Department of Mechanical Engineering
Thermal Engineering Gas Dynamics Lab

Laboratory in charge

Prof. Anand Thorat

Laboratory Technician

Mr. Saurabh Verma

List of Experiments

Applied Thermodynamics (PCC-ME 402)

1. Study of Boiler Draught and their classification.
2. Study of Lamont boiler with demonstrate model.
3. Study of Benson boiler with demonstrate model.
4. Study of Velox boiler with demonstrate model.
5. Study of Loffler boiler with demonstrate model
6. Study and Numerical on Heat balance sheet for a Boiler.
7. Study of steam condenser and its types with demonstrate model.
8. Study and find the volumetric efficiency of a Reciprocating air compressor
9. To determine the Nozzle coefficient of the given Nozzle meter.
10. To find the calorific value of fuel by using Bomb Calorimeter

List of Equipments with Price

S No.	List of Equipments	Date	Price
1.	Cornish Boiler Model	03/05/2011	7500
2.	Separating and Throttling Calorimeter	12/01/2015	35,200
3.	Joules Apparatus	12/01/2015	18,400
4.	Lamont Boiler Model	12/01/2015	4875
5.	Convergent Divergent Nozzle	12/01/2015	18,750
6.	Surface Condenser Model	12/01/2015	3900
7.	Parrallel and counter flow Heat Exchanger	12/01/2015	18,000
8.	Benson Boiler Model	13/01/2015	4875
9.	Model of gas Turbine	18/01/2015	10,800
10.	Lancashire Boiler Model	03/05/2015	7300
11.	Locomotive Boiler Model	03/05/2015	7300
12.	Loeffler Boiler Model	16/08/2015	4875
13.	VeloxBoiler Model	16/08/2015	6675
14.	Jet Condenser Model with Counter flow	16/08/2015	3750
15.	Single Acting Double stage Air Compressor	16/08/2015	51,000
16.	Jet Condenser Model with Parellel flow	17/08/2015	3750
17.	Bomb Calorimeter with oxygen cylinder	14/12/2015	68,434
18.	Orsat Appratus	05/03/2019	46,332

List of Major Equipments with Price

S. No.	List of Equipments	Date of Purchase	Price (in Rs.)
1	Bomb Calorimeter	14-12-15	60,990
2	Single Acting Double stage Air Compressor	16-08-15	51,000
3	Orsat Appratus	05-03-19	46,332
4	Separating and Throttling Calorimeter	12-01-15	35,200

List of Equipments purchased in Last Five Years with Price

S No.	List of Equipments	Date	Price
1.	Orsat Appratus	05/03/2019	46,332
2.	Bomb Calorimeter with oxygen cylinder	14/12/2015	68,434
3.	Jet Condenser Model with Parellel flow	17/08/2015	3750
4.	Single Acting Double stage Air Compressor	16/08/2015	51,000
5.	Jet Condenser Model with Counter flow	16/08/2015	3750
6.	VeloxBoiler Model	16/08/2015	6675
7.	Loeffler Boiler Model	16/08/2015	4875

LAB MANUAL

Thermal Engineering & Gas Dynamics Lab

(ME-601)

IPS Academy, Indore

Institute of Engineering & Science
Mechanical Engineering Department

LAB MANUAL

Thermal Engineering & Gas Dynamics Lab

(ME-601)

Name ……………………………………………….

Session ……………Semester …………………….

Enrollment No. ……………..

Contents

Vision of the Institute

To be the fountainhead of novel ideas & innovations in science & technology & persist to be a foundation of pride for all Indians.

Mission of the Institute

M1: To provide value based broad Engineering, Technology and Science where education in students is urged to develop their professional skills.

M2: To inculcate dedication, hard work, sincerity, integrity and ethics in building up overall professional personality of our student and faculty.

M3: To inculcate a spirit of entrepreneurship and innovation in passing out students.

M4: To instigate sponsored research and provide consultancy services in technical, educational and industrial areas.

Vision of the Department

To be a nationally recognized, excellent in education, training, research and innovation that attracts, rewards, and retains outstanding faculty, students, and staff to build a Just and Peaceful Society.

Mission of the Department

M1: Imparting quality education to the students and maintaining vital, state-of-art research facilities for faculty, staff and students.

M2: Create, interpret, apply and disseminate knowledge for learning to be an entrepreneur and to compete successfully in today's competitive market.

M3: To inculcate Ethical, Social values and Environment awareness.

Program Education Objectives (PEOs)

PEO1: To enrich graduates with fundamental knowledge of Physics, Chemistry and advanced mathematics for their solid foundation in Basic Engineering science.

PEO2: To provide graduates to design the solution of engineering problems relevant to mechanical engineering design through the process of formulating, executing & evaluating a design solution as per need with socio-economic impact consideration and related constraints.

PEO3: To provide graduates with experience in learning and applying tools to solve theoretical and open ended mechanical engineering problems.

PEO4: To provide a contemporary grounding in professional responsibility including ethics, global economy, emerging technologies and job related skills such as written and oral communication skills and to work in multidisciplinary team.

PEO5: Prepare graduates to be interested, motivated, and capable of pursuing continued life-long learning through beyond curriculum education, short term courses and other training programme in interdisciplinary areas.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of Mechanical engineering problems.

PO2: Problem analysis: Identify, formulate, and analyze mechanical engineering problems to arrive at substantiated conclusions using the principles of mathematics, and engineering sciences.

PO3: Design/development of solutions: Design solutions for mechanical engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: An ability to design and conduct experiments, as well as to analyze and interpret data.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to mechanical engineering problems with an understanding of the limitations.

PO6: The engineer and society: Apply critical reasoning by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Mechanical engineering practice.

PO7: Environment and sustainability: Understand the impact of the Mechanical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: An understanding of professional and ethical responsibility.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Ability to communicate effectively. Be able to comprehend and write effective reports documentation.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply this to Mechanical engineering problem.

PO12: Life-long learning: ability to engage in life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Engage professionally in industries or as an entrepreneur by applying manufacturing and management practices.

PSO2: Ability to implement the learned principles of mechanical engineering to analyze, evaluate and create advanced mechanical system or processes.

Course Outcomes (COs)

After completion of the course the students are able to-

CO	Statement	BT Level
CO1.	Demonstrate the knowledge of operating characteristics of steam generator and their working performance.	**BT-02**
CO2.	Recognize the Rankine cycles and their types on pressure - volume and Temperature – Entropy diagram and evaluate their efficiencies.	**BT-01**
CO3.	Evaluate the performance of various steam turbines and their staging.	**BT-05**
CO4.	Explain the working of various types of air compressors and evaluate their performance.	**BT-02**
CO5.	Evaluate the Performance of steam condenser, steam nozzle and cooling towers.	**BT-05**

Laboratory Regulations and Safety Rules

1. Read the instructions mentioned in the manual carefully and then proceed for the experiment.
2. Mishandling of lab equipment will not be tolerated at all. If any student is found guilty; he/she should be punished/ discarded from the lab.
3. Care must be taken while dealing with electrical connections.
4. Issued the needed/ supporting equipments by the concerned teacher/lab.technician & return the same duly before leaving the lab.
5. If any defect or discrepancy noticed in the particular instrument/equipment while the students are using, they will be fined/ punished for the same.
6. Put your bags on the rack outside the lab before entering in lab.
7. Switch off the lights, fans and all the equipments used, before leaving lab.
8. Students will replace their chairs to its specific position before leaving the lab.

INDEX

S.No.	Exercise	Date	Grade	Signature
1.	Study of Boiler Draught and their classification.			
2.	Study of Lamont boiler with demonstrate model.			
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Experiment No.1

Aim: To study the function of Boiler Draught & its Classification.

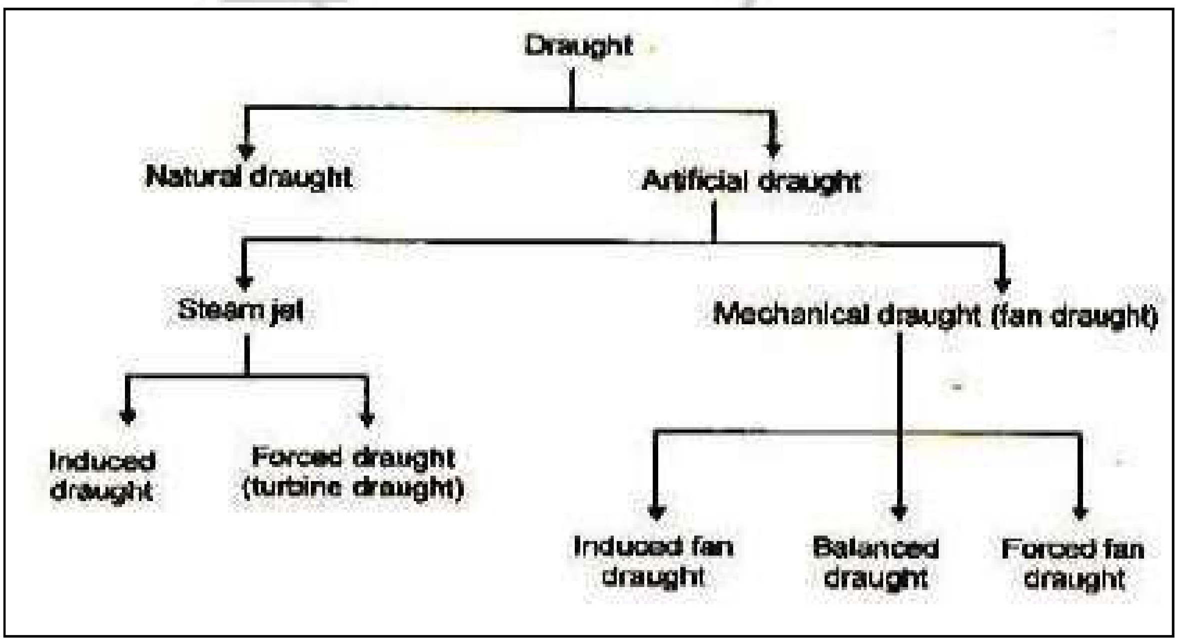
Introduction-

Draught is defined as the difference between absolute gas pressure at any point in a gas flow passage and the ambient (same elevation) atmospheric pressure. Draught is achieved by small pressure difference which causes the flow of air or gas to take place. It is measured in millimeter (mm) or water.

The purpose of draught is as follows:

1. To supply required amount of air to the furnace for the combustion of fuel the amount of fuel that can be burnt per square root of grate area depends upon the quantity of air circulated through fuel bed.
2. To Remove the gaseous products of combustion.

Classification of Draught:-



Artificial Draught

If the draught is produced by steam jet or fan it is known as artificial draught

Steam jet Draught:

It employs steam to produce the draught

Mechanical draught

It employs fan or blowers to produce the draught.

Induced draught

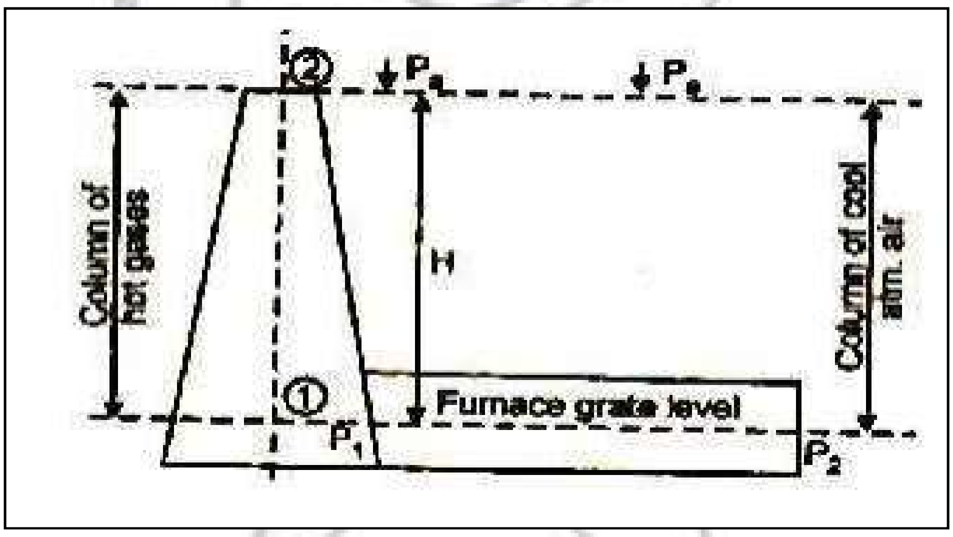
The flue is drawn (sucked) through the system by a fan or steam jet

Forced draught

The air is forced into system by a blower or steam jet.

Natural Draught:

Natural draught system employs a tall chimney as shown in figure. The chimney is a vertical tubular masonry structure or reinforced concrete. It is constructed for enclosing a column of exhaust gases to produce the draught. It discharges the gases high enough to prevent air pollution. The draught is produced by this tall chimney due to temperature difference of hot gases in the chimney and cold external air outside the chimney.



Natural Draught

Artificial Draught

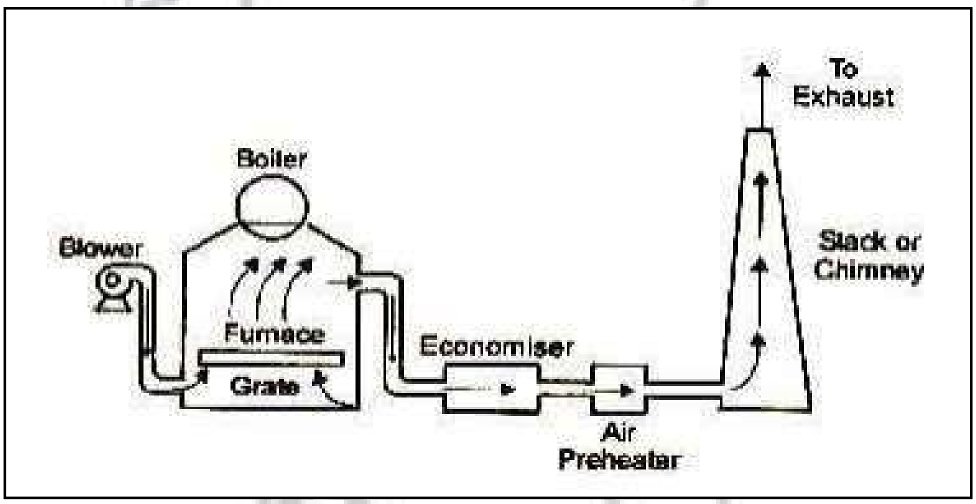
It has been seen that the draught produced by chimney is affected by the atmospheric conditions. It has no flexibility, poor efficiency and tall chimney is required. In most of the modern power plants, the draught used must be independence of atmospheric condition, and it must have greater flexibility (control) to take the fluctuating loads on the plant. Steam power plants requiring 20 thousand tons of steam per hour would be impossible to run without the aid of draft fans. A chimney of an reasonable height would be incapable of developing enough draft to remove the tremendous volume of air and gases (400×10^{3} m3 to 800×10^{3} m3 per minutes). The further advantage of fans is to reduce the height of the chimney needed.

The draught required in actual power plant is sufficiently high (300 mm of water) and to meet high draught requirements, some other system must be used, known as artificial draught. The artificial draught is produced by a fan and it is known as fan (mechanical) draught. Mechanical draught is preferred for central power stations.

Forced Draught

In a forced draught system, a blower is installed near the base of the boiler and air is forced to pass through the furnace, flues, and economizer, air-preheater and to the stack. This draught system is known as positive draught system or forced draught system because the pressure and air is forced to flow through the system.

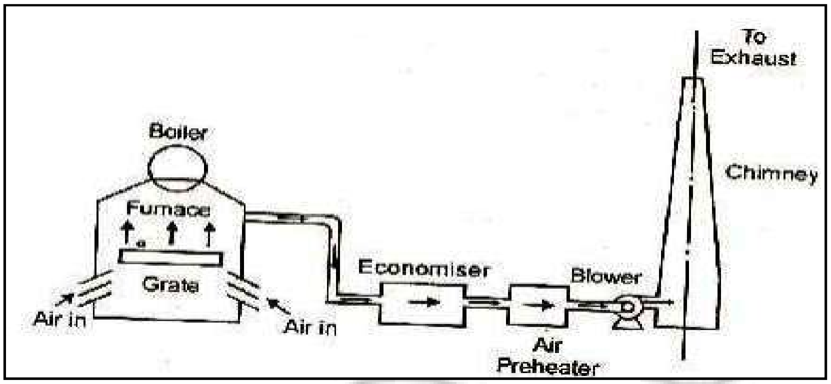
The arrangement of the system is shown in figure. A stack or chimney is also in this system as shown in figure but its function is to discharge gases high in the atmosphere to prevent the contamination. It is not much significant for producing draught therefore height of the chimney may not be very much



Forced Draught

Induced Draught:

In this system, the blower is located near the base of the chimney instead of near the grate. The air is sucked in the system by reducing the pressure through the system below atmosphere. The induced draught fan sucks the burned gases from the furnace and the pressure inside the furnace is reduced below atmosphere and induces the atmospheric air to flow through the furnace. The action of the induced draught is similar to the action of the chimney. The draught produced is independent of the temperature of the hot gases therefore the gases may be discharged as cold as possible after recovering as much heat as possible in air-preheater and economizer.

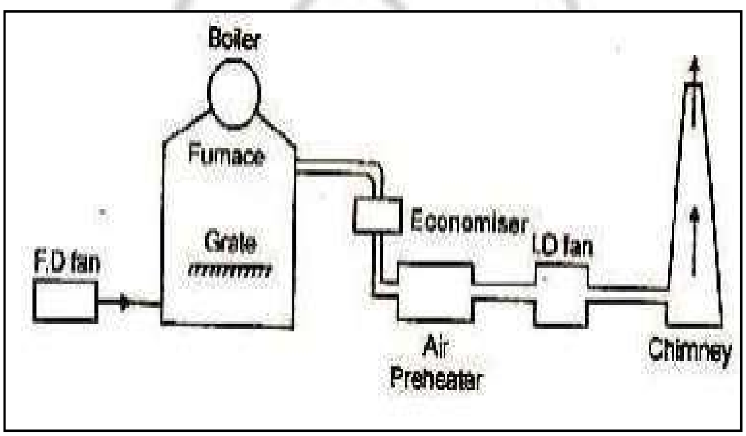


Induced Draught

Balanced Draught:

It is always preferable to use a combination of forced draught and induced draught instead of forced or induced draught alone. If the forced draught is used alone, then the furnace cannot be opened either for firing or inspection because the high pressure air inside the furnace will try to blow out suddenly and there is every chance of blowing out the fire completely and furnace stops.

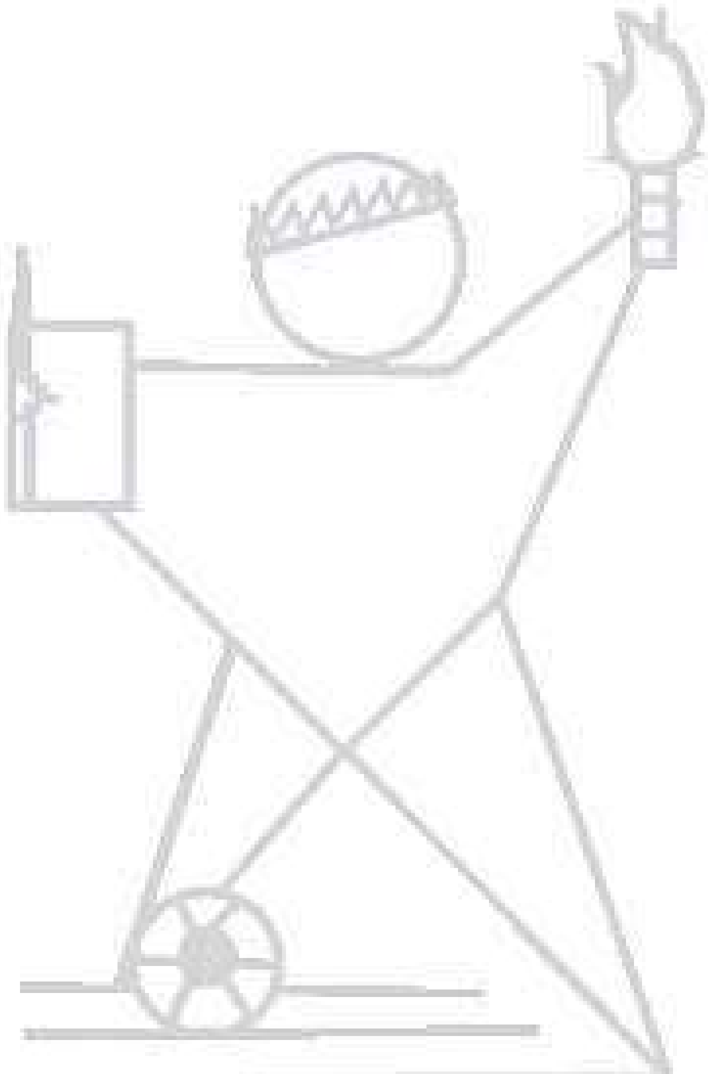
If the induced draught is used alone, then also furnace cannot be opened either for firing or inspection because the cold air will try to rush into the furnace as the pressure inside the furnace is below atmospheric pressure. This reduces the effective draught and dilutes the combustion.

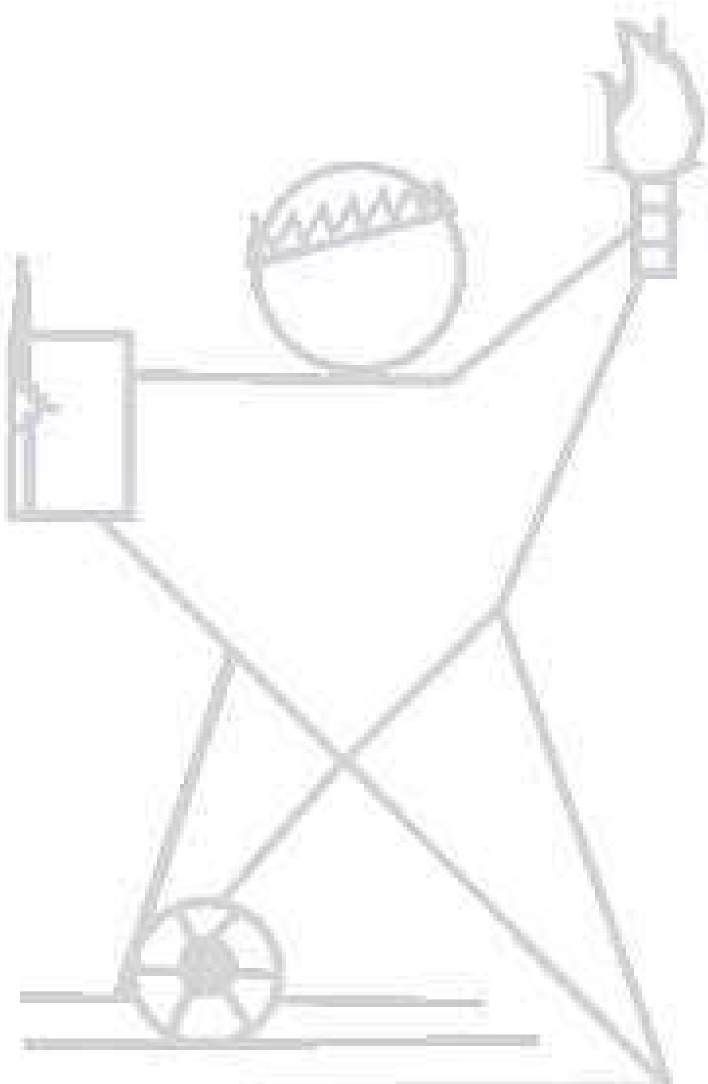


Balanced Draught

Questions

1. Write the classification of Boiler
2. What are the characteristics of a good Boiler?
3. Write the difference between fire tube and water tub boiler.(Any 7)





Experiment No.2

Aim: To study the working of Lamont Boiler.

Construction:

Lamont boiler is vertical boiler. It has two types of evaporator namely convective evaporator and radiant evaporator. Radiant evaporator are mounted as near as possible to the combustion chamber. The economizer is also used in La Mont boiler to heat the feed water from flue gases. This heated water passed to evaporating drum. At the top of the boiler air pre heater is installed to heat the air which is required for combustion in combustion chamber.

Working:

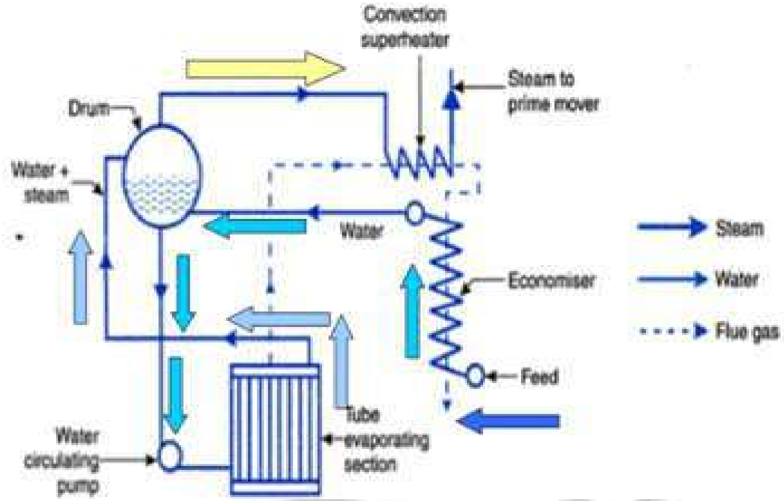
The feed water from hot well is supplied to a storage and separating drum through the economizer. The most of the sensible heat is supplied to the feed water passing through the economizer. A centrifugal pump circulates the water equal to 8 to 10 times the weight of steam evaporated. This Water is circulated through the evaporator tubes and part of the water evaporated is separated in the separator drum. The large quantity of water circulated prevents the tubes from being overheated. The centrifugal pump delivers the feed water to the headers at pressure of 2.5 bars above the drum pressure. The distribution header distributes the water through the nozzle into the evaporator. The steam separated in the boiler is further passed through the super heater and then supplied to the turbine. The air drawn by the blower is preheated in the air pre heater by the flue gases before these are discharged through the chimney. Then this air is supplied to the combustion chamber.

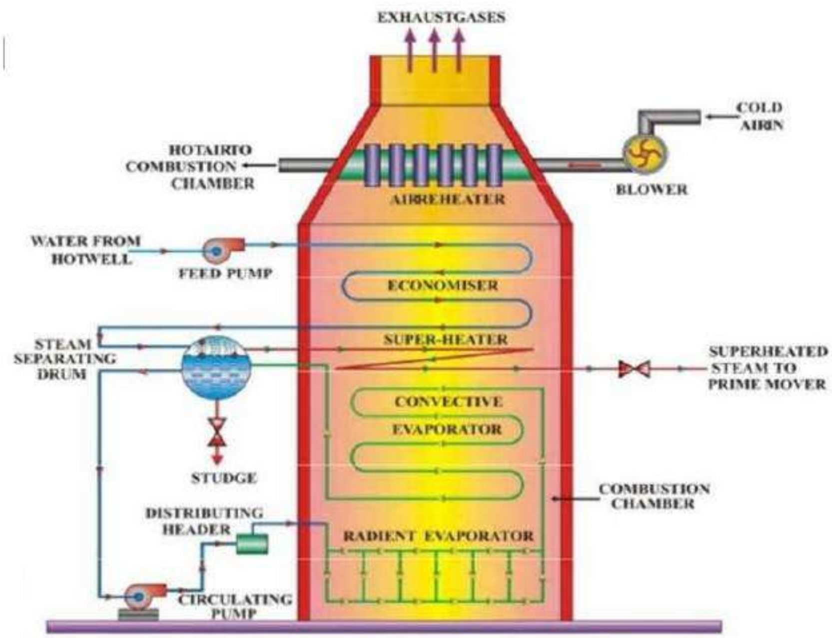
Advantages:

1. The boiler can generate steam up to a pressure of 150 bars and the generation rate of steam ranges from 30000 to 45000 kg per hour.
2. Starting of Lamont boiler is quick.

Disadvantages:

1. Bubbles are formed at the inner face of heating tube. Because of which it reduces the heat transfer rate.





Lamont Boiler

Questions

1. Write the name and function of various Boiler Mountings.
2. Write the Main features of high pressure Boiler.

Experiment No. 3

Aim: To Study the working of Benson Boiler

Introduction:

Benson Boiler is a water tube high pressure boiler having forced circulation. It works on the principle that if the boiler pressure is raised to critical pressure (225 kg/cm^2) then there is no formation of steam bubbles because the steam and water at this pressure will have the same Density. To achieve this water is fed to the boiler at critical pressure. At this pressure water will be directly converted to superheated steam as the latent heat at critical pressure is zero. Overall efficiency of plant is decreased as a lot of energy is consumed by feed water. Operating the boiler at a slightly lower pressure than the critical pressure efficiency can be increased. Thermal efficiency up to 90% can be achieved.

Working Principle of Benson Boiler:

This boiler has a unique characteristic of absence of steam separating drum. The entire process of heating, steam generation and superheating is done in a single continuous tube.

Economiser

The feed water by means of the feed pump is circulated through the economiser tubes. Hot flue gases pass over the economizer tubes and the feed water is preheated.

Radiant evaporator

The feed water from the economiser flows into the radiant evaporator with radiant parallel tube sections. The radiant evaporator receives heat from the burning fuel through radiation process and Majority of water is converted into steam in it.

Convection Evaporator

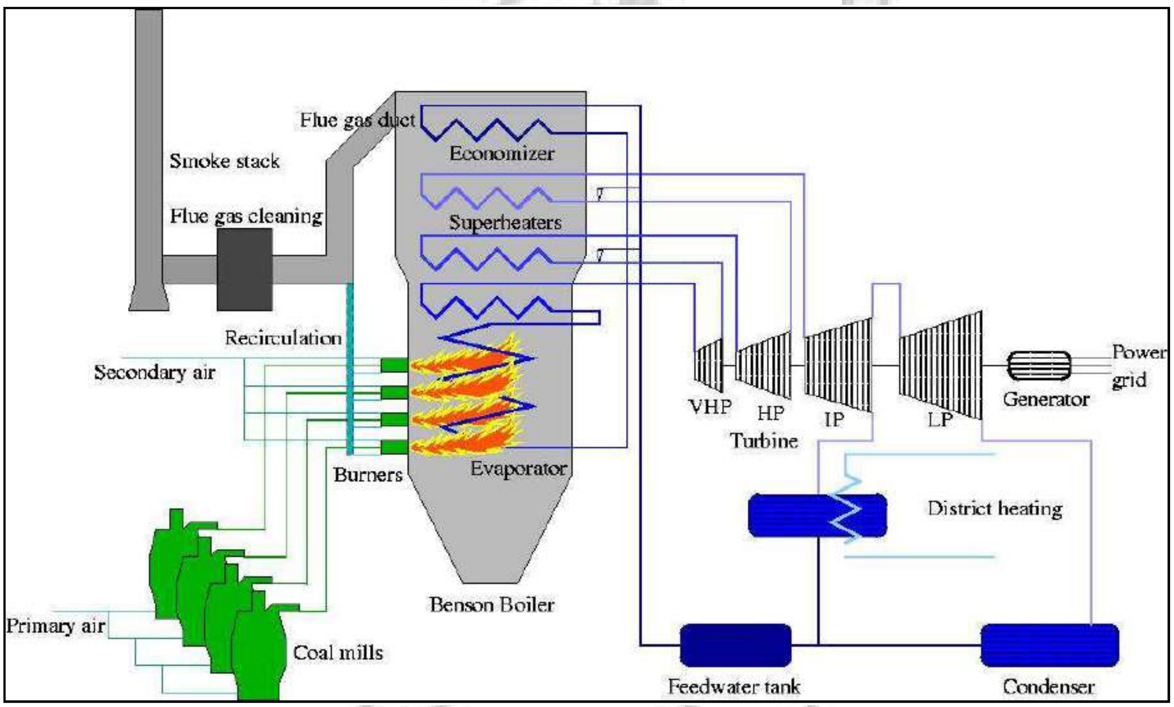
The remaining water is evaporated in the convection evaporator, absorbing the heat from the hot gases by convection. Thus the saturated high pressure steam at a pressure of 210 kg/sq.cm is produced.

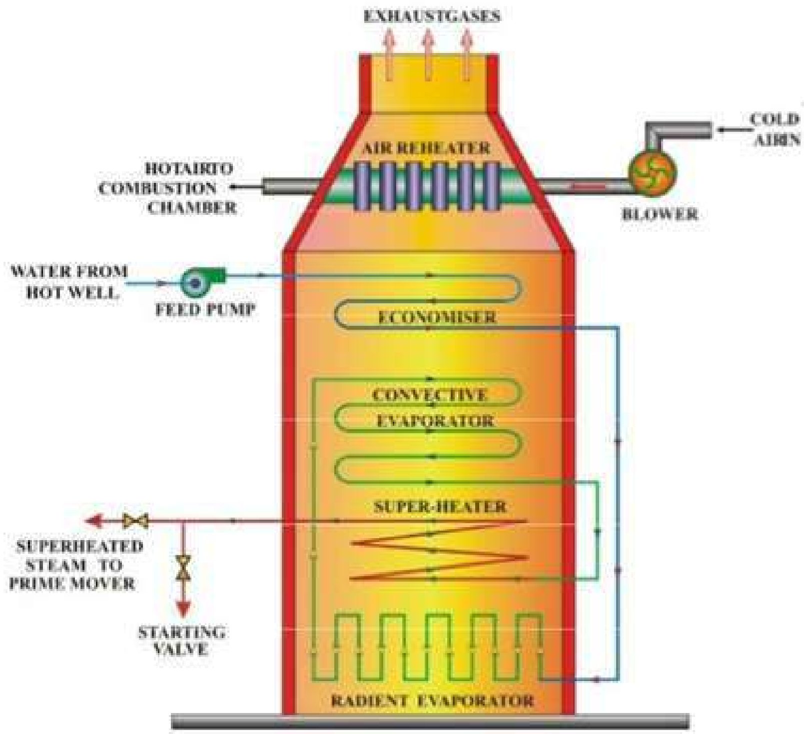
Convection super heater

The saturated steam is now passed through the convection superheated where the saturated steam as superheated to 650'C. The radiant evaporator, the convection evaporator and the convection super heater are all arranged in the path of the flue gases.

Capacity

Capacity of Benson boiler is about 150 tonnnes/hr, at a pressure of 210 kgf/sq.cm, and at a temperature of 650'C. (Efficiency may be improved by running the boiler at a pressure slightly Lower than the critical pressure).





Benson Boiler

Salient features of Benson Boiler

1. As there are no drums, the total weight of Benson boiler is 20% less than other boilers. This also reduces the cost of the boilers.
2. As no drums are required, the transfer of the Benson parts is easy. Majority of the parts may be carried to the site without pre-assembly.
3. Since no drum is used, this is an once-through boiler and the feed water entering at one end is discharged as superheated steam at the other end.
4. Circulating pump and down comers are dispensed with.

Advantages:-

1. As the generation of steam is carried out in the evaporating tubes at pressure higher than critical pressure it doesn't require any evaporating drum.
2. The boiler can be started in short time in 10 to 15 minutes only.
3. Benson boiler is lighter in weight with high generation rate of steam.
4. Due to absence of the evaporating drum the total weight is 20% less than other boilers.
5. The super heater of the Benson boiler is the integral part of forced circulation system therefore no special starting arrangement for super heater is required.
6. The cost of the boiler is reduces as there is no evaporating drum.7.Bubble formation is eliminated in Benson boiler which is critical problem in Lamont boiler.

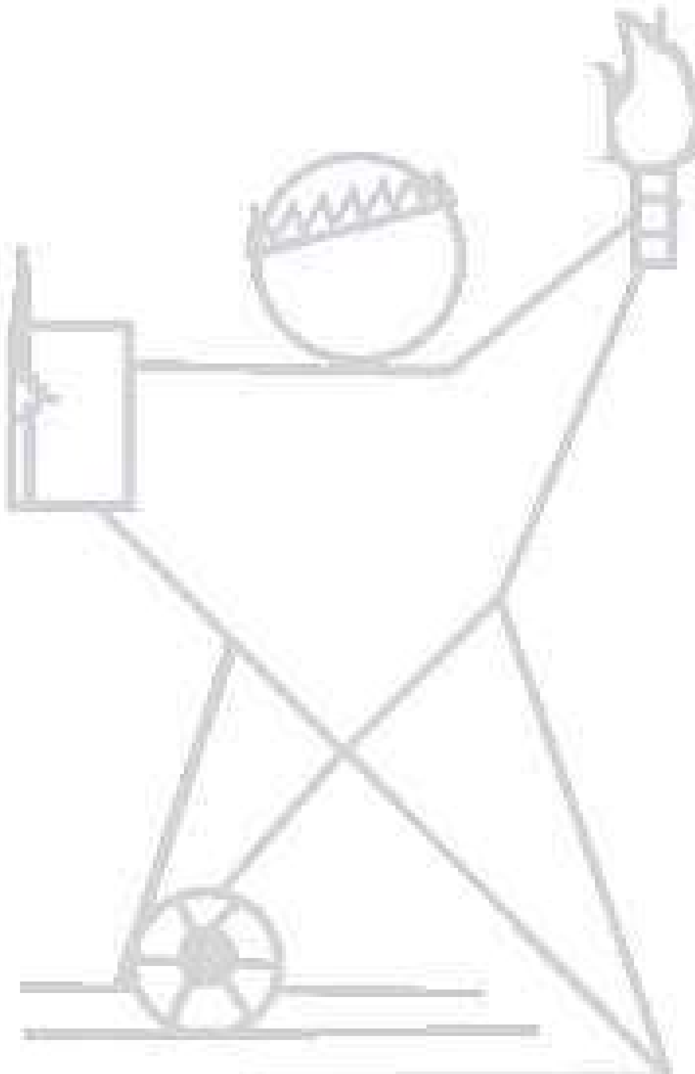
Disadvantages:-

1. The evaporation process will leave small deposits during conversion of water into steam due to which it requires frequent cleaning. To obviate this problem, the water softening plant is requiring.

2. Tubes are likely to be overheated in case of water flow is insufficient.

Questions.

1. Write the function of Boiler accessories also show their position in boiler plant with Block Diagram.
2. What is Equivalent Evaporation of a Boiler?



Experiment No. 4

Aim: To Study the working of Velox Boiler

Construction:

In Velox boiler pressurized combustion is used so axial flowcompressor is used which is run by gas turbine. The combustion chamber and evaporating tubes are arranged in such a way that the hot products from combustion chamber directly passed to annulus of evaporating tubes. Steam separator is arranged tangential to evaporating tubes. Hot flue gases are used for running gas turbine, for Economizer, and for super heater.

Working:

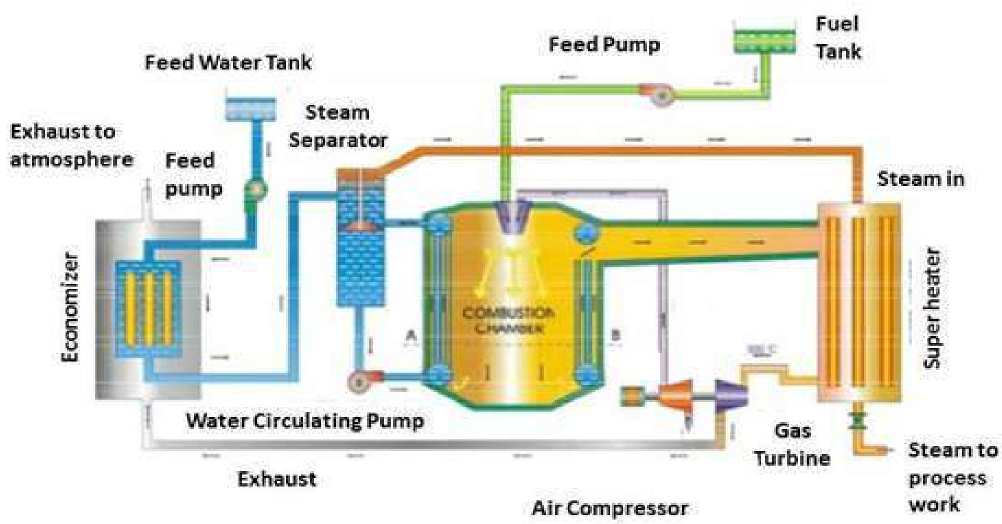
As we know heat transfer rate is much higher in sonic velocity than that of the subsonic velocity. Same concept is utilized in the design of Velox boiler in order to reduce the surface area hence the size of evaporating tubes. The salient feature of the Velox boiler is pressurized combustion. Air drawn from surroundings by axial flow compressor is compressed up to 2.5 to 3 bar pressure. Compressed air at above sonic velocity and the fuel are injected into the vertical combustion chamber. The hot products of combustion at high velocity are passed into the annulus of the concentric evaporating tubes. These hot gases transfer heat to feed water flowing inside the concentric evaporative tubes. Hot gases circulated about 10 to 20 times that of feed water circulation. The wet steam generated in the evaporative tubes is passed to a steam separator in tangential direction. It forms the vortex in the separator and due to centrifugal action moisture content of steam is separated. This separated water is pumped back into feed water line. The dry steam separated is passed through the super heater tubes where it is superheated with the help of hot flue gases collected from evaporating tubes. The hot gases discharged from the super heater are expanded in gas turbine. The power developed by the turbine issued to drive the compressor. The exhaust of the gas turbine is used to heat the feed water in the economizer before these are discharged to the surroundings through the chimney.

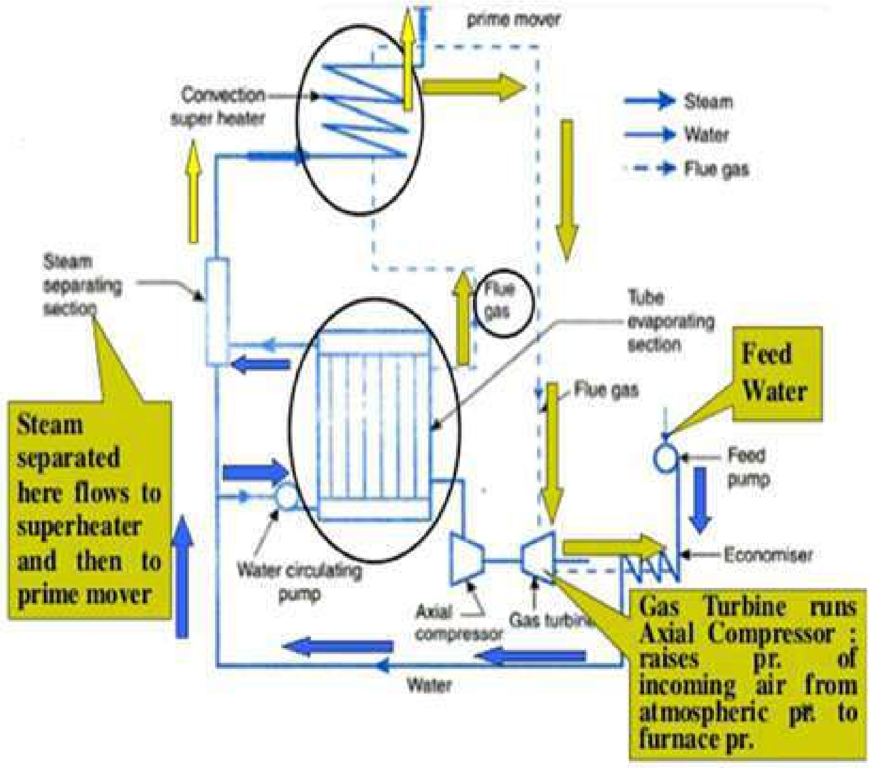
Advantages:

1. Velox boiler is compact.
2. Very high combustion rates are possible as 35 to 45 million kJ per cu. m. of combustion chamber volume.
3. Low excess air is required as the pressurized air is used and the problem of draught is simplified.

Disadvantages:-

1. It can only operate on liquid or gaseous fuels

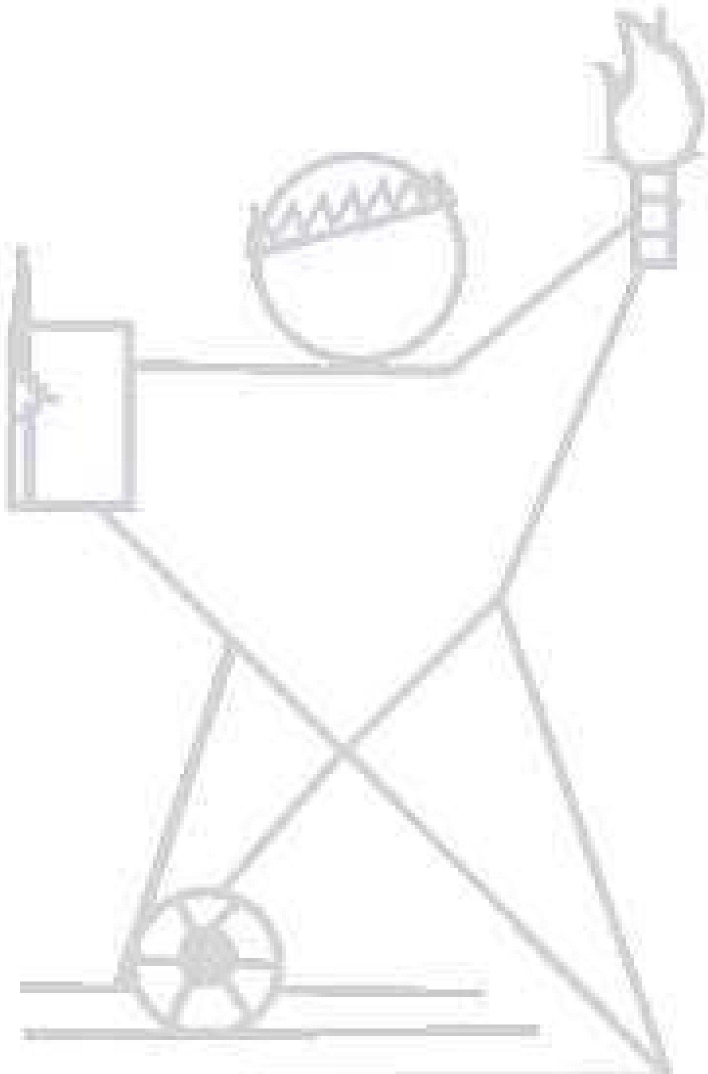




Velox Boiler

Questions.

1. Define subcritical and supercritical Boiler.
2. Write the advantages of artificial Draught over natural Draught
3. What is Fluidized-bed combustion Boiler



Experiment No.5

Aim: To study the working of Loffler Boiler.

Construction:

Components in Loffler boiler are air pre heater, evaporating drum radiant and convective evaporator feed pump etc. in Loffler boiler H.P. and L.P. boilers are added with steam circulating pump. The economizer is used to heat the incoming water from feed pump. Steam circulating pump draws superheated steam from evaporating drum.

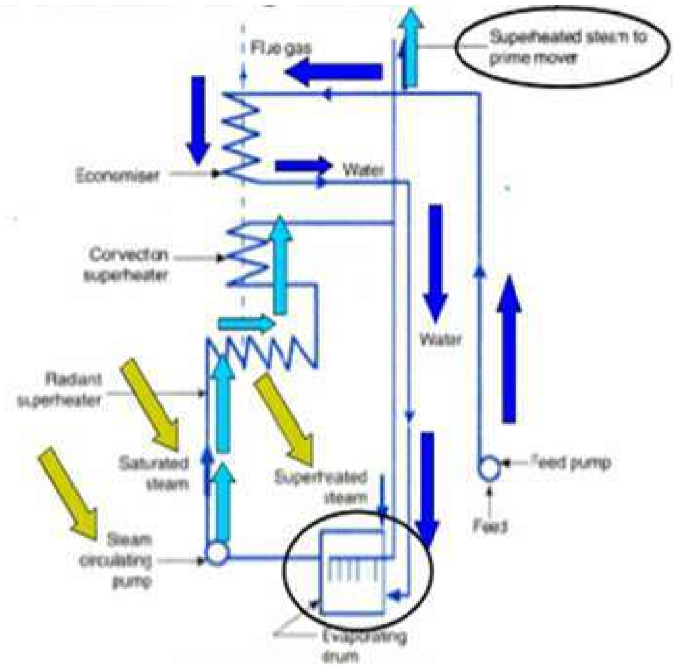
Working:

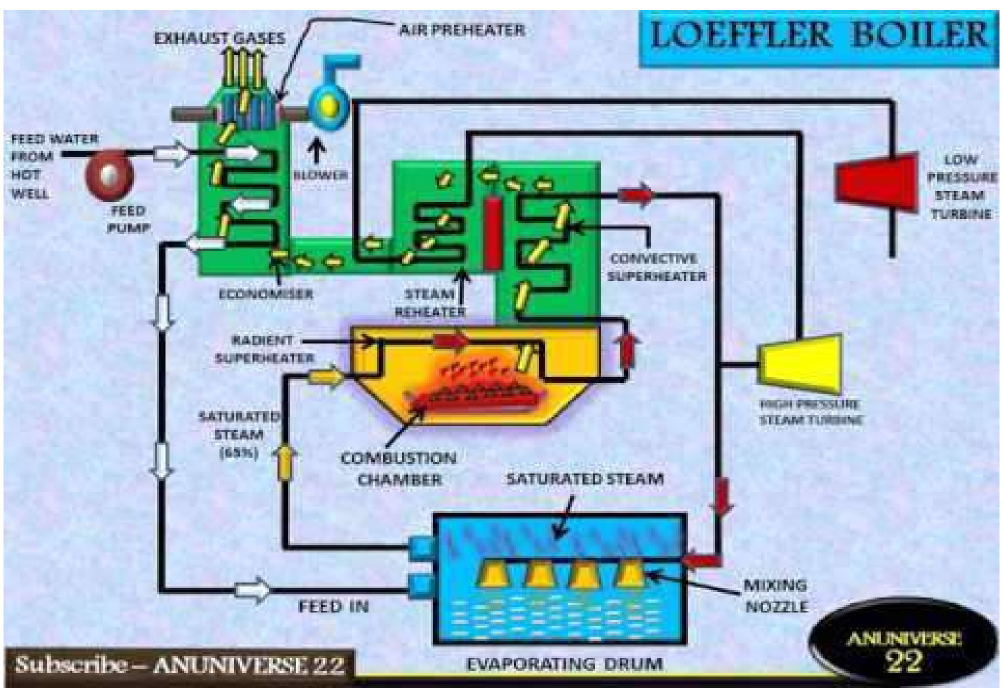
The major difficulty in Lamont boiler is the deposition of salt and sediment on the inner surface of the water tubes. This difficulty was solved in Loffler boiler by preventing the flow of water into the boiler tubes. Most of the steam is generated outside from the feed water using part of the superheated steam coming out from the boiler. The arrangement is shown in the following diagram. The pressure feed pump draws the water through the economizer and delivers it into the evaporator drum as shown. About 35% f the steam coming out from the super heater is supplied to the H.P. steam turbine. The steam coming out from H.P. turbine is passed through reheated before supplying to L.P. turbine. The amount of heat generated in the evaporator drum is equal to the steam tapped (65%) from the super heater. The nozzles which distribute the superheated steam throughout the water into the evaporator drum are of specialdesign and avoid priming and noise. This boiler can carry higher saltsconcentration than any other type.

Advantages:

1. Loffler boiler can carry higher salt concentration than any other type of boiler.
2. Since evaporating tubes of Loffler boiler carries only superheated steam there is no salt deposition so it is suitable for marine applications.

Diagram of Loffler Boiler

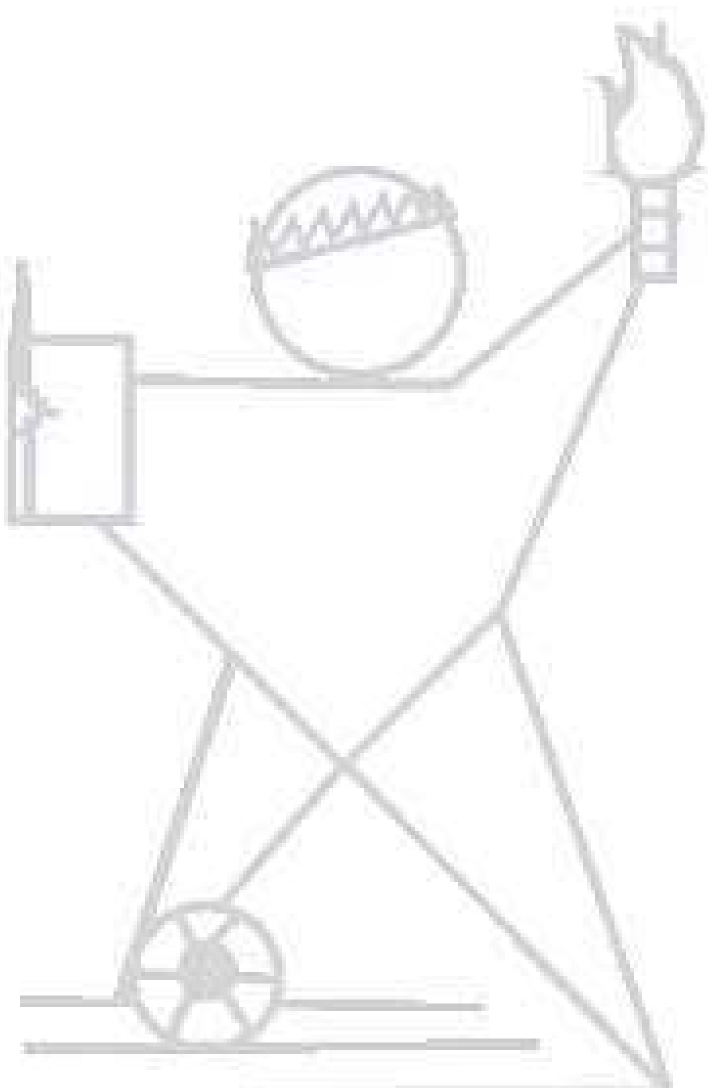


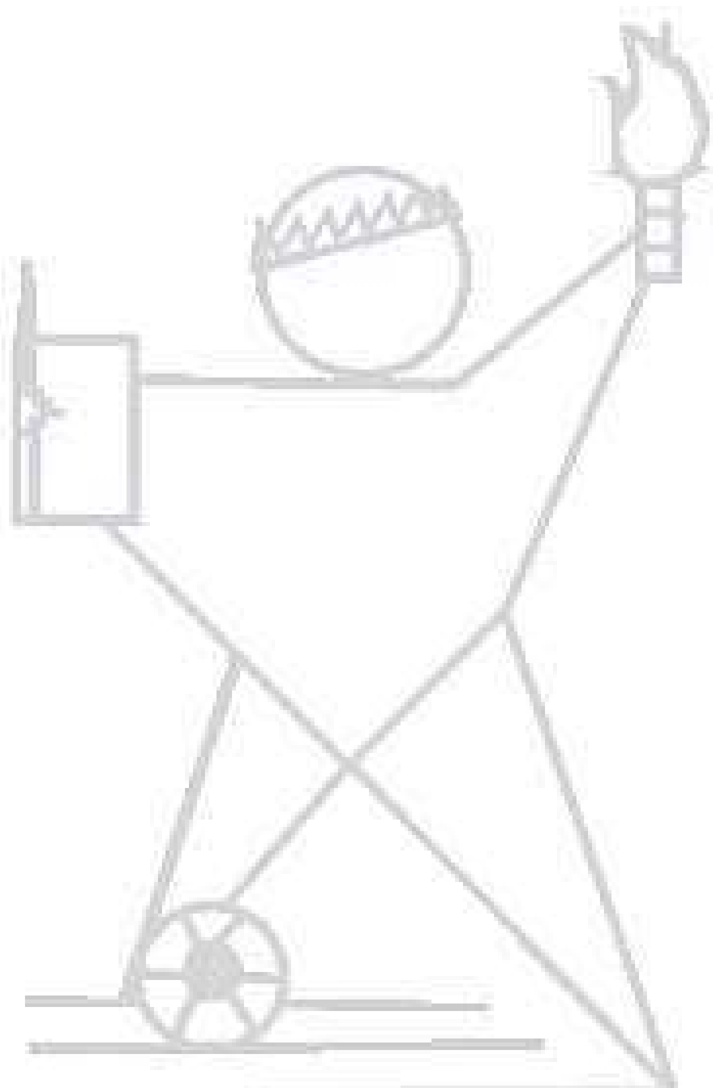


Loeffler Boiler

Questions

1. Write the special features of a Loeffler Boiler
2. How the Boiler efficiency is defined.
3. Write short note on conventional Boiler.





Experiment No.6

Aim:- To study of heat balance sheet for given boiler.

Heat losses in the boiler:-

The efficiency of boiler is never 100 % as only a portion of heat supplied by the fuel is utilized rest of it is lost:-

1. Heat carried away by dry product of combustion.
2. Heat carried away by the steam product by the combustion of hydrogen present in fuel.
3. Heat carried away by moisture in fuel and air.
4. Heat loss due to incomplete combustion of carbon to carbon monoxide instead of carbon dioxide and thus escape of combustible matter in the flue gases and ash.
5 Heat loss due to radiation.

Method of minimizing the heat loss:-

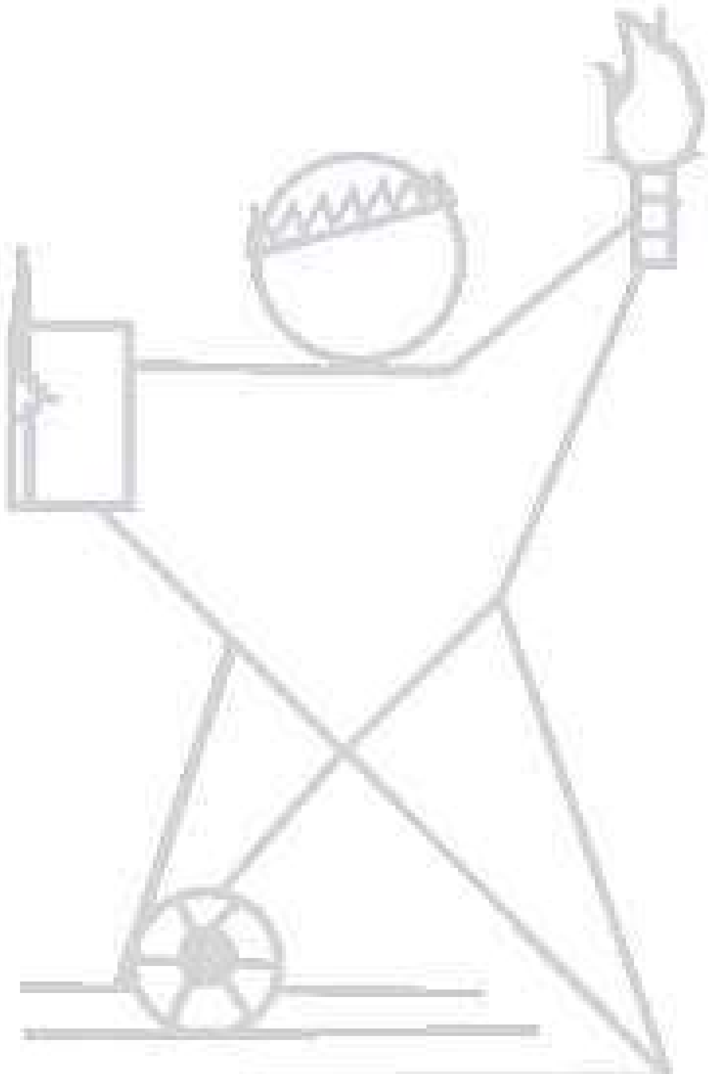
1. The heat loss to chimney gases may be minimized by installing an economizer in between the boiler and chimney.
2. Loss of heat may be minimized by providing the boiler with an effective draught system which will ensure sufficient supply of air through the fuel in furnace.
3. Heat loss due to unburnt fuel which may fall into ash pit may be minimized by properly sizing of coal.
4. Heat loss due to moisture content in the fuel may be minimized by making the fuel dry before charging into the boiler furnace.
5. Heat loss due to external radiation may be minimized by providing effective covering of insulating material on the boiler parts which are liable to radiate heat.

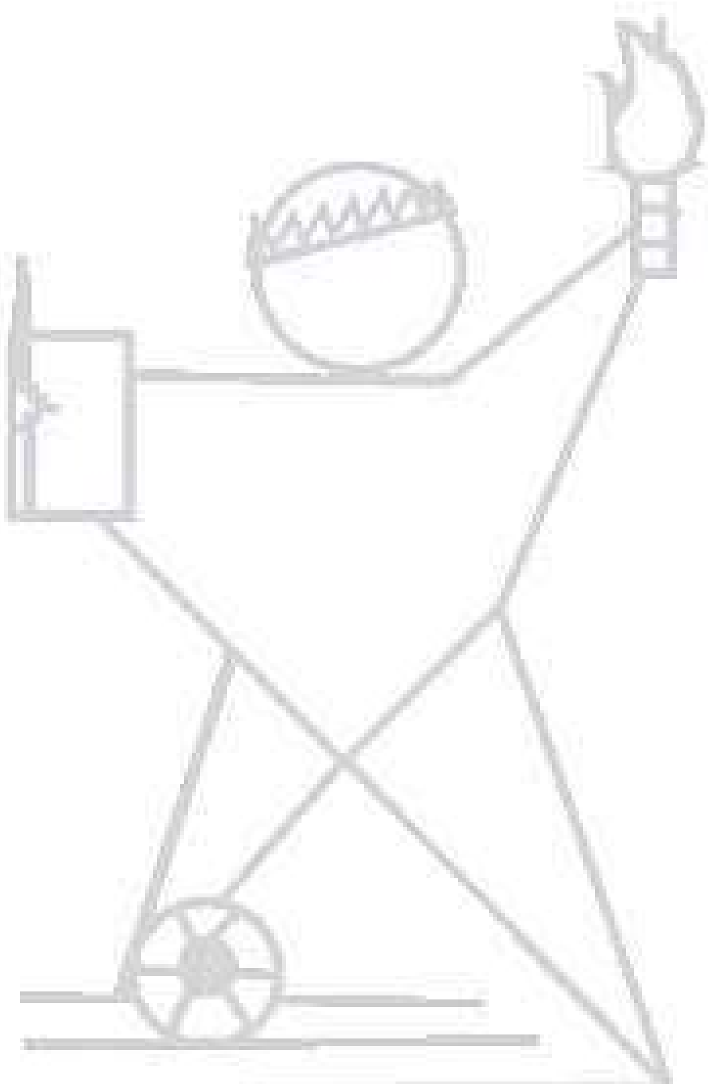
Heat Balance Sheet (Basis 1 Kg of low grade fuel)

Heat supplied	KJ	Heat Expenditure	KJ	% age (In approx.)
Gross heat supplied		(a) Heat utilized in steam generation (b) Heat carried away by flue gases (c) Heat utilized in evaporating and superheating the moisture fuel and water vapour formed due to burning of hydrogen of fuel (d) Heat loss by incomplete combustion (e) Heat uncounted for such as radiation and error etc.		
Total		Total		100

Questions

1. Write the various types of heat loss in boiler Plant.
2. Draw the heat balance sheet per minute basis for a certain Boiler





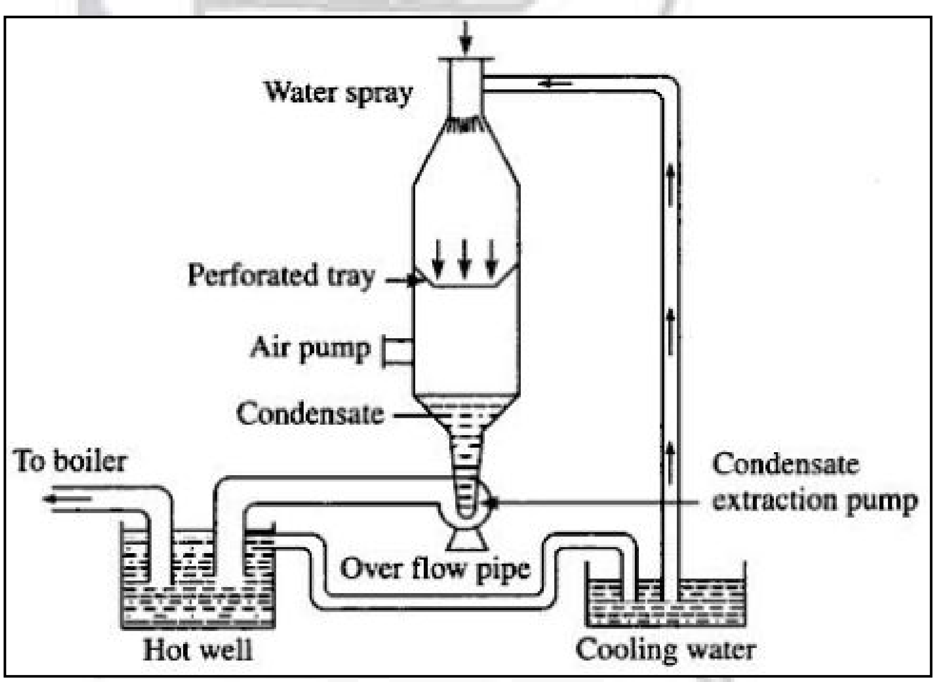
Experiment No. 7

Aim: - To study of Steam Condenser and its types with demonstrate model.

Theory:- Condenser is an appliance in which steam is condensed and the and the energy given up steam in the condensing process is passed to a coolant, which is water. It is of two types, depending upon the way in which the cooling water cools the exhaust steam.

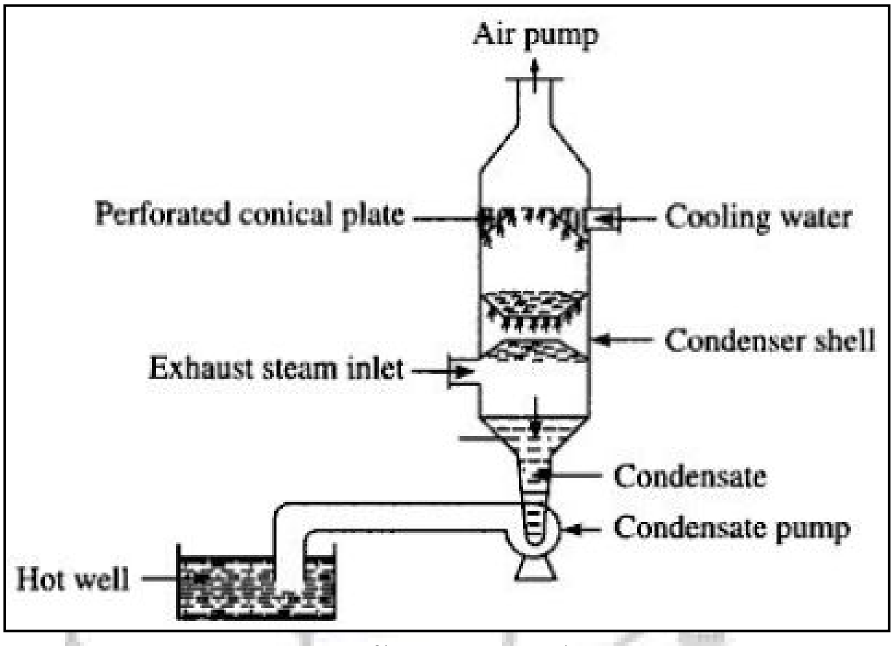
1. **Jet condenser:-** In this type of condenser, the cooling water and exhaust steam come into direct contact and the temperature of condensate is the same as that of cooling water leaving the condenser. It is the three of types:-

(a) **Parallel flow type:-** In which both exhaust steam and cooling water outer at the top of condenser and then flow in downward direction. The condensate and water are collected from the bottom.



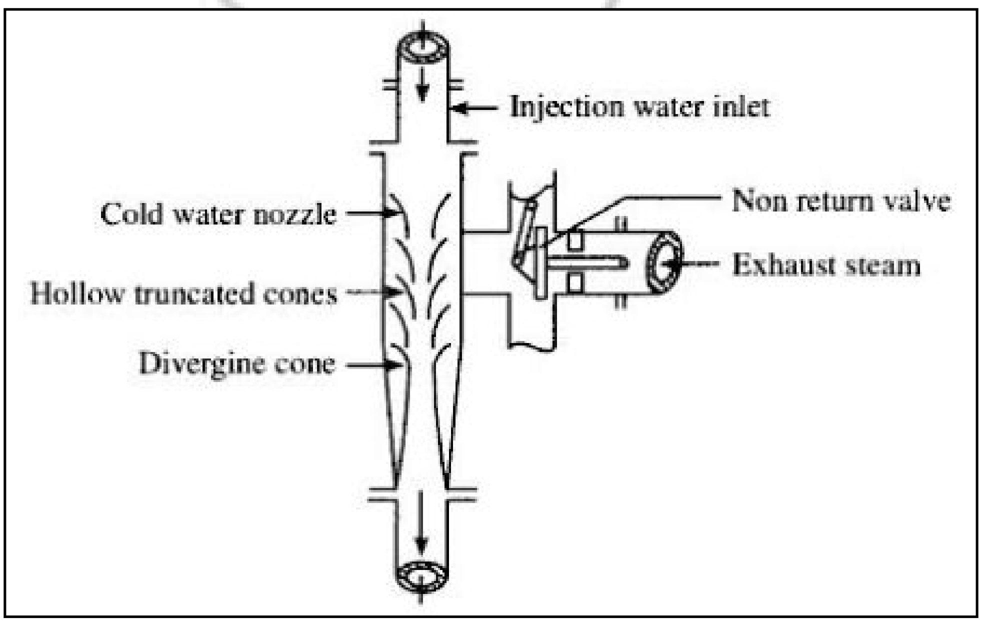
Parallel flow type Condenser

(b) **Counter flow type:-** Exhaust steam and cooling water outer from the opposite direction. Usually the exhaust steam at the bottom and rises up while the cooling water enters at the top and flow downward.



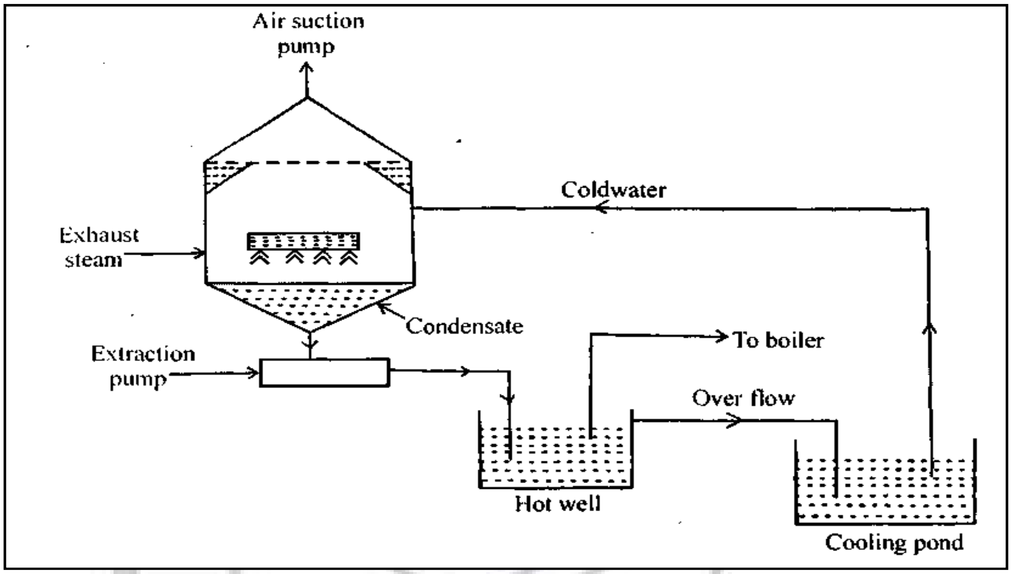
Counter flow type Condenser

(c) Ejector type:- The mixing of exhaust steam and cooling water takes place in a series of combining cones and K. E. of steam is utilized to assist in draining the water from the condenser into net well against the pressure of atmospheric. Parallel flow and contra flow condenser are further sub divided in two categories:-



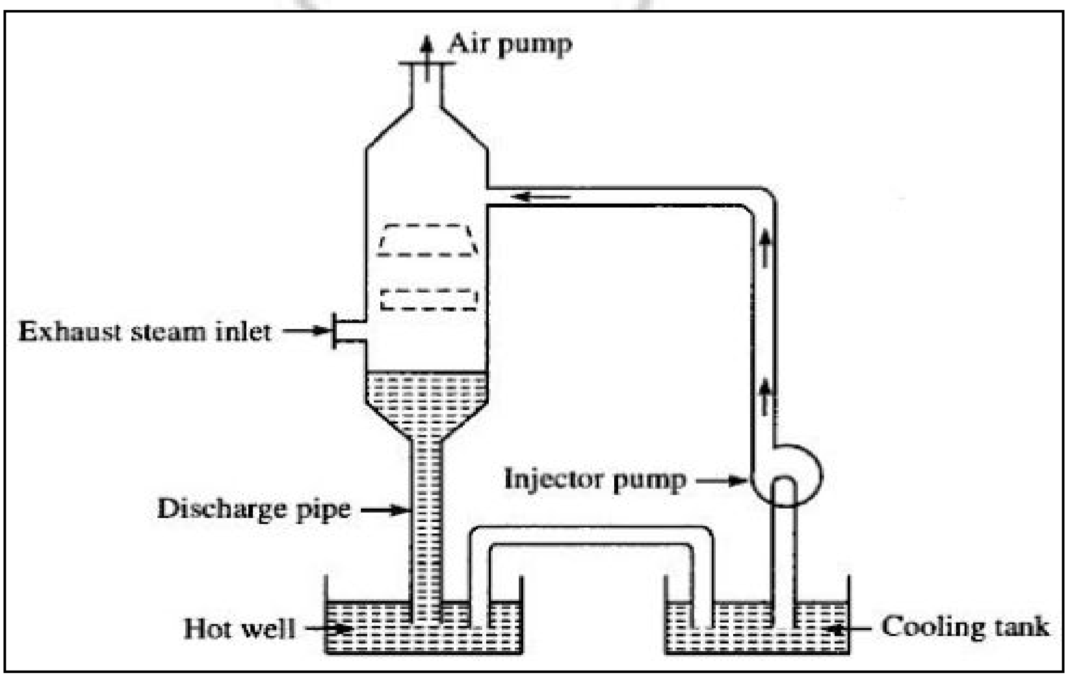
Ejector Type Condenser

(i) **Low level type:-** According to the position of condensing chamber, in case of low level type the overall height of the unit is low enough type. So that the condenser may be directly placed be near the steam turbine or engine. In this type of condenser, an extraction pump is required for drawing out the condensate, cooling water and air.



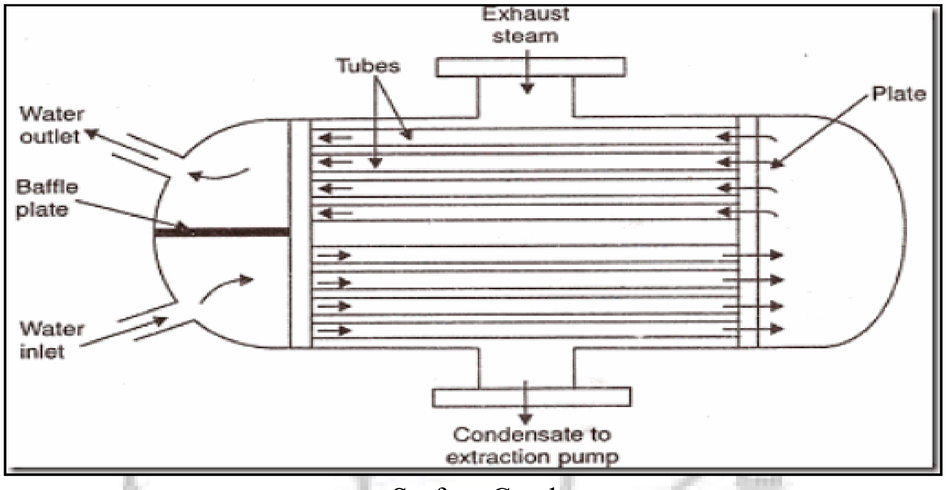
Low Level type Jet condenser

(ii) High level type:- High level condenser is similar to low level jet condenser except that it uses a barometric type or trail pipe for cooling the vacuum & removing the condensate & in some cases the non condensable gases.



High Level type Jet condenser

2 Surface condenser: - The exhaust steam and the cooling water don't come into direct contact. The steam to be condensed is made to flow over the outside of a nest of type through which the cooling water circulates. It is following types:-



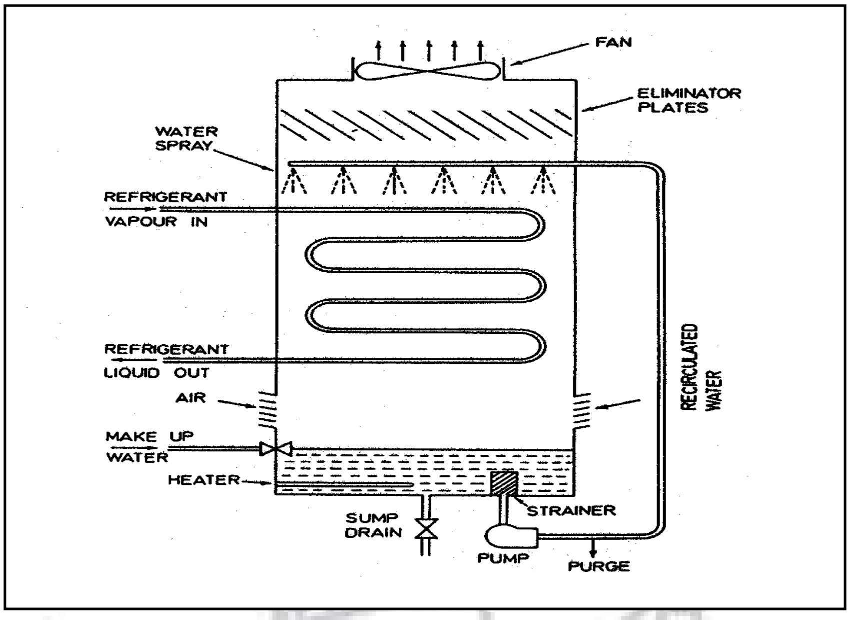
Surface Condenser

(a) **Down flow type:-** The steam enters at the top and flows down over the tube through which water is circulated. As the condensed steam floe perpendicular to the direction of flow of cooling water inside the tubes, this condenser is also called cross- surface condenser.

(b) **Central flow type:-** In the centre of the tube nest is located the suction of air extracting pump thus resulting in the flow of steam rapidly inwards. There is better contact between the outer surface of tubes and the steam due to the volute casting round the nest of the tubes

(c) **Inverted type:-** The steam after entering at the bottom rises up and then again flows down following a path near the outer surface of the condenser. The condensate extraction pump is providing at the bottom while the suction pipe of the air extraction pump connected to the top.

(d) **Evaporative condenser:-** When the supply of cooling water is limited, its quantity required to condensate the steam may be greatly reduced by covering the circulating water to evaporative under small particle pressure due to heat capacity of gilled pipe it has the periods without seriously affecting the vacuum.



Evaporative type Jet condenser

Condenser efficiency:- Condenser efficiency is defined as the ratio of the difference between the outlet and inlet temperature of cooling water to the difference between the temperature corresponding the vacuum in the condenser and the inlet temperature of cooling water.

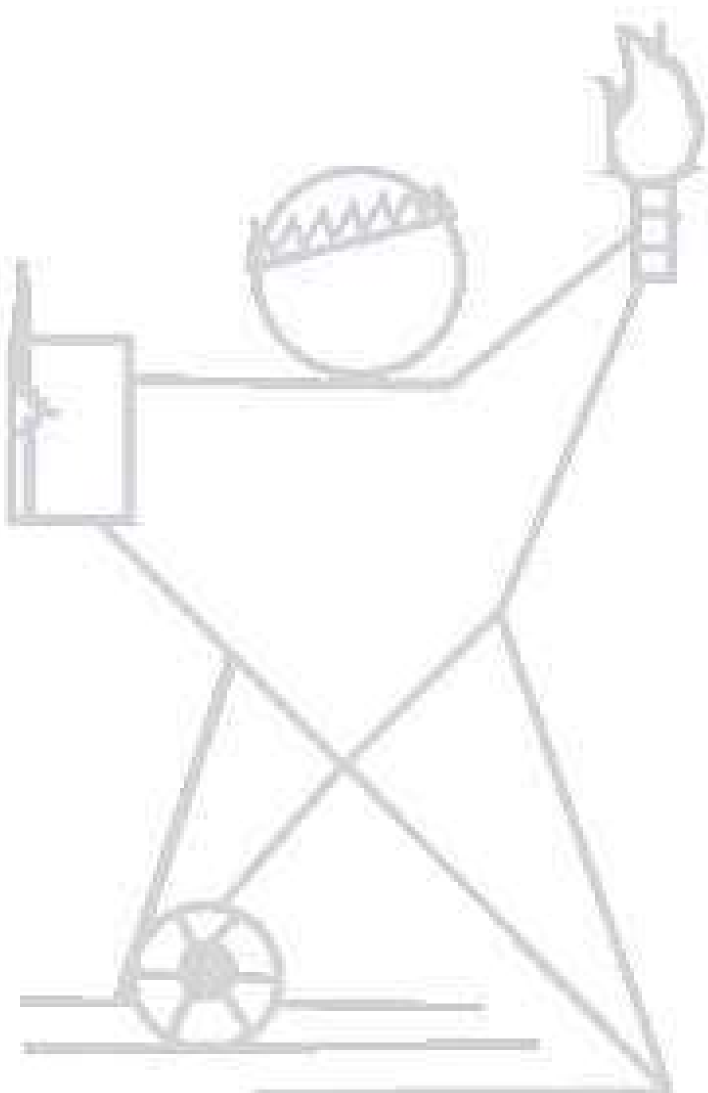
Condenser efficiency = Rise in temp. of cooling water

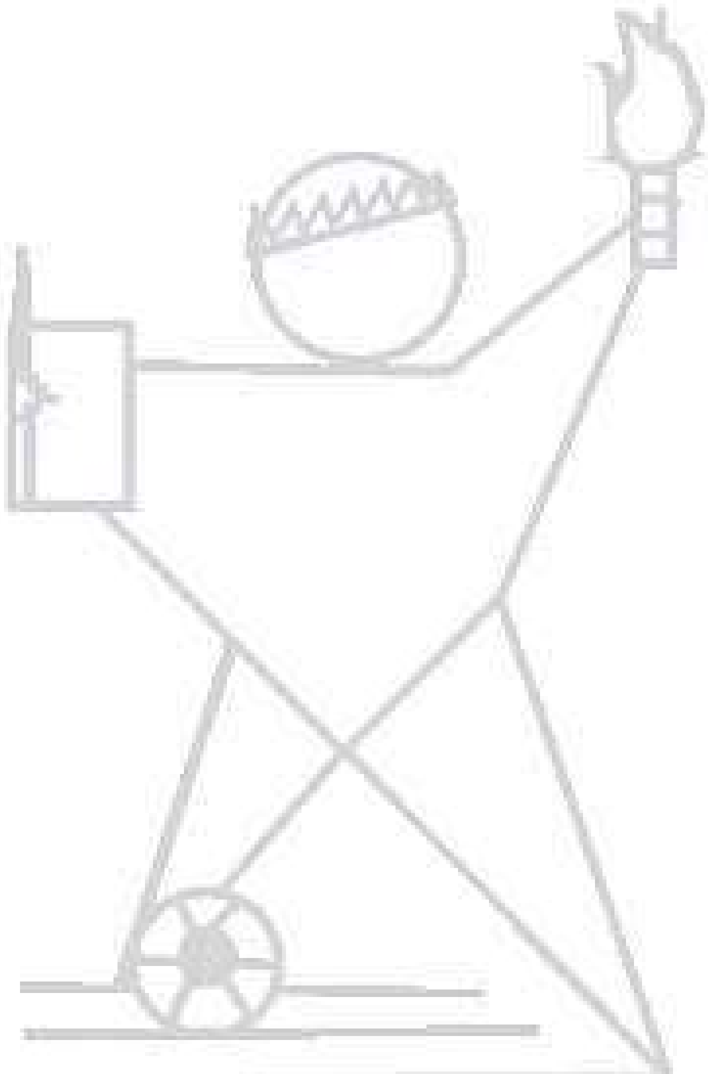
(temp. correspondence to vacuum)

- (inlet temp. of cooling water in condenser)

Questions

1. Write the difference between jet condenser and surface condenser
2. Write the estimation of cooling water required in condenser
3. What is cooling Tower write Explain its types briefly





Experiment No. 8

Aim:- To study and find the volumetric efficiency of a Reciprocating air compressor.

Theory:- This may be regarded as a machine which compresses or which is used to increase the pressure of air by reducing its volume.

Reciprocating compressor:- This is a machine which compresses air by means of piston reciprocating inside a cylinder.

Working:- It consist a piston which is enclosed within a cylinder and equipped with suction and discharge valve. The piston receives the power from the main shaft through a crank shaft and connecting rod. A fly wheel is fitted on the main shaft to ensure turning moment to be supplied throughout the cycle of operations.

Rotary compressor may be classified as:-

1. Positive displacement compressor
2. Non – positive displacement compressor

Positive displacement compressors are
future classified as:-

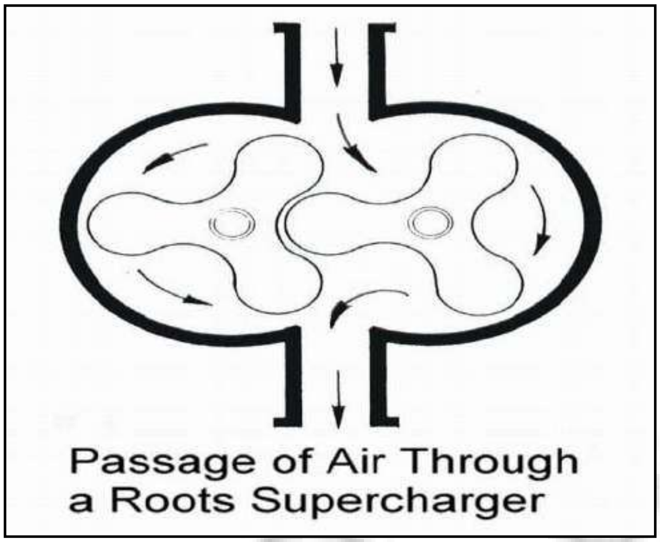
(a) Roots blower
(b) Crescent or Vane blower
(c) Lysholm compressor
(d) Screw compressor

Non – positive compressor are classified as:-

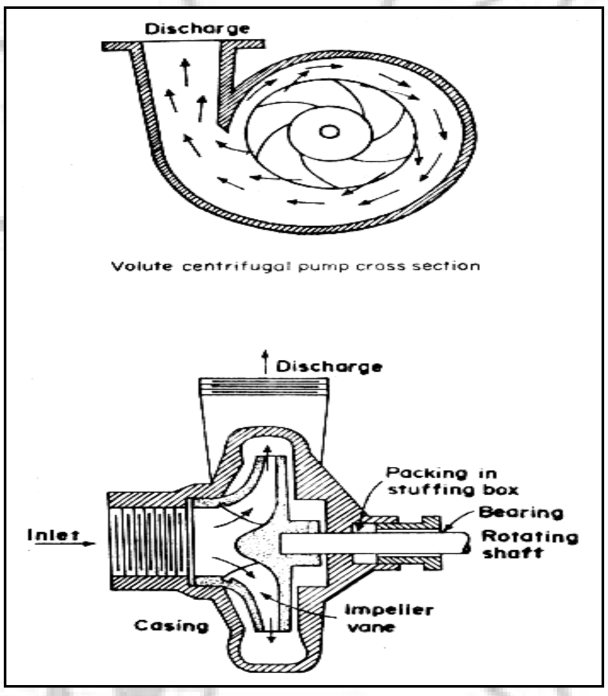
(a) Centrifugal compressor
(b) Axial flow compressor

1. **Positive displacement compressor:-** It have two sets of mutually engaging cam surface or lobes. The air is trapped between the lobes and the pressure rise take place either be back blow of air from receive by squeezing action and back blow of air.

(a) Roots blower:- in which back flow of high pressure air from the receive creates rise in pressure.



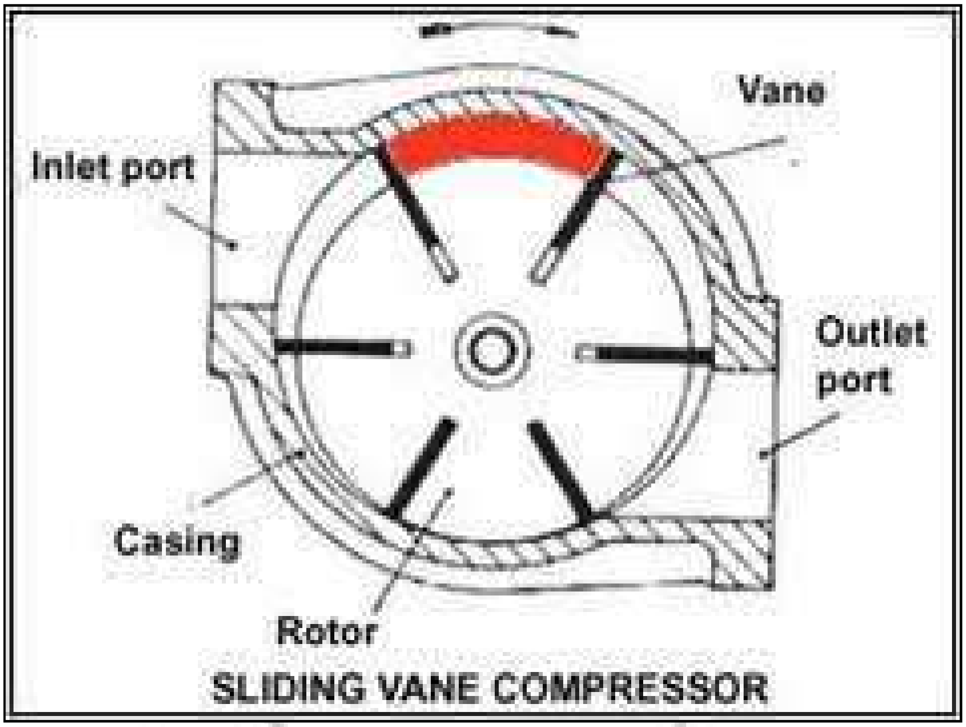
(b) Vane blower:- in which combined squeezing action and back flow of air creates rise in pressure.



Van Blower

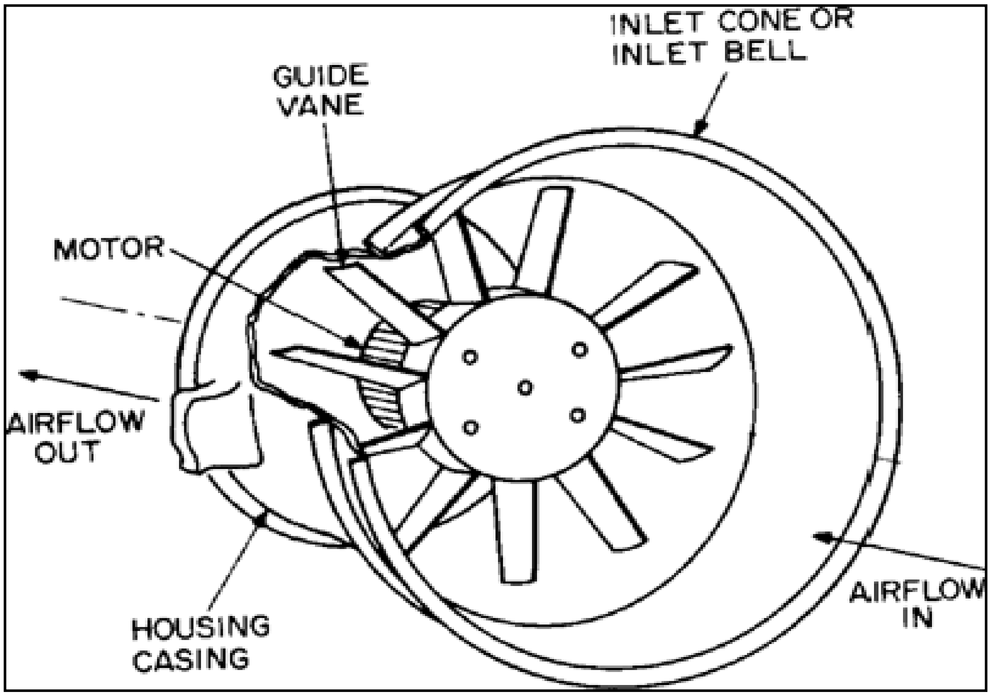
3 **Non – positive displacement compressor: -** The pressure rise in these machine is not due to space reduction or back blow action of the high pressure air from the receive as in the case of positive compressor but is due to transfer of K. E. of the fluid to the pressure energy by one or more rotating rings of curved blades known as 'Impeller'.

(a) Centrifugal compressor:- The rotating member known as the Impeller consist a large number of blades and is mounted on the compressor shaft inside stationary casting. As the impeller rotates the pressure in the region a falls and hence the air enters through the eye and flow radially outwards through the impeller blades as of the compressor. Both velocity and pressure increase as the air flow through the cylinder or impeller blades. Air enters through the convergent passage formed by the diffuse blades.



Centrifugal compressor

(b) Axial flow compressor:- It is more commonly used, the air flows in an axial direction right from the intake to the delivery. The working principle is illustrated in fig. The stator encloses the rotor both of which are provided with rings of blades. As the air enters in the direction it flows through the alternately arranged stator and rotor blade ring the air gets compressed successively. For efficient operation the blades are made of aerofoil section based on aero-dynamic theory. The annular area is made divergent as shown in order to keep the flow velocity constant throughout the length of compressor.



Axial flow compressor

Double Stage Reciprocating Air Compressor

Objective:

To study about two cylinder Two stage Reciprocating air compressor and find out isothermal efficiency and volumetric efficiency.

Discription:

Two stage compressors is reciprocating type driven by a prime mover AC motor through belt. The test rig consists of a base on which the tank (air reservoir) is mounted. The electrical safety valve & mechanical safety valves are provided. The suction side of low pressure cylinder is connected to the air tank with an orifice plate. The pressure drop across the orifice plate can be measured by water manometer. The output of the motor is recorded by the swinging field arrangement. The input of the motor can be measured by an energy meter.

Compressor Details & Parameters:

Diameter of Low pressure Cylinder (D) = 70mm

Stroke length (L) = 85mm

Procedure:

1. Close the outlet valve.
2. Check the manometer connections. The manometer is filled with water up to the half level.
3. Start the compressor and note down initial energy meter reading and spring balance reading.
4. Read the tank pressure gauge for a particular pressure.
5. Note down the RPM of the compressor from the digital speed indicator.
6. Note down the manometer readings.
7. Note down the spring balance reading.
8. Note down the reading of energy meter for a given no of revolutions.

Repeat the experiment for various discharge pressures.

Calculations:

1. **Actual volume flow rate of air :**

$$V_a = C_d \times A \times V_a$$

$$C_d A\sqrt{2gh} \times 3600 \text{ m}^3\text{/hr}$$

$$Cd \times A \times \sqrt{\frac{2gh_w}{1000}\;\frac{\rho_w}{\rho_a}}$$

Where; C_d is the co-efficient of discharge = 0.62

d = Diameter of orifice = 15 mm (0.015 m)

A= Cross section area of orifice m^2

ρ_w = 1000 kg/m cu (Density of Water)

ρ_a = 1.293 kg/ m cu (Density of Air)

h_w = pressure drop across orifice plate in mm of water

2. Swept Volume = Vs (m^3/hr)

$$Vs = A \times L \times N_c \times 60$$

D is diam. of piston = 70 mm = 0.07 m

L is stroke length = 85 mm = 0.085 m

N_c is speed of the compressor in RPM.

P_1= Inlet Pressure of Air Kgf/cm^2

P_2= Discharge Pressure of air Kgf/cm^2

3. Volumetric Efficiency =

$$\eta_v = \frac{V_a}{V_s} \times 100$$

4. Isothermal efficiency of the compressor =

$$\eta_{isoth} = \frac{W_{iso.}}{W_{act.}}$$

$$W_{iso.} = p_1 v_1 \ln \frac{p_2}{p_1}$$

$$W_{act.} = \frac{n}{n-1} p_1 v_1 \left[\left(\frac{p2}{p1} \right)^{\frac{n-1}{n}} - 1 \right]$$

(ii) Power input to the motor is found form the energy meter is provided.

6. Readings:

Readings are noted in the tabular column given below.

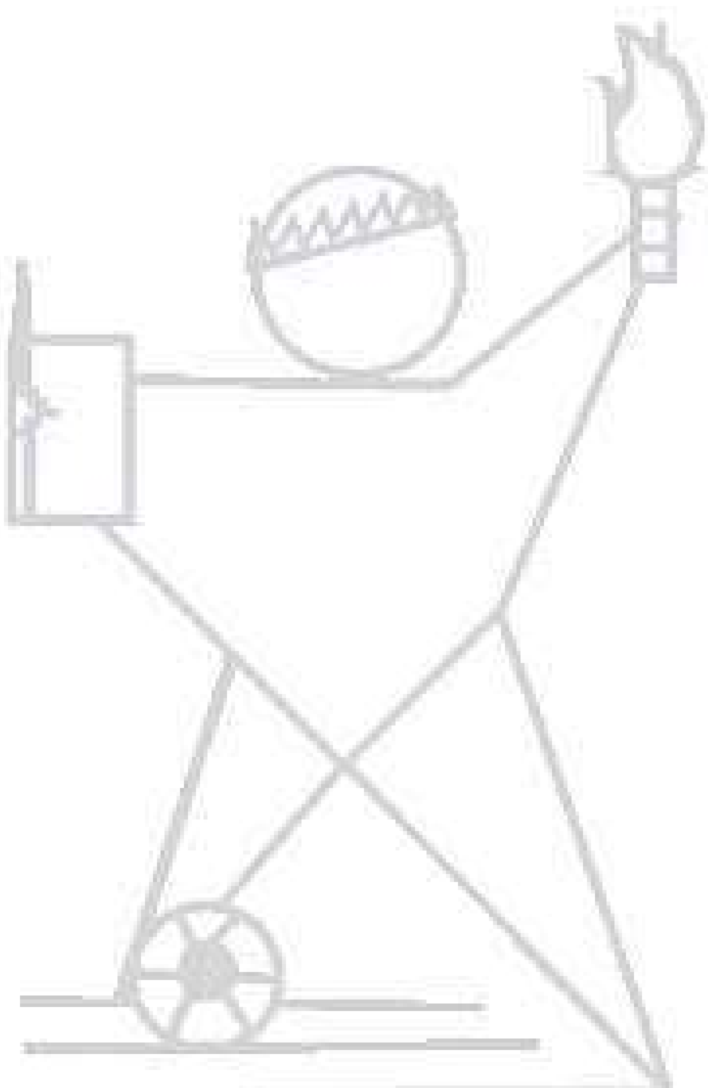
S.No	Inlet pressures p_1 Kg/cm2	Discharge Pressure P_2	$\frac{p_2}{p_1}$ =	N_c	N_m	h_w, mm	η_{vol}	η_{iso}

7. Graphs :

Graphs of Volumetric efficiency and isothermal efficiency are drawn for various discharge pressures of air form the compressor.

Questions

1. Write the difference between axial flow compressor and Centrifugal compressor
2. What is Volumetric Efficiency of Compressor?



Experiment No. 9

Aim: To Determine Nozzle coefficient of the given Nozzle meter.

Introduction: A Nozzle is fitted at the end of pipe of which is used for transmission of power as in case of hydraulic power station.

Theory : Nozzle is a tapering mouth piece which converts total head available at the nozzle into equivalent head. The pressure of outlet end of the nozzle is atmospheric hence the energy is entirely in kinetic form.

Experimental Procedure:

Firstly pump was initiated to have water flood through the pipe to which Nozzle meter is connected two tapping or two connections were given to the mercury manometer to have head developed. But this head developed is in term of Hg. As the difference to two mercury limbs are adjusted, the discharge of water through pipe is measured for 60 seconds in measuring tank. The procedure difference was noted with manometer & theoretical discharge can be obtained for the 1st set was fully open & reading for maximum discharge was noted. Then gradually discharge was reduced by use of valve. Pressure difference was noted down. Thus 3 reading are taken & Theoretical & actual discharge were calculated & were compared at last of all coefficient of discharge for Nozzle was determined for each reading by taking mean of them which given as average coefficient of discharge for Nozzle.

Observations :

Diameter of Pipe	(d_1)	:	26 mm.		
Diameter of Nozzle	(d_2)	:	13 mm.		
Area of Pipe	(A_1)	:	5.22×10^{-4} m^2		
Area of Nozzle	(A_2)	:	2.01×10^{-4} m^2		
Area of Tank	(A)	:	0.5 x 0.35	=	0.175 m^2

Observation Table:

Sr. No.	Manometer Difference In (H_{hg}) mm.	Time for 100mm Rise of Water Level (t) Sec
1.		
2.		
3.		
4.		

Calculations:

1. Actual Discharge (Q_A):

$$Q_A = \frac{A \times H}{t} \quad 10^{-3} \ \ m^3/sec$$

2. Manometer Difference In Terms of Water Column (H) :

$$= H_{hg} \frac{S_1 - S_2}{S_2}$$

S_1= Density of mercury 13600 kg/m^3

S_2= Density of Water1000 kg/m^3

3. Theoretical Discharge (Q_{th}) :

$$Q_{th.} = \frac{A_1 A_2 \sqrt{2gH}}{\sqrt{A_1^2 - A_2^2}} \quad 10^{-3} \ \ m^3/sec$$

3. Coefficient of Discharge Of Nozzle meter (C_d):

$$C_d = \frac{Q_{act}}{Q_{theo}}$$

4. Result Table:

Sr. No.	Height Of Water (H) mtr. Of Water	Actual Discharge (Q_A) m^3/Sec	Theoretical Discharge (Q_{TH}) m^3/Sec	Co-Efficiency of Discharge	Average Co-Efficient of Discharge(C_d)
1					
2					
3					
4					

Experiment No. 10

Aim: - To study determination of Calorific Value of Fuels by using Bomb calorimeter.

Apparatus: - Bomb Calorimeter

Theory:- The "calorific value or heating value" of the fuel is defined as the energy liberated by the complete oxidation of a unit mass or volume of a fuel. It is expressed in kJ/kg for solid and liquid fuels and kJ/m^3 for gases.

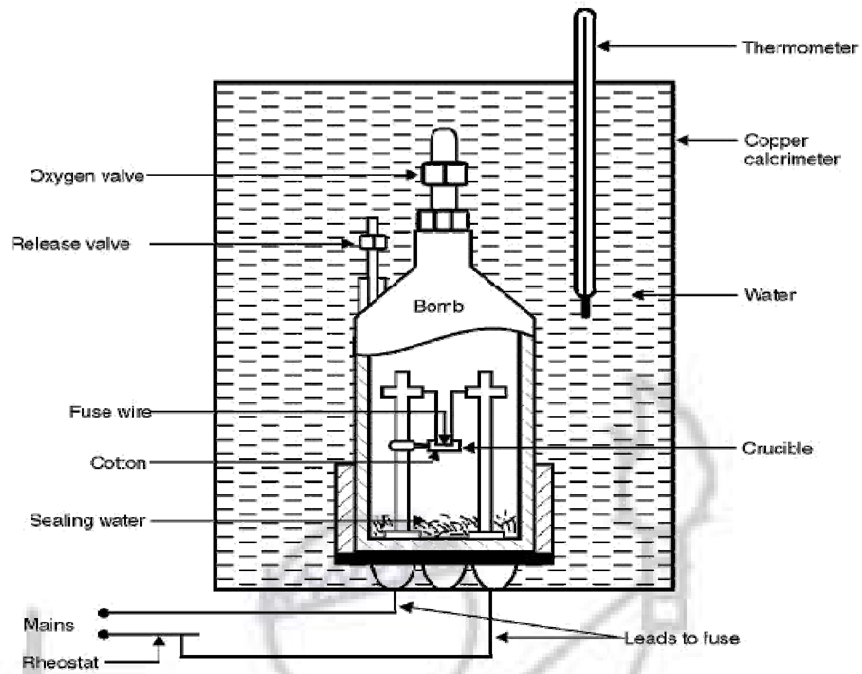
The higher heating value, HHV, is obtained when the water formed by combustion is completely condensed.

The lower heating value, LHV, is obtained when the water formed by combustion exists completely in the vapour phase.

Bomb calorimeter:

The calorific value of solid and liquid fuels is determined in the laboratory by 'Bomb calorimeter'. It is so named because its shape resembles that of a bomb. Figure shows the schematic sketch of a bomb calorimeter.

The calorimeter is made of austenitic steel which provides considerable resistance to corrosion and enables it to withstand high pressure. In the calorimeter is a strong cylindrical bomb in which combustion occurs. The bomb has two valves at the top. One supplies oxygen to the bomb and other releases the exhaust gases. A crucible in which a weighted quantity of fuel sample is burnt is arranged between the two electrodes as shown in Figure. The calorimeter is fitted with water jacket which surrounds the bomb. To reduce the losses due to radiation, calorimeter is further provided with a jacket of water and air. A stirrer for keeping the temperature of water uniform and a thermometer to measure the temperature up to accuracy of 0.001°C is fitted through the lid of the calorimeter.



Bomb Calorimeter

Procedure:

To start with, about 1 gm of fuel sample is accurately weighed into the crucible and a fuse wire (whose weight is known) is stretched between the electrodes. It should be ensured that wire is in close contact with the fuel. To absorb the combustion products of sulphur and nitrogen 2 ml of water is poured in the bomb. Bomb is then supplied with pure oxygen through the valve to an amount of 25 atmospheres. The bomb is then placed in the weighed quantity of water, in the calorimeter. The stirring is started after making necessary electrical connections, and when the thermometer indicates a steady temperature fuel is fired and temperature readings are recorded after 1/2 minute interval until maximum temperature is attained. The bomb is then removed; the pressure slowly released through the exhaust valve and the contents of the bomb are carefully weighed for further analysis. The heat released by the fuel on combustion is absorbed by the surrounding water and the calorimeter.

From the above data the calorific value of the fuel can be found in the following way:

Let W_f = Weight of fuel sample (kg),

W = Weight of water (kg),

C = Calorific value (higher) of the fuel (kJ/kg),

W_e = Water equivalent of calorimeter (kg),

T_1 = Initial temperature of water and

calorimeter, T_2 = Final temperature of water and

calorimeter, T_c = Radiation corrections, and c =

Specific heat of water.

Heat released by the fuel sample = $W_f \times C$

Heat received by water and calorimeter

$= (W_w + W_e) \times c \times [(T_2 - T_1) + T_c]$.

Heat lost = Heat gained

$$W_f \times C = (W + W_e) \times c \times [(T_2 + T_1) + T_c]$$

Find the value of C in above equation.

[Value of c is 4.18 in SI units and unity in MKS units.]

Note:

1. Corrections pertain to the heat of oxidation of fuse wire, heat liberated as a result of formation of sulphuric and nitric acids in the bomb itself.

2. It should be noted that bomb calorimeter measures the higher or gross calorific value because the fuel sample is burnt at a constant volume in the bomb. Further the bomb calorimeter will measure the H.C.V. directly if the bomb contains adequate amount of water before firing to saturate the oxygen. Any water formed from combustion of hydrogen will, therefore, be condensed. The procedure of determining calorific values of liquid fuels is similar to that described above. However, if the liquid fuel sample is volatile, it is weighed in a glass bulb and broken in a tray just before the bomb is closed. In this way the loss of volatile constituents of fuels during weighing operation is prevented.