in the grate area where it burn to produce hot gases. (here hot gases move into the & red tube which take it inside the shell where it exchange its heat with surrounding water. take heat and after some time it start boiling to produce steam. hot gases upon reaching at the end of the &retube2 divided into two section and each move into the one of two side flue which take them once again at the front section of the boiler where they move into the bottom flue and bottom flue take them toward the chimney. Chimney throw these gases out of the boiler into the atmosphere. in this process hot gases travels complete length of boiler thrice that is once in & red tube then in side tube and at last bottom flue'. maximum heat transfer is taken place at fire tube and shell section then taken place at side flue and at last at bottom 'flue.

Application of Cornish boiler

Cornish boiler are used in many industries like textile. Sugar, paper, tire, chemical etc. They are also used to produce steam to run steam turbine. They are also used in many marines

Advantages of Cornish boiler

Cornish boiler have simple design and easy construction. One of its main advantages is its Compactness and portability

- Low construction and maintenance cost
- it has ability to overcome load fluctuation.

Water tube boiler:-

The boiler in which the water circulates inside the tubes which are surrounded by hot gases from the furnace is called water tube boiler.

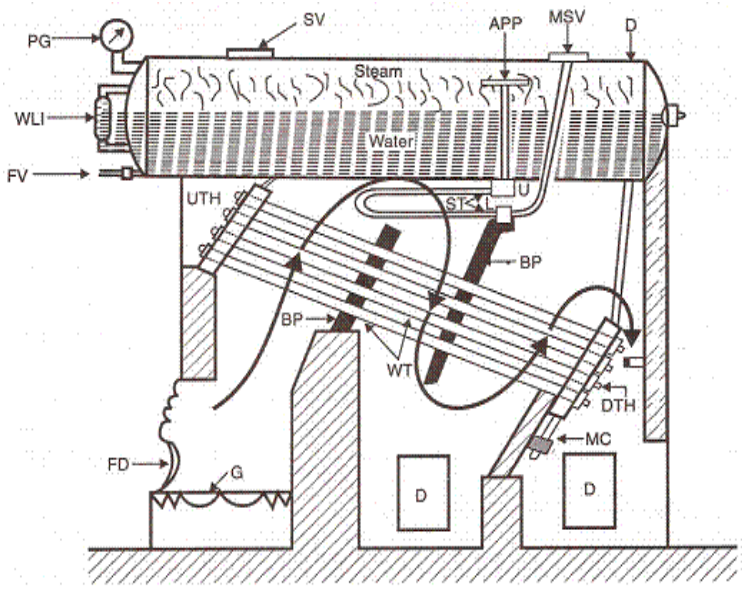
Example: Babcock and Wilcox boiler, Vertical water tube boiler

Babcock and Wilcox boiler:-

- It is straight tube, stationary tube water tube boiler.]

- It consists of steam and water drum. It is connected by a short tube with header at the back end.

- The water tubes are inclined to the horizontal and connect the uptake header to the down take header.
- Each row of the tube is connected with two headers, and there are plenty of such rows.
- A mud box is provided with each down take header and the mud, that settles down is removed.
- A hopper is provided to supply the coal.
- A baffle is present which moves upward and down to circulate the smoke inside the boiler.
- The dampers are operated by a chain which passes over a pulley to the front of a boiler to regulate the draught.
- The boiler is suspended on steel girders, and surrounded on all the 4 sides by the fire brick walls.
- A door is provided for a man to enter the boiler for repairing and cooling.
- Water circulates from the drum into the header and through the tubes to header and again to the drum.
- Water continues to circulate like this till it is evaporated.
- A steam super heater consists of a large number of steel tubes and contains two boxes; one is superheated steam box and other is saturated steam box.
- The steam generated above the water level in the drum flows in the dry pipe and through the inlet tubes into the superheated steam box.
- The steam, during its passage through the tubes ,gets further heated and through the outlet pipe to the stop valve.
- The boiler is fitted with usual mountings, such as safety valve, feed valve, water level indicator and pressure gauge.



D = Drum
DTH = Down take header
WT = Water tubes
BP = Baffle plates
D = Doors
G = Grate
FD = Fire door
MC = Mud collector
WLI = Water level indicator

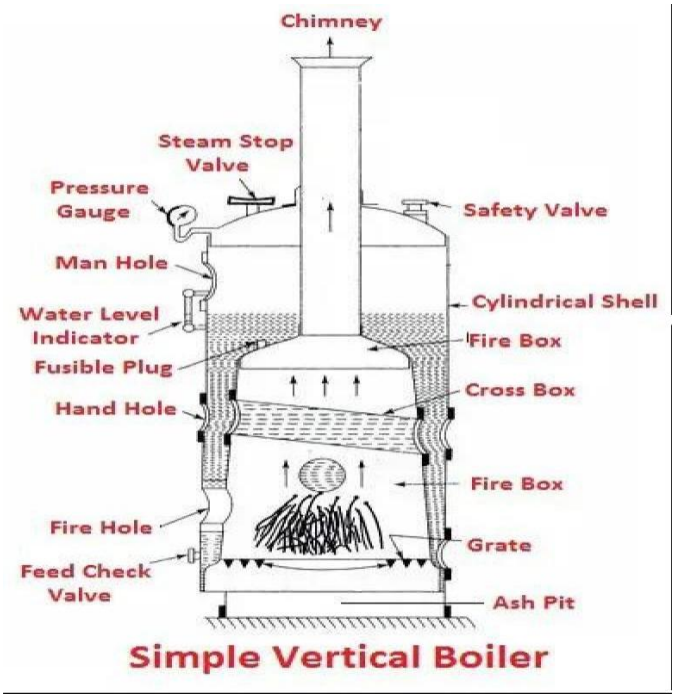
PG = Pressure gauge
ST = Superheater tubes
SV = Safety valve
MSV = Main stop valve
APP = Antipriming pipe
L = Lower junction box
U = Upper junction box
FV = Feed valve

Conclusion: -

From the above experiment we have successfully studied about Babcock and Wilcox boiler (water tube).

Vertical water ube boiler

A simple vertical boiler produces steam at low pressure and in small quantities. It is, therefore, used



for Low power generation or at places where space is limited. The construction of this type of boiler is shown in the figure.

Parts of Simple Vertical Boiler

The following are the construction parts of a simple vertical boiler:

1. Ash pit
2. Grate
3. Feed check valve
4. Fire hole
5. Firebox
6. Hand hole
7. Cross tubes
8. Fusible plug

9 Pressure gauge

10 Steam stop valve

11 Safety valve

12 Chimney

1. Ash Pit

The purpose of the ash pit is to collect fuel ash after burning the fuel.

2. Grate

The grate usually consists of cast iron bars which are spaced aside so that the air (required for combustion) can pass through them. It is a platform, in the combustion chamber, upon which the fuel is burnt.

3. Feed Check Valve

The purpose of a feed check valve is to regulate the flow of water from the feed pump. The Firehole is provided at the air rear end of the boiler. The solid fuel is inserted and burned into the furnace through this hole.

5. Fire Box

The fire box is a type of a box in this the burning of the solid fuel takes place.

6. Hand hole

The hand hole is provided in the shell opposite the ends of each cross tube for cleaning the cross tube.

7. Cross Tubes

One or more cross tubes are either fastened or arranged into the furnace to enhance the heating surface and improve water circulation.

8. Fusible Plug

The function of the fusible plug is to put-o the re 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.

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12. Fusible Plug

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

14. Safety Valve

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 value.

Chimney

The chimney is located on the top portion of the boiler. It is employed to throw out the exhaust smoke and gases to the environment.

Working of Simple Vertical Boiler

It consists of a cylindrical shell surrounding a nearly cylindrical firebox. The firebox is slightly tapered towards the top to allow the ready passage of the steam to the surface. At the bottom of the firebox, is a grate. The firebox is provided with two or more inclined cross tubes.

The inclination of the cross tubes is provided to improve the heating surface as well as to increase the circulation of water. An uptake tube passes from the top of the firebox to the chimney. The hand hole is fitted opposite to the end of each water tubes for cleaning the depositions.

A manhole is located at the top portion of the boiler for a man to enter and to clean the boiler. A mud hole is provided at the bottom of the shell to remove the mud that settles down. The space between the boiler shell and firebox is filled with water to be heated.

Advantages of Simple Vertical Boiler

The following are the advantages of a simple vertical boiler:

1. The initial cost is low because of fewer parts.
2. Maintenance cost is low.
3. Working is simple.
4. It is easy to install and replace.
5. It occupies a small space on the ground.
6. These type of boilers have water level tolerance.

Disadvantages of Simple Vertical Boiler

The following are the disadvantages of simple vertical boiler: The vertical design of this boiler limits its work in many places.

1. Steam production is limited because of the limited great area.
2. The impurities settle at the bottom and thus prevents the water from heating up.
3. The boiler tube should be kept small to reduce height. As a result, most of the available heat is lost through the chimney, as the tubes have very little time to heat.

Application of Simple Vertical Boiler

The following are the application of a simple vertical boiler:

1. Simple vertical boilers may have applications in railway locomotives, for example, a railway steam engine.
2. Simple vertical boilers are employed in road vehicles such as steam wagons or steam lorry.
3. The simple vertical boiler has a very well-known application that is a steam tractor.
4. The number of boats is particularly small which uses simple vertical boilers to power the engine.
5. In some parts of the world ordinary vertical boilers are used in the steam donkey.

6. Simple vertical boilers are also worked in steam cranes and steam shovels.

Conclusion

From the above experiment we studied boilers successfully.