SCHEME : K

Name : _____

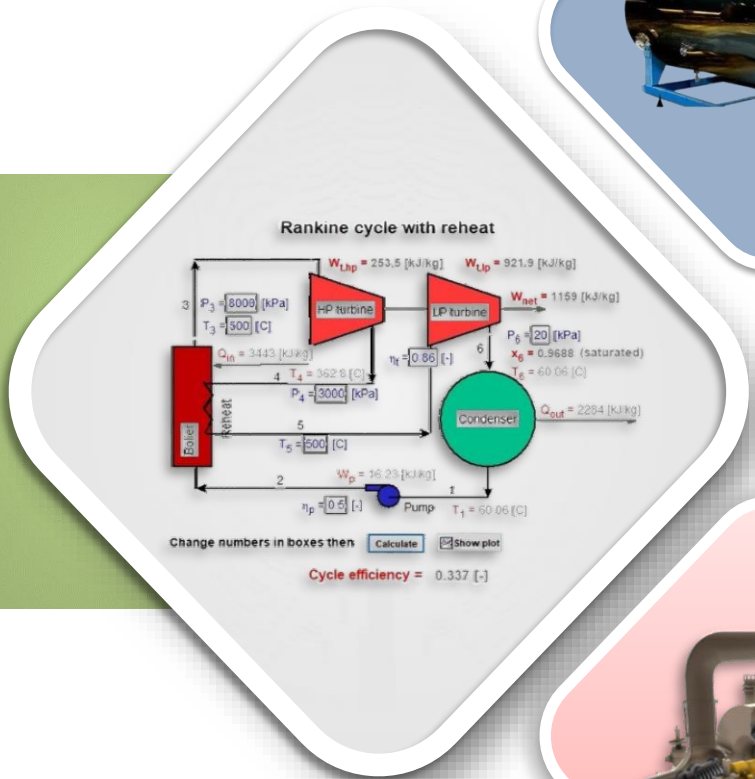
Roll No. : _____ Year : 20___ 20___

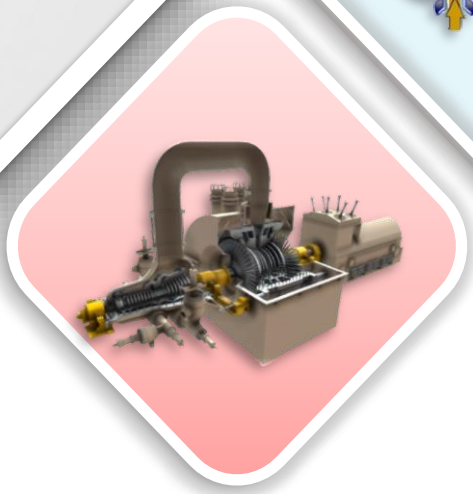
Exam Seat No. : _____

LABORATORY MANUAL FOR

THERMAL ENGINEERING

(313310)





MECHANICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- Skill development in line with industry requirements.
- Industry readiness and improved employability of Diploma holders.
- Synergistic relationship with industry.
- Collective and Cooperative development of all stake holders.
- Technological interventions in societal development.
- Access to uniform quality technical education.

A Practical Manual

for

Thermal Engineering
(313310)

Semester– (III/IV)

"K-SCHEME"

(Diploma in Mechanical/Production Engineering)
(ME/PG)

Maharashtra State
Board of Technical Education, Mumbai

(Autonomous) (ISO-9001-2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai
(Autonomous) (ISO: 9001: 2015) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai – 400051,
(Printed on July,2024)

Maharashtra State
Board of Technical Education, Mumbai

Certificate

This is to certify that Mr. /Ms.……...

Roll No. ……..……of Third/Fourth semester of Diploma in ……...…. .... of Institute ……..... (Code :…….....) has completed the term work satisfactorily in course **Thermal Engineering (313310)** for the academic year 20……....to 20…..... as prescribed in the curriculum.

Place :…… Enrollment No : ……

Date :…… Exam Seat No: ……..…….....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K'Scheme curricula for engineering diploma programs with National Education Policy 2020 (NEP2020) and outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a vehicle to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'K' scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age-old practice of conducting practical to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical.

Every practical in this manual begins by identifying the practical significance industry expected outcome competency, course level learning outcomes and laboratory learning outcomes which serves as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Thermal engineering is the one of the core engineering course for mechanical engineering students. Diploma mechanical engineers (also called technologists) have to work with various power producing and power absorbing devices like boilers, turbines, compressor, IC. Engines and refrigerators etc.

The course will enable students to establish foundation required to design, operate and maintain these devices. Thermal power plants are still contributing major share in electricity production in India. This course emphasizes on steam boilers and allied components that are used in many industrial sectors. Students will be able to calculate various parameters required to determine the performance of these devices.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Lab Manual Development Team

Programme Outcomes (POs) to be achieved through practical of this course

Following POs are expected to be achieved through the practical of the (Thermal Engineering) course.

PO1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the mechanical engineering problems.

PO 2. Problem analysis: Identify and analyze well-defined mechanical engineering problems using codified standard methods.

PO 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 in mechanical engineering.

PO 4. Engineering Tools, Experimentation and Testing: Apply modern mechanical engineering tools and appropriate technique to conduct standard tests and measurements.

PO 5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO 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.

PO 7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes in mechanical engineering.

List of Industry Relevant Skills

The following industry-relevant skills of the competency 'Use principles of thermal engineering to maintain thermal related equipment's' are expected to be developed in students by undertaking the practical of this laboratory manual.

1. Demonstrate the working of steam boilers, steam turbines, steam condensers, and heat exchangers as a leader/ team member.
2. Calculate/ measure different properties of the system using appropriate measuring instruments.
3. Identify different components of thermal engineering devices.
4. Identify different faults in the various thermal engineering devices.
5. Operate and maintain most of the thermal engineering devices.

Practical- Course Outcome matrix

Course Outcomes (COs)

CO1 - Apply fundamental concepts of thermodynamics to various thermodynamic systems.
CO2 - Determine various properties of steam using a steam table.
CO3 - Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers efficiently.
CO4 - Select proper heat exchanger for given application.
CO5 - Identify different components of an I.C. Engine.

Sr. No.	Laboratory Practical Titles	CO 1	CO 2	CO 3	CO 4	CO 5
1	*Use thermometer, pressure gauge, rotameter, energy meter to measure temperature, pressure, discharge, and energy	√	-	-	-	-
2	*Measurement of discharge of air using an air box.	-	√	-	-	-
3	*Trace the path of flue gases and water steam circuit with the help of a Fire Tube boiler - Cochran Boiler	-	-	√	-	-
4	*Trace the path of flue gases and water steam circuit with the help of Water Tube boiler - Babcock & Wilcox Boiler.	-	-	√	-	-
5	*Demonstration & working of Boiler Mountings (Any Two)	-	-	√	-	-
6	*Demonstration & working of Boiler Accessories (Any Two)	-	-	√	-	-
7	Demonstration & working of Impulse & Reaction steam turbine.	-	-	√	-	-
8	Demonstration & working of condensers a. Water-cooled condensers. b. Air-cooled condensers.	-	-	√	-	-
9	Observe simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers, and electrical generators.	-	-	√	-	-
10	Illustrate the methods of compounding used in steam turbines.	-	-	√	-	-
11	*Conduct a trial on conduction setup of metallic rod and calculate thermal conductivity.	-	-	-	√	-
12	Conduct a trial on Stefan Boltzmann setup and calculate Stefan Boltzmann constant.	-	-	-	√	-
13	Identify different equipment's in laboratory having heat exchangers and classify heat exchangers. Write construction and working of heat exchangers.	-	-	-	√	-
14	*Assembling and dismantling of single cylinder I.C Engine.	-	-	-	-	√
15	Identify different components of multicylinder I.C. Engine and write function of each component.	-	-	-	-	√

Guidelines to Teachers

1. A teacher needs to ensure that a dated log book for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to submit for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practical.
3. For difficult practical's if required, a teacher could provide a demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines
11. Experimental setups proposed are guidelines. Teacher can do better and give his valuable feedback to MSBTE on further improvements in lab manual.
12. Teachers shall use any suitable demo/open source simulation software available on internet to perform practical no. 9.

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a dated log book for the whole semester, apart from this laboratory manual which s/he has to submit for assessment to the teacher in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, student need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Technical Manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.
5. Students are expected to perform the experiments in group (as applicable) whereas calculations shall be made independently.

Content Page

List of Practical and Progressive Assessment Sheet

Sr.No	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA- PR marks (25)	Dated sign. of teacher	Remarks (if any)
1	*Use thermometer, pressure gauge, rotameter, energy meter to measure temperature, pressure, discharge and energy	01					
2	* Measurement of discharge of air using air box.	10					
3	*Trace the path of flue gases and water steam circuit with the help of Fire Tube boiler - Cochran Boiler	17					
4	*Trace the path of flue gases and water steam circuit with the help of Water Tube boiler - Babcock & Wilcox Boiler.	23					
5	*Demonstration & working of Boiler Mountings	29					
6	*Demonstration & working of Boiler Accessories	36					
7	Demonstration & working of Impulse & Reaction steam turbine.	44					
8	Demonstration & working of condensers a. Water-cooled condensers. b. Air-cooled condensers.	51					
9	Observe simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers, and electrical generators.	57					
10	Illustrate the methods of compounding used in steam turbines.	63					

Sr.No	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA- PR marks (25)	Dated sign. of teacher	Remarks (if any)
11	*Conduct a trial on conduction setup of metallic rod and calculate thermal conductivity.	72					
12	Conduct a trial on Stefan Boltzmann setup and calculate Stefan Boltzmann constant.	79					
13	Identify different equipment's in laboratory having heat exchangers and classify heat exchangers. Write construction and working of any 03 heat exchangers.	86					
14	*Assembling and dismantling of single cylinder I.C Engine.	94					
15	Identify different components of multicylinder I.C. Engine and write function of each component.	100					
	Total						

Note: To be transferred to Proforma of CIAAN-2023.

A suggestive list of LLOs is given in the above table. More such LLOs can be added to attain the COs and competency. A judicial mix of a minimum 12 or more practical's need to be performed, out of which, the practical's marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No:1 Use thermometer, pressure gauge, rotameter, energy meter to measure temperature, pressure, discharge, and energy.

I. Practical Significance

In various practicals of thermal engineering students need to measure the thermodynamic properties or parameters like temperature, pressure, discharge, and energy consumption. To perform these practical's students should able to handle as well as read the instruments like thermometer, pressure gauges, U tube manometer, flow meters and energy meter etc. Conversion of reading taken by these instruments in different units into SI unit is also necessary.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer -

- Able to take reading on various instruments like thermometer, pressure gauges, U tube manometer, flow meter and energy meter etc.
- Able to take care of above instruments.

III. Course Level Learning Outcome (CO)

CO1- Apply fundamental concepts of thermodynamics to various thermodynamic systems.

IV. Laboratory Learning Outcome(s)

Measure temperature, pressure, energy, discharge, using instruments such as contact type thermometer, U tube manometer, Rotameter, energy meter.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background

Temperature: Temperature is an intensive thermodynamic property, which determines the degree of hotness or the level of heat intensity of a body. The temperature of a body is measured by an instrument known as a thermometer. In different industrial applications, the temperature of the body or fluids is required to be measured by an appropriate temperature-measuring device to check, analyze, and control the systems. The temperature measurement is needed in furnaces, boilers, steam turbines, automobile sector in engines, refrigeration and air-conditioning systems, etc.

The most common units of temperature used today are Celsius, Fahrenheit, and Kelvin. The SI unit of temperature is the Kelvin.

Temperature in ^0C = (Temperature in ^0F - 32) × 5/9

Temperature in ^0K = (Temperature in ^0F – 32) × 5/9 + (273.15)

Temperature in ^0F = (Temperature in ^0C ×9/5) + 32

Pressure: Pressure measurement is the analysis of an applied force by a fluid on a surface. Pressure is typically measured in units of force per unit of surface area. Many techniques have been developed for the measurement of pressure. The instruments used to measure and display pressure in the integral unit are called pressure gauges. The pressure gauges are commonly used in pumps, turbines; Hydraulic/Pneumatic operated machines, etc. The SI unit for pressure is the Pascal (Pa), equal to one Newton per square meter (N/m^2).

The higher unit is kN/m^2 or kPa. Fluid pressure is measured in bar, $kg/cm^{2,}$ and pound per square inch. (PSI)

Flow Measurement: Flow measurement is the use of a flow meter to measure the volume or mass of fluid passing through a specific point over a given period. The volumetric flow of liquids and gases, generally represented by the symbol Q, is normally expressed in m^3/sec or liter/hour. Mass flow is expressed in kilograms per second (kg/sec) or kilograms per hour (kg/h).

Energy measurement: Electrical energy is defined as the product of electrical power and time, and it is measured in joules (J). One joule of electrical energy is equal to one watt of power consumed for one second. Mathematically, we can write:

Energy = Power x Time

1 Joule= 1-watt x 1 second

Watt-hour (Wh) is the amount of electrical energy consumed by a device or a system that draws one watt of power for one hour. It shows how fast the power is consumed over a period of time. One watt-hour is equivalent to 3,600 joules. For example, a 15 W LED light bulb consumes 15 Wh of electrical energy in one hour.

Kilowatt-hour (kWh) is a larger unit of electrical energy that is commonly used for household appliances and utility bills. One kilowatt-hour is equal to 1,000 watt-hours or 3.6 mega joules. For example, a refrigerator that draws 300 W of power consumes 300 Wh or 0.3 kWh of electrical energy in one hour.

VII. Experimental setup

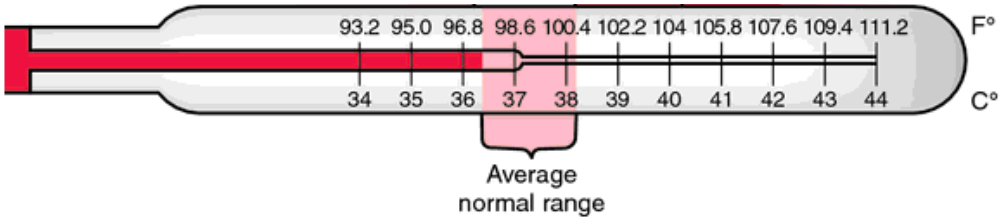


Fig 1.1 Thermometer

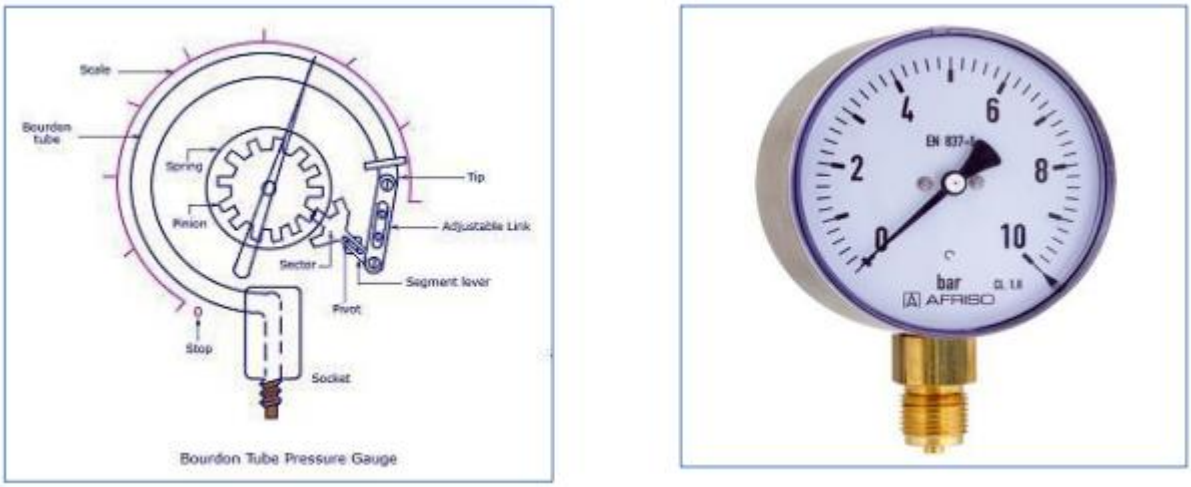


Fig.1.2 Bourdon Tube Pressure gauge
(Source: https://www.afriso.com/en/PM/Industrial-technology/Mechanical-pressure-measuring-instruments)

Figure 1.3 Single phase Energy Meter (Electronic)

Figure 1.4 Single phase Energy Meter (Mechanical)

Fig1.5 Vapor Compression Refrigeration System test rig for measurement of presssure, temperature and flow of refrigerent.

Fig 1.6 Reciprocating compressor test rig for measurement of presssure, temperature and flow of air.

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Parameters	Suggested Broad Specification	Quantity
1	Thermometers	0-1100 C	02
2	Pressure gauges	0-10 (Kg/ cm²) / bar or 0-200 PSI	02
3	Energy meter	Single-phase energy meter	02
4	Reciprocating Air Compressor Test Rig	Working model of reciprocating air compressor showing bourdon pressure gauge (Range 0-12 Kg/cm²)/bar) at various locations.	01
5	Vapor Compression Refrigeration System test rig	Working model of vapor compression refrigeration system showing bourdon pressure gauge (Range 0-12 Kg/cm²)/bar) on the high-pressure and low-pressure side and a water calorimeter to measure the temperature of water.	01

IX. Precautions to be Followed

- Avoid improper handling of all instruments.
- Handle the mercury thermometer with due care.
- Use safety shoes.
- Use tools safely.

X. Procedure

1. Explain the working principle of a thermometer, bourdon pressure gauge, energy meter, etc.
2. Explain the functions of each component of a thermometer, bourdon pressure gauge and energy meter, etc.
3. Explain the various scales marked on a thermometer, bourdon pressure gauge and energy meter, etc.
4. Select any one experimental setup as mentioned in the above table in which all parameters like temperature, pressure, and electrical energy consumption can be measured.
5. Take readings with thermometer, and bourdon tube pressure gauge mounted at various locations on set up.
6. For energy meter take reading on energy meter provided on reciprocating air compressor test rig for compressor input or compressor/ heater input in VCR test.
7. Set the last decimal reading (red digits) of the energy meter at any convenient round digit.
8. Start the air compressor, heater/ compressor in the VCR test rig
9. Run air compressor, heater/ VCR compressor till the reading in last (red decimal) changes to next round digit.
10. Record the difference in kWh (fractional) and the total time required in seconds in the given observation table.
11. Write the readings in the observation tables provided for various instruments/equipment.

XI. Observations and calculations

Observations -

Temperature measurement

Sr. No	Source	Temperature		
		^{0}C	^{0}F	^{0}K
1	Water			
2	Chilled water			
3	Hot water			
4	Room/ ambient air			

Pressure measurement

Sr. No	Parameters	Pressure		
		Kg/cm^2	Bar	PSI
1	Suction pressure of refrigerant in VCR test rig			
2	Discharge pressure of refrigerant in VCR test rig			
3	H.P. cylinder pressure in air compressor			
4	Pressure of air in compressor receiver.			

Energy measurement

Sr.No.	Parameter	Time	Initial Reading Kwh	Initial Reading Kwh	Difference	Energy KJ
1	Energy consumption at compressor input for Reciprocating air compressor.					
2	Compressor/Heater input in VCR test rig					

(Note - *Students can select any other suitable source for measurement of temperature, pressure, and energy requirement and write in the above tables)

Calculations –

Temperature measurement

Temperature in ^0C = …….
Temperature in ^0K = Temperature in ^0C + 273 = …….
Temperature in ^0F = (Temperature in ^0C ×9/5) + 32 = ……

Pressure measurement

Pressure in Kg/cm^2 = …….
Pressure in Bar = Pressure in Kg/cm^2 ×0.980 = ……
Pressure in PSI = Pressure in Kg/cm^2 × 14.223 = …….

Energy measurement

Initial reading in energy meter, E_1 = ---------- kWh
Final reading in energy meter, E_2 = ---------- kWh
Total time taken = ---------- second.

Net energy consumed (kWh)= $(E1–E_2)$ (kW) × time (h)

= $(E_1–E_2)$ × 1000 Joule/sec × time (sec)

= ----------J/sec × …….sec

= ----------J

Net energy consumed (kWh) = ----------KJ

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. List the different types of temperature-measuring instruments used in industries.
2. Collect specifications of different temperature measuring devices used in different applications.
3. Collect specifications of the bourdon pressure gauge used in different applications.
4. Explain the construction and working of the Bourdon pressure gauge with a neat sketch.
5. List the different applications where bourdon pressure gauges are used.
6. List the different types of pressure-measuring instruments used in industries.

[Space for Answer]

XVI. References / Suggestions for Further Reading

- Mercury Thermometer: Principle, Construction, and Calibration https://youtu.be/-UIZh60VajE?si=MWzyjw7SPP3YPsj6
- Pressure Measurementshttps://youtu.be/GBkWDClKPiA?si=KUKataStgIthKRPE
- Measurement of energy using single phase energy meter connection, https://youtu.be/BErVoBvZExg?si=YJUjNDNz3_m1MgI0

XVII Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Handling of the measuring Instruments	20%
2	Taking readings of required parameters	20%
3	Calculation of final readings	20%
	Product Related (10 Marks)	**(40%)**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	20%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No:2 Measurement of discharge of air using an air box

I. Practical Significance

Many industries require precise measurement and control of airflow rates for efficient operation of equipment and processes. Students will have to perform tests of reciprocating air compressors, and IC engines, and measurement of convective heat transfer coefficient. In all these cases calculation of the airflow rate at the inlet of these devices is important. Students shall be able to calculate this flow rate which is expressed in m^3/s.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer -
'Able to evaluate the performance of industrial mechanical systems such as air compressors, IC engines, etc.'

III. Course Level Learning Outcome (CO)

CO2 - Determine various properties of steam using a steam table.

IV. Laboratory Learning Outcome(s)

- Measure parameters required to determine the air flow rate.
- Calculate the actual volume of air at the suction of the reciprocating air compressor

V. Relative Affective Domain-related Outcome(s)-

- Demonstrate working as a leader/ team member.
- Maintain tools and equipment.
- Follow ethical Practices.
- Practice good housekeeping.

VI. Minimum Theoretical Background with diagram

The equation of state is a fundamental concept in thermodynamics and fluid mechanics that relates the state variables of a substance under various conditions of temperature, pressure, and volume. Equation of state can be used to calculate the density of air. This indicates the relation between the ideal gas's pressure, volume, and temperature. Air can be approximated to perfect gas. This equation can be used in air compressors, and IC engines to calculate air volume flow rate at the inlet of these devices. In this first law, a steady-state energy equation is applied across the orifice through which air flows. Students gain proficiency in using instruments like the air box, anemometer, orifice plate, and manometers. These skills are crucial for engineers involved in testing, calibration, and maintenance of flow measurement equipment.

VII. Experimental setup

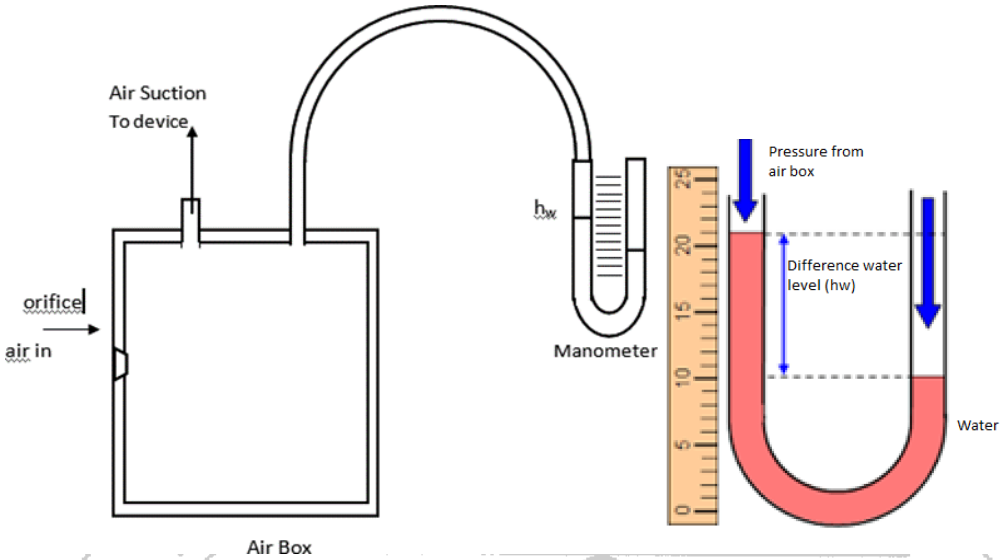


Fig 2.1 Air for measurement of airflow rate

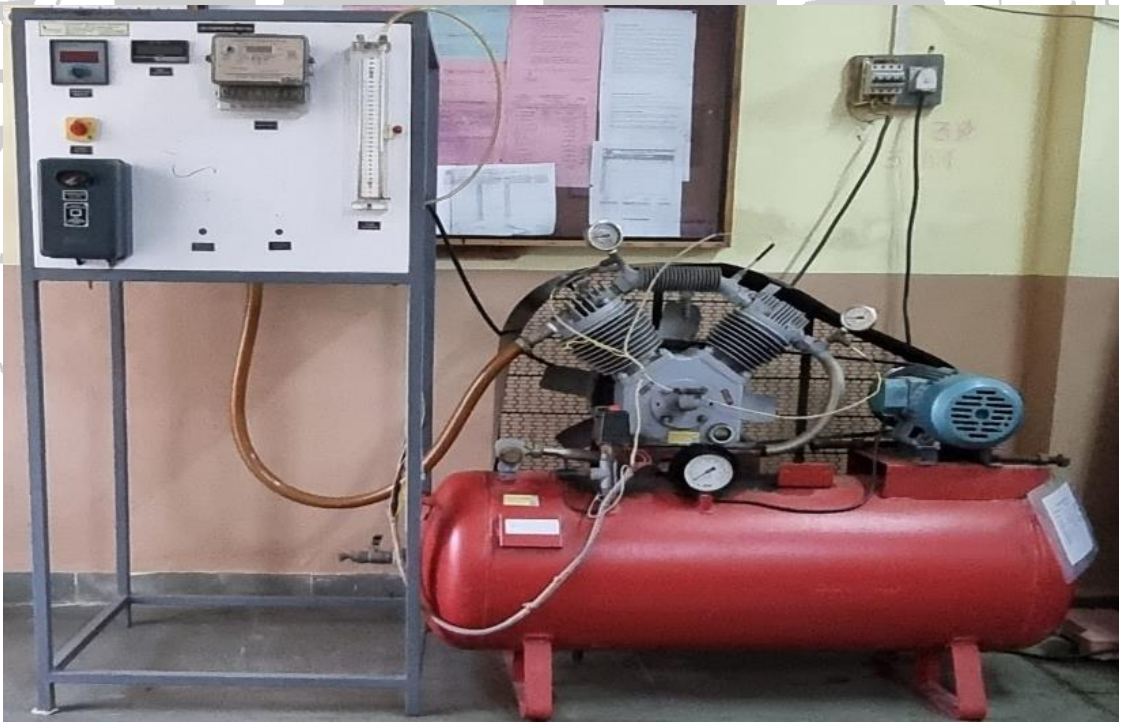


Figure 2.2 Reciprocating air compressor test rig

VIII. Required Resources /Apparatus/Equipment with specification

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Reciprocating air compressor test rig	Pressure gauge range from 0 to 10 bar, Water Manometer U shaped glass tube, Orifice plate diameter 6 to 30 mm, Air box, speed up to 650 rpm.	01

IX. Precautions to be Followed

- Avoid improper handling of two stage air compressor.
- Stay away from rotating components.
- Check oil level and air leaks in compressor before it is started.

X Procedure

1. Fill the manometer with water up to half level.
2. Keep the delivery valve and manometer cock on the suction line in closed position.
3. Start the compressor and open the manometer cock. Then, let the air pressure build up in the tank.
4. Run it till tank pressure becomes 2 bar.
5. Maintain the pressure of air inside the tank constant, by adjusting the delivery valve.
6. Open air delivery valve so that tank pressure will not rise further.
7. Take manometer reading.
8. Measure the intake air temperature (T_1) at the suction of the LP cylinder.
9. Calculate air flow rate in m^3/s.
10. Repeat the same procedure by increasing pressure by 2 bar in each step.

XI Observations and calculations

Observation Table –

Sr.No	Pressure in tank	h_1	h_2	$h_w = h_1 - h_2$
1	2 bar			
2	4 bar			
3	6 bar			
4	8 bar			

Calculations –

1. **Density of air**

Using the characteristic gas equation,

$P_1 \times V_1 = m_a \times R_a \times T_1$.

Where, m_a = mass of air, R_a = Characteristic gas constant = 287 J/kg

T_1 = Temperature of air at the inlet of compressor in ^0K

i.e $m_a = P_1 x V_1 / (R_a x T_1)$

Now density of air

$\rho_a = m_a / V_1 = [P_1 x V_1 / (R_a x T_1)] / V_1$ ..... where P1 is absolute pressure in N/m^2.

$\rho_a = [P_1 / (R_a x T_1)]$

= ……..

ρ_a =……. kg/m^3

2. **Water manometric head**

hw= $h_1 – h_2$= .....

hw =..... mm of water

hw = …….m of water

3. **Air ahead causing the flow of air**

ha = hw x ρ_w / ρ_a Where, ρ_w = Density of water = 1000 kg/m^3

h_a=(.....x 1000) / (.....)

h_a = ……..m of air

4. **Actual volume of free air delivered**

Va.= C_d x a x $\sqrt{2gha}$ m^3/sec

Where, C_d = Coefficient of discharge

a = Area of orifice = $(\pi/4) \times d^2$ = ……m^2

g = Gravitational constant = 9.81 m/s^2

ha = Air ahead causing the flow of air in m of air.

Va.= C_d x a x $\sqrt{2gha}$ m^3/sec

Va = …….m^3/s

XII. Results

Sr.No	Pressure in tank	Actual volume of free air delivered m^3/s
1	2 bar	
2	4 bar	
3	6 bar	
4	8 bar	

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Which types of instruments are typically used in an air box setup to measure air discharge accurately?
2. List the factors that affect the accuracy of air discharge measurements using an air box.
3. Write an equation of state and state meaning of all terms involved with their units.
4. If the pressure of the atmosphere changes what will be an effect on the volume flow rate of air at the inlet of the compressor?

[Space for Answer]

XVI References / Suggestions for Further Reading

- https://youtu.be/oizDyOJQu4g?si=oUgBq0rIlsnGa1jH
- Measurement of discharge of air using air box with reciprocating air compressor, https://youtu.be/UADNxsgQo_Y?si=GCniByFNmvtJeHh4.
- http://www.em-ea.org/guide%20books/book3/chapter%203.3%20compressed%20air%20system.pdf.

XVII Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the measuring Instruments	20%
2	Taking readings of required parameters	20%
3	Calculation of final readings	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of result	10%
5	Conclusions	10%
6	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 03 Trace the path of flue gases and water steam circuit with the help of Fire Tube boiler - Cochran Boiler.

I. Practical Significance

The Fire Tube Boiler is well suited for low and medium Industries that require steam or high-temperature water, such as textile industries, due to its low-pressure uses. In a few sectors, raising the temperature of the water or oil is required rather than turning the water into steam. To operate boilers, locating the path of steam and gases is necessary. Learning about Cochran boilers helps students grasp the principles of steam generation, including factors like combustion, heat transfer, and boiler efficiency.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer –
'To operate and maintain industrial fire tube boilers effectively and efficiently'.

III. Course Level Learning Outcome (s)

CO 3- Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Identify various components of the fire tube boiler
- Show the path of flue gases and water steam circuit

V. Relative Affective Domain-related Outcome(s)

- Demonstrate working as a leader/a team member
- Follow safety practices
- Understand the environmental impact of steam boilers.
- Follow ethical Practices.

VI. Relevant Theoretical Background

The Cochran boiler is a vertical, multi-tube boiler generally used for small-capacity steam generation. It is popularly known as a simple vertical boiler because of its small footprint and relatively simple design. Cochran boilers are made in different evaporative capacities, ranging from 150 to 3000 kg/hr., and working pressure up to 15 bar. The efficiency of the Cochran Boiler ranges from 70% to 75%. There is an external hemispherical cylindrical shell and a firebox in the boiler. Multiple fire tubes run through the boiler from the furnace, connecting the front and rear tube plates. Fuel (typically coal, wood, or oil) is burned in the furnace, producing hot gases. these hot gases pass through the fire tubes, heating the surrounding water in the shell. Steam is generated in the space between the shell and the fire tubes. Cochran boilers are used in industries such as textiles, food processing, chemical, and pharmaceutical industries where moderate steam pressures are sufficient for process heating and power generation.

VII. Experimental setup

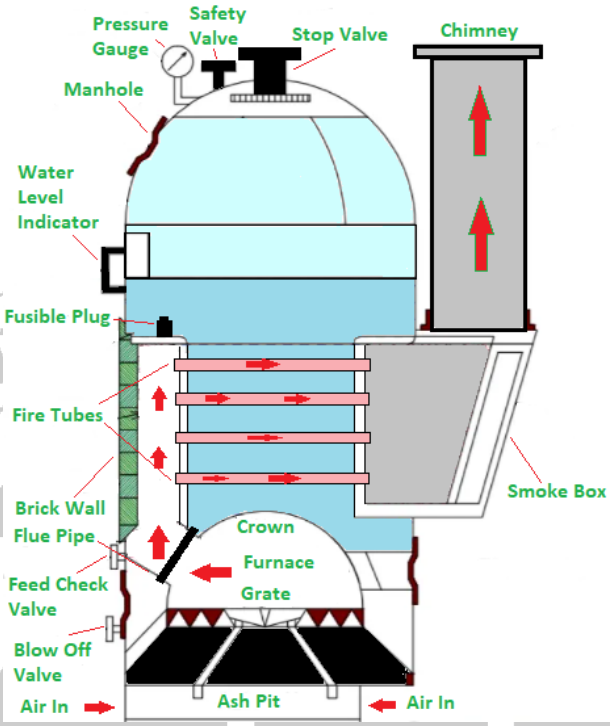


Fig 3.1 Cochran Boiler
(Source: https://mechanicalbasics.com/cochran-boiler-construction-working-advantages/)

Fig 3.2 Cut section model of Cochran Boiler

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Cochran Boiler	Cut section Model/Chart of Cochran boiler showing all important components and path of flue gases and water steam circuit	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of boiler Models.
- Use safety shoes.

X. Procedure

1. Select the Cochran boiler model for demonstration.
2. Observe the boiler model selected for study purpose.
3. Explain the working principle of a fire tube boiler.
4. Identify the main components of a selected Cochran boiler.
5. Observe the location of each component.
6. State the functions of each component of the Cochran boiler
7. Trace the path of flue gases and water/ steam circuits.
8. Explain the construction and working of the Cochran boiler using a model.

XI. Observation and calculations

Draw the labeled diagram of the Cochran boiler showing the path of flue gas and water /steam circuit.

Name of the boiler	Name of component	Function
Cochran Boiler	Shell	
	Furnace	
	Grate	
	Combustion Chamber	
	Fire Tubes	
	Smokebox	
	Chimney	

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. List any four names of fire tube boilers.
2. Write typical specifications any fire tube boiler.
3. Illustrate the meaning of internally fired boilers and list the names of internally fired boilers.
4. State the difference between an internally fired and externally fired boiler.
5. State the applications of fire tube boilers.
6. Explain why a fire tube is not used in high-pressure applications.
7. Collect the information on packaged-type boilers.

[Space for Answer]

XVI. References / Suggestions for Further Reading

- https://youtu.be/AMBbxlAXd2A?si=sD2GnDe_bNHFOFbu
- https://youtu.be/7Pp8cFjo5CQ?si=FztIc9mhqUM-EHkt
- https://youtu.be/493LPdMF1dE?si=bBx0poHrOsvY0x2J

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
	Product Related (15 Marks)	**(40%)**
3	Interpretation of different components of a Cochran boiler	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 04 Trace the path of flue gases and water steam circuit with the help of Water Tube boiler - Babcock & Wilcox Boiler

I. Practical Significance

Water tube boilers are typically larger and can handle higher pressure and temperatures than fire tube boilers. They also have a higher thermal efficiency, which means they can convert a larger amount of fuel into useful energy. Water tube boilers are widely used in various industries such as power generation, chemical processing, ships, and manufacturing. Understanding their operation, maintenance, and design principles prepares students for careers in these fields. To operate boilers, it is necessary to locate and understand the path of flue gases and water-steam circuits.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer - 'To operate and maintain industrial water tube boilers effectively and efficiently'.

III. Course Level Learning Outcome (s)

CO 3- Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Identify various components of the water tube boiler.
- Show the path of flue gases and water steam circuit.

V. Relative Affective Domain-related Outcome(s)

- Demonstrate working as a leader/a team member
- Follow safety practices
- Understand the environmental impact of steam boilers.
- Follow ethical Practices.

VI. Relevant Theoretical Background

The Babcock and Wilcox boiler is a water tube boiler. It is one of the most widely used boilers in power plants and industrial facilities due to its reliability, efficiency, and ability to handle a wide range of fuels. In this type of boiler, water is circulated inside the tubes and hot gases flow over the tubes. It is a Horizontal drum axis, natural draft, natural circulation, multi tubular, stationary, solid fuel, and externally fired water tube boiler. Inside the boiler shell, numerous water tubes are arranged in a symmetrical pattern. These tubes connect the water drum at the bottom with the steam drum at the top. The arrangement of water tubes ensures efficient heat transfer and water circulation. All tubes are tilted with a concrete wall which usually presents the upper side of furnaces and is also attached to a steam drum. On the steam drum safety valve, manhole, and superheater system are present. Steam Flow Pipe is attached to the superheater. The design provides efficient heat transfer, good water circulation, and easy maintenance, making it suitable for a wide range of industrial applications.

VII. Experimental setup

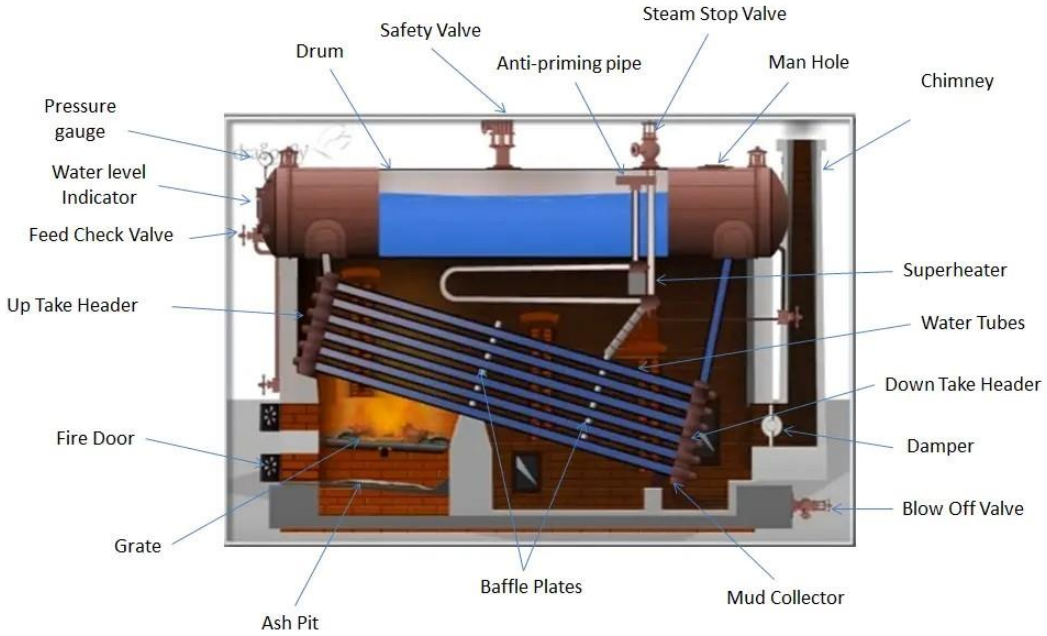


Fig 4.1: Babcock and Wilcox Boiler
(Source: https://www.mechanicalbooster.com/2017/01/babcock-and-wilcox-boiler)

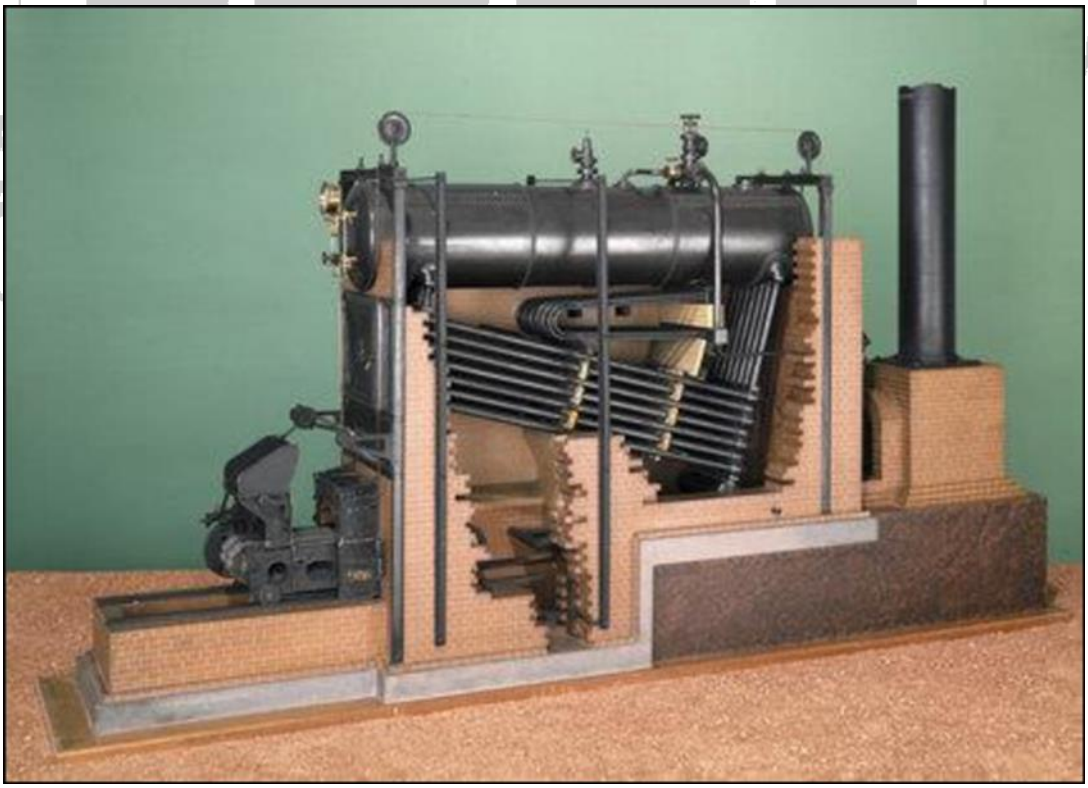


Fig 4.2: Cut section model of Babcock and Wilcox Boiler

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Babcock and Wilcox Boiler	Cut section Model/Chart of Babcock and Wilcox boiler showing all important components and path of flue gases and water steam circuit	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of boiler Models.
- Use safety shoes.

X. Procedure

1. Select the Babcock and Wilcox boiler model for demonstration.
2. Observe the boiler model selected for study purpose.
3. Explain the working principle of a water tube boiler.
4. Identify the main components of a selected boiler.
5. Observe the location of each component.
6. State the functions of each component of the selected boiler.
7. Trace the path of flue gases and water/ steam circuits.
8. Explain the construction and working of the Babcock and Wilcox boiler using a model.

XI. Observation and calculations

Draw the labeled diagram of the Babcock and Wilcox boiler showing the path of flue gas and water /steam circuit.

Name of the boiler	Name of component	Function
Babcock and Wilcox Boiler	Drum	
	Fire door	
	Grate	
	Upper take header	
	Down take header	
	Water tubes	
	Chimney	

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Classify the boilers.
2. List any four names of water tube boilers.
3. Write typical specifications for Babcock and Wilcox boiler.
4. Compare the water tube and fire tube boiler.
5. State the applications of water tube boilers.
6. Explain high-pressure boilers? List any two high-pressure boilers.

[Space for Answer]

XVI. References/Suggestions for further reading

- www.youtube.com/watch?v=Xp7ZNAc9Fis
- www.youtube.com/watch?v=0DdzZLkQL98
- www.youtube.com/watch?v=xaxGZZR2lsc

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (10 Marks)		**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
Product Related (15 Marks)		**(40%)**
3	Interpretation of different components of a Babcock and Wilcox boiler	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 05 Demonstration and working of Boiler Mountings

I. Practical Significance

Boiler mountings are compulsory parts of a boiler as per Indian Boiler Act, 1923. Boilers cannot function without mountings. The safe operation of boilers depends on the use of mountings. There are two types of mountings viz. control mountings and safety mountings. Knowledge of boiler mountings enables students to optimize boiler performance by monitoring and controlling parameters such as pressure, water level, and temperature. This understanding contributes to efficient energy usage and operational cost savings in industrial processes.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer -

- Explain the working of different mountings of the steam boiler.
- State functions of each mounting of the steam boiler.
- Able to read/adjust/operate boiler mountings while working on boilers.

III. Course Level Learning Outcome (s)

CO 3- Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Identify various components of Boiler mounting.
- Show the path of flue gases and water steam circuit

V. Relative Affective Domain-related Outcome(s)

- Maintain tools and equipment.
- Follow ethical Practices.

VI. Relevant Theoretical Background

Boiler mountings are crucial components installed on a boiler to ensure its safe and efficient operation. These mountings are typically fitted directly onto the boiler shell or drum and play important roles in controlling various aspects of the boiler's operation, monitoring its performance, and ensuring safety. Different mountings of boilers mainly include safety mountings like a safety valve, water level indicator, fusible plug, pressure gauge, and control mountings like a feed check valve, steam stop valve, and blow-off cock. Maintenance of these boiler mountings is important for safe working of boilers. These boiler mountings are essential for the safe, efficient, and reliable operation of boilers in industrial settings. They work together to monitor and control various parameters such as steam pressure, water level, and feed water flow, while also providing crucial safety mechanisms to protect against overpressure and other potential hazards.

VII. Experimental setup

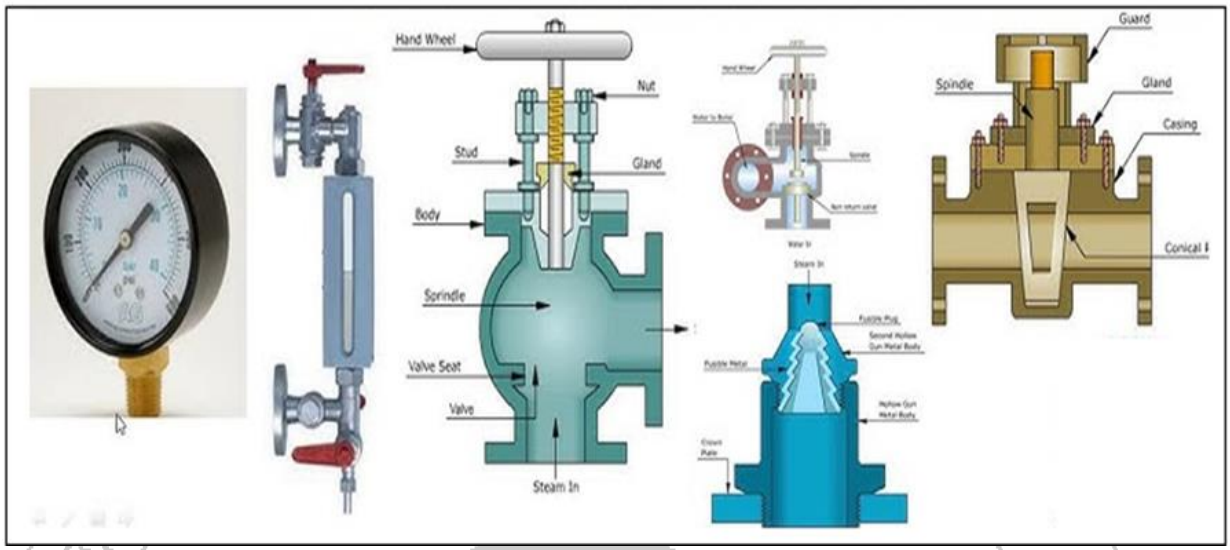


Fig 5.1: Boiler Mountings

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Safety Valve	Model/Chart of any one type of safety valve showing all important parts	01
2	Steam Stop Valve	Model/Chart of any one type of steam stop valve showing all important parts	01

(Note – Teacher can use any two mountings available in a laboratory)

IX. Precautions to be followed (Safety instructions / Rules / Standards)

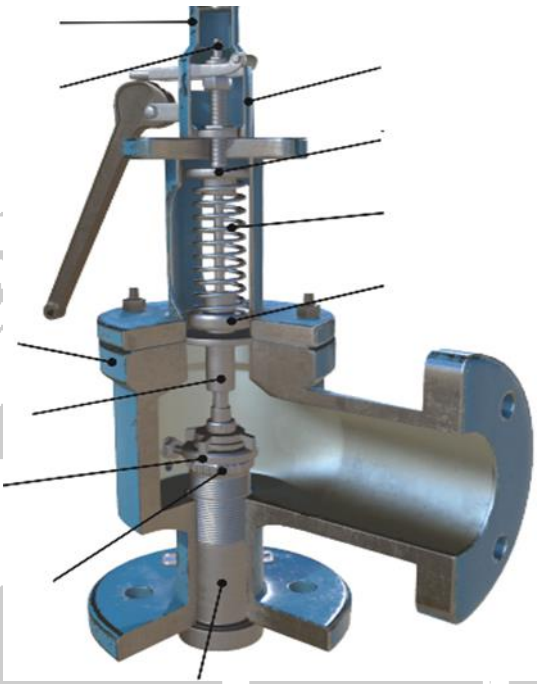
- Avoid improper handling of boiler mounting Models.
- Use safety shoes.

X. Procedure

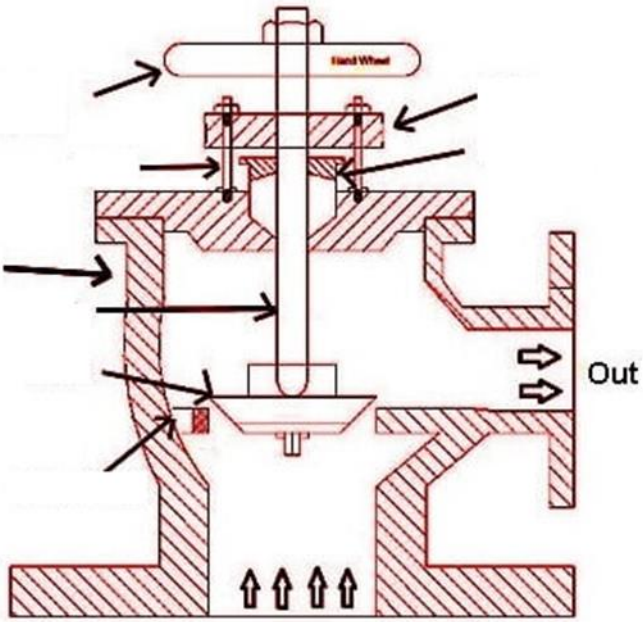
1. Select boiler mountings available for demonstration.
2. Locate the selected mounting on the boiler model.
3. Observe the selected mounting thoroughly.
4. Write the function of the mounting in the given table.
5. List the parts and state the function of each part in the given table.
6. Explain the working of a selected mounting

XI. Observation and calculations

(Note-Draw the sketch of the actual mounting /model of mounting of the boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below.)



Name of Mounting: ----------



Name of Mounting: ----------

Sr. No	Name of Mounting	Name of sub-component	Function of sub-component
1	Safety Valve		
2	Steam Stop Valve		
3			
4			

(*Student can select any other mounting other than given in the above observation table)

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain the importance of safety valves in a boiler. How do safety valves prevent boiler explosions?
2. State the importance of the water level indicator in a boiler.
3. State the function of a fusible plug in a boiler.
4. List different boiler mountings and state functions of each mounting.
5. Which type of safety valve is used in high-pressure and low-pressure boilers?
6. Draw the neat labeled sketch of the fusible plug.
7. State the importance of a feed check valve in a boiler feed water system.
8. State the function of a bottom blowdown valve in a boiler? How does it help in maintaining boiler water quality?
9. Collect information on digital pressure gauges and water/ steam flow meters (control mountings) used in modern high-pressure boilers.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=whv4Nt4Y4AY
- https://www.youtube.com/watch?v=dLe36eyO1mk
- https://www.youtube.com/watch?v=eJRI1uue_lQ
- https://www.youtube.com/watch?v=dx-72VVv3m4
- http://www.spiraxsarco.com/Resources/Pages/Stearn-Engineering-Tutorials/the-boiler house/boiler-fittings-and-mountings.aspx
- http://www.brighthubengineering.com/marine-engines-machinery/73157-inspection-of-boiler-mountings/
- https://www.youtube.com/watch?v=yi7gJuwLGYk (Safety valve assembly)

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
Product Related (10 Marks)		**(40%)**
3	Interpretation of different components of a Mountings	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 06 Demonstration and working of Boiler Accessories

I. Practical Significance

Boiler accessories like economizers, air preheaters, and superheaters improve boiler systems' overall efficiency by recovering waste heat or optimizing fuel consumption. Students must learn how these accessories impact energy efficiency, environmental sustainability, and operational costs of industrial processes. Boiler accessories are components installed inside or outside the boiler to increase efficiency and proper operation. They are not necessary for boilers to function. However, energy conservation is an important aspect of any thermal engineering system. Accessories improve the performance of boilers or allied thermal systems.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- Explain the working of different accessories of steam boilers.
- State functions of each accessories of the steam boiler.
- Able to operate/maintain boiler accessories while working on boilers.

III. Course Level Learning Outcome (s)

CO-3 Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Identify various components of boiler accessories.
- Show the path of flue gases and water steam circuit.

V. Relative Affective Domain-related Outcome(s)

- Maintain tools and equipment.
- Follow ethical Practices.

VI. Relevant Theoretical Background

Boiler accessories are those components that are installed either inside or outside the boiler to increase the efficiency of the plant and to help in the proper working of the plant. These accessories are designed to enhance the performance of boilers and ensure their safe and efficient operation. some common boiler accessories are a superheater, economizer, air preheater, feed water pump, etc. Boiler accessories like air pre-heaters and economizers are heat recovery units and extract heat from flue gases from the boiler. A superheater is employed for increasing work output from available steam as well as take-off possible condensation in the steam turbine thereby avoiding erosion and corrosion of turbine blades. The primary function of a superheater is to enhance the thermal efficiency of a boiler system by raising the temperature of steam. This process ensures that the steam leaving the boiler is dry and superheated, which is beneficial for various industrial applications. Feedwater

pumps are responsible for supplying water to the boiler. They ensure a continuous flow of water into the boiler to replace steam that has been released.

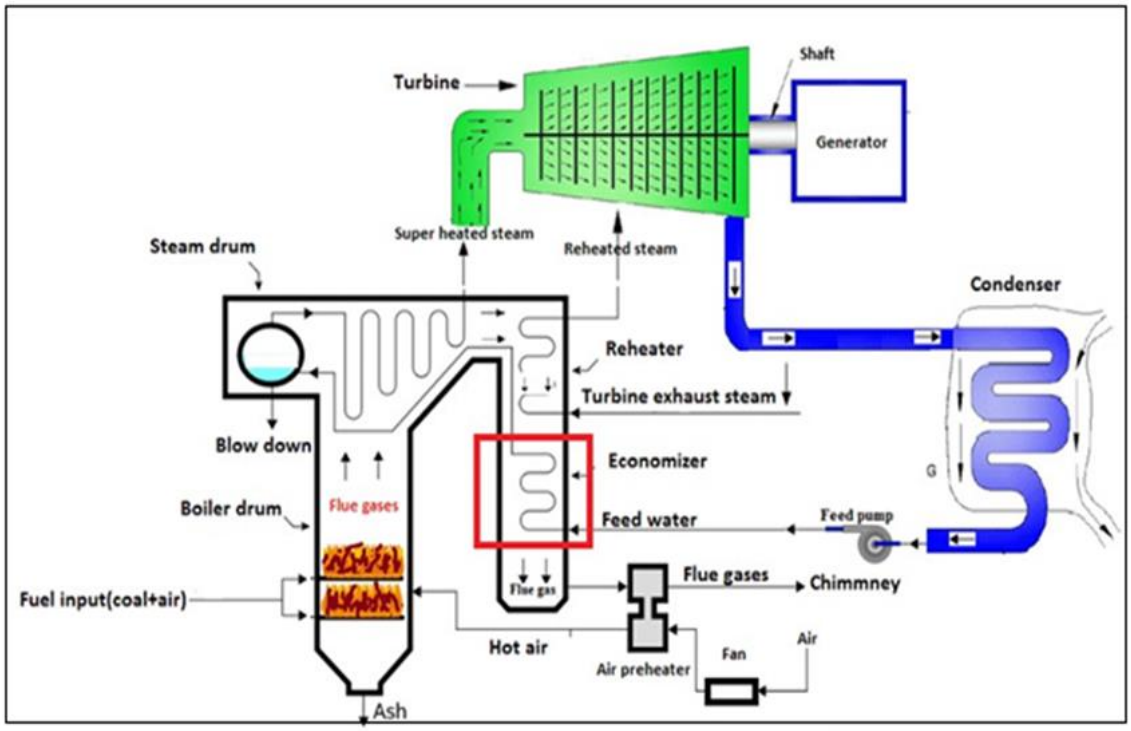


Fig 6.1: Layout of Thermal Power Plant showing locations of boiler accessories.
(Source: https://www.researchgate.net/figure/Economizer-in-a-coal-fired-Boiler-adapted-from-7-Fig-1-shows-the-location-of_fig1_318289043)

VII. Experimental setup

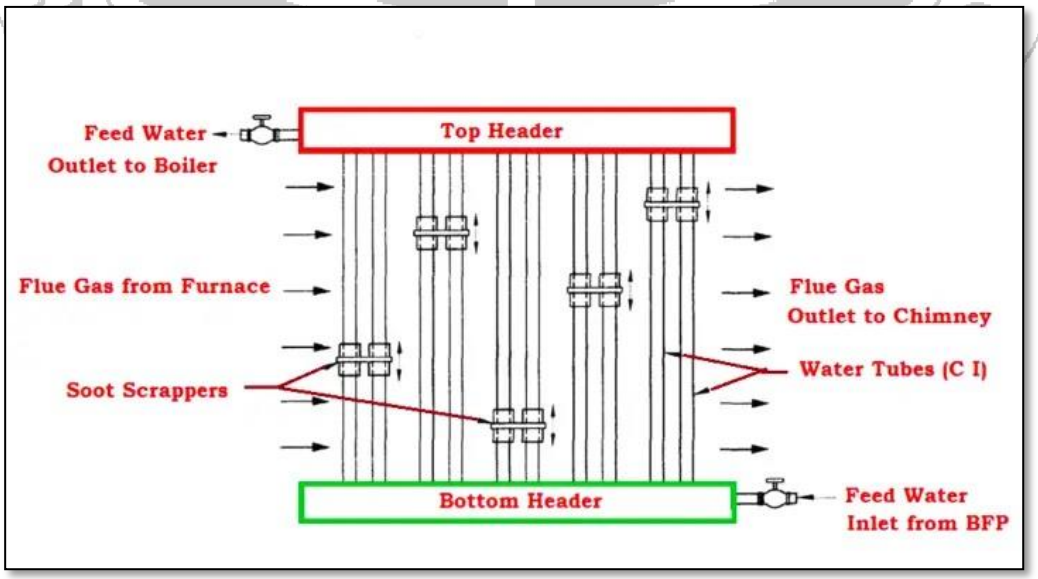


Fig 6.2: Economizer
(Source: https://instrumentationtools.com/economizer)

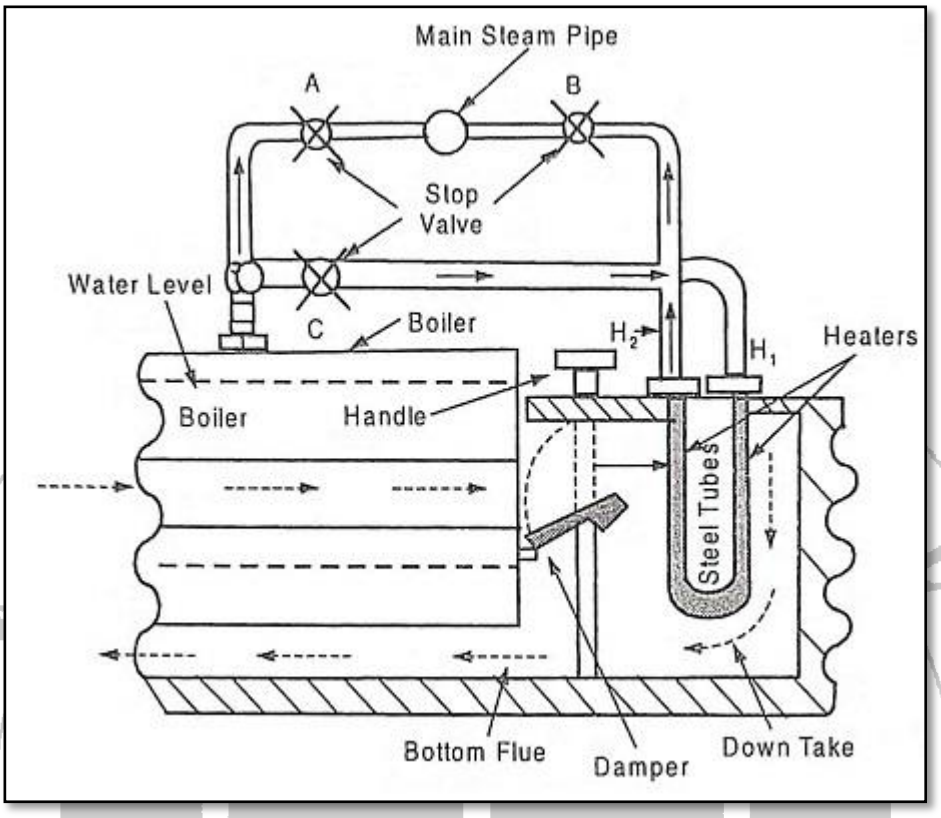


Fig 6.3: Superheater
(Source: https://www.eeeguide.com/subsystems-of-thermal-power-plant)

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Economizer	Model/Chart showing all important parts	01
2	Superheater	Model/Chart showing all important parts	01

(Note – Teacher can use any two models/charts of accessories available in a laboratory)

IX. Precautions to be followed (Safety instructions / Rules / Standards)

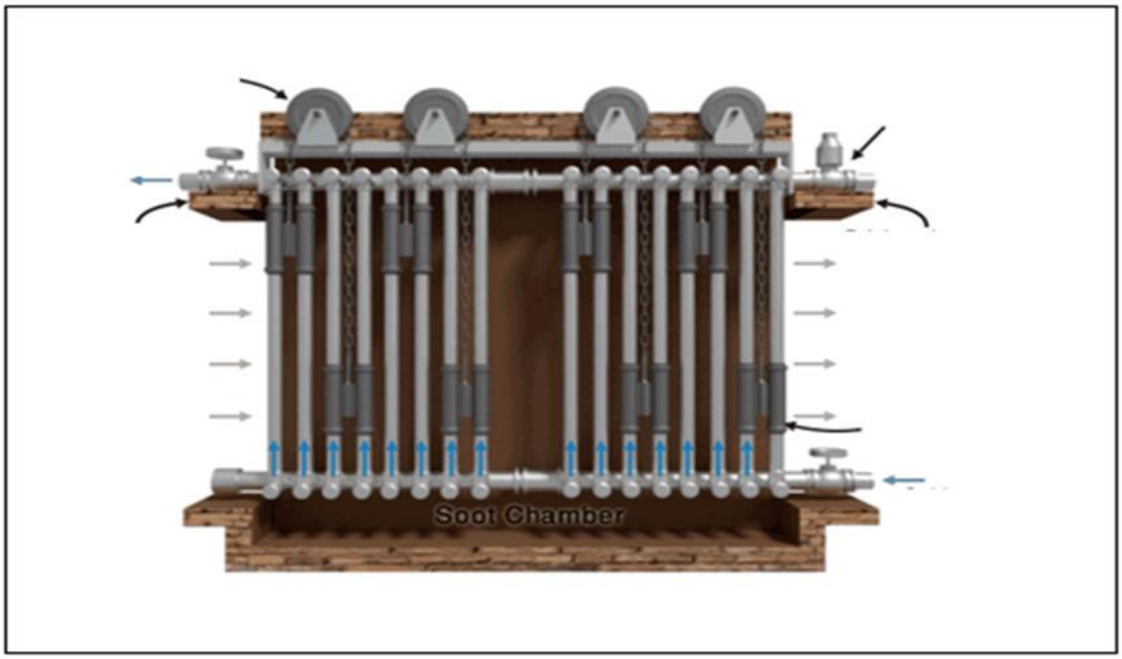
- Avoid improper handling of boiler accessories models**.**
- Use safety shoes.

X. Procedure

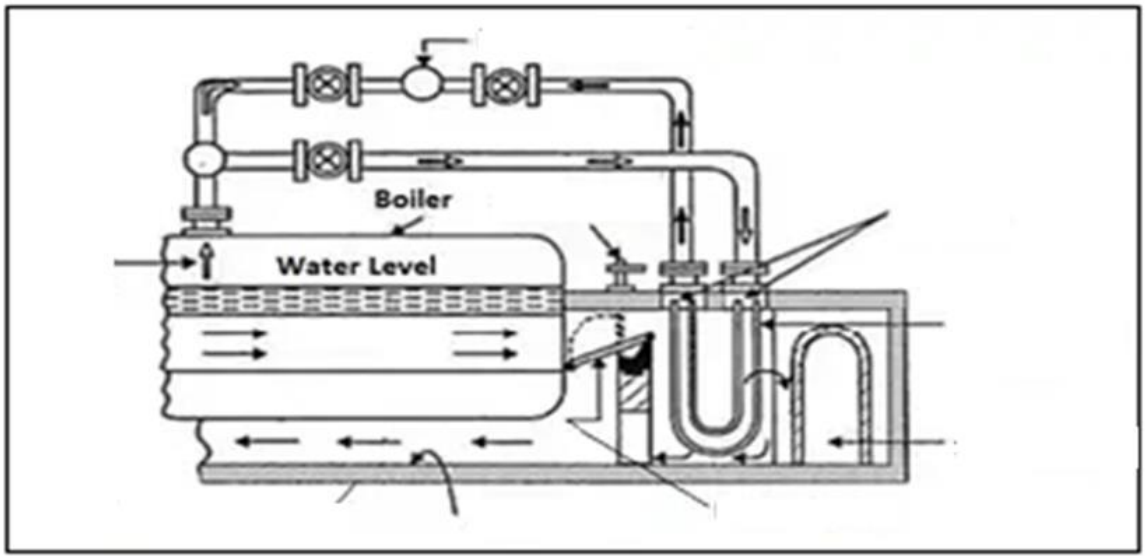
1. Select boiler accessories available for demonstration.
2. Locate the selected accessories on the boiler model.
3. Observe the selected accessories thoroughly.
4. Write the function of the accessories in the given table.
5. List the parts and state the function of each part in the given table.
6. Explain the working of selected accessories.

XI. Observation and calculations

(Note-Draw the sketch of the actual mounting /model of mounting of the boiler available in your laboratory and label the components. In case components are not visible redraw and label the figure given below.)



Name of accessory: ----------



Name of accessory: ----------

Sr. No	Name of Accessory	Name of sub-component	Function of sub-component
1	Economizer		
2	Superheater		
3			
4			

(*Student can select any other accessory other than given in the above observation table)

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain how an economizer works to improve the efficiency of a boiler system.
2. List the typical applications where economizers are most effective in industrial settings.
3. State the different types of superheaters used in boiler systems and their respective advantages.
4. Illustrate the use of de-superheater in super-heater.
5. Explain the effect of the placement of a superheater within the boiler system on its efficiency and performance.
6. State the purpose of an air preheater in a boiler system.
7. List the non-condensing type economizers.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=whv4Nt4Y4AY
- https://www.youtube.com/watch?v=dLe36eyO1mk&t=30s
- https://www.youtube.com/watch?v=iZVqB_7f1Lc
- https://www.youtube.com/watch?v=y4anGmVTd-M
- http://www.brighthubengineering.com/marine-engines-machinery/74949 inspection-carried-out-in-boiler-superheater-and-in-steam-drum
- https://www.icicaldaie.com/en/news/the-complete-guide-for-the-maintenance-of-your-steam-boiler/

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
Product Related (10 Marks)		**(40%)**
3	Interpretation of different components of boiler accessories	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 07 Demonstration & working of Impulse &Reaction steam turbine

I. Practical Significance

Steam turbines are widely used in power plants to generate electricity. They convert thermal energy from steam into mechanical energy, which drives generators to produce electricity. Steam turbines are important devices in the field of thermal engineering. Many industries rely on steam turbines for various applications beyond power generation, such as driving pumps, compressors, and other machinery. Understanding how steam turbines work prepares students for roles in industries like oil refining, chemical processing, and manufacturing.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- To operate and maintain steam turbines and axillary devices.
- State functions of each component of a Steam turbine

III. Course Level Learning Outcome (s)

CO3 - Use suitable strategies to maintain the steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Select turbine model for demonstration.
- Demonstrate the construction and working

V. Relative Affective Domain-related Outcome(s)

- Maintain tools and equipment.
- Follow ethical Practices.

VI. Relevant Theoretical Background

Steam turbines are mechanical devices that convert thermal energy in pressurized steam into mechanical work. They are critical components in many power generation plants and industrial processes where large amounts of mechanical power are required. Steam turbines operate on the principle of Newton's third law of motion, where steam under high pressure is directed against a series of blades mounted on a shaft. The force of the steam causes the shaft to rotate, and this rotational energy is used to drive generators, pumps, compressors, or other machinery. Mainly they are categorized into two types i.e. Impulse turbines and Reaction turbines.

Principle of Impulse Turbine: An impulse turbine is a type of steam turbine that operates based on the principle of converting the kinetic energy of a high-velocity steam jet into mechanical energy. It has nozzles and moving blades. The nozzles are convergent-divergent type while moving blades are symmetrical in shape. The steam jets that are created by the nozzle are directed at the turbine rotor blade with high velocity. The force exerted by the jets causes the rotor to rotate. There is no any change in the steam pressure as it passes over the blades. Impulse

turbines are therefore also known as constant-pressure turbines. These turbines are widely used in power generation in steam power plants, cogeneration, etc.

Principle of Reaction Turbine: A reaction steam turbine operates based on the reaction force exerted by the steam as it changes direction and velocity through the turbine blades. In the reaction turbine, there are alternate rows of fixed blades and moving blades. The shape of the blade is an airfoil and the passage or cross-sectional area between the blades is uniformly increasing which acts as a nozzle. Hence in a reaction turbine, there are no separate nozzles like an impulse turbine. The steam expands in fixed blades as well as in moving blades as it passes through them. As a result of the pressure drop in the moving blade the relative velocity of steam increases when it leaves the moving blades. A reaction force will be produced. This force will make the moving blades rotate. Moving blades are fixed on the rotor of the turbine and fixed blades are part of the casing or hood of a turbine.

VII. Experimental setup

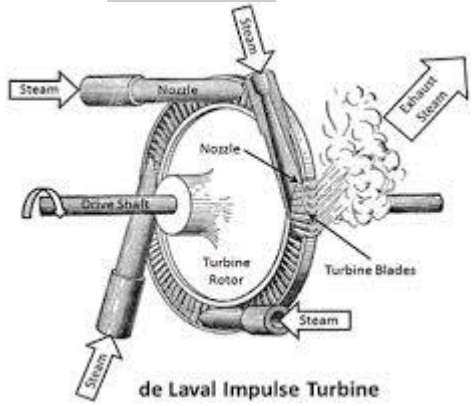


Fig 7.1: Impulse Turbine

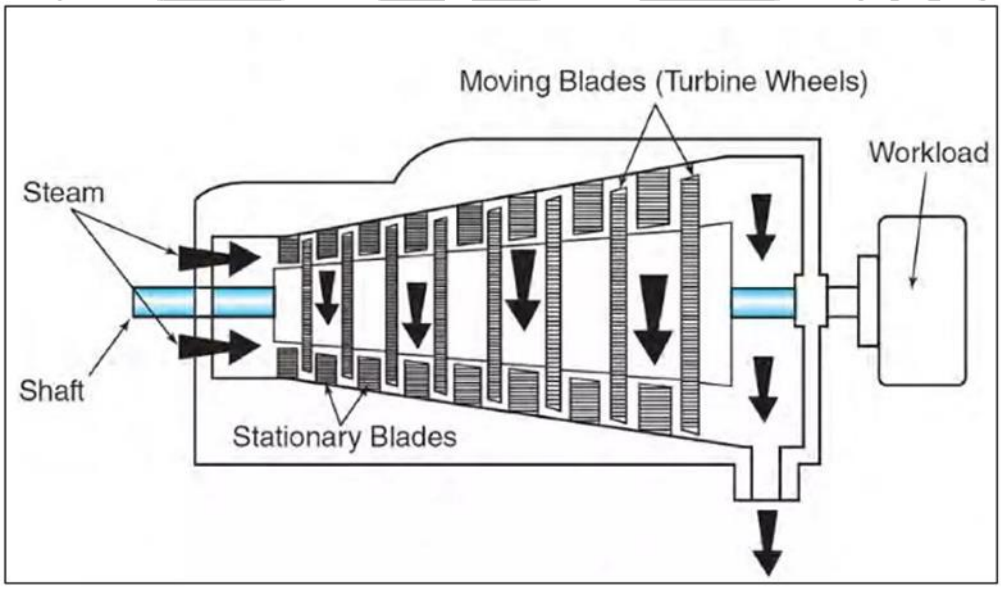


Fig 7.2: Reaction Turbine

VIII. Required Resources/apparatus/equipment with specifications

Sr. No	Name of Resource	Suggested Broad Specification	Quantity
1	Impulse Turbine	Model/Chart of Impulse Turbine showing all important parts	01
2	Reaction Turbine	Model/Chart of Reaction Turbine showing all important parts	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

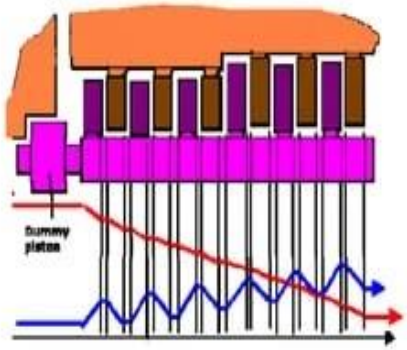
- Avoid improper handling of turbine models.
- Use safety shoes.

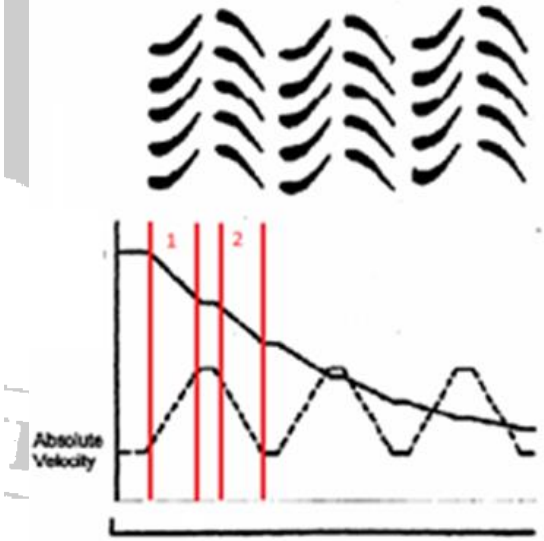
X. Procedure

1. Select the turbine model for demonstration.
2. Observe the turbine model selected for study purposes.
3. Identify the main components of a selected turbine.
4. Locate different components of the given turbine.
5. State the function of each impulse and reaction turbine component.
6. Explain the working principle of impulse and reaction turbine.
7. Demonstrate the working of impulse and reaction turbine using the model

XI. Observations and calculations

Complete the labeling of the following diagrams.





Name of diagram ..... **Name of diagram .....**

Sr. No	Name of Turbine	Name of component	Function of component
1	**Impulse Turbine**	Nozzle	
		Moving Blades	
		Diaphragm	
		Bearings	
		Turbine Seals	
		Turbine casing	
2	**Reaction Turbine**	Fixed Blades	
		Moving Blades	
		Bearings	
		Turbine Seals	
		Turbine casing	

XII. Results

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain why an impulse turbine is not used in high-pressure applications.
2. Illustrate the selection of an impulse turbine over a reaction turbine, and vice versa.
3. Draw a pressure-velocity variation diagram of an impulse and reaction turbine.
4. List practical applications where impulse turbines are commonly used.
5. Collect specifications of steam turbines used in different applications
6. Compare the working principle of a reaction turbine with that of an impulse turbine.
7. State the materials commonly used in modern steam turbines.
8. Collect data on steam turbines used in the non-conventional power sector.
9. Explain the advancements that have been made in turbine blade materials to withstand high temperatures and pressures.
10. State any four applications of reaction steam turbine.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.mechanicalengineeringsite.com/steam-turbine-basic-parts.
- https://www.gepower.com/steam/steam-turbines.
- https://youtu.be/dS3GpvIl6fc?si=NQmC4dtAWinyAASN
- Failure of Steam Turbine-Deposits Formation and Corrosion Damages, https://youtu.be/Mv5N20KoO3U?si=FEWtuNPC1IxXytdk
- https://www.youtube.com/watch?v=h1Yt4ibYXfA
- https://www.youtube.com/watch?v=0rsGU7MHcyc
- https://www.youtube.com/watch?v=Osy9S35ydlY

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
	Product Related (10 Marks)	**(40%)**
3	Interpretation of different components of steam turbines	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 08 Demonstration & working of Water-cooled condensers and Air-cooled condensers.

I. Practical Significance

Steam condensers have a wide range of applications across various sectors such as thermal power plants, nuclear power plants, Chemical and Petrochemical Plants, Pharmaceutical industry due to their critical role in converting steam back into liquid water. For diploma engineering students, studying the working of steam condensers is essential for developing a comprehensive understanding of thermal systems and their applications.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- Identify different types of water-cooled and air-cooled condensers.
- List different components of the condenser.
- State the function of each component.

III. Course Level Learning Outcome (s)

CO3 – Use suitable strategies to maintain the steam boiler, steam turbine, steam condenser & cooling towers efficiently.

IV. Laboratory Learning Outcome(s)

- Select the condenser model for demonstration.
- Identify various components of condensers.

V. Relative Affective Domain-related Outcome(s)

- Demonstrate working as a leader/a team member
- Follow safety practices
- Understand the environmental impact of steam condensers.

VI. Relevant Theoretical Background

The condenser is one of the key elements of steam-based thermal power plants. It is a closed vessel in which the exhaust steam from the exit of the turbine is condensed with the help of cooling water while maintaining a vacuum, resulting in an increase in work output and efficiency of the plant and the recirculation of condensate as feed water to the boiler. It is a heat exchanger in which heat transfer takes place from high-temperature steam to a low-temperature liquid with the help of cooling like air or water. About 50 to 60 percent of total heat supplied in a power plant is rejected in a condenser therefore; the cooling system plays a vital role in condensing the steam. The condensers are classified based on the cooling medium used air-cooled condenser and water-cooled condenser. In air-cooled condensers, heat is removed by air using either natural or forced circulation. The condensers are made of steel, copper, or aluminum tubing provided with fins to improve air-side heat transfer. In water-cooled condensers, water is the external fluid. Depending upon the construction, water cooled condensers can be further classified into: Double pipe or tube-in-tube type, Shell-and-coil type and Shell-and-tube type.

VII. Experimental setup

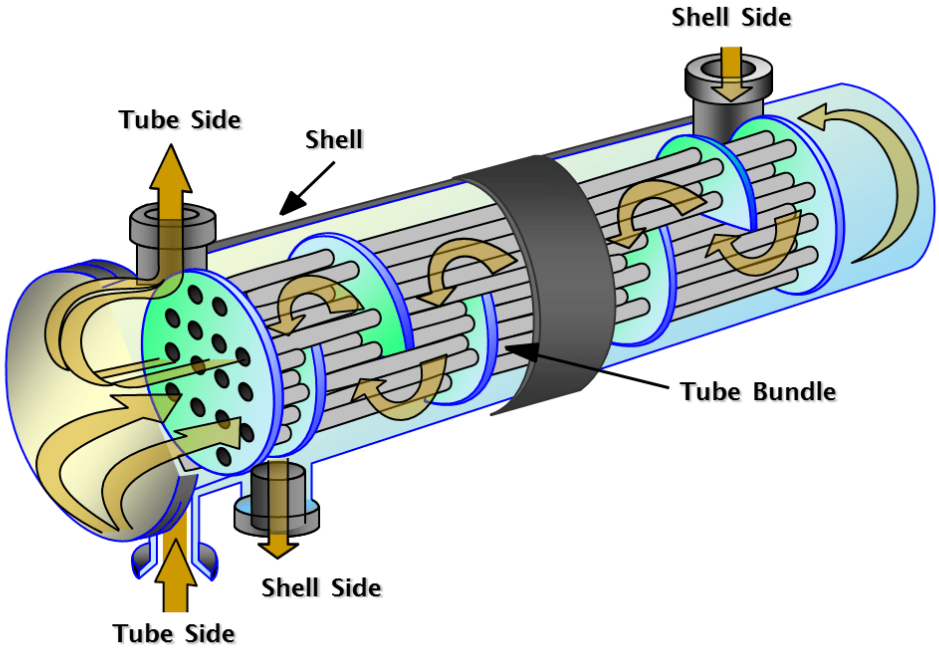


Fig 8.1: Shell and Tube Condenser

(Source: https://arvengtraining.com/en/basics-of-shell-tube-heat condenser)

Fig 8.2: Plate Fin and Tube type Condenser

(Source: https://www.hydro.com/en/aluminium/industries/hvacr/fin-and-tube-heat-exchangers)

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Shell and Tube type condenser	Model/Chart of Shell and Tube type condenser showing all important parts	01
2	Plate fin-and-tube type condenser	Model/Chart of Plate fin-and-tube type condenser showing all important parts	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of condenser Models.
- Use safety shoes.

X. Procedure

1. Select the condenser model for demonstration.
2. Observe the condenser model selected for study purpose.
3. Explain the working principle of a selected condenser.
4. Identify the main components of a selected condenser.
5. Observe the location of each component.
6. State the function of each component of a selected condenser.

XI. Observation and calculations

Water cooled condenser

Particular	Name of component	Function
Shell and Tube type condenser		

Air cooled condenser

Particular	Name of component	Function
Plate fin-and-tube type condenser		

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Compare water-cooled and air-cooled steam condensers.
2. Explain the factors influencing the selection of either water-cooled or air-cooled steam condensers for industrial applications, such as power generation or chemical processing.
3. Draw a neat sketch of any one water-cooled condenser.
4. State the importance of maintaining proper vacuum levels in a steam condenser.
5. Illustrate the role of condensate extraction pumps in a steam condenser.
6. List the primary methods used to remove non-condensable gases from a steam condenser.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=DuLFDzQVTU4
- https://www.youtube.com/watch?v=HXkzH_EB3ow
- https://www.youtube.com/watch?v=_6Si9hB5amc
- https://www.youtube.com/watch?v=ES0cGsWIzGQ
- https://www.youtube.com/watch?v=1iTllotCOcg

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Handling of the models/setup	30%
2	Observations of the models/setup	30%
	Product Related (10 Marks)	**(40%)**
3	Interpretation of different components of steam turbines	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 09 Observe simulation of Thermal Power Plant and write specifications of boilers, turbines, condensers, and electrical generators.

I. Practical Significance

Online free/demo software is available for students which allows students to change certain parameters of thermal power plants and observe changes in other parameters. Simulations offer a realistic, yet safe environment for students to engage with the operation of a thermal power plant. Thermal power plants are intricate systems with various interconnected components. By observing simulations, students can gain a deeper understanding of how these components work together to generate electricity, including boilers, turbines, generators, cooling systems, and control mechanisms. Observing simulations provides an opportunity for students to witness potential issues or malfunctions that can occur in a thermal power plant.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- Use simulation software
- Maintain tools and equipment

III. Course Level Learning Outcome (s)

CO3 - Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers.

IV. Laboratory Learning Outcome(s)

- Use simulation software.
- Select input parameters to observe the output.

V. Relative Affective Domain-related Outcome(s)

- Follow ethical Practices
- Practice energy conservation

VI. Relevant Theoretical Background

A thermal power plant is a facility that generates electricity by converting heat energy into electrical energy. It typically uses fossil fuels such as coal, oil, or natural gas to produce heat, although some plants use renewable sources such as biomass or geothermal energy. Various control and instrumentation systems monitor and regulate the operation of the power plant, ensuring safe and efficient performance. This includes systems for process control, monitoring equipment health, and managing plant operations. Several parameters like steam pressure, steam temperature, and reheat temperatures affect the performance of a thermal power plant. Thermoflow, SimTherm, EES (Engineering Equation Solver), Energy3D, cycle tempo, and MATLAB are some simulation software available online with free demo versions.

VII. Experimental setup (Software)

Name of the software - EES (Engineering Equation Solver) Demo version. (Any suitable software)

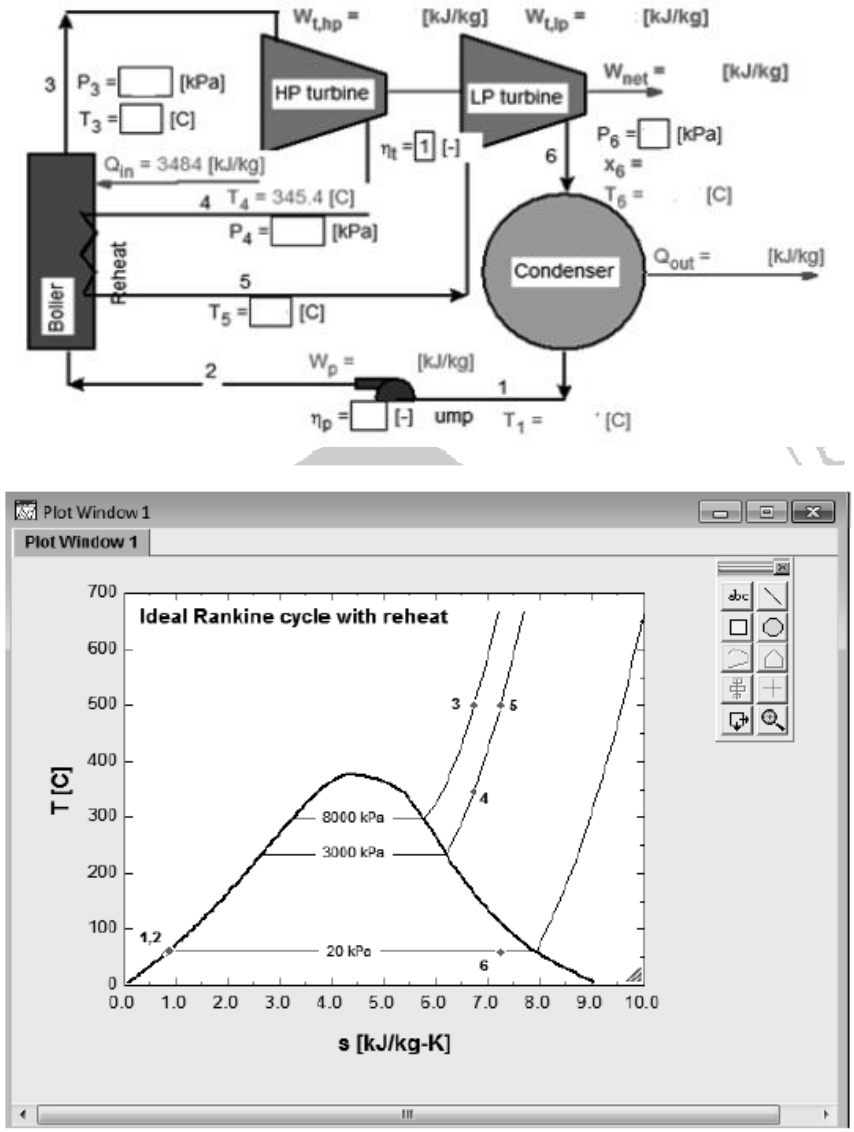


Fig.9.1 EES T-S Curve

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Any suitable software	Demo version	01
2	Computer laboratory with PCs	Latest Configuration	25

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Do not use pirated copies of any software
- Change values of one parameter at a time initially to observe output changes

X. Procedure

1. Open website www.fchart.com
2. Download the demo version of EES.
3. Go to "Examples" in the main menu. You will get a drop-down menu list.
4. Click on "Getting started with EES"
5. Click on "steam cycle diagram window input".
6. You will find one already framed problem on a steam power plant in the "Equations window"
7. Learn equations window.
8. Go to "Windows" in the main menu.
9. Click on "Diagram window"
10. You will get a diagram window for a steam power plant.
11. Again, go to "Windows" in the main menu.
12. Click on "plot windows".
13. You will get a T-S plot for the given problem on your screen.
14. Now you can vary different parameters on the diagram window and observe changes in other parameters.
15. Prepare excel sheet tables for different inputs you have given changes in the rest of the parameters.
16. Create some more examples on your own.

XI. Observations and calculations

P_3 Kpa	T_3 ^0C	P_5 KPa	T_5 ^0C	P_6 KPa	W_p (kJ/kg)	W_{thp} (kJ/kg)	W_{thp} (kJ/kg)	W_{net} (kJ/kg)	Q_{out} kJ/kg	Cycle Efficiency

(Note – The above table can be changed as per requirement)

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Define thermal efficiency of the steam power plant, and how can it be improved.
2. Illustrate the effect of condenser pressure on the overall efficiency of the power plant.
3. List the parameters that need to be monitored to ensure optimal performance of the steam turbine.
4. State the software tools commonly used for simulating steam power plants.
5. Explain the use of simulation software to optimize the operation of a steam power plant for maximum efficiency.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=D0i1E_lE_TE
- https://www.youtube.com/watch?v=TE95-CCh5Ds
- https://www.youtube.com/watch?v=ILutW7IarZ0
- https://www.youtube.com/watch?v=LqWSsH6Oguw
- https://www.youtube.com/watch?v=BJvCV1VxGMs
- https://www.youtube.com/watch?v=Bbnex2ZGioM
- https://www.youtube.com/watch?v=q6m7RKk1Twk

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Simulating various parameters within appropriate ranges satisfactorily	30%
2	Completion of observation table	30%
Product Related (10 Marks)		**(40%)**
3	Interpretation of results obtained by changing input parameters	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No:10 Illustrate the methods of compounding used in steam turbines

I. Practical Significance

Compounding methods in steam turbines help students understand the basics of energy conversion processes and how thermal energy is transformed into mechanical energy. Studying different compounding techniques enables students to grasp how these methods improve the efficiency of steam turbines by reducing energy losses and optimizing performance. Steam turbines are used in various industries such as manufacturing, petrochemicals, and marine propulsion. Proficiency in compounding principles is valuable across these sectors. Knowledge of steam turbine compounding is crucial for students aiming to work in power plants, as it directly relates to the operation and maintenance of turbines used for electricity generation.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:
'Use principles of thermal engineering to maintain, reduce energy losses, and improve the efficiency of steam turbines used in various industrial applications.'

III. Course Level Learning Outcome (s)

CO3 - Use suitable strategies to maintain steam boiler, steam turbine, steam condenser & cooling towers.

IV. Laboratory Learning Outcome(s)

- Demonstrate the process of compounding.

V. Relative Affective Domain-related Outcome(s)

- Follow safety practices
- Follow ethical Practices
- Practice energy conservation

VI. Relevant Theoretical Background

The steam turbine is a rotary prime mover employed to convert the energy of high-pressure and high-temperature steam from the boiler into useful mechanical work. Steam turbines are most widely used for generating electricity and fall under the category of work-producing turbo machines.in the case of a simple impulse turbine, the whole of the kinetic
energy of the steam has to be absorbed by a single rotor leading to a very high rotational speed of about 30000 rpm. This speed is too high for practical use, and a great amount of energy is lost in the form of leaving loss. Therefore, it becomes imperative to assimilate some improvements in simple impulse turbines to bring their rotational speed to practical limits and achieve high performance. To fix the above problem a method called compounding is employed to reduce the rotational speed of the impulse turbine. In this method, arrangements are made in such a way that the energy of steam is utilized in more than one set of nozzles and moving blades keyed together to a common shaft. The speed reduction can be achieved by either dropping the pressure in the set of nozzles through several stages till it reaches the condenser pressure or by dropping the entire pressure in the first set of nozzles and then guiding the high-velocity steam jet through a

series of moving blades till maximum energy is absorbed. Compounding of impulse turbines can be done in three ways.

1. Pressure compounding
2. Velocity compounding
3. Pressure-velocity compounding

VII. Experimental setup

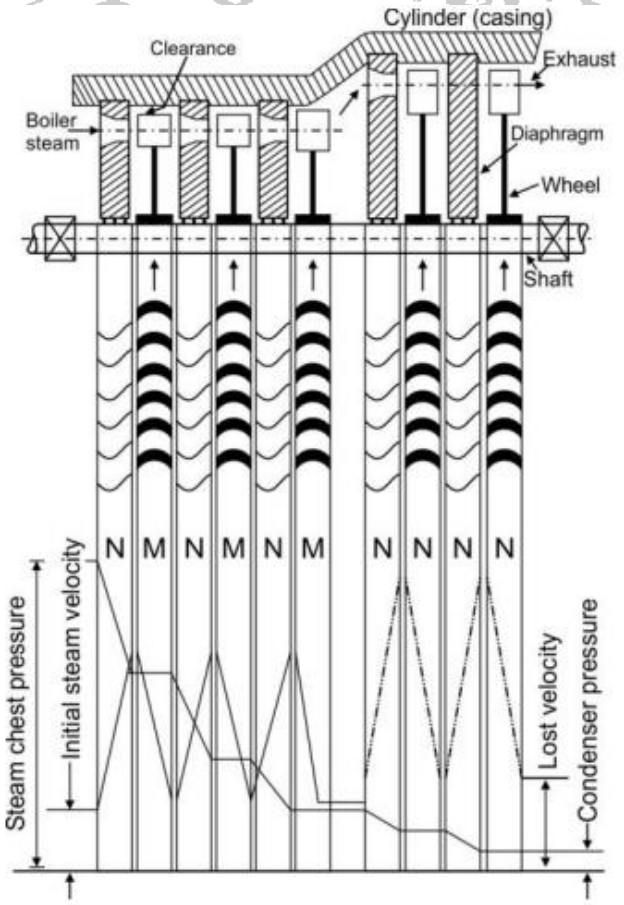


Fig 10.1: Pressure Compounding

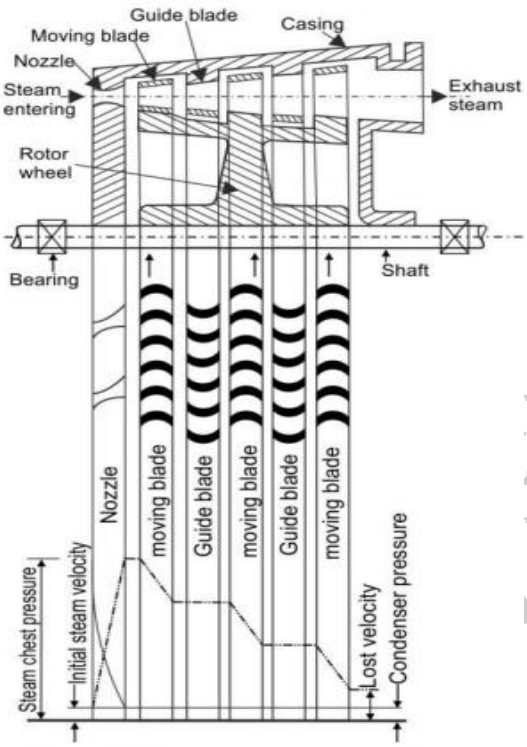


Fig 10.2: Velocity Compounding

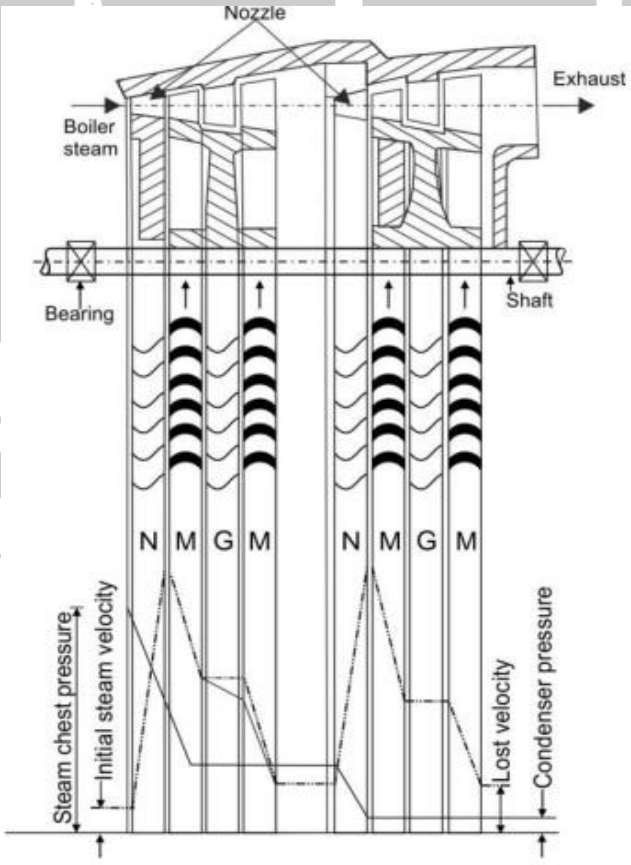


Fig 10.3: Pressure -Velocity Compounding

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Impulse Turbine /Reaction Turbine	Suitable models/charts available in the laboratory that can be used for the demonstration of the process of compounding in steam turbines.	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of a steam turbine model.
- Use safety shoes.

X. Procedure

1. Select the steam turbine model/chart engine for demonstration.
2. Observe the steam turbine model selected for study purpose.
3. Explain the principle of compounding in a steam turbine.
4. Observe the different components of a selected steam turbine.
5. Observe the variations in pressure & velocity of steam during compounding.
6. Sketch the variations in pressure and velocity.
7. Identify the method of compounding.

XI. Observations and calculations

1. Pressure Compounding

Write the process of pressure compounding

Show the variations in pressure and velocity during pressure-compounding

2. Velocity Compounding

Write the process of velocity compounding

Show the variations in pressure and velocity during velocity-compounding

3. Pressure - Velocity Compounding

Write the process of pressure velocity compounding

Show the variations in pressure and velocity during pressure - velocity-compounding

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. State the primary purpose of compounding in steam turbines.
2. Compare pressure compounding and velocity compounding.
3. State the main advantages of pressure-velocity compounded turbines.
4. Explain how compounding improves the thermal efficiency of a steam turbine.
5. List industrial applications in which steam turbine compounding is beneficial and why.
6. Illustrate the emerging trends in steam turbine compounding technology.
7. List the challenges associated with compounding steam turbines.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=n1O8C6lb2Ho
- https://www.youtube.com/watch?v=h1Yt4ibYXfA
- https://www.youtube.com/watch?v=SPg7hOxFItI
- https://www.youtube.com/watch?v=wk1hRwLSnPM

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Handling the model	30%
2	Observation of the model	30%
	Product Related (10 Marks)	**(40%)**
3	Interpretation of different components of a Steam turbine & method of compounding	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No:11 Conduct a trial on the conduction setup of metallic rod and calculate thermal conductivity

I. Practical Significance

It helps students to understand the conduction principles of heat transfer. Understanding thermal conductivity is crucial for various real-world applications, such as designing efficient heat exchangers, thermal insulations, and cooling systems in industries like automotive, aerospace, and HVAC. Understanding thermal conductivity is crucial for designing efficient heat exchangers, thermal insulation systems, and other engineering applications where heat transfer plays a significant role. Students become familiar with experimental techniques and instruments used in measuring thermal conductivity, such as calorimeters, thermocouples, and temperature sensors.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- Apply Fourier's law of conduction to the given situation.
- Calculate heat transfer by conduction.

III. Course Level Learning Outcome (s)

CO4 - Select the proper heat exchanger for a given application.

IV. Laboratory Learning Outcome(s)

- Measure parameters required to determine thermal conductivity.
- Determine the thermal conductivity of the metallic rod.

V. Relative Affective Domain-related Outcome(s)

- Follow safety practices
- Follow ethical Practices
- Practice energy conservation.

VI. Relevant Theoretical Background

Thermal conductivity is a fundamental property of materials that describes their ability to conduct heat. It quantifies how efficiently a material can transfer heat through it when there is a temperature gradient present. The thermal conductivity (K) of a material is typically expressed in units of watts per meter-Kelvin ($W/m\cdot^0K$). Mathematically thermal conductivity can be described by Fourier's Law of Heat Conduction: The law states that the heat flux (Q), which is the amount of heat energy transferred per unit area per unit time, is proportional to the negative gradient of temperature (dT/dx) in the direction of heat flow.

i.e. $Q/A \alpha - (dT/dx)$

$Q = - K.A. (dT/dx)$

Where: Q is the heat flux in W/m^2

K is the thermal conductivity of the material in $W/m\cdot^0K$

(dT/dx) is the temperature gradient along the direction of heat flow in $^0K/m$

A is the area normal to the direction of heat flow in m^2

VII. Experimental setup

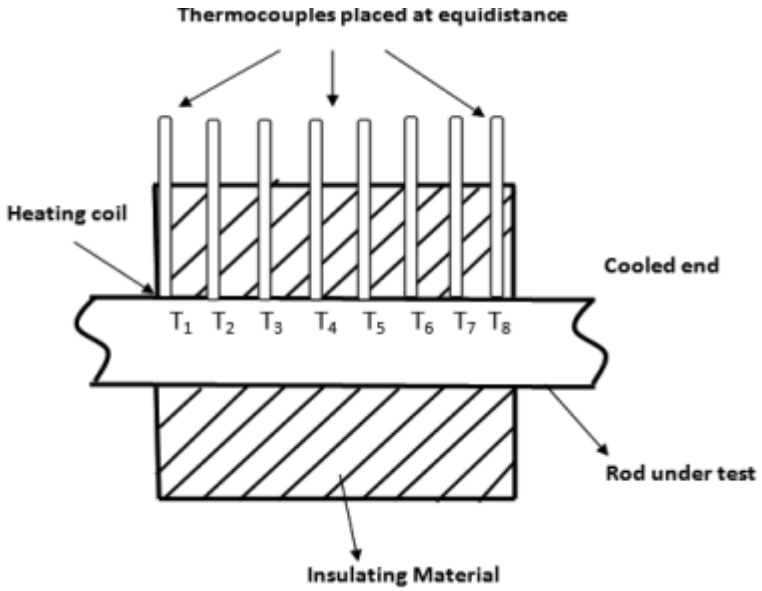


Fig 11.1 Conduction setup of metallic rod

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental set up for determination of thermal conductivity of metallic rod	Adequately insulated Metallic bar of suitable length having heating arrangement at one end. Thermocouple mounted on the metallic bar (6 to 9 in no). Thermocouples in the insulation shell (2 in no). Heater coil. Arrangement for cooling another end of rod. Temperature indicator, 13 channels Dimmerstat for heater coil: 2A / 230 V Measuring flask for water flow rate Stopwatch	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Check all the electrical connections before running.
- Do not give heater input without the supply of water.
- Run the water in the jacket for about 5 min after the experiment.
- Before starting and after finishing the experiment the heater controller should be in off position.
- Operate all the switches and controls gently.
- Do not touch the heated surface with bare hands.
- Use safety shoes.

X. Procedure

1. Give necessary electrical and water connections to the instrument.
2. Start the electric supply.
3. Give input to the heater by slowly rotating the dimmerstat and adjust it to a voltage equal to 80 V, 120 V, etc.
4. Start the cooling water supply through the water jacket and adjust it about 300 cc to 500 cc per minute.
5. Rod temperature will start rising. Go on checking the temperatures at time intervals of 5 minutes.
6. Wait till a steady state is reached.
7. Note the temperature at different points on the metallic rod with the help of thermocouples mounted on it (T_1 to T_8) when a steady state is reached.
8. Measure inlet & outlet temperature of water (T_9& T_{10})
9. Repeat the experiment for different heater inputs.
10. After the experiment is over, switch off the electrical connections, allow the water to flow for some time in the water jacket, and then stop it.

XI. Observation and Calculations

Observation Table –

Sr.No	Voltage (V)	Current (I)	Test Rod Temperatures in ^{0}C								Water Inlet Temp.	Water Outlet Temp.
			T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1												
2												
3												
4												
5												

(Note- Multiple readings are required to reach a steady state. Use final readings for the calculation once a steady state is reached)

Calculations –

1. Mass flow rate of cooling water (M_w) = ...Kg/s
2. Diameter of given metallic rod (d) =.....m
3. Area of given metallic rod $A_d = (\pi/4) \times d^2$ = ...m^2
4. Specific heat of cooling water = Cp_w = 4.180 KJ/Kg ^{0}C
5. Total length of given metallic rod = ……m
6. Test length of given metallic rod = ……m
7. Distance between any two thermocouples on metallic rod = ……mm

The heater will heat the bar at its end and heat will be conducted through the bar to another end. When steady state is reached, heat passing through the any section of the rod is heat taken by water.

According to Fourier's law of heat conduction,

$Q = - K.A. (dT/dx)$

Where, Q = Heat lost by metallic rod = V × I =……. watts

(Neglecting heat lost through insulating material)

A = Area of given metallic rod = ...m^2

(dT/dx) = Temperatures gradient = ……^{0}K/m

(Note – Temperature gradient can be calculated by plotting a graph of temperature Vs distance at which thermocouples are positioned and then finding the slope of the curve obtained)

$K = Q / A. (dT/dx)$

= ……

= ……

K = …… W/m.^{0}K.

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain the phenomenon of heat transfer by conduction.
2. Define thermal conductivity, and state its unit.
3. Interpret the effect of temperature on the thermal conductivity of materials.
4. Explain the mathematical equation that represents Fourier's Law of heat conduction and how it relates to temperature gradients and heat flux.
5. Interpret the effect of thickness of a material on the rate of heat transfer by conduction.
6. List the common methods used to measure temperature gradients along the length of the metallic rod during the experiment.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=ljmWQlKm61U&list=PLbRMhDVUMge4mnym5cCEKm_gTR_FLVve&index=1
- https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
- https://www.youtube.com/watch?v=sKnE5qvz0fc&list=PLbRMhDVUMngeygd_uWiLqa3fzA2h7vdRx
- https://www.youtube.com/watch?v=cscInTcRCzQ

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Performance of the experiment	20%
2	Taking readings of required parameters	20%
3	Calculations	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of Results	10%
5	Conclusions	10%
6	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 12 Conduct a trial on Stefan Boltzmann's setup and calculate Stefan Boltzmann's constant

I. Practical Significance

Stefan-Boltzmann's constant relates the temperature of an object to the rate at which it emits thermal radiation. Understanding this constant helps students grasp concepts related to heat transfer, such as blackbody radiation, emissivity, and the Stefan-Boltzmann law, which are relevant across various engineering disciplines. Students may apply this constant when designing heat exchangers, thermoelectric generators, or thermal insulation systems to ensure efficiency and reliability. Students can gain a deeper understanding of how thermal radiation behaves and how it relates to the temperature of an object, reinforcing their knowledge of basic principles in thermodynamics and electromagnetism. This law is useful in calculating the energy transferred by radiation from the emitting surface to the receiving surface such as heat transfer by solar radiation, radiation heat from the furnace wall, induction heating coils, etc.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer:

- Apply Stefan Boltzmann's law to the given situation
- Calculate heat transfer by radiation

III. Course Level Learning Outcome (s)

CO4 - Select the proper heat exchanger for a given application.

IV. Laboratory Learning Outcome(s)

- Measure parameters required to determine Stefan Boltzmann constant.
- Determine Stefan Boltzmann constant.

V. Relative Affective Domain-related Outcome(s)

- Follow safety practices
- Follow ethical Practices
- Practice energy conservation

VI. Relevant Theoretical Background

The most commonly used law of thermal radiation is the Stefan Boltzmann Law. All the substances emit thermal radiation. When heat radiation is incident over a body, part of the radiation is absorbed, transmitted through, and reflected by the body. A surface that absorbs all thermal radiation incidents over it is called a black surface. For the black surface, transmissivity and reflectivity are zero and absorptivity is unity. Stefan-Boltzmann law states that the amount of radiation emitted by a black body per unit area is directly proportional to the fourth power of the absolute temperature. i.e.

$E/A \alpha T^4$ i.e. $E/A = \sigma T^4$

Where, E = Radiation emitted by a black body in watt

A = Surface area in m^2

σ =Stefan-Boltzmann constant (5.67×10^{-8} w/m^2k^4) , T = Absolute temperature in ^0K

VII. Experimental setup

Fig 12.1: Stefan Boltzmann Apparatus

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Stefan Boltzmann Apparatus	Insulated Hemispherical enclosure with water jacket	01
		Copper test disc	01
		Base plate	01
		Sleeve	01
		Thermocouples	05
		Temperature indicator digital 0-200^{0}C with built-in cold junction compensation and a timer set for 5 Sec.	01
		Immersion water heater of suitable capacity	01
		Tank for hot water.	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Never put 'ON" the heater before putting water in the tank.
- Put 'OFF' the heater before draining the water from the heater tank.
- Drain the water after completion of an experiment
- Operate all the switches and controls gently.
- Do not touch the heated surface with bare hands.
- Use safety shoes.

X. Procedure

1. Make sure the water jacket's inlet cock is closed, and then fill the heater tank with enough water.
2. Switch on the heater and regulate the power input using the heater regulator.
3. Note the temperature of water by thermocouple. When it starts boiling or reaches a temperature up to 90^0C put off the heater.
4. See that the drain cock of the water jacket is closed and open water inlet cock.
5. See that there is sufficient water above the top of the hemisphere.
6. After water attains the maximum temperature, open the valve of the heater and dump it into the enclosure jacket.
7. The hemispherical enclosure will come to some uniform temperature T in a short time after filling the hot water in the jacket.
8. The enclosure will soon come to thermal equilibrium conditions.
9. Note down the hemisphere temperatures (up to channels 1 to 4).
10. Note down the test disc temperature (i.e. channel 5).
11. Insert the Test Disk through the hole provided at the bottom of the hemispherical portion and start the timer. The buzzer will start ringing.
12. Record the temperature at different instants of time (at the time interval of 5 sec) using the stopwatch. Take at least 8-10 readings.

XI. Observation and Calculations

Observation Table –

Hemisphere Temperature

Thermocouple	T_1	T_2	T_3	T_4
Temperature ^{0}C				
Temperature ^{0}K				

Test disc Temperature

Time Interval (Sec)	0	5	10	15	20	25	30	35	40
Test disc Temperature (^{0}C)									

Calculations –

1. Temperature to which water is heated = ...^{0}C
2. Mass of test disc, m = ...Kg
3. Diameter of test disc, d =.....m
4. Area of test disc, $A_D = (\pi/4) \times d^4$ = ...m^2
5. Specific heat of the test disc (For Copper) = Cp_D = 0.4186 KJ/Kg ^{0}C
6. Initial Test disc temperature $T_D = T_5$=.....^{0}K
7. Average temperature of the hemisphere $T_H = (T_1+T_2+T_3+T_4)/4$ = ...^{0}K
8. Plot a graph of the temperature rise of the test disc with time as a base and find out its slope at its origin. i.e.$(dT/dt)_{t=0}$ = ...K/sec

(Note: In this equation (dT / dt) t = 0 denotes the rate of rise temperature of the disc at the instance when its temperature is T_5 and will vary. It is best-measured at time t = 0. This is obtained from a plot of the temperature rise of a disc with respect to time and obtaining its slope at t = 0 when Temperature = T_5. This will be the required value of dT / dt at t = 0. The thermocouple mounted on the disc is to be used for this purpose.

Now heat radiated by the hemisphere is equal to the heat absorbed by copper disc.

$\sigma \times A_D \times (T_H^4 - T_D^4) = m \times Cp_D \times (dT/dt)_{t=0}$

i.e. $\sigma = \{m \times CpD \times (dT/dt)_{t=0}\} / \{A_D \times (T_H^4 - T_D^4)\}$

σ = ...$W/m^2 K^4$

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Write the relationship between radiation heat transfer and the Stefan-Boltzmann constant.?
2. Illustrate the use of the Stefan-Boltzmann constant in engineering applications involving radiation heat transfer.
3. Explain the phenomenon of radiative heat transfer, and how it differs from conduction and convection.
4. Define Black body & emissivity.
5. What is blackbody radiation, and how does it relate to radiative heat transfer?
6. List examples of engineering systems or processes where radiative heat transfer plays a significant role.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://archive.nptel.ac.in/courses/112/107/112107256/
- https://www.youtube.com/watch?v=CDncSyDvpdQ
- https://www.youtube.com/watch?v=TIFGm-QusM4

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Performance of the experiment	20%
2	Taking readings of required parameters	20%
3	Calculations	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of Results	10%
5	Conclusions	10%
6	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.13 Identify different equipments in laboratory having heat exchangers and classify heat exchangers.

I. Practical Significance

The devices which transfer heat from one fluid to another are called heat exchangers. Heat exchange is necessary for many industrial processes, as well as chemical reactions. Heat exchangers are often found in air conditioner cooling coils, automotive radiators, and refrigeration unit condensers. These are used in a variety of industries such as HVAC (Heating, Ventilation, and Air Conditioning), power generation, chemical processing, oil and gas, and automotive industries. Heat exchanger knowledge is relevant to many modern engineering challenges, from renewable energy systems to advanced manufacturing processes. Understanding their classification and function prepares students for roles in these sectors.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer: 'Use principles of thermal engineering to maintain thermal related equipments to practice energy conservation'.

III. Course Level Learning Outcome (s)

CO4 - Select proper heat exchanger for given application.

IV. Laboratory Learning Outcome(s)

- Identify different heat exchangers available in laboratory.
- Demonstrate the construction and working.

V. Relative Affective Domain-related Outcome(s)

- Follow safety practices
- Practice good housekeeping.
- Follow ethical Practices

VI. Relevant Theoretical Background

Heat exchangers are devices that facilitate heat transfer between two or more fluids at different temperatures. The fluids may be in direct contact with each other or separated by a solid wall. Heat Exchangers can be classified based on their principle of operation and the direction of flow. In the parallel flow heat exchangers, both hot and cold fluids flow in the same direction, whereas in the counter flow type, fluids flow in opposite directions. The temperature of the fluid changes in the direction of flow and consequently there occurs a change in the thermal head causing the flow of heat. The temperature profiles at the two fluids in parallel and counter flow are curved and have logarithmic variations. LMTD is less than the arithmetic mean temperature difference. So, it is always safer for the designer to use LMTD to provide a larger heating surface for a certain amount of heat transfer. Many types of heat exchangers are developed to meet the demand of processes. Applications of heat exchangers are wide, such as steam power plants, chemical processes, building heating, air conditioning, household refrigerators, car radiators, radiators for space vehicles, etc.

VII. Experimental setup

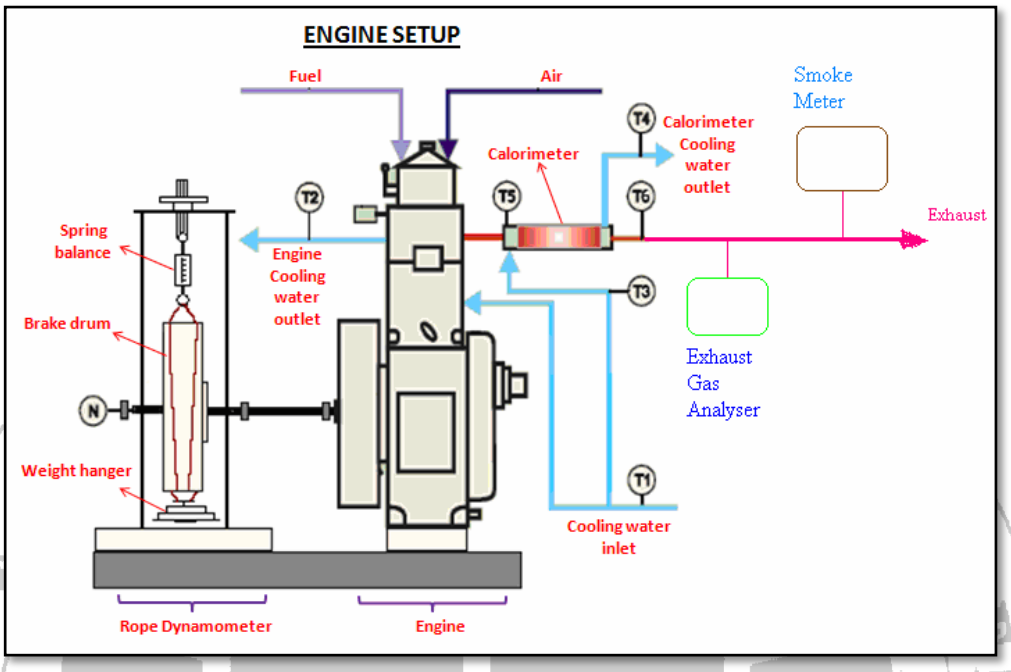


Fig 13.1: Line diagram of I.C. Engine Test Rig

(Source: https://www.researchgate.net/figure/Figure-1-Schematic-diagram-of-engine-test-rig_fig1_242587592)

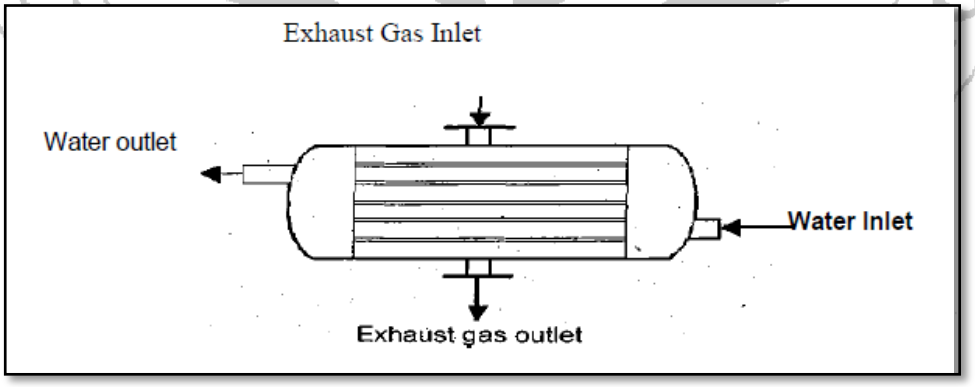


Fig 13.2: Exhaust gas Calorimeter

Fig 13.3: Refrigeration Test Rig

(Source: https://www.enggmod.com/vapour_compression_refrigeration_test_rig.html)

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Different test rigs available in laboratory having provision of heat exchangers	Suitable size with temperature sensors for measuring hot and cold fluid temperatures	02

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of test rig.
- Operate the test rig as per given procedure.
- Before starting the I.C. engine test rig, oil level in sump and jacket cooling water supply must be checked.
- Do not tamper with any of engine setting.
- In case of refrigeration test rig Never operate the unit, keeping the condenser fan switched off.
- Do not operate the unit if voltmeter on the panel reads less or more voltage than specified.

X. Procedure

1. Start the identified test rig.
2. Locate the heat exchanger in this test rig.
3. Run it for a few minutes till it stabilizes.
4. Switch ON the temperature indicator and allow for the temperature to become Steady. Switch ON the channel selector to the required thermocouple and observe Temperature variations with time.
5. Measure the temperature of hot and cold fluids at inlets and outlets and note down it in the observation table.
6. Repeat the procedure with another test rig available in the laboratory.
7. Calculate the LMTD using the equations given below.

XI. Observation and Calculations

Observation Table -

Sr. No	Name of Test Rig	Name of Heat Exchanger	Type of Heat Exchanger	Hot Fluid in Temperature Thi	Hot Fluid Out Temperature Tho	Cold Fluid in Temperature Tci	Cold Fluid Out Temperature Tco
1							
2							

Calculations –

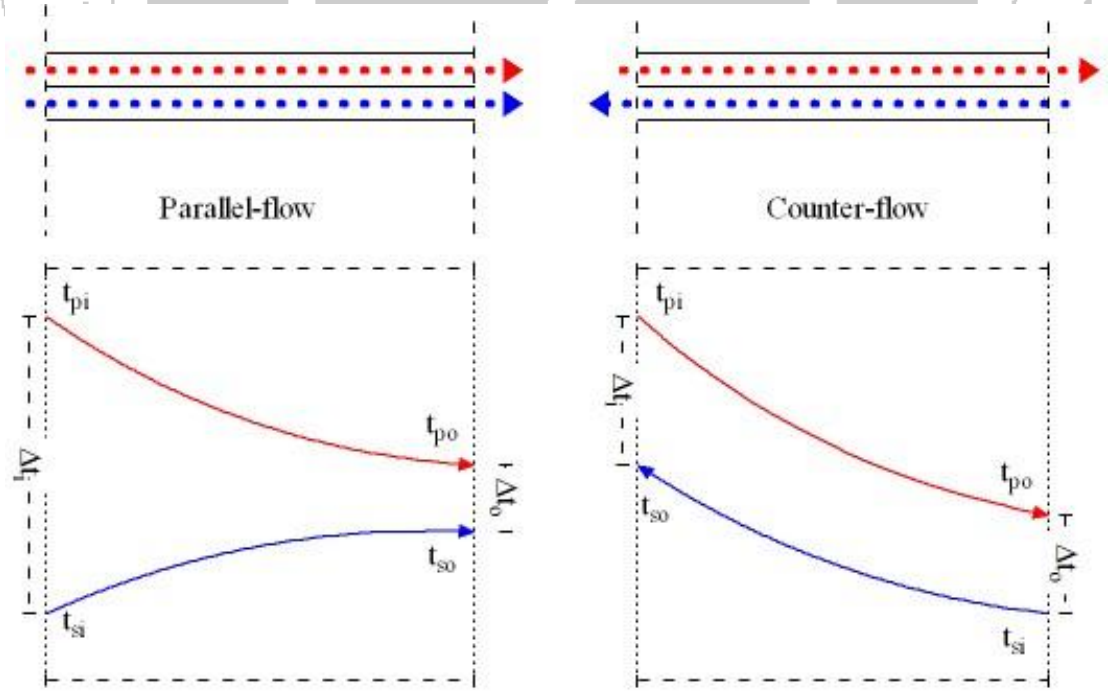


Fig 13.4: LMTD for Parallel flow and Counterflow heat exchanger

For Parallel flow Heat Exchanger

Ti = Thi – Tci = …….=……

To = Tho – Tco = …….=……

LMTD = (Ti – To) / In (Ti / To) =…….

For Counterflow Heat Exchanger

Ti = Thi – Tco = ……. =……

To = Tho – Tci = …….=……

LMTD = (Ti – To) / In (Ti / To) =……

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Classify the heat exchangers.
2. State the advantages and disadvantages of shell-and-tube heat exchangers compared to plate heat exchangers.
3. Draw the schematic diagram of a shell-and-tube heat exchanger and indicate its various parts.
4. List the factors that need to be considered when selecting the type of heat exchanger for a specific application.
5. State the effect of flow arrangement (counter flow, parallel flow, cross flow) on the heat transfer efficiency of a heat exchanger.
6. In what scenarios would a finned-tube heat exchanger be preferred over other types?
7. Illustrate the use of heat exchangers in renewable energy systems.
8. Explain the concept of fouling.
9. Define effectiveness of a heat exchanger.
10. Illustrate the concept of LMTD & overall heat transfer coefficient.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.youtube.com/watch?v=TzFZ49h6Yx0
- https://www.youtube.com/watch?v=cQRQkFaAyAw
- https://www.youtube.com/watch?v=OyQ3SaU4KKU
- https://www.youtube.com/watch?v=SWKQzPv5jC0
- https://www.youtube.com/watch?v=3aZytBGSG_k
- https://www.youtube.com/watch?v=WoijizwTxec

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Performance of the experiment & writing observations	20%
2	Taking readings of required parameters	20%
3	Calculations	20%
Product Related (10 Marks)		**(40%)**
4	Interpretation of Results	10%
5	Conclusions	10%
6	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No:14 Assembling and dismantling of single cylinder I.C Engine

I. Practical Significance

After performing this practical students will learn about various engine components such as the cylinder, piston, crankshaft, camshaft, valves, and fuel injectors. This knowledge is crucial for understanding how each part functions and interacts with others. Students learn how to utilize torque wrenches, micrometers, and other tools and instruments that are necessary when working on engines. Practical acquaintance with engines is required for many mechanical engineering positions. This hands-on training makes students more job-ready, providing them an advantage in the employment market. Learning how to assemble and dismantle an engine helps students acquire diagnostic abilities. They learn how to detect and troubleshoot typical problems such as engine knocking, misfiring, and oil leaks.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer: 'Maintain Internal Combustion Engines thorough understanding of the procedure of Assembling and dismantling& use of different tools'.

III. Course Level Learning Outcome (s)

CO5 - Identify different components of an I.C. Engine.

IV. Laboratory Learning Outcome(s)

Select the proper tools. Identify various subassemblies and accessories of an engine.

V. Relative Affective Domain-related Outcome(s)

- Follow safety practices
- Practice good housekeeping.
- Maintain tools and equipment.
- Follow ethical Practices

VI. Relevant Theoretical Background

An internal combustion engine is a device in which combustion occurs inside the engine cylinder. I.C. engine works in four strokes –suction, compression, expansion, and exhaust. If four stokes take place in one cylinder then it is called a Single cylinder I.C. engine. Dismantling is the process of removing all the engine parts to know various sub-assemblies of an engine, identify the parts and their location in the sub-assemblies, and inspect parts to know their physical and functional condition. Dismantling of I.C. Engine is a feature of preventive as well as breakdown maintenance. After dismantling or repair, all the parts are put back together. This is called engine assembly (reassembly). Engine assembly mainly consists of three major sub-assemblies, cylinder and related parts, piston and related parts, and valve mechanism components.

VII. Experimental setup

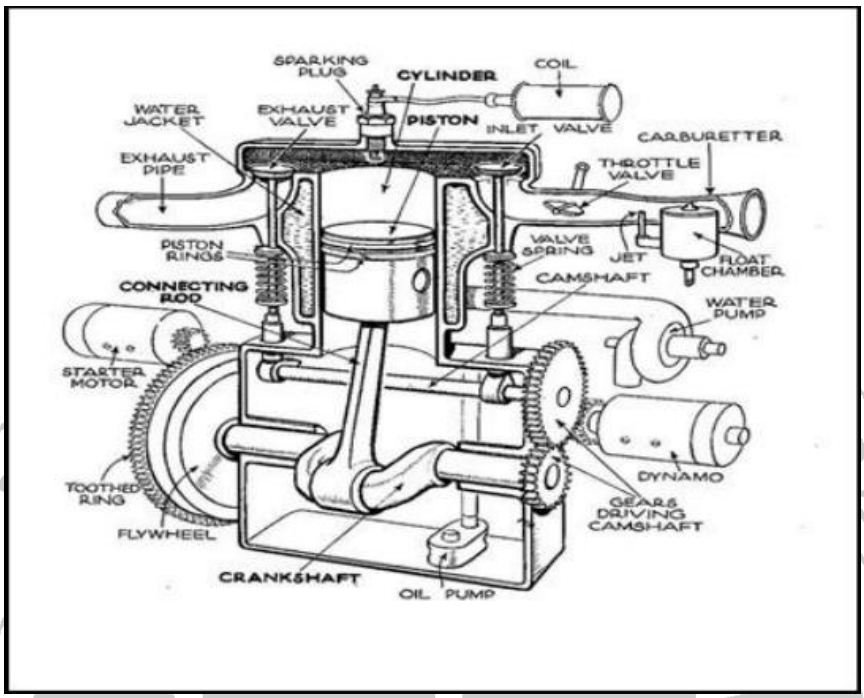


Fig 14.1: Single Cylinder Diesel Engine (In section)

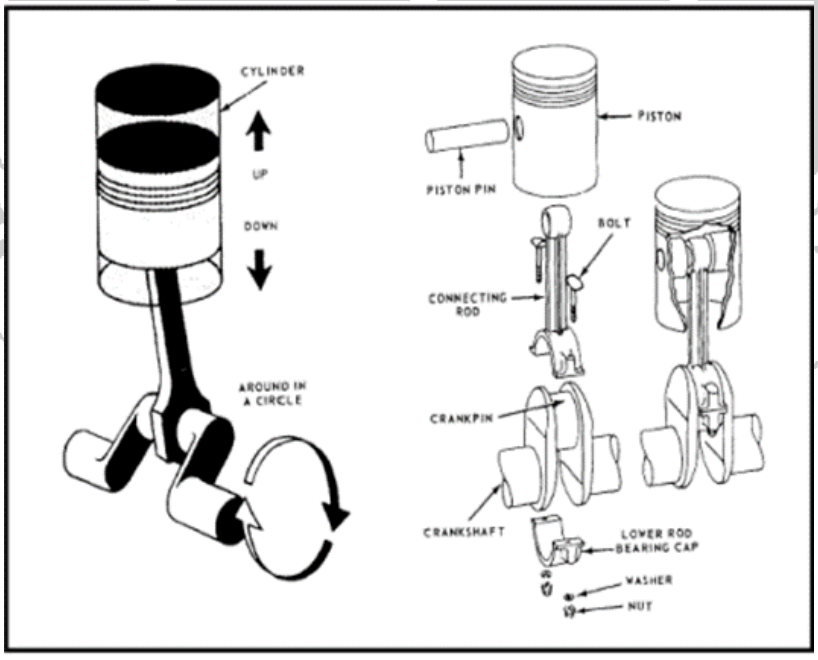


Fig 14.2: Piston sub-assembly (exploded view)

Fig.14.3: Tool Box

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Toolbox	Adjustable wrench – 10/250 mm	1
		Plier – 8”/200mm	1
		Piston ring remover	1
		Ball peen Hammer – 500 gm,	1
		Claw hammer- 1/4 LB	1
		Allen key set – 1.5 to 10-inch	1
		Screwdriver set – 5 pieces	1
		Open-end jaw spanner set- 6-7 to 30-32	1
		Round/box spanner set - 6-7 to 30-32	1
		Rachet set – 10mm to 32 mm	1

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of an I.C. Engine.
- Use special and recommended tools for the assembly and dismantling of an I.C. Engine.
- Use a clean workbench for the assembly and dismantling of an I.C. Engine.
- Care must be taken while removing the components.

X. Procedure

1. Select the available I.C. engine model for dismantling.
2. Select the proper tools and equipment.
3. Apply recommended tools to remove engine accessories and components of an I.C. engine.
4. Identify the various subassemblies and accessories of the Engine
5. Understand the functions of different parts.
6. Examine all the components carefully
7. Observe their physical and functional conditions.
8. Locate different areas that need maintenance/replacement.

XI. Observation and calculations

Sr.No	Particulars	Remark (Material /Functions/Observations/Specifications)
1	Bore diameter	
2	Piston diameter	
3	Number of strokes	
4	Length of stroke	
5	No. of oil rings	
6	No. of compression rings	
7	Cylinder Head	
8	Poppet valves/ports	
9	Valve springs	
10	Camshaft	
11	Head gasket	
12	Cylinder block	
13	Piston	
14	Gudgeon pin	
15	Connecting rod	
16	Crankshaft	

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. List the basic tools required for dismantling and assembling a single-cylinder IC engine. State its purpose
2. State the precautions to be taken before starting the dismantling process of an IC engine.
3. Write the recommended sequence for assembling a single-cylinder IC engine.
4. Draw a neat labeled sketch of a piston
5. List the name of the gasket material used in the cylinder head.

[Space for Answer]

XV. References/Suggestions for further reading

- https://engineproblem.com.au/procedures/engine-assembly
- https://www.youtube.com/watch?v=vvqiioLIXtU&list=PLET1GQlHfInNMkHFDGaj7OLKhnzyRmQuV
- https://www.youtube.com/watch?v=uJivC7452gE
- https://www.youtube.com/watch?v=Pu7g3uIG6Zo
- https://www.youtube.com/watch?v=wCCGnT6Nq0I
- https://www.youtube.com/watch?v=lR6ku_g_eNI

XVI. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the tools	15%
2	Dismantling of engine components	15%
3	Identification of I.C. Engine components	15%
4	Assembling of engine components	15%
Product Related (10 Marks)		**(60%)**
5	Interpretation of different components of an I.C. Engine	20%
6	Conclusions	20%
7	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 15 Identify Different Components of Multicylinder I.C. Engine and Write Function of Each Component.

I. Practical Significance

An internal combustion engine (IC engine) is a type of heat engine that converts the chemical energy stored in fuel into mechanical energy (heat energy). It is commonly used in vehicles, power generators, and various industrial applications. For students to fully understand the fundamentals of mechanical and automotive engineering, they must have a working knowledge of the components of IC engines. It enables students to develop skills such as assembling and disassembling engines, performing maintenance, and troubleshooting issues.

II. Industry/Employer Expected Outcome (s)

This practical is expected to develop the following skills for the industry/Employer: 'List different components of multicylinder I.C. Engine and State each component's function'.

III. Course Level Learning Outcome (s)

CO5 - Identify different components of an I.C. Engine.

IV. Laboratory Learning Outcome(s)

Locate different components of multicylinder I.C. Engine.

V. Relative Affective Domain-related Outcome(s)

- Demonstrate working as a leader/a team member
- Follow safety practices
- Understand the environmental impact of IC engines.

VI. Relevant Theoretical Background

An internal combustion engine (IC engine) is a type of heat engine that converts the chemical energy stored in fuel into mechanical energy. In an I.C. engine combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. IC engines can be classified according to the number of strokes, no of cylinders, type of ignition, type of working cycles, type of Cooling System, type of Cylinder Arrangement, etc. The main components of an IC Engine are, Cylinder head, Piston, Piston pin, Connecting rod, Engine block, Crankshaft, Camshaft, Exhaust valve, Intake valve, exhaust manifold, and Intake manifold. A multi-cylinder internal combustion engine (I.C. engine) is an engine that contains more than one cylinder for the combustion of fuel and air mixture. These engines are commonly used in automobiles, motorcycles, boats, and various other applications where internal combustion power is required. Multi-cylinder engines typically produce more power compared to single-cylinder engines of similar size. This is because they can burn more fuel and air mixture per cycle, generating more torque and horsepower. Additionally, they tend to run more smoothly due to the overlapping power strokes and reduced vibration compared to single-cylinder engines. Multi-cylinder engines can achieve higher thermal efficiency compared to single-cylinder engines.

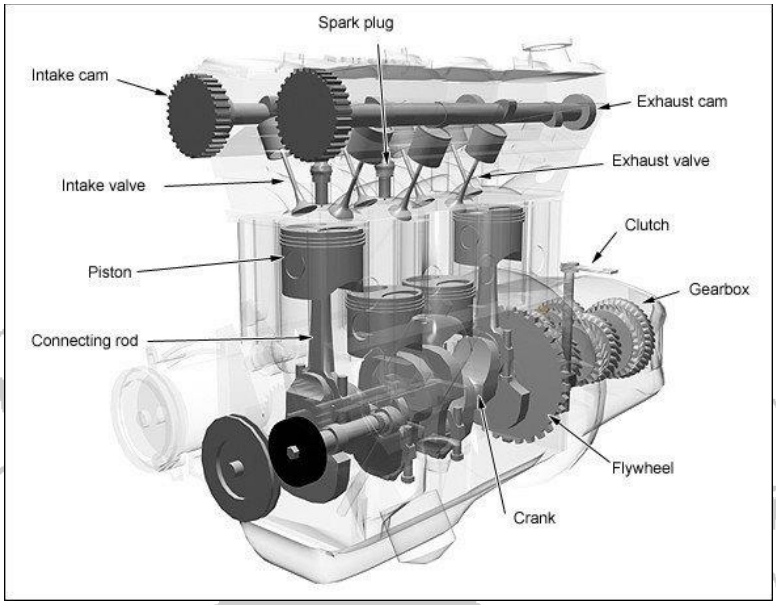


Fig.15.1: I.C. Engine Components

VII. Experimental setup

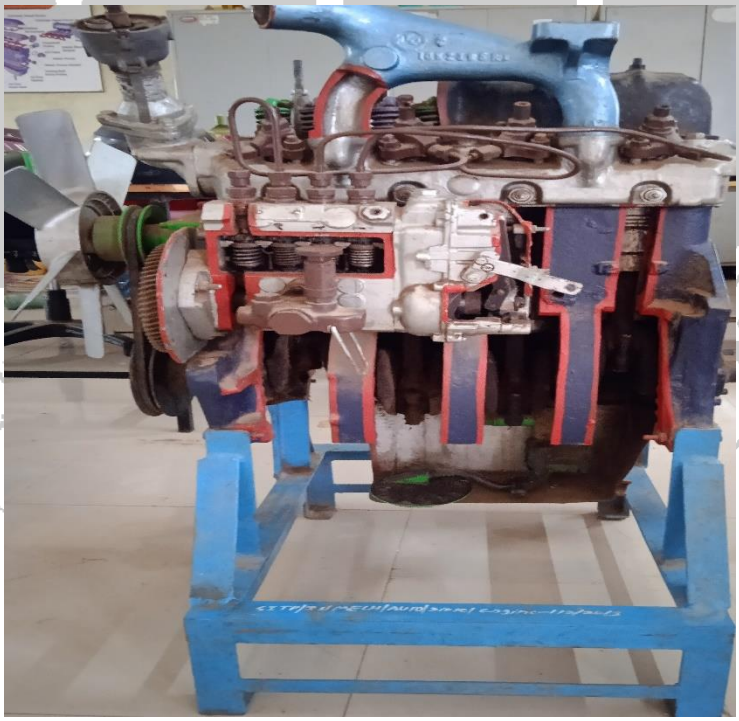


Fig 15. 2: Cut Section Model of Multicylinder I.C. Engine

VIII. Required Resources/apparatus/equipment with specifications

Sr.No	Name of Resource	Suggested Broad Specification	Quantity
1	Multicylinder I.C. Engine	Model of Multicylinder I.C. Engine showing all important parts	01

IX. Precautions to be followed (Safety instructions / Rules / Standards)

- Avoid improper handling of an I.C. Engine Model.
- Use safety shoes.

X. Procedure

1. Select the I.C. engine model for demonstration.
2. Observe the I.C. engine model selected for study purpose.
3. Explain the working principle of an I.C. engine.
4. Identify the main components of an I.C. engine.
5. Observe the location of each component.
6. State the function of each component of an I.C. engine.

XI. Observation and calculations

Particular	Name of component	Location	Material	Function
Multicylinder I.C. Engine	Cylinder			
	Cylinder head			
	Connecting rod			
	Crank Shaft			
	Camshaft			
	Crank Case			
	Piston			
	Piston Ring			
	Exhaust manifold			
	Intake manifold			
	Intake valve			
	Exhaust valve			

XII. Result(s)

XIII. Interpretation of results

XIV. Conclusion and recommendation

XV. Practical-related questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of identified CO.

1. Explain the working of a four-stroke diesel engine.
2. Compare carbureted and a fuel-injected IC engine.
3. State the functions of the crankshaft and camshaft in an IC engine.
4. Explain the purpose of using lightweight materials in the construction of IC engine components.
5. List the applications in which diesel engines are preferred over gasoline engines, and why?
6. Illustrate the use of an IC engine in a hybrid vehicle.

[Space for Answer]

XVI. References/Suggestions for further reading

- https://www.mecholic.com/basic-components-of-engine.
- https://studentlesson.com/components-of-internal-combustion-engine.
- https://science.howstuffworks.com/innovation/inventions/internal-combustion-engine.
- https://www.youtube.com/watch?v=H_RgFXjg-5s

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Handling of the models/setup	20%
2	Observations of the models/setup	20%
Product Related (10 Marks)		**(40%)**
3	Interpretation of different components of an I.C. Engine	10%
4	Conclusions	10%
5	Practical related questions	20%
	Total	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	