

GOVERNMENT POLYTECHNIC SHEOHAR



LABORATORY MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING

III SEMESTER

BASIC THERMODYNAMICS

SUBJECT CODE: P2425304

SESSION: 2024-27

TEACHING AND LEARNING SCHEME: -

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		C	T				
2425304	Basics Thermodynamics	2	1	4	2	9	6

COURSE OBJECTIVES

- To develop fundamental understanding of thermodynamic concepts, systems, properties, heat, and work.
- To enable students to understand and apply the laws of thermodynamics to engineering systems.
- To build the ability to analyse thermodynamic processes and cycles used in engineering applications
- To impart knowledge of steam properties, boilers, and their practical industrial applications.
- To develop competency in analysing behaviour of ideal gases, real gases, and pure substances.

COURSE OUTCOMES

CO-1 Assess thermodynamic properties and systems.

CO-2 Apply the laws of thermodynamics to the given systems.

CO-3 Analyse thermodynamics cycles.

CO-4 Quantify the behaviour of boiler based on the thermodynamic cycle.

CO-5 Analyse processes involving ideal gases and real substances.

LABORATORY SCHEDULE

DAY	1ST	2ND	3RD	4TH	5TH	6TH
	(10:00 AM-11:00 AM)	(11:00 AM-12:00 PM)	(12:00PM -01:00PM)	(01:00 PM-02:00PM)	(02:30 PM-03:30PM)	(03:30PM-04:30PM)
MONDAY						
TUESDAY					BASIC THERMODYNAMICS LAB	
WEDNESDAY						
THURSDAY					BASIC THERMODYNAMICS LAB	
FRIDAY						
SATURDAY						

MR. Kapil Deo Kumar

Faculty In-charge

MR. Rahul Kumar

Instructor In-charge

General Instructions & Safety Measures

- Wear **proper lab uniform, safety shoes, and avoid loose clothing.**
- Perform experiments **only after understanding procedure and with instructor permission.**
- Do not touch **hot surfaces, steam pipes, or boilers**; use protective gloves if required.
- Handle **electrical equipment with dry hands** and switch OFF power before connections.
- Stay away from **rotating/moving parts** of engines, turbines, and pumps.
- Ensure **pressure limits are not exceeded** and release pressure safely before opening systems.
- Maintain **safe distance from steam outlets, valves, and high-temperature zones.**
- Record observations **carefully and report any fault, leakage, or abnormality immediately.**
- Keep the lab **clean, dry, and free from water/oil spills to avoid accidents.**
- In emergency, **switch off equipment, inform instructor, and use safety devices (fire extinguisher, exits).**

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DATE _____

GRADE/MARKS

[illegible]

Exp. No.	Experiment Name	Mapped CO
1	Calibration of instruments	CO1
2	Petrol Engine study	CO2
3	Diesel Engine study	CO2
4	Heat Pump (COP)	CO2
5	Steam Turbine efficiency	CO2
6	Laws of Thermodynamics	CO3
7	Low Pressure Boilers	CO4
8	High Pressure Boilers	CO4
9	Pressure–Temperature relation	CO5

Exp. No.	Experiment Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2
1	Calibration of instruments	3	2	2	3	-	-	1	2	-
2	Petrol Engine study	3	2	2	2	1	-	1	3	2
3	Diesel Engine study	3	2	2	2	1	-	1	3	2
4	Heat Pump (COP)	3	3	2	3	1	2	2	2	2
5	Steam Turbine efficiency	3	3	2	3	1	2	2	3	2
6	Laws of Thermodynamics	3	3	2	2	2	-	2	2	-
7	Low Pressure Boilers	3	2	2	2	2	-	1	3	-
8	High Pressure Boilers	3	2	2	2	2	-	1	3	-
9	Pressure–Temperature relation	3	2	2	3	2	-	1	2	-

Experiment-I

Calibration of Thermometers and Pressure Gauges

1) Aim of Experiment

To calibrate thermometer and pressure gauge using standard reference instruments.

2) Practical Significance

Ensures accuracy of measurement instruments used in thermodynamic systems, improving reliability of experimental and industrial results.

3) Theory

Calibration is the process of comparing a measuring instrument with a standard instrument. Errors like zero error, scale error, and hysteresis may occur. Accurate measurement of temperature and pressure is essential in thermodynamic processes.

4) Apparatus Required

Thermometer, pressure gauge, standard thermometer, dead weight tester, water bath, heat source

5) Procedure

- Set up thermometer in water bath
- Heat water gradually
- Record readings of standard and test thermometer
- Apply known pressure using dead weight tester
- Record gauge readings
- Plot calibration curve





6) Observation

Thermometer Calibration			
S.No	Standard (°C)	Observed (°C)	Error
1			
2			
3			
4			
5			

Pressure Gauge			
S.No	Standard (bar)	Observed (bar)	Error
1			
2			
3			
4			
5			

7) Conclusion

Instrument accuracy is improved after calibration and correction values are established.

Experiment-II

Study of Petrol Engine (Spark Ignition Engine)

1) Aim of Experiment

- To study the construction of a petrol engine using a cross-sectional model
- To identify various components of the engine
- To understand the working of a four-stroke petrol engine

2) Practical Significance

Petrol engines are widely used in automobiles such as motorcycles, cars, and small utility vehicles. Understanding their construction and working is essential for mechanical engineers involved in automobile design, maintenance, and operation.

This experiment helps students to visualize the internal components and working mechanism of an internal combustion engine. It develops the ability to identify engine parts, understand energy conversion processes, and relate theoretical thermodynamic cycles with practical systems. Knowledge of petrol engines is also important for diagnosing faults, improving efficiency, and reducing emissions.

3) Theory

A petrol engine is an internal combustion engine (IC engine) in which combustion of fuel (petrol) takes place inside the cylinder. It works on the Otto cycle and uses a spark plug for ignition.

Main Components of Petrol Engine

- Cylinder
- Piston
- Connecting rod
- Crankshaft
- Inlet valve
- Exhaust valve
- Spark plug
- Carburettor

Working Principle (Four-Stroke Cycle)

1. Suction Stroke

- Inlet valve opens

- Air-fuel mixture enters cylinder
- Piston moves downward

2. Compression Stroke

- Both valves closed
- Mixture compressed
- Temperature and pressure increase

3. Power Stroke

- Spark plug ignites mixture
- Rapid combustion occurs
- High pressure pushes piston downward

4. Exhaust Stroke

- Exhaust valve opens
- Burnt gases expelled
- Piston moves upward

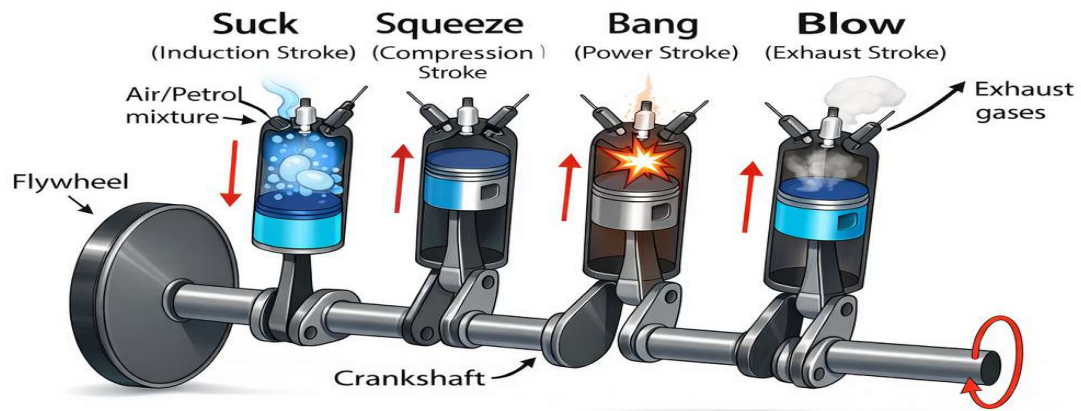
4) Apparatus Required

- Cross-sectional model of petrol engine
- Chart/diagram of engine
- Pointer (for identification)

5) Procedure

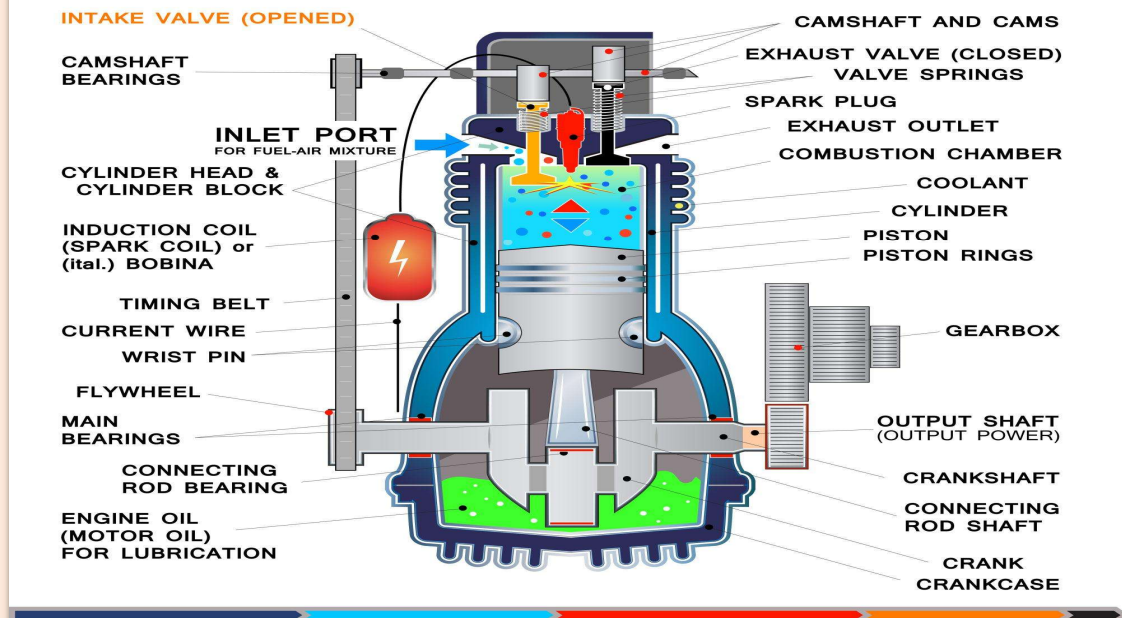
- Place the petrol engine model on a flat surface.
- Carefully observe the external and internal structure of the engine.
- Identify and locate major components such as piston, cylinder, valves, spark plug, and crankshaft.
- Rotate the crankshaft manually (if possible) to observe the movement of piston and valves.
- Study the sequence of strokes in the engine cycle.
- Note the function of each component.

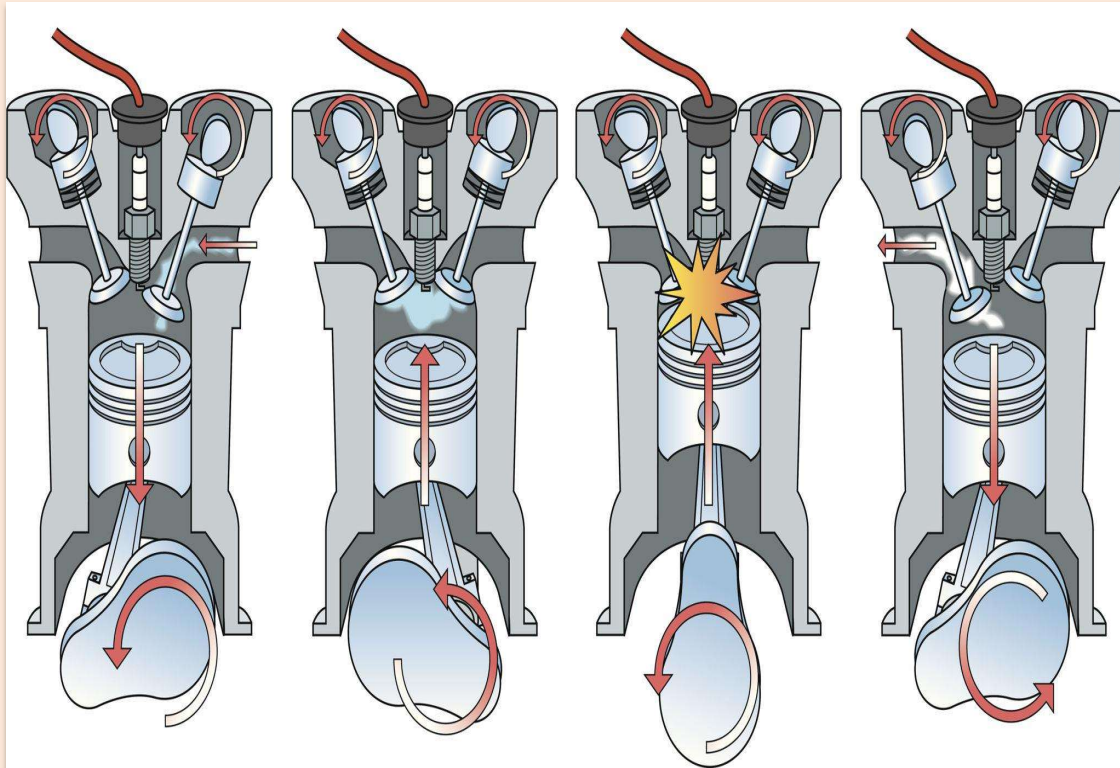
Four Stroke Engine



1. **Suck - Induction Stroke** – Air/Petrol mixture drawn in.
2. **Squeeze - Compression Stroke** – Valves close and piston moves up.
3. **Bang - Power Stroke** – Electric spark from spark plug ignites mixture.
4. **Blow - Exhaust Stroke** – Piston moves up pushing gases out.

PISTON PETROL ENGINE ENGINE WITH INTERNAL COMBUSTION CROSS SECTION AND PARTS (SINGLE CYLINDER):





6) Observation

S. No.	Component Name	Function
1	Cylinder	Encloses piston and combustion space
2	Piston	Converts pressure into mechanical work
3	Spark Plug	Ignites air-fuel mixture
4	Inlet Valve	Allows entry of air-fuel mixture
5	Exhaust Valve	Releases burnt gases
6	Crankshaft	Converts reciprocating motion to rotary motion

7) Conclusion

The construction and working of a petrol engine were successfully studied using a cross-sectional model. All major components were identified, and the four-stroke cycle was clearly understood. It is concluded that petrol engines operate on spark ignition and are widely used in light vehicles due to their smooth operation and quick response.

EXPERIMENT-III

Study of Diesel Engine (Compression Ignition Engine)

1) Aim of Experiment

- To study the construction of a diesel engine using a cross-sectional model
- To identify the various components of a diesel engine
- To understand the working of a four-stroke diesel engine

2) Practical Significance

Diesel engines are widely used in heavy vehicles such as trucks, buses, tractors, and in industrial applications like power generation and marine engines. They are preferred due to their higher efficiency, durability, and better fuel economy compared to petrol engines.

This experiment helps students understand the construction and working of a diesel engine using a cross-sectional model. It provides practical knowledge of engine components, combustion process, and energy conversion. Understanding diesel engines is essential for mechanical engineers involved in maintenance, design, and troubleshooting of engine systems.

3) Theory

A diesel engine is an internal combustion engine (IC engine) in which fuel combustion takes place due to high compression of air, without the use of a spark plug. It works on the Diesel cycle and uses a fuel injector for injecting diesel into the cylinder.

Main Components of Diesel Engine

- Cylinder
- Piston
- Connecting rod
- Crankshaft
- Inlet valve
- Exhaust valve
- Fuel injector
- Flywheel

Working Principle (Four-Stroke Diesel Engine)

1. Suction Stroke

- Inlet valve opens

- Only air enters the cylinder
- Piston moves downward

2. Compression Stroke

- Both valves closed
- Air is highly compressed
- Temperature rises significantly

3. Power Stroke

- Diesel fuel injected into hot compressed air
- Self-ignition occurs (no spark needed)
- Combustion produces high pressure
- Piston is pushed downward

4. Exhaust Stroke

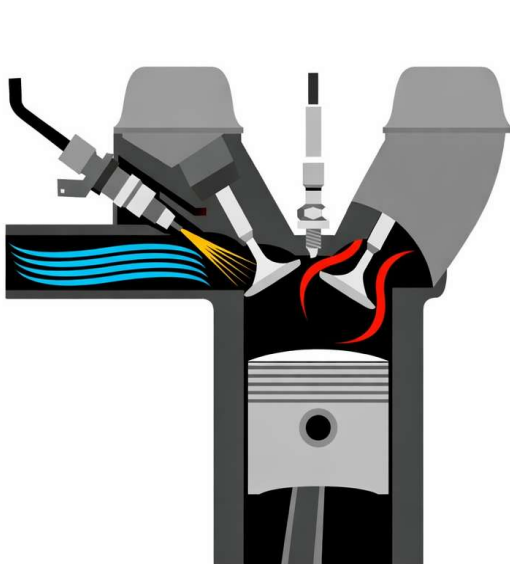
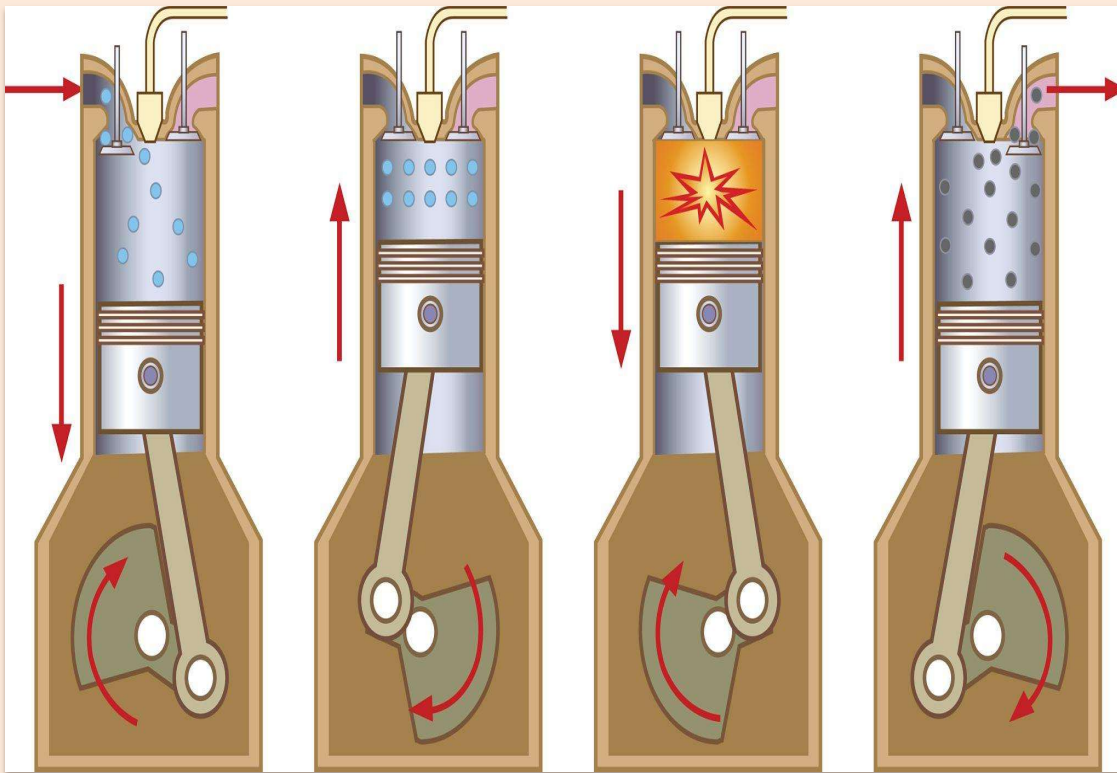
- Exhaust valve opens
- Burnt gases expelled
- Piston moves upward

4) Apparatus Required

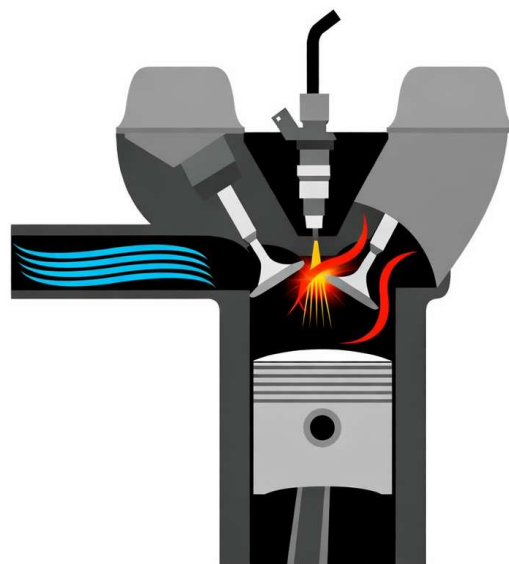
- Cross-sectional model of diesel engine
- Engine chart/diagram
- Pointer for identification

5) Methodology / Procedure

- Place the diesel engine model on a stable platform.
- Observe the outer and inner construction of the engine.
- Identify all major components such as piston, cylinder, injector, valves, and crankshaft.
- Rotate the crankshaft manually to observe piston movement and valve operation.
- Study the sequence of four strokes (suction, compression, power, exhaust).
- Note the role of the fuel injector in combustion.



**Petrol Engine
Combustion**



**Diesel Engine
Combustion**

6) Observation

S. No.	Component Name	Function
1	Cylinder	Encloses the combustion space
2	Piston	Converts pressure into mechanical work
3	Fuel Injector	Injects diesel fuel into cylinder
4	Inlet Valve	Allows air to enter
5	Exhaust Valve	Releases burnt gases
6	Crankshaft	Converts reciprocating motion into rotary motion
7	Flywheel	Maintains uniform rotation

7) Conclusion

The construction and working of a diesel engine were successfully studied using a cross-sectional model. All major components were identified, and the four-stroke cycle was clearly understood. It is concluded that diesel engines operate on compression ignition, offer higher efficiency, and are widely used in heavy vehicles and industrial applications.

EXPERIMENT-IV

Verification of First and Second Law of Thermodynamics using Heat Engine

1) Aim of Experiment

- To verify the First Law of Thermodynamics (energy conservation)
- To verify the Second Law of Thermodynamics (direction of heat flow)
- To study the working of a heat engine

2) Practical Significance

The laws of thermodynamics form the foundation of all energy systems such as engines, turbines, refrigerators, and power plants. The first law explains energy conservation, while the second law defines the direction of heat flow and efficiency limitations.

This experiment provides practical understanding of how energy is converted from heat to work in a heat engine. It helps students relate theoretical concepts with real systems and understand why no machine can achieve 100% efficiency. This knowledge is essential for designing efficient thermal systems and minimizing energy losses in engineering applications.

3) Theory

◆ First Law of Thermodynamics

The first law states that energy can neither be created nor destroyed, it can only be transformed from one form to another.

$$Q = W + \Delta U$$

Where:

- Q = Heat supplied to system
- W = Work done by system
- ΔU = Change in internal energy

For a cyclic process:

$$Q = W$$

◆ Second Law of Thermodynamics

The second law states that:

- Heat always flows from a higher temperature body to a lower temperature body

- It is impossible to convert all heat into work (efficiency < 100%)

◆ Heat Engine Concept

A heat engine works between two reservoirs:

- Source (high temperature)
- Sink (low temperature)

It absorbs heat from the source, converts part of it into work, and rejects the remaining heat to the sink.

4) Apparatus Required

- Heat engine model / setup
- Thermometers
- Stopwatch
- Measuring devices (for heat/work)
- Fuel or electrical heating arrangement

5) Methodology / Procedure

- Set up the heat engine apparatus properly.
- Start the heat source and allow the system to reach steady state.
- Measure the **heat input (Q_1)** supplied to the engine.
- Measure the **heat rejected (Q_2)** to the surroundings.
- Determine the **work done (W)** by the system.
- Record all readings carefully.
- Verify whether the relation $Q_1 = Q_2 + W$ holds true.
- Observe the direction of heat flow from source to sink.

6) Observation

S. No.	Heat Supplied Q_1 (J)	Heat Rejected Q_2 (J)	Work Done W (J)
1			
2			
3			

7) Conclusion

The experiment successfully verified both the First and Second Laws of Thermodynamics using a heat engine. It was observed that total heat supplied is equal to the sum of work done and heat rejected, confirming energy conservation. Also, heat flow occurs naturally from high to low temperature and complete conversion of heat into work is not possible. Thus, the fundamental principles of thermodynamics were validated experimentally.

EXPERIMENT-V

Study of Low-Pressure Boiler

1) Aim of Experiment

- To study the construction and working of low-pressure boilers
- To identify various components, mountings, and accessories
- To understand the applications of low-pressure boilers

2) Practical Significance

Low pressure boilers are widely used in small-scale industries, workshops, and domestic applications such as heating, cooking, and small steam generation systems. They operate at relatively low pressures, making them safer, easier to maintain, and economical.

Understanding the construction and working of low-pressure boilers is essential for mechanical engineers, as it helps in selecting appropriate boilers, ensuring safe operation, and performing maintenance. This experiment develops practical knowledge about boiler components, mountings, and accessories, which are critical for efficient steam generation.

3) Theory

A boiler is a closed vessel in which water is heated to produce steam by the application of heat. A low-pressure boiler operates at pressures typically below 80 bar and is mainly used for small-scale applications.

◆ Types of Low-Pressure Boilers

- Cochran Boiler
- Lancashire Boiler

◆ Main Components of Boiler

- Shell: Outer cylindrical body containing water and steam
- Furnace: Area where fuel is burnt
- Fire Tubes: Carry hot gases through water
- Chimney: Releases flue gases

◆ Boiler Mountings (Safety Devices)

- Safety valve
- Pressure gauge

- Water level indicator
- Fusible plug

◆ Boiler Accessories (Efficiency Improvement)

- Economizer
- Superheater
- Air preheater

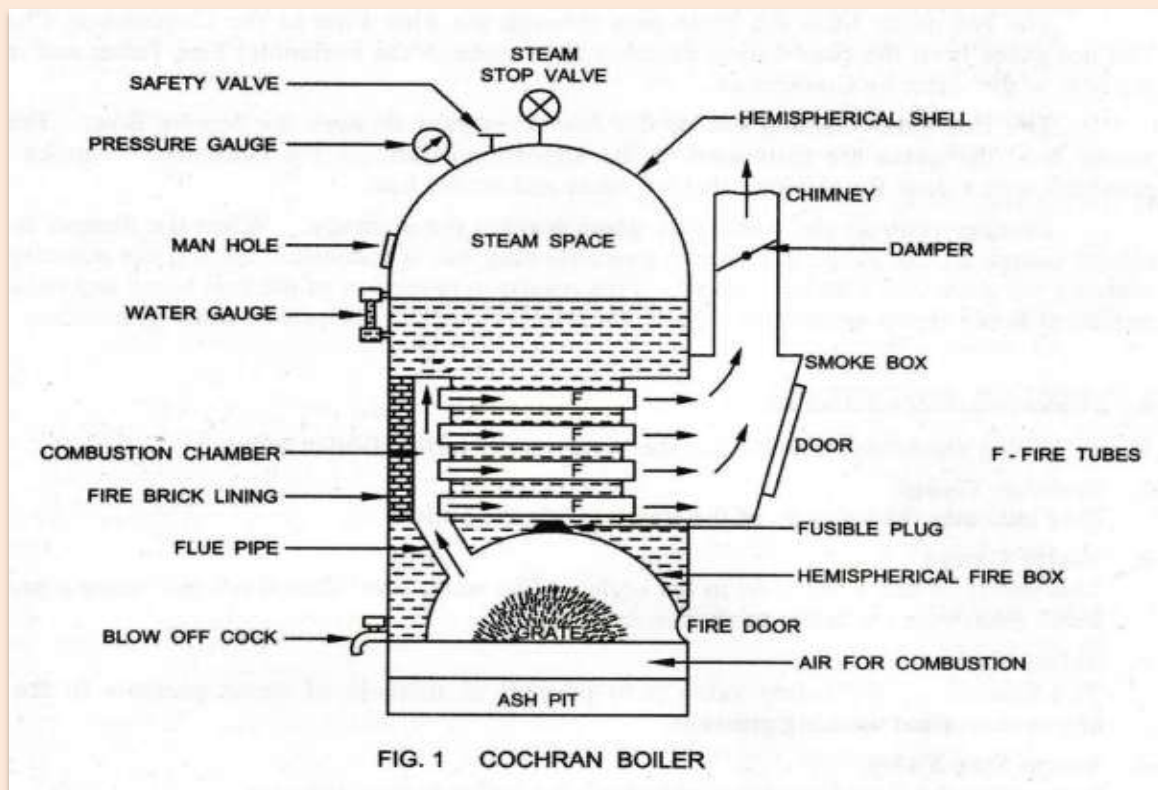
◆ Working Principle

Fuel is burnt in the furnace, producing hot gases. These gases pass through fire tubes surrounded by water. Heat transfer takes place, converting water into steam. The steam is collected and supplied for various applications.

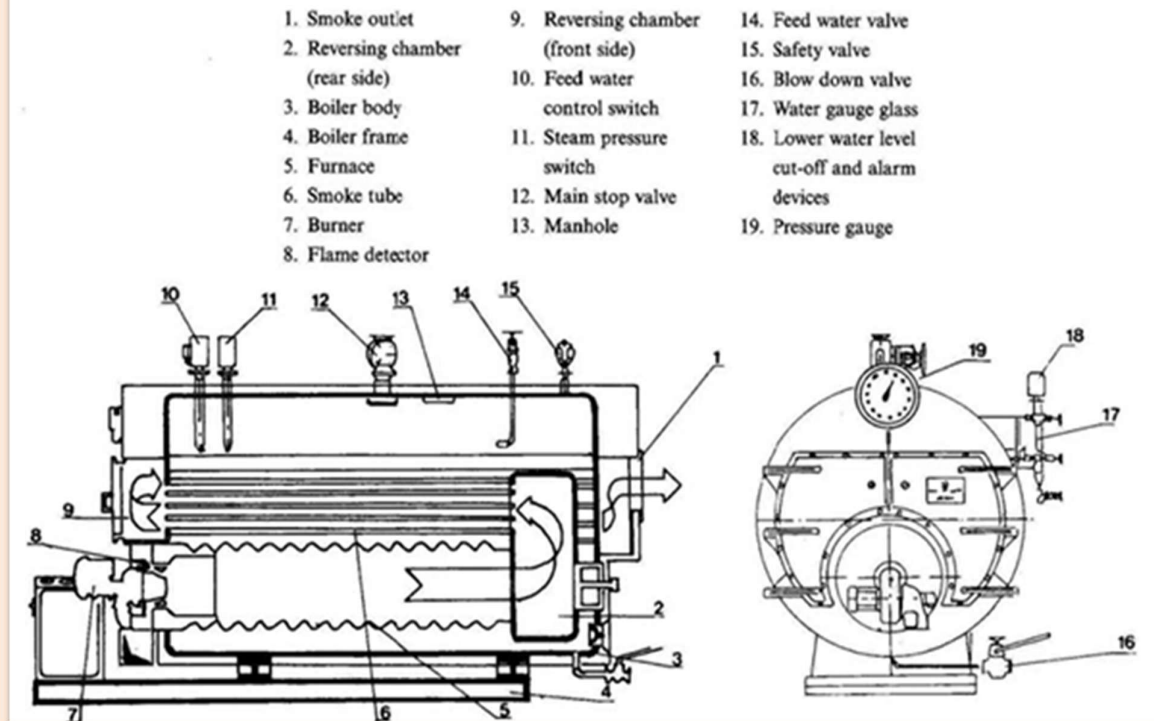
4) Apparatus Required

- Working model of low-pressure boiler (Cochran/Lancashire)
- Boiler mountings and accessories model
- Chart/diagram of boiler

5) Methodology



FIRE-TUBE BOILER



- Place the boiler model on a stable platform.
- Observe the external and internal structure of the boiler.
- Identify main components such as shell, furnace, and fire tubes.
- Locate boiler mountings like safety valve, pressure gauge, and water level indicator.
- Identify accessories such as economizer and superheater.
- Study the flow of flue gases and heat transfer process.
- Note the working principle and steam generation process.

6) Observation

S. No.	Component Name	Function
1	Shell	Contains water and steam
2	Furnace	Burns fuel to generate heat
3	Fire Tubes	Transfer heat to water
4	Chimney	Releases exhaust gases

5	Safety Valve	Prevents excessive pressure
6	Pressure Gauge	Measures steam pressure
7	Water Level Indicator	Indicates water level

7) Conclusion

The construction and working of a low-pressure boiler were successfully studied using a model. All major components, mountings, and accessories were identified. It is concluded that low pressure boilers are simple, safe, and economical for small-scale applications, although they have lower efficiency compared to high pressure boilers.

EXPERIMENT-VI

Study of High-Pressure Boilers

1) Aim of Experiment

- To study the construction and working of high-pressure boilers
- To identify various components, mountings, and accessories
- To understand the advantages of high-pressure boilers over low pressure boilers.

2) Practical Significance

High pressure boilers are extensively used in thermal power plants, industries, and large-scale steam generation systems. They operate at high pressures and temperatures, resulting in higher efficiency and better steam generation rates compared to low pressure boilers.

Understanding high pressure boilers is essential for mechanical engineers because these systems are the backbone of power generation and industrial processes. This experiment provides practical knowledge of advanced boiler construction, working principles, and components such as superheaters and economizers, which enhance efficiency and performance.

3) Theory

A high-pressure boiler is a steam generating device that operates at pressures generally above 80 bar. These boilers are designed to produce large quantities of steam at high pressure and temperature, which improves thermal efficiency.

◆ Types of High-Pressure Boilers

- Babcock and Wilcox Boiler
- Lamont Boiler
- Loeffler Boiler

◆ Main Components

- Water Tubes: Water flows inside tubes and gets heated
- Steam Drum: Collects steam generated
- Furnace: Burns fuel to produce heat
- Superheater: Converts saturated steam into superheated steam
- Economizer: Preheats feed water using flue gases
- Air Preheater: Preheats air for combustion

◆ Boiler Mountings

- Safety valve
- Pressure gauge
- Water level indicator
- Fusible plug

◆ Working Principle

In high pressure boilers, water circulates through tubes (water-tube boiler). Hot gases produced by fuel combustion flow over these tubes. Heat transfer takes place, converting water into steam. The steam is collected in the steam drum and may be further heated in a superheater before use.

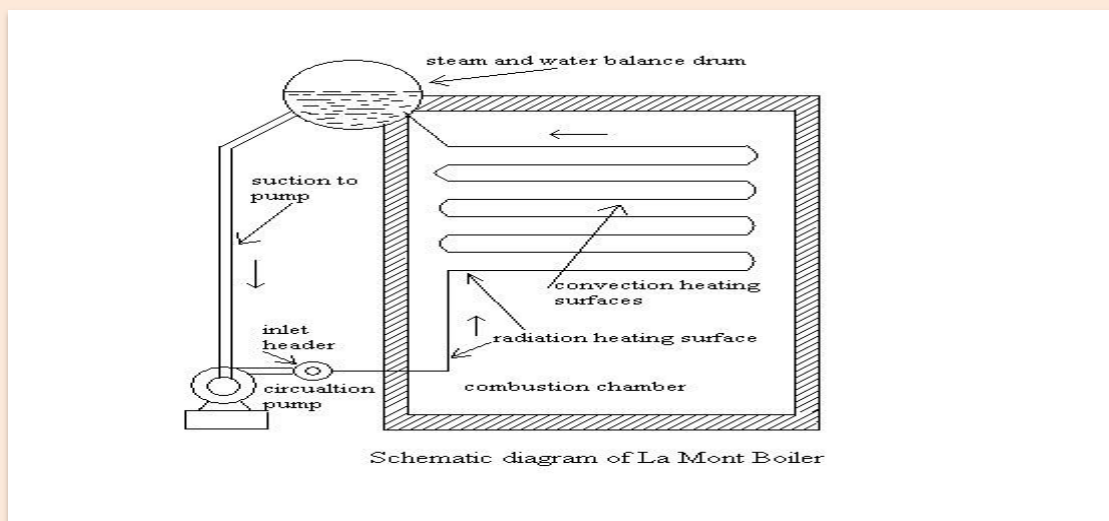
◆ Advantages of High-Pressure Boilers

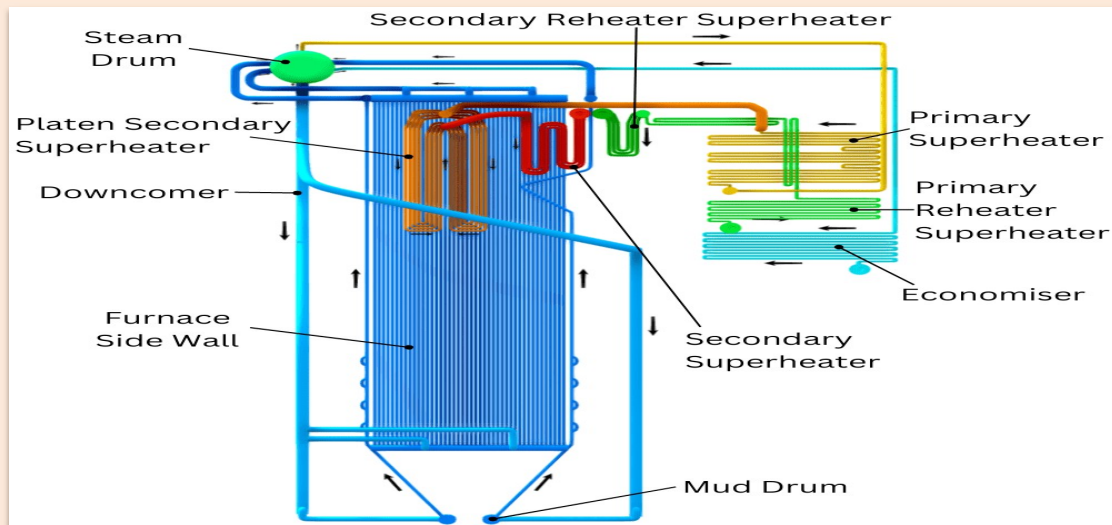
- Higher efficiency
- Rapid steam generation
- Better heat transfer
- Suitable for power plants

5) Apparatus Required

- Model of high-pressure boiler (Babcock & Wilcox / Lamont)
- Boiler mountings and accessories model
- Chart/diagram of boiler

6) Procedure





- Place the high-pressure boiler model on a stable surface.
- Observe the construction and identify the type of boiler.
- Identify major components such as water tubes, steam drum, furnace, and superheater.
- Locate mountings like safety valve, pressure gauge, and water level indicator.
- Identify accessories such as economizer and air preheater.
- Study the flow of water, steam, and flue gases in the system.
- Understand the process of steam generation and superheating.

7) Observation

S. No.	Component Name	Function
1	Water Tubes	Carry water and transfer heat efficiently
2	Steam Drum	Collects generated steam
3	Furnace	Produces heat by burning fuel
4	Superheater	Increases steam temperature

5	Economizer	Preheats feed water
6	Air Preheater	Preheats air for combustion
7	Safety Valve	Ensures safe operation
8	Pressure Gauge	Measures steam pressure

8) Conclusion

The construction and working of a high-pressure boiler were successfully studied. All major components, mountings, and accessories were identified. It is concluded that high pressure boilers are more efficient, produce steam rapidly, and are widely used in power plants and industrial applications due to their superior performance.