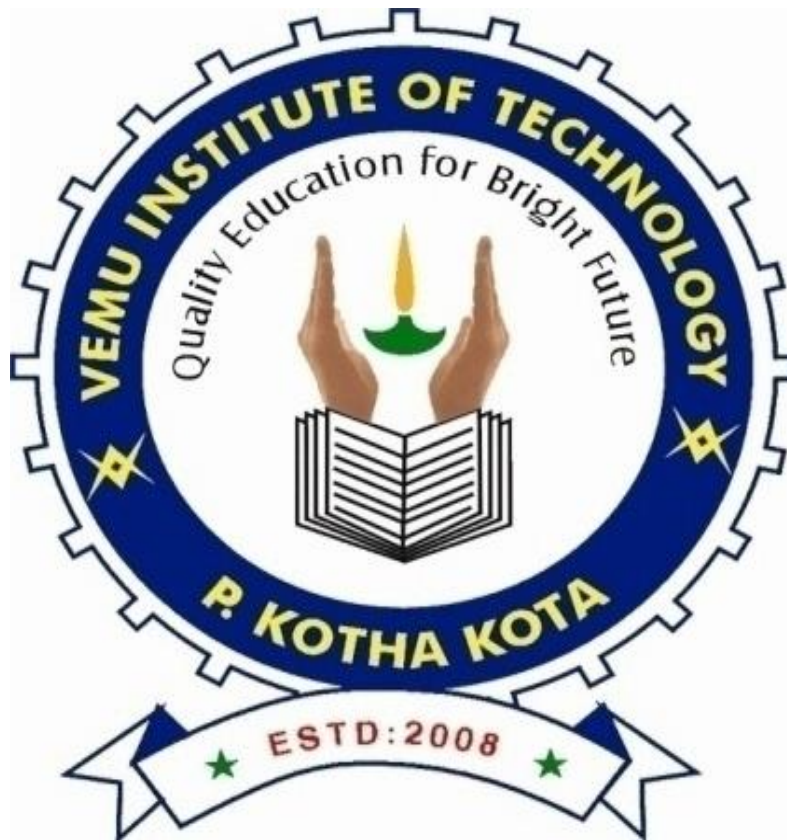


# VEMU INSTITUTE OF TECHNOLOGY

(Affiliated To JNTUA University)

## APPLIED THERMODYNAMICS LAB (20A03401P)

### LAB MANUAL



**DEPARTMENT**  
Of  
**MECHANICAL ENGINEERING**

# VEMU INSTITUTE OF TECHNOLOGY

(Affiliated To JNTUA University)

**APPLIED THERMODYNAMICS LAB (20A03401P)**

**LAB OBSERVATION**

**Certificate**

Department of .....

This is to certify that the bonafide record of work done by

Mr./Miss.....Bearing Roll No.....is a student of

.....In.....branch has completed

.....Experiments in.....laboratory during the Academic

year.....

**Signature of HOD**

**Signature of Lab- In charge**

## APPLIED THERMODYNAMICS LAB (20A03401P)

<b>Subject Code</b>	<b>: 20A03401P</b>	<b>No. of Credits</b>	<b>: 1.5</b>
<b>No. of Contact Hours /week</b>	<b>: 03</b>	<b>Max. Marks</b>	<b>: 70</b>
<b>Total No. of Contact Hours</b>	<b>:</b>		

### **COURSE OBJECTIVES:**

1. To Analyse the functioning and performance of I.C. Engines.
2. To evaluate the heat losses in the I.C engines.
3. To evaluate the performance of the air compressor.
4. To illustrate the working and evaluate the performance of refrigeration system.
5. To understand the psychrometric properties of air and evaluate the performance of air conditioning system.

### **COURSE OUTCOMES:**

<b>Upon completion of this course, students should be able to:</b>	
<b>C01</b>	Analyze the performance characteristics of diesel engine.
<b>C02</b>	Analyze the performance characteristics and Morse test on single/multi cylinder petrol engine.
<b>C03</b>	Analyze the performance characteristics of an air compressor.
<b>C04</b>	Evaluate the COP of refrigeration system.
<b>C05</b>	Evaluate the psychrometric properties and Coefficient of performance of Refrigerator and heat pipe.

# *Course Outcomes*

S. No	Name of The Experiment	COs
1.	Demonstration of diesel and petrol engines by cut models	CO1
2.	Port timing diagram of 2-stroke petrol engine	CO1
3.	Valve timing diagram of 4-stroke diesel engine	CO2
4.	Performance of 2-stroke single cylinder petrol engine	CO2
5.	Morse test on multi cylinder petrol engine	CO2
6.	Performance of 4-stroke single cylinder diesel engine	CO1
7.	Performance of two stage reciprocating air compressor	CO3
8.	Assembly and disassembly of diesel and petrol engines	CO1
9.	Performance of Refrigeration system	CO4
10.	Performance of Air conditioning system	CO5
Content Beyond the Syllabi		
11.	Performance of variable compression ratio single cylinder petrol engine	
12.	Study of Steam Boilers	

# INDEX

S. No	Name of The Experiment	Date	Page. No	Remarks
1.	Demonstration of diesel and petrol engines by cut models			
2.	Port timing diagram of 2-stroke diesel engine			
3.	Valve timing diagram of 4-stroke petrol engine			
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12.	Study of Steam Boilers			

## ***Department of Mechanical Engineering***

### **VEMU INSTITUTE OF TECHNOLOGY:P.KOTHAKOTA**

#### **Vision of the Department:**

To become a Centre of excellence in the field of Mechanical Engineering by producing professional graduates with technical knowledge, research, consultancy and entrepreneurial skills along with leadership qualities, ethics and lifelong learning to cater the needs of the society.

#### **Mission of the Department:**

- ✓ To impart quality education and training to nurture globally competitive mechanical engineers by state-of-the art laboratories and core instructions through eminent faculty members.
- ✓ To establish linkages with Premiere industries and research organizations to bring excellence in technical problem solving skills, research and consultancy services.
- ✓ To empower the graduates globally competent with creative thinking, leadership skills, lifelong learning, spirit of entrepreneurship, social and ethical values by offering value based education.

Ex. No :

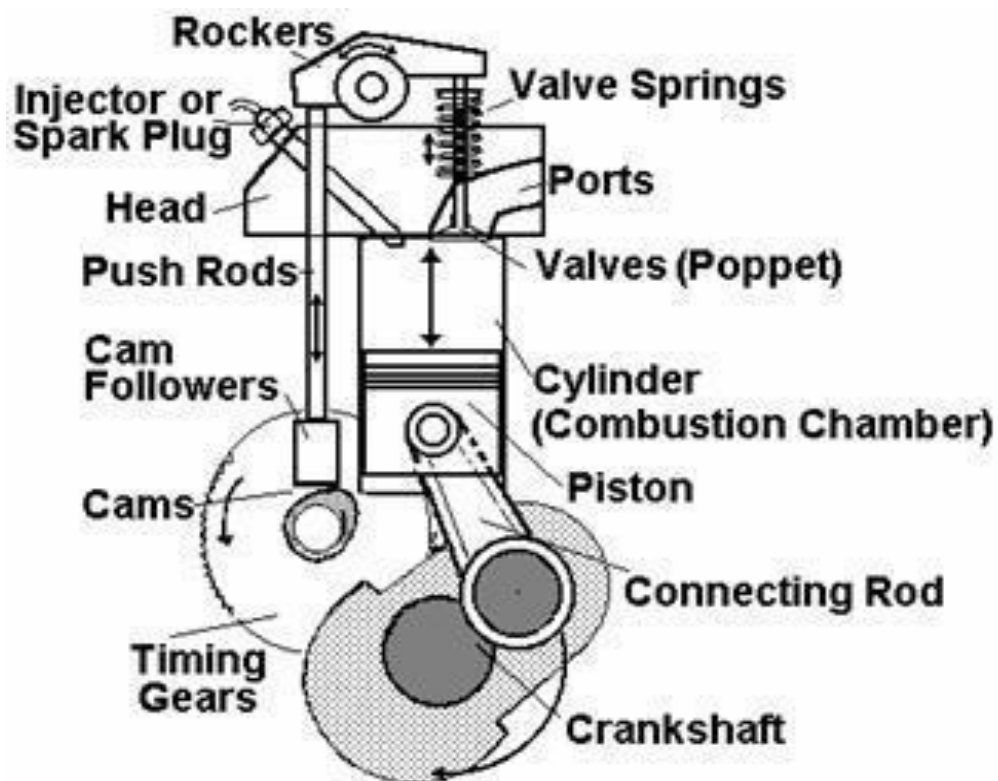
Date :

## CUT MODELS OF DIESEL AND PETROL ENGINES

### Cut model of four stroke Diesel engines.

**AIM:-** To study the cut model of an I.C engine and observe various parts of an I.C engine.

**DIAGRAM:-**

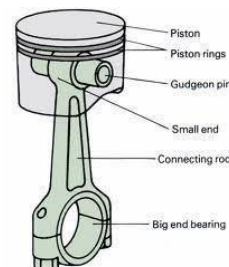


Cut Model of 4 Stroke I.C Engine

### PARTS OF I.C ENGINE:-

**Piston:** It moves from **BDC to TDC**. One stroke of piston is define as movement of piston form one Extreme (TDC or BDC) to other extreme (BDC to TDC).

**Material:** Cast Iron, Aluminum Alloy.

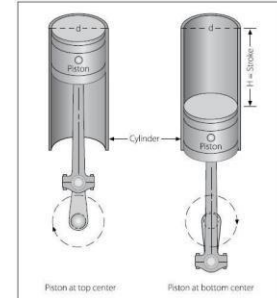


**Function:** Its purpose is to change the volume enclosed by the cylinder, to exert a force on a fluid inside the cylinder or to cover and uncover ports. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod or connecting rod.

**Cylinder:** It is same as used in four stroke engine except it does not have valve mechanism. It has two ports on side wall of cylinder.

**Material:** Cast Iron, Alloy Steel.

**Function:** It provide the space for combustion and compression.



**Crankshaft:** It is used to convert reciprocating motion of piston into rotary motion.

**Material:** Alloy steel, SG Iron.

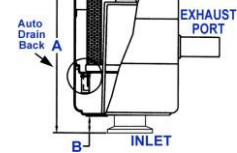


**Function :** Its help in converting reciprocating motion of piston into rotary motion.

**Inlet and Exhaust Port:** Two stroke engines contain ports except valves. These ports open and closed due to piston movement. When the piston is moving towards TDC inlet ports opens and when it moves toward BDC exhaust port opens.

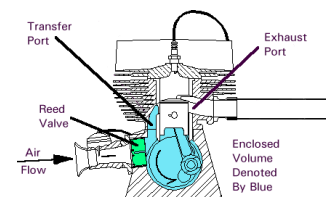
**Materials:** Special Alloy Steel.

**Function:** Its helps in the entry and exit of the fuel whenever needed.



**Transfer Port:** These engines contain one extra port which is known as transfer port. It is connected from crankcase to combustion chamber. Its main function is to supply the charge from crankcase to combustion chamber when piston is moving from TDC to BDC.

**Material:** Special Steel Alloy.



**Function:** It directs the fresh intake charge into the upper part of the cylinder, pushing the residual exhaust gas down the other side of the deflector and out the exhaust port.

**Inlet and Exhaust Manifold:** These are connected to inlet and exhaust port and regulate the flow of charge and exhaust gases.

**Material:** Special Aluminium alloy



**Figure . Inlet and Exhaust Manifold**

**Function:** The primary function of the intake manifold is to *evenly* distribute the combustion mixture (or just air in a direct injection engine) to each intake port in the cylinder head. an exhaust manifold collects

the exhaust gases from multiple cylinders into a smaller number of pipes – often down to one pipe.

**Flywheel:** It need smaller flywheel compare to four stroke engine because less power fluctuation.

**Material:** Cast Iron



**Function:** Its helps in fluctuation of speed.

**Crankcase:** This is the part where crankshaft situated. The inlet port is also connected with crankcase. First charge enters into crankcase and send to combustion chamber through transfer port.

**Material:** Aluminum Alloy, Steel, Cast Iron.

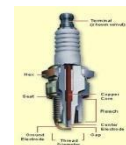


**Function:** Both sides of the piston are used as working surfaces: the upper side is the power piston, the lower side acts as a scavenging pump. As the piston rises, it pushes out exhaust gases and produces a partial vacuum in the crankcase, which draws in fuel and air. As the piston travels downward, the compressed fuel/air charge is pushed from the crankcase into the cylinder.

**Spark Plug:** It is a device for delivering electric current from an ignition system to the combustion chamber of a spark-ignition engine to ignite the compressed fuel/air mixture by an electric spark, while containing combustion pressure within the engine.

**Material:** Copper and Nickel Alloy.

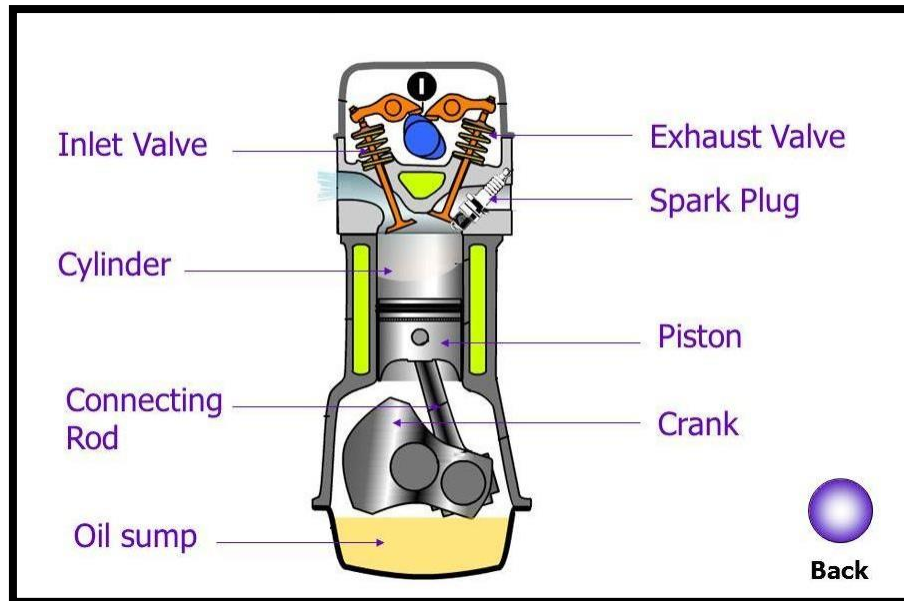
**Function:** To ignite the air/fuel mixture. Electrical energy is transmitted through the spark plug, jumping the gap in the plugs firing end if the voltage supplied to the plug is high enough. This electrical spark ignites the gasoline/air mixture in the combustion chamber.



**Figure. Spark Plug**

## Cut model of four stroke petrol engines.

**APPARATUS:-** Model of two stroke and four stroke petrol engine.



### **THEORY:-**

#### **WORKING PRINCIPLE OF FOUR STROKE PETROL ENGINES:-**

There are four strokes which are as follows:

- i) Suction stroke*
- ii) Compression stroke*
- iii) Expansion or working or power stroke*
- iv) Exhaust stroke*

i) **SUCTION STROKE:** The suction stroke starts with the piston at top dead centre position. During this stroke, the piston moves downwards by means of crank shaft. The inlet valve is opened and the exhaust valve is closed. The partial vacuum created by the downward movement of the piston sucks in the fresh charge (mixture of air and petrol) from the carburetor through the inlet valve. The stroke is completed during the half revolution (180°) of the crank shaft, which means at the end of the suction stroke, piston reaches the bottom head centre position.

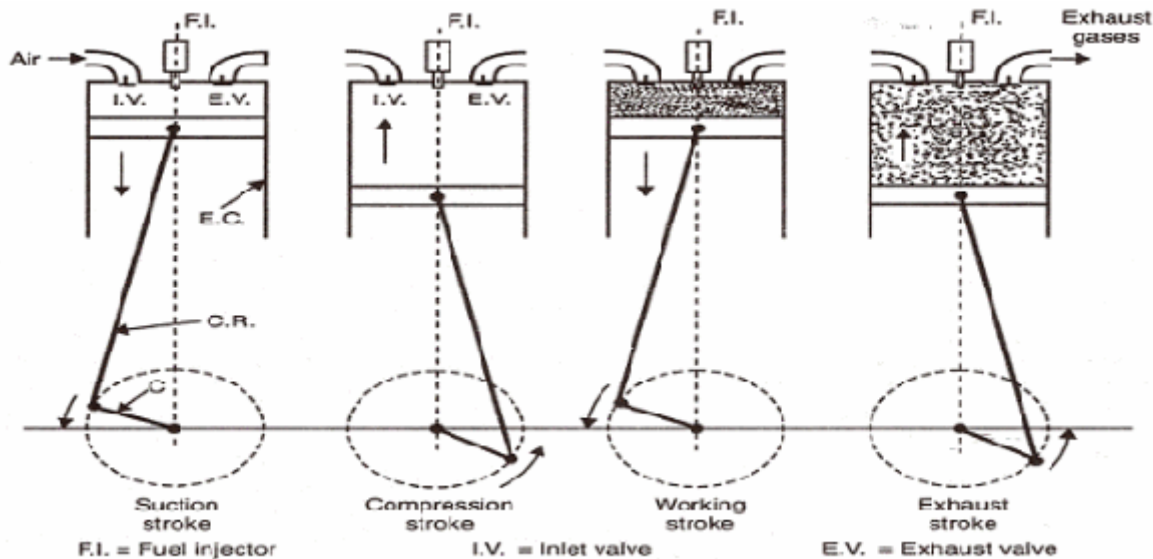


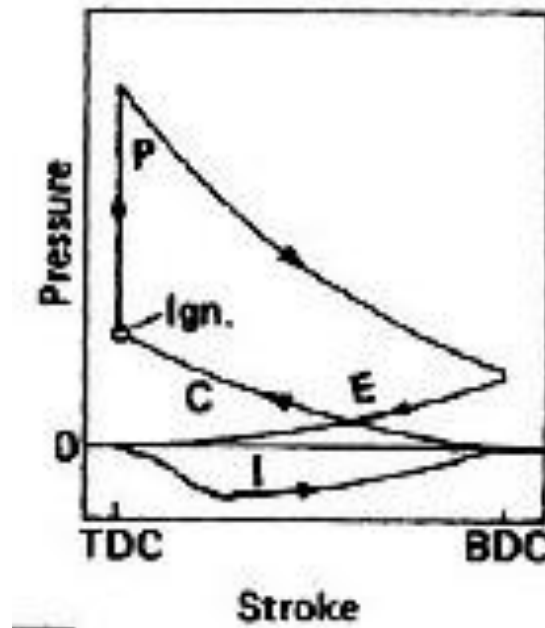
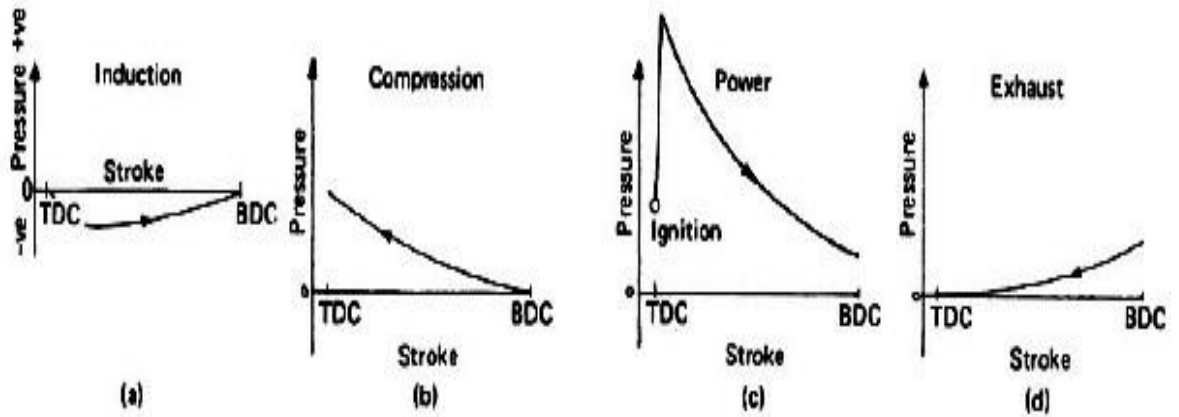
Figure .suction, compression, power and exhaust stroke

ii) **COMPRESSION STROKE:** During this stroke the inlet and exhaust valves are closed and the piston returns from bottom dead centre position. As the piston moves up, the charge is compressed. During compression the pressure and temperature rises. This rise in temperature and pressure depends upon the compression ratio (in petrol engines the compression ratio generally varies between 6:1 and 9:1). Just before the completion of the compression stroke, the charge is ignited by means of an electric spark, produced at the spark plug.

iii) **WORKING OR EXPANSION STROKE:** The ignition of the compressed charge. Just before the completion of compression stroke, causes a rapid rise of temperature and pressure in the cylinder. During this stroke the inlet and exhaust valves remain closed. The expansion of gases due to the heat of combustion exerts pressure on the piston due to which the piston moves downward, doing some useful work.

iv) **EXHAUST STROKE:** The exhaust valve is opened and the inlet valve remain closed. The piston moves upward (from its BDC position) with the help of energy stored in the flywheel during the working stroke. The upward movement of the piston discharges the burnt gases through the exhaust valve.

At the end of exhaust stroke, piston reaches its TDC position and the next cycle starts



<b>Ex. No :</b>	<b>PORT TIMING DIAGRAM OF TWO STROKE PETROL ENGINE</b>
<b>Date :</b>	

## **Aim**

To draw the port timing diagram of given two stroke petrol engine.

## **Apparatus Required**

1. Two stroke petrol engine
2. Measuring tape
3. Chalk

## **Theory and Description**

In the case of two stroke petrol engines the inlet and exhaust valves are not present. Instead, the slots are cut on the cylinder itself at different elevation and they are called ports. There are three ports are present in the two stroke cycle engine.

1. Inlet port
2. Transfer port
3. Exhaust port

The diagram which shows the position of crank at which the above ports are open and close are called as “port timing diagram”.

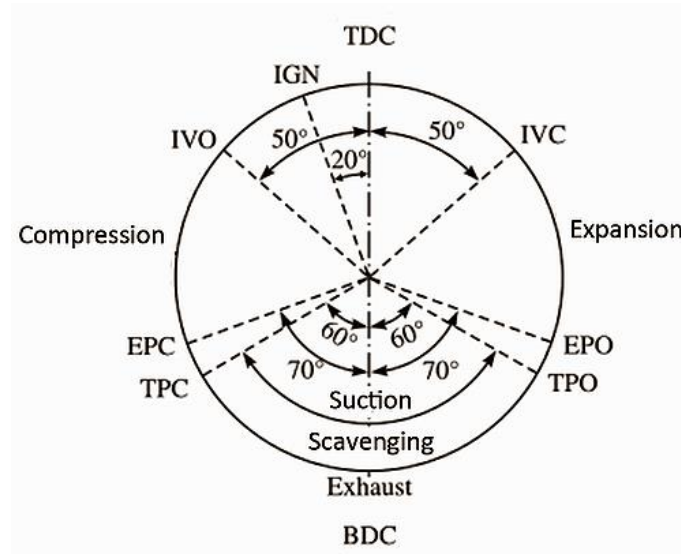
The extreme position of the piston at the bottom of the cylinder is called “**Bottom Dead Centre**” [BDC]. The extreme position of the piston at the top of the cylinder is called “**Top Dead Centre**” [TDC].

In two stroke petrol engine the inlet port open when the piston moves from BDC to TDC and is closed when the piston moves from TDC to BDC.

The transfer port is opened when the piston is moved from TDC to BDC and the fuel enters into the cylinder through this transport from the crank case of the engine. The transfer port is closed when piston moves from BDC to TDC. The transfer port opening and closing are measured with respect to the BDC.

The exhaust port is opened, when the piston moves from TDC to BDC and is closed when piston moves from BDC to TDC. The exhaust port opening and closing are measured with respect to the BDC.

## Port Timing Diagram



## Tabulation

S.No	Piston Position (BDC or TDC)	Port opening period in degrees
Inlet port opens		
Inlet port closes		
Transfer port opens		
Transfer port close		
Exhaust port opens		
Exhaust port closes		

**Actual Port Timing Diagram**

## Procedure

1. Remove the ports cover and identify the three ports.
2. Mark the TDC and BDC position of the fly wheel. To mark this position follow the same procedure as followed in valve timing diagram.
3. Rotate the flywheel slowly in usual direction (usually clockwise) and observe the movement of the piston.
4. When the piston moves from BDC to TDC observe when the bottom edge of the piston. Just uncover the bottom end of the inlet port. This is the inlet port opening (IPO) condition, make the mark on the flywheel and measure the distance from TDC.
5. When piston moves from TDC to BDC observe when the bottom edge of the piston completely covers the inlet port. This is the inlet port closing (IPC) condition. Make the mark on the flywheel and measure the distance from TDC.
6. When the piston moves from TDC to BDC, observe, when the top edge of the piston just uncover the exhaust port. This is the exhaust port opening [EPO] condition. Make the mark on the flywheel and measure the distance from BDC.
7. When the piston moves from BDC to TDC, observe, when the piston completely cover the exhaust port. This is the exhaust port closing condition [EPC]. Make the mark on the flywheel and measure the distance from BDC.
8. When the piston moves from TDC to BDC observe, when the top edge of the piston just uncover the transfer port. This is the transfer port opening [TPO] condition. Make the mark on the flywheel and measure the distance from BDC
9. When the piston moves from BDC to TDC, observe, when the piston completely covers the transfer port. This is the transfer port closing [TPC] condition. Make the mark on the flywheel and measure the distance from BDC.



## **Result**

The port timing diagram for the given two stroke cycle petrol engine was drawn.

VEMU Institute of Technology

Ex. No:

Date :

**VALVE TIMING DIAGRAM OF FOUR STROKE  
DIESEL ENGINE**

### **Aim**

To draw the valve timing diagram of the given four stroke cycle diesel engine.

### **Apparatus Required**

1. Four stroke cycle diesel engine
2. Measuring tape
3. Chalk
4. Piece of paper

### **Theory and Description**

The diagram which shows the position of crank of four stroke cycle engine at the beginning and at the end of suction, compression, expansion, and exhaust of the engine are called as Valve Timing Diagram.

The extreme position of the bottom of the cylinder is called “Bottom Dead Centre” [BDC]. In the case of horizontal engine, this is known as “Outer Dead Centre” [ODC]. The position of the piston at the top of the cylinder is called “Top Dead Centre” [TDC]. In case of horizontal engine this is known as “Inner Dead Centre” [IDC]

### **Inlet Valve opening and closing**

In an actual engine, the inlet valve begins to open  $5^{\circ}$  to  $20^{\circ}$  before the piston reaches the TDC during the end of exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the TDC. If the inlet valve is allowed to close at BDC, the cylinder would receive less amount of air than its capacity and the pressure at the end of suction will be below the atmospheric pressure. To avoid this inlet valve is kept open for  $25^{\circ}$  to  $40^{\circ}$  after BDC.

### **Exhaust valve opening and closing**

Complete clearing of the burned gases from the cylinder is necessary to take in more air into the cylinder. To achieve this exhaust valve is opens at  $35^{\circ}$  to  $45^{\circ}$  before BDC and closes at  $10^{\circ}$  to  $20^{\circ}$  after the TCC. It is clear from the diagram, for certain period both inlet valve and exhaust valve remains in open condition. The crank angle for which the both valves are open are called as overlapping period. This overlapping is more than the petrol engine.

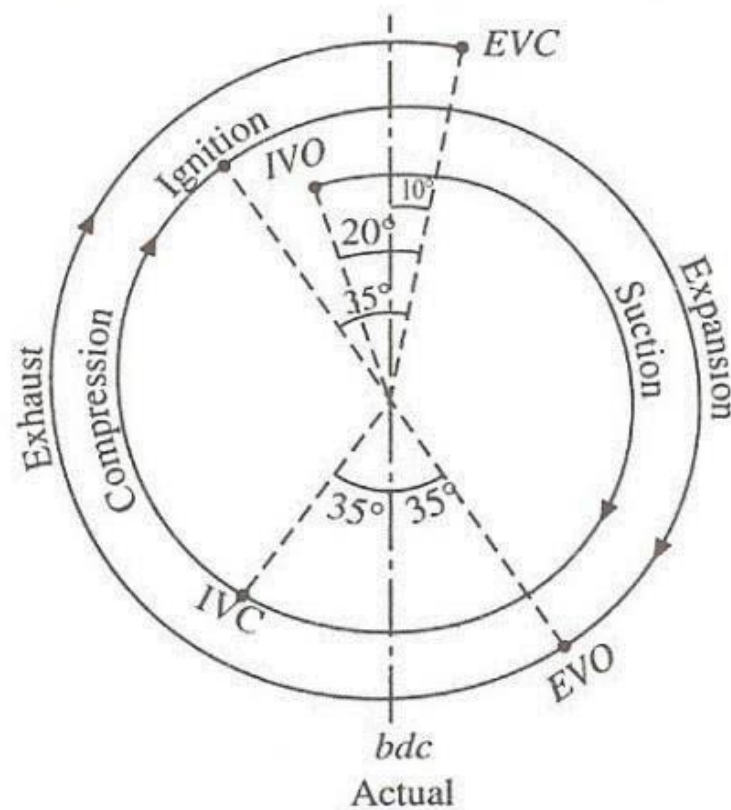
### **Fuel valve opening and closing**

The fuel valve opens at  $10^{\circ}$  to  $15^{\circ}$  before TDC and closes at  $15^{\circ}$  to  $20^{\circ}$  after TDC. This is because better evaporation and mixing fuel.

## Tabulation

S. No	Piston position (BDC or TDC)	Distance from their respective dead centers in "cm"	Valve opening period in degrees
Inlet valve opens			
Inlet valve closes			
Exhaust valve opens			
Exhaust valve closes			

## Valve Timing Diagram



## Actual Valve Timing Diagram

## Formula Used

$$\text{Crank Angle } (\theta) = \frac{S}{\pi D} \times 360^\circ \text{ (in degrees)}$$

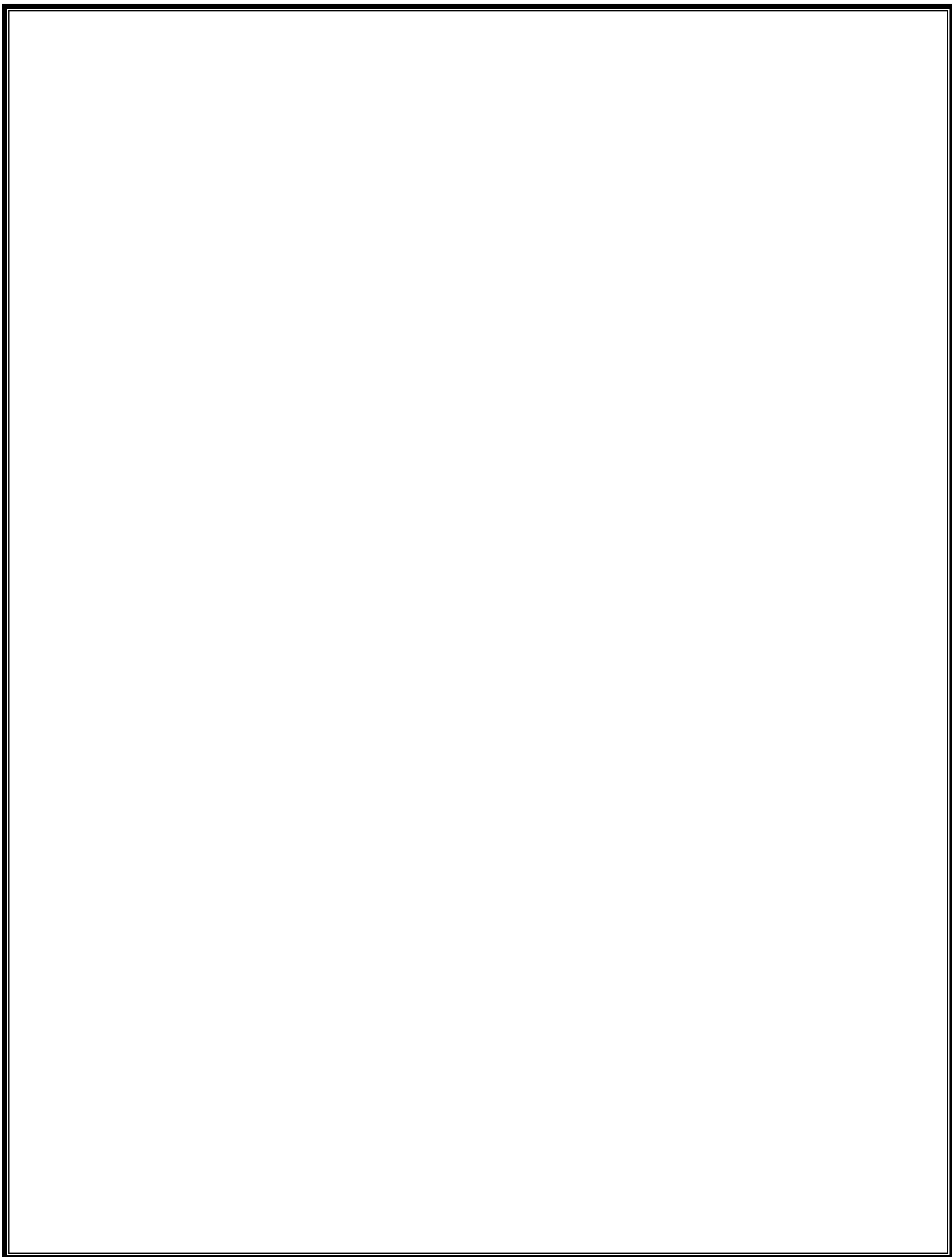
Where,

D = Circumference of the flywheel.

S = Distance of the valve opening or closing position marked on flywheel with respect to their dead centre.

## Procedure

1. Remove the cylinder head cover and identify the inlet valve, exhaust valve and piston of particular cylinder.
2. Mark the BDC and TDC position of flywheel.
3. This is done by rotating the crank in usual direction of rotation and observe the position of the flywheel, when the piston is moving downwards at which the piston begins to move in opposite direction. i.e. from down to upward direction. Make the mark on the flywheel with reference to fixed point on the body of the engine. That point is the BDC for that cylinder. Measure the circumference. That point is TDC and is diametrically opposite to the BDC.
4. Insert the paper in the tappet clearance of both inlet and exhaust valves.
5. Slowly rotate the crank until the paper in the tappet clearance of inlet valve is gripped.
6. Make the mark on flywheel against fixed reference. This position represent the inlet valve open (IVO). Measure the distance from TDC and tabulate the distance.
7. Rotate the crank further, till the paper is just free to move. Make the marking on the flywheel against the fixed reference. This position represents the inlet valve close (IVC). Measure the distance from BDC and tabulate the distance.
8. Rotate the crank further, till the paper in the tappet clearance of exhaust valve is gripped. Make the marking on the flywheel against fixed reference. This position represents the exhaust valve open (EVO). Measure the distance from BDC and tabulate.
9. Then convert the measured distances into angle in degrees.



**Result**

The valve timing diagram for the given four stroke Diesel engine was drawn.

<b>Ex. No:</b>	<b>TWO STROKE SINGLE CYLINDER PETROL ENGINE TEST RIG -ELECTRICAL LOADING</b>
<b>Date :</b>	

**Aim:**

To conduct a performance test on two stroke single cylinder petrol engine

**Instrumentation:**

1. Digital RPM Indicator to measure the speed of the engine.
2. Digital temperature indicators to measure various temperatures.
3. Differential manometer to measure quantity of air sucked into cylinder.
4. Burette with manifold to measure the rate of fuel consumed during test.
5. Digital voltmeter to measure the voltage.
6. Digital ammeters to measure the current.

**Engine Specification**

ENGINE	: BAJAJ
BHP	: 2.5 HP
RPM	: 2800RPM
FUEL	: PETROL
No OF CYLINDERS	: SINGLE
BORE	: 56.7mm
STROKE LENGTH	: 56.7mm
STARTING	: KICK START
WORKING CYCLE	: TWO STROKE
METHOD OF COOLING	: AIR COOLED
METHOD OF IGNITION	: SPARK IGNITION
ORIFICE	: DIA20 mm

**Dc Generator Specification**

TYPE	: SELF EXCITED, DC Compound generator
POWER	: 2.2 Kw
SPEED	: 3000 RPM (max)
RATED VOLTAGE	: 220v DC

**Resistance Load Bank Specification**

RATING	: 2.5Kw, 10(single phase)
VARIATION	: In 5 steps by dc switches
COOLING	: Air cooled

## Observations

Brake power	: BP
Specific fuel consumption	: SFC
Actual volume	: $V_a$
Brake thermal efficiency	: $\eta_{bth}$
Swept volume	: $V_s$
Volumetric efficiency	: $\eta_{vol}$

## Description:

This engine is a two stroke single cylinder, air cooled, spark ignition type petrol engine. It is coupled to a loading system which is in this case is a DC GENERATOR, having a resistance load bank which will take load with the help of de switches.

## Fuel Measurement:

The fuel supplied to the engine from the main fuel tank through a graduated measuring fuel gauge (Burette). To measure the fuel consumption of the engine, fill the burette by opening the cock. By starting a stop clock, measure the time taken to consume X cc of fuel by the engine.

## Air Intake Measurement:

The suction side of the engine is connected to an Air tank The atmospheric air is drawn into the engine cylinder through the air tank The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the Air tank This pressure drop is used to calculate the volume of air drawn into the cylinder (Orifice diameter is 20 mm).

**Lubrication:** The engine is lubricated by mechanical lubrication Lubricating oil recommended- SAE 40 or Equivalent.

## Temperature Measurement:

A digital temperature indicator with selector switch is provided on the panel to read the temperature in degree centigrade, directly sensed by respective thermocouples located at different places on the test rig.

T1 = AMBIENT TEMPERATURE

T2 = EXHAUST GAS OUTLET TEMPERATURE FROM ENGINE

## Loading System:

The engine shaft is directly coupled to the DC Generator, which can be loaded by resistance load bank. The load can be varied by switching ON the Load bank switches for various loads.



**Pictorial view of Petrol engine**

### **Engine performance Test.**

#### **1. Brake Power.**

$$BP = \frac{VI}{1000 \times \eta_{gen}} \text{ in Kw}$$

#### **2. Mass of Fuel Consumed**

$$M_{fc} = \frac{x \times 0.82 \times 3600}{1000 \times T} \text{ in Kg/hr}$$

### 3. Specific Fuel consumption

$$S_{fc} = \frac{M_{fc}}{BP} \text{ in Kg/Kw hr}$$

### 4. Actual volume of air sucked into the cylinder

$$V_a = C_d \times A \times (2gh)^{0.5} \text{ in m}^3$$

$$h = \frac{\rho_w}{\rho_{air}} \times h_w$$

Where,

$$\rho_{air} = P_a / RT_a$$

A = area of orifice  $\pi d^2/4$

$h_w$  = manometer reading in mm

$\rho_w$  = density of water - 1000

$\text{kg/m}^3$   $\rho_{air}$  = density of air;

1.193  $\text{kg/m}^3$

$C_d$  = co-efficient of discharge = 0.62

### 5. Swept Volume

$$V_s = \frac{\pi}{4} d^2 L N \times 60$$

Where,

D=Diameter of the bore

L=Stroke length

N=speed in Rpm

6. Volumetric efficiency

6.  $\eta_{vol} = (V_a/V_s) \times 100$  in percentage.

### 7. Brake thermal efficiency

$$\eta_{bth} = \frac{BP \times 3600 \times 100}{M_{fc} \times CV} \text{ in Percentage}$$

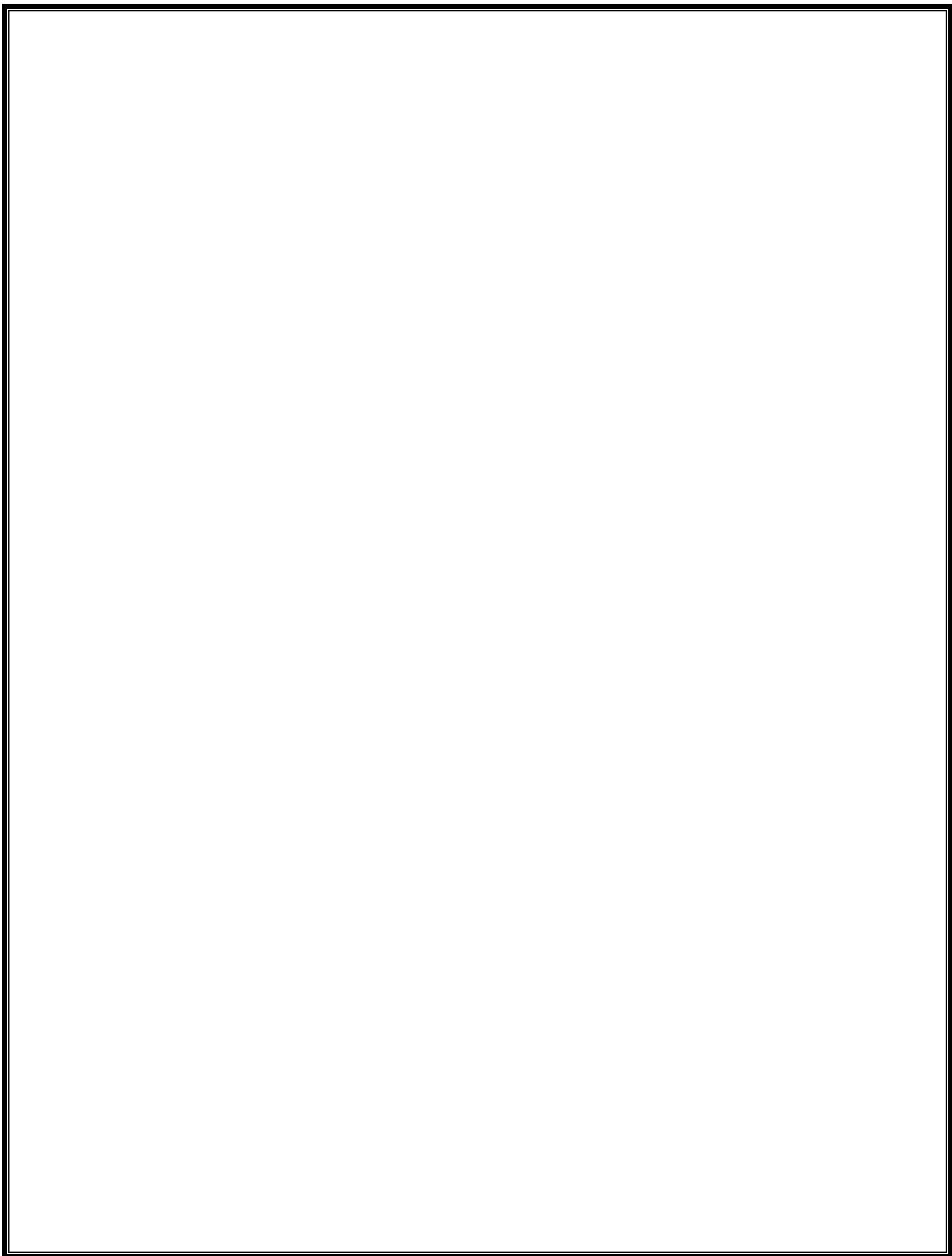
Where

CV=Calorific value of petrol=43,000KJ/Kg

### 8. Mechanical efficiency

$$\eta_{mech} = \frac{BP \times 100}{IP} \text{ in Percentage}$$





## **Result**

Experimental test was conducted on given petrol engine and Brake power developed in the cylinder is determined and Volumetric efficiency is also determined.

<b>Ex. No:</b>	<b>MORS TEST ON MULTI CYLINDER PETROL ENGINE</b>
<b>Date :</b>	

### **Aim**

To conduct the Morse test on given multi cylinder petrol engine in order to determine the Indicated power developed in the each cylinder of the engine and to determine the mechanical efficiency.

### **Apparatus Required**

1. Multi cylinder petrol engine with ignition cut off arrangement.
2. Loading arrangements.
3. Tachometer.

### **Specifications**

Bore	: 73 mm
Stroke	: 90 mm
Capacity	: 1500 CC
Power	: 7.36 kW @ 1500 rpm
Dynamometer	: 2000 for metric
Constant	: 2720 for SI

### **Theory and Description**

For slow speed engine the indicated power is directly calculated from the indicator diagram. But in modern high speed engines, it is difficult to obtain accurate indicator diagram due to inertia forces, and therefore, this method cannot be applied. In such cases the Morse test can be used to measure the indicated power and mechanical efficiency of multi cylinder engines. The engines test is carried out as follows. The engine is run at maximum load at certain speed. The B.P is then measured when all cylinders are working.

Then one cylinder is made in operative by cutting off the ignition to that cylinder. As a result of this the speed of the engine will decrease. Therefore, the load on the engine is reduced so that the engine speed is restored to its initial value. The assumption made on the test is that frictional power is depends on the speed and not upon the load on the engine.



## Performance

**1. Maximum load**  $(W_{\max}) = \frac{BP \times 2720}{N \times 0.736}$  in KW

**2. Total fuel consumption**  $(T_{fc}) = \frac{q \times \rho \times 3600}{t \times 1000}$

Where,

q=Fuel consumption for 10cc

t=Time taken for 10cc fuel

$\rho$ =Specific gravity of petrol = 0.726

**3. Specific fuel consumption**  $S_{fc} = \frac{M_{fc}}{BP}$  in Kg/Kw hr

**4. Heat Input**  $(HI) = (T_{fc} \times CV) / 3600$  in Kw

**5. Indicated Power**  $(IP) = IP1 + IP2 + IP3$

$IP1 = BP - BP1$

$IP2 = BP - BP2$

$IP3 = BP - BP3$

6. **Brake Thermal efficiency ( $\eta_{bth}$ ) = BP/HP in Percentage**

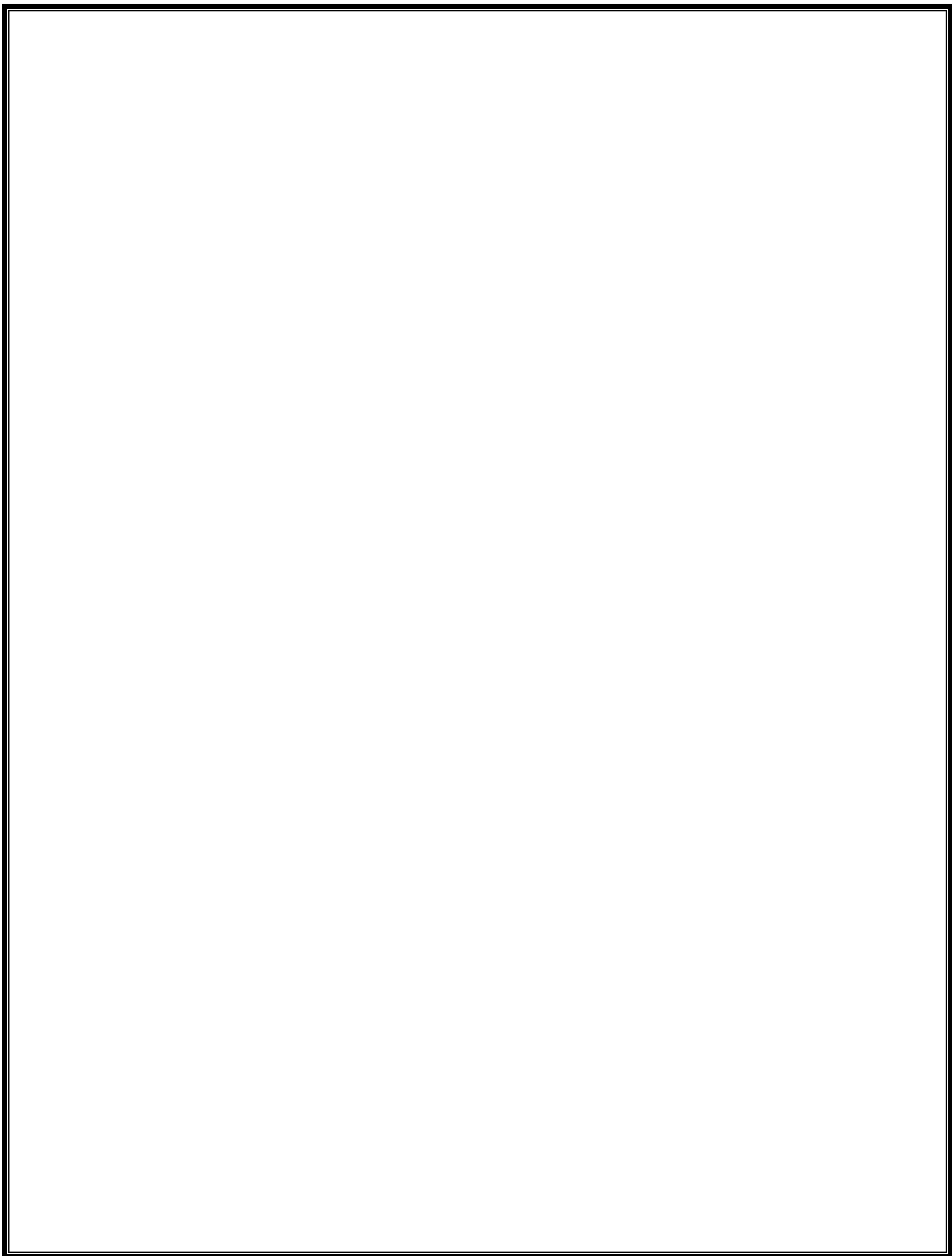
7. **Indicated Thermal efficiency ( $\eta_{ith}$ ) = IP/HP in Percentage**

8. **Mechanical efficiency ( $\eta_{mech}$ ) =  $\frac{BP \times 100}{IP}$  in Percentage**

9. **Friction Power (FP) = IP-BP in Kw**

## **Procedure**

1. Check the engine for fuel availability, lubricant and cooling water connections.
2. Release the load completely on the engine and start the engine in no load conditions and allow the engine to run for few minutes to attain the rated speed.
3. Apply the load and increase the load up to maximum load. (All four cylinders should be in working). Now note the load on the engine and speed of the engine say the speed is 'N' rpm
4. Cut-off the ignition of first cylinder, now the speed of engine decreased. Reduce the load on the engine and bring the speed of the engine to 'N' rpm. Now note the load on the engine.
5. Bring the all four cylinders are in working conditions and cut off the 2<sup>nd</sup>, 3<sup>rd</sup> cylinder in turn and adjust the load to maintain same 'N' rpm and note the load .



## **Result**

Morse test was conducted on given petrol engine and indicated powers developed in each cylinder are determined and mechanical efficiency is also determined.

<b>Ex. No :</b>	<b>PERFORMANCE TEST ON A 4-STROKE SINGLE CYLINDER DIESEL ENGINE BY MECHANICAL LOADING</b>
<b>Date :</b>	

### Aim

To conduct Performance test on a Single cylinder 4-stroke diesel engine and draw the characteristics curve.

### Specifications

Single cylinder, vertical, water cooled, 4-stroke diesel engine.

Made	: Kirloskar
Bore	: 87.5 mm
Stroke	: 110 mm
Speed	: 1500 rpm
Power	: 5HP/3.7 kW
Fuel	: High speed diesel oil
Calorific value	: 44000 KJ/kg
Specific gravity of oil	: 0.8275
Type of loading	: Mechanical Loading

### Performance

1. Brake power (BP) =  $2\pi NT/60,000$  in KW

T = Torque developed across the brake drum = W x R

R = Brake drum radius

2. Total fuel consumption ( $T_{fc}$ ) =  $\frac{q \times \rho \times 3600}{t \times 1000}$

Where,

q = Fuel consumption for 10cc

t = Time taken for 10cc fuel

$\rho$  = Specific gravity of Diesel = 0.834

3. Specific fuel consumption ( $S_{fc}$ ) =  $\frac{T_{fc}}{BP}$  in Kg/Kw-hr

**Tabulation**

S. No	TFC	SFC	HI	BP	IP	$\eta_m$	$\eta_{bt}$	$\eta_{it}$	BMEP	IMEP
	kg/hr	kg/hr kW	kW	kW	kW	%	%	%	kN/m <sup>2</sup>	kN/m <sup>2</sup>

**4. Heat Input (HI)**=( $T_{fc}$  x CV)/3600 in Kw

Where CV=43600KJ/Kg

**5. Indicated Power (IP)**=BP+FP

**6. Brake thermal efficiency ( $\eta_{bth}$ )**=(BP/HI) x 100

**7. Indicated thermal efficiency ( $\eta_{ith}$ )**=(IP/HI) x 100

**8. Mechanical efficiency ( $\eta_{bth}$ )**=(BP/IP) x 100

**9. Indicated Mean effective pressure (IMEP)**=(IP\*60)/LANK in KN/m<sup>2</sup>

**10. Brake Mean effective pressure (BMEP)**=(BP\*60)/LANK in KN/m<sup>2</sup>

Where

A-Area of cylinder

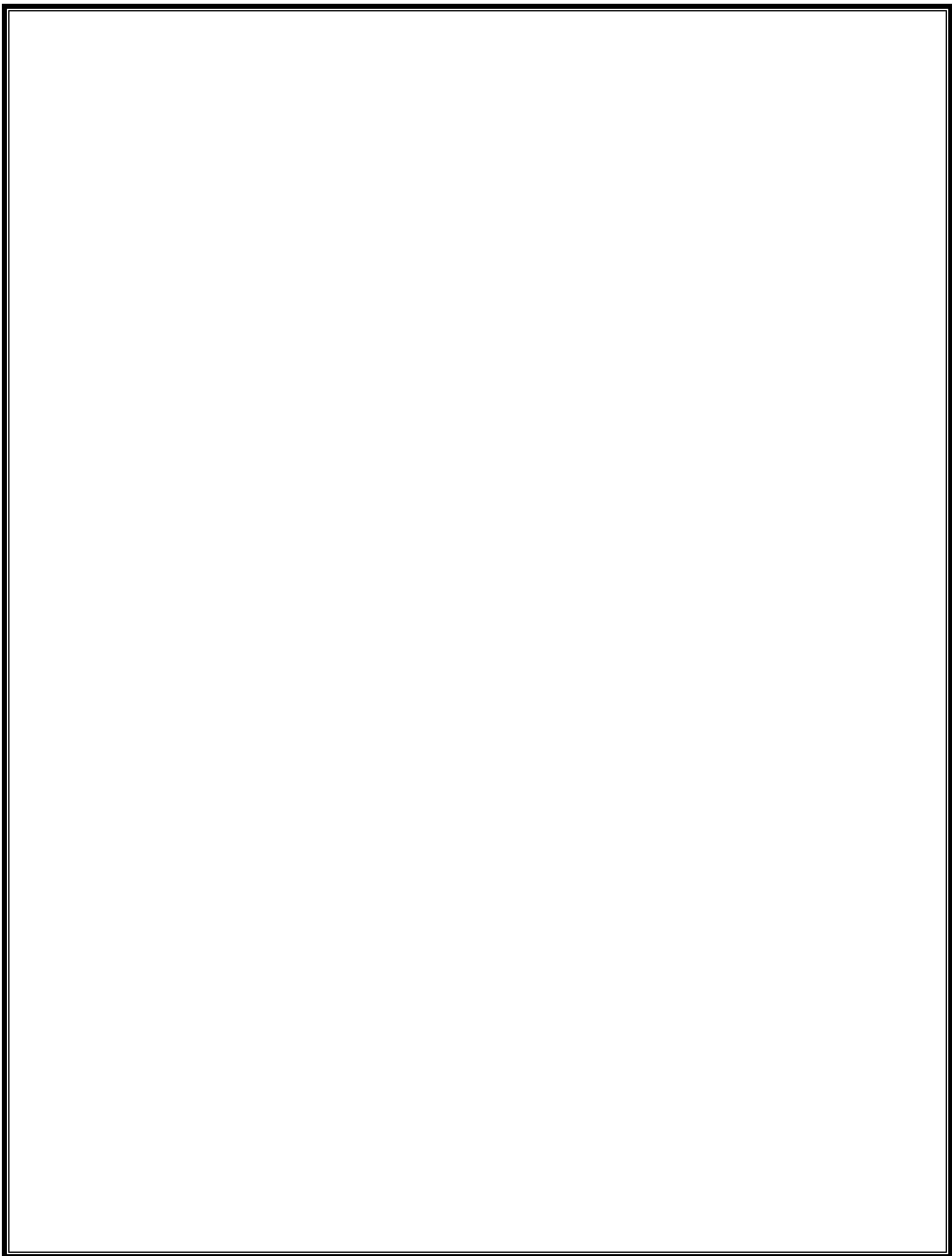
L-Stroke length

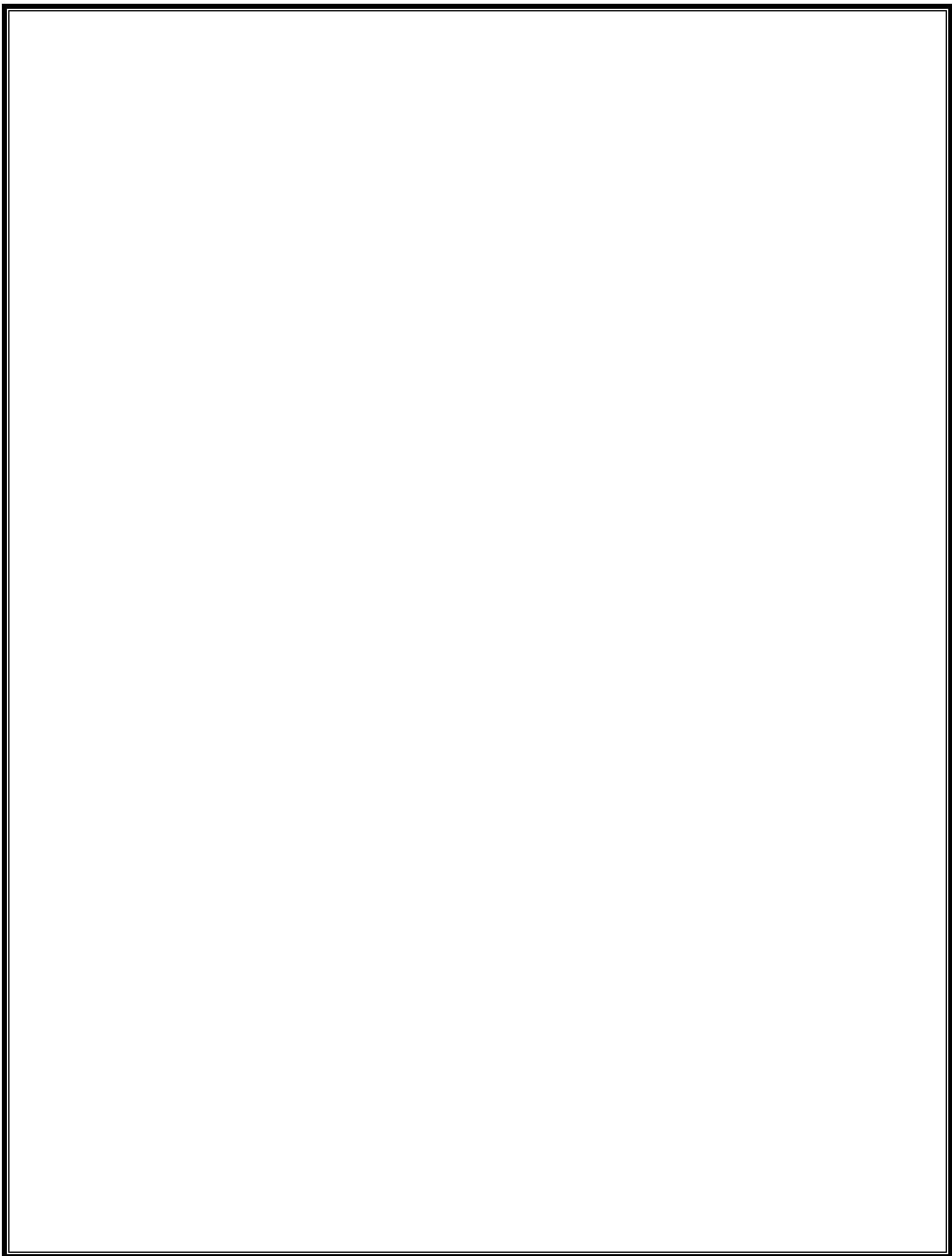
N-Engine speed

K-No of Cylinder

Procedure

1. Calculate maximum load to be applied for a selected engine.
2. Check the fuel supply, water circulation in the water system and lubricating oil in the oil sump.
3. Ensure no load condition
4. The engine is started and allowed to run on idle speed for a few minutes.
5. Gradually the engine is loaded by mechanical brake method and the speed is maintained constant.
6. Make sure the cooling water is supplied to the brake drum.
7. Load the engine in steps of 0%, 25%, 50%, 75% & 100% of maximum load to be applied.
8. Note the corresponding readings of spring balance, fuel consumption, manometer reading.
9. After taking the readings, unload the engine, allow it to run for few minutes and then stop the engine.





## Graph

1. BP Vs TFC (To find frictional power in **William's Line Graph Method**)
2. BP Vs TFC, SFC, IP, HI, BMEP, IMEP,  $\eta_m$ ,  $\eta_{ith}$ ,  $\eta_{bth}$

## **Result**

The performance test was conducted on the Single cylinder diesel engine and the Performance curves were drawn.

<b>EX.NO :</b>	<b>PERFORMANCE TEST ON RECIPROCATING MULTISTAGE AIR COMPRESSOR</b>
<b>DATE :</b>	

**AIM:** To determine volumetric efficiency and isothermal efficiency of the given air compressor.

### FORMULA USED

1. **Volumetric efficiency,  $\eta_v = \frac{\text{Actual volume flow rate of air at STP}}{\text{Swept volume}}$**

2.  **$\eta_v = (V_{as} / V_{sw})$**

Where,  **$V_{as} = (P_a V_a) / (T_a P_s)$**  in m<sup>3</sup>/s

$P_a$  = Atmospheric pressure

$T_a$  = Absolute room temperature

$T_s$  = Standard temperature

$P_s$  = Standard pressure

3.  **$V_a = \text{Volume flow rate of air} = C_d * A * \sqrt{2gH_a}$**

Where,

$C_d = 0.6$

$A = \text{orifice area} = \frac{\pi d^2}{4}$

$H_a = (H_w \times 1000) / \rho_a$

Where,  $H_w$  = water head in m

**$\rho_a = P_a / RT_a$**

**$V_{sw} = ALN$**  in m<sup>3</sup>/s

Where, A-Area of the cylinder

L-Stroke Length

N-Speed of compressor in rps.

$$4. \text{ Indicated power ( IP )} = \frac{3600 * n}{N * t}$$

Where n=number of impulse in energy meter

N-Energy meter constant

t = Time taken for impulse in sec

$$5. \text{ Isothermal Power} = P_a V_a (\log_e P_d / P_a) \text{ in Kw}$$

$$6. \text{ Isothermal efficiency ( } \eta_{iso} \text{ )} = (\text{Isothermal power} / \text{Indicated Power}) \times 100$$

**Tabulation**

S.no	Delivery Pressure in bar		Manometer reading in cm			Time taken for 50 impulse in energy meter in sec
	Gauge Pressure	Absolute Pressure	h1	h2	h1-h2	

## **DESCRIPTION**

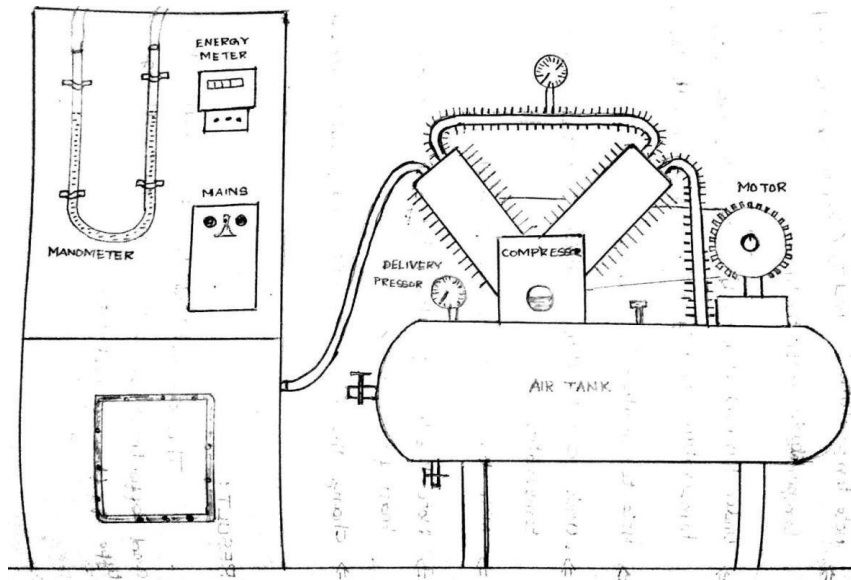
- It consist of an air cooled, two stage reciprocating compressor driven by three phase AC motor coupled through a speed reduction V-belt drive
- The compressor is provided with an air cool fins, an intercooler, an after cooler and a fan mounted the shaft supplies the cooling air.
- Suction of the connected to a large air chamber provided with a flexible diaphragm in order to remove pulsation and to maintain a continues flow of air through a sharp edged orifice which is mounted on the side of the vessel.
- The pressure drop across the orifice is indicated by an 'U' tube manometer reading.
- The delivery of the compressor is connected to an air receiver, which is fitted with a pressure gauge. An automatic high pressure power cut off switch, pressure release valves, an outlet and a condensed water drain cock.
- A direct on line starter is provided to start the motor an 'U" tube manometer is mounted on the air intake chamber .An air filter on the suction line and belt guard for the belts are also provided.

## **PROCEDURE**

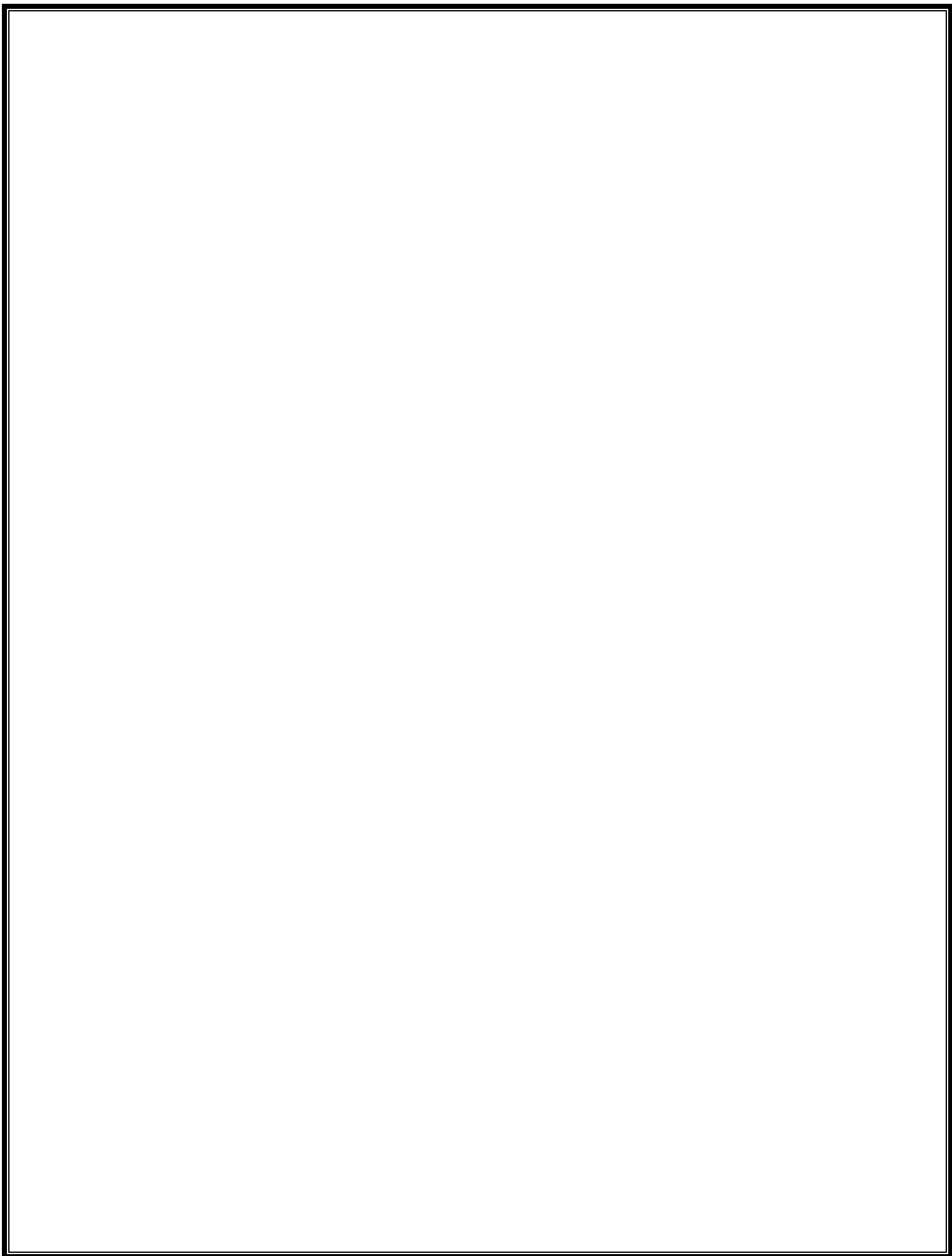
1. Start the compressor motor, open the outlet of receiver and when the pressure gauge reading is about 0 kg/cm<sup>2</sup>
2. Note down the 'U' tube manometer reading.
3. Note down the time for 'n' revolutions in energy meter.
4. Close the delivery valve partially and repeat the procedure for delivery pressures of 2, 4, 6, 8, 10 kg/cm<sup>2</sup>.
5. Check the oil level in compressor before starting the compressor.
6. Stop the compressor motor and release the pressure in receiver and drain the water completely.

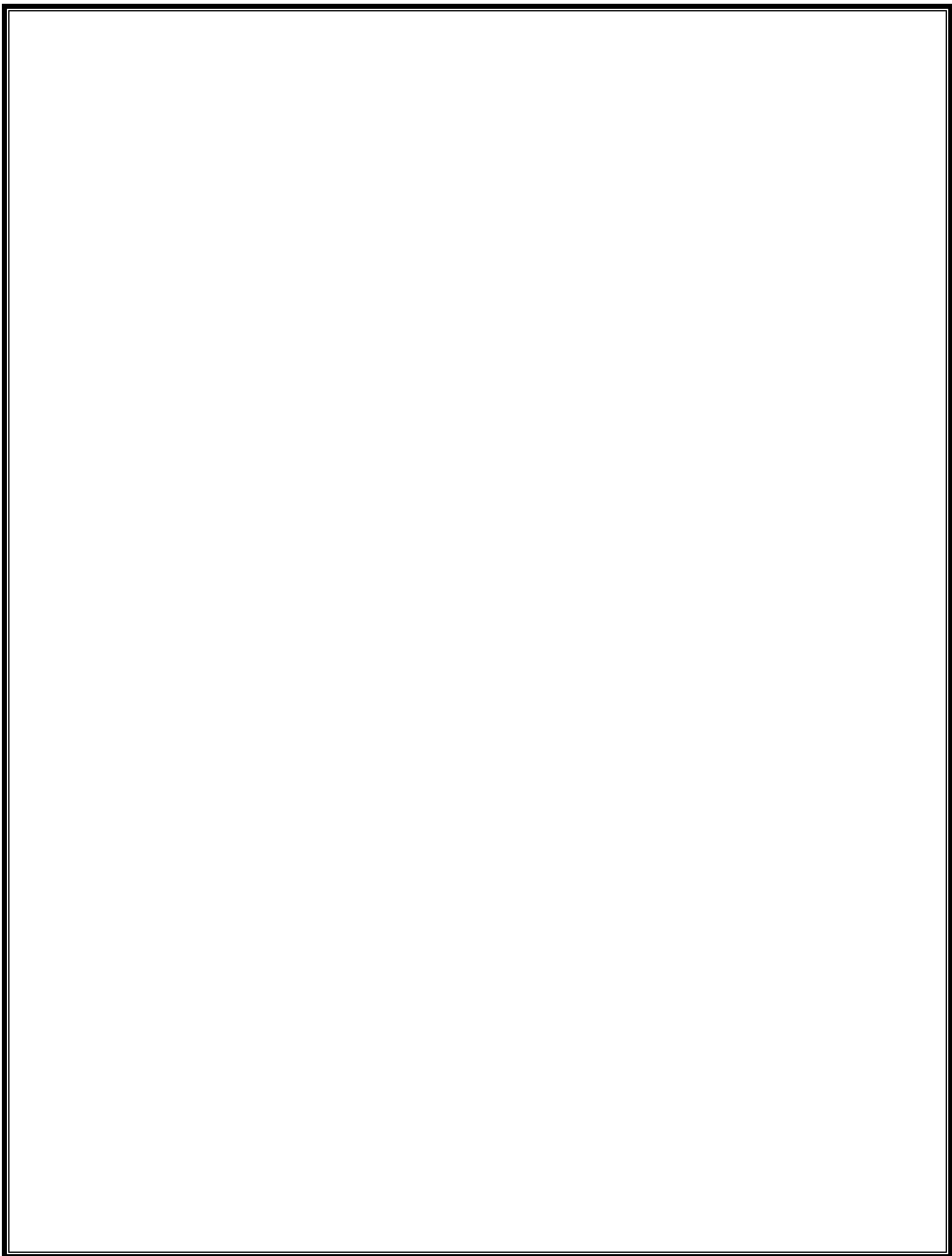


**Pictorial view of multi stage air compressor**



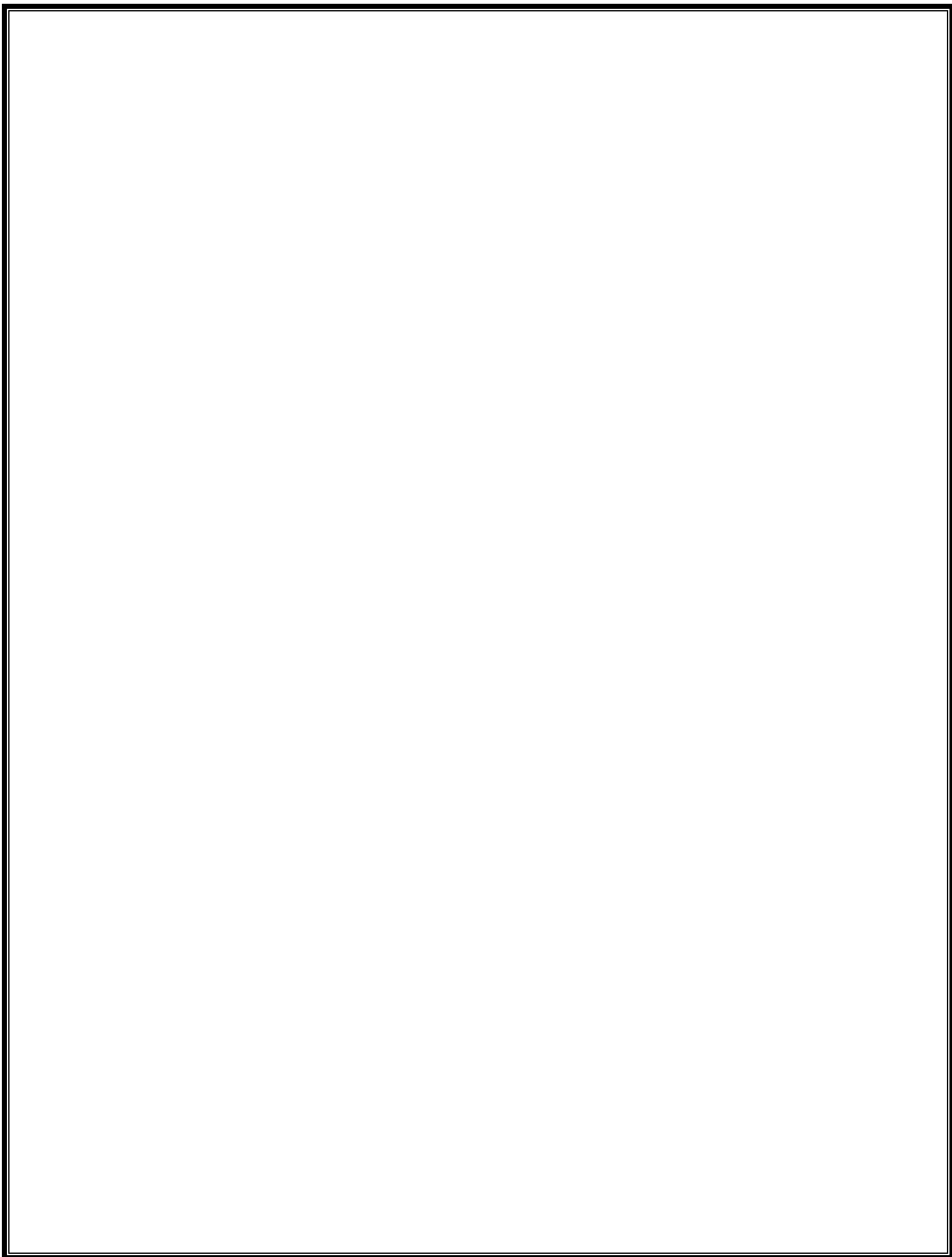
**Experimental view of multi stage air compressor**

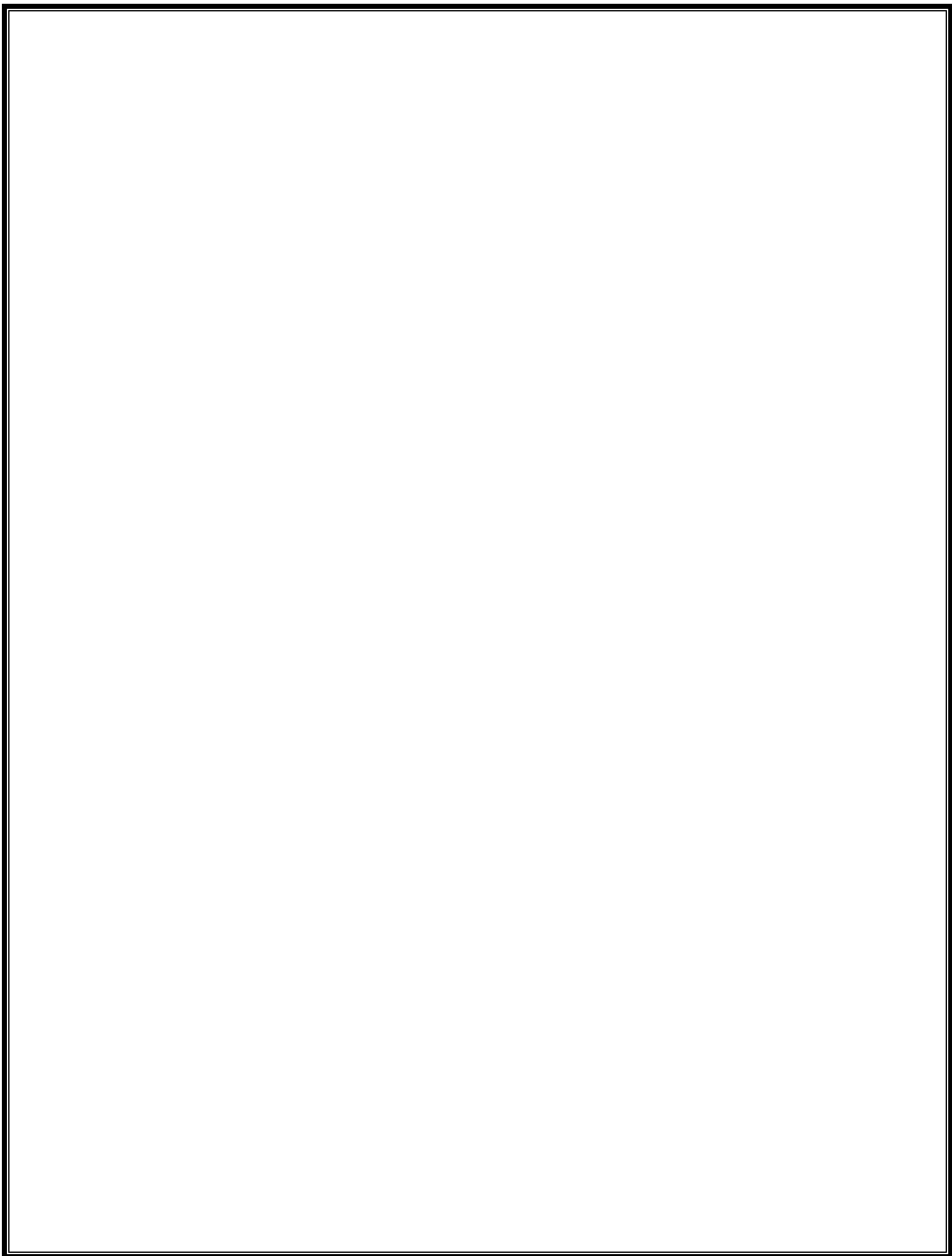




### Calculation Tabulation

S.No	Delivery Pressure in $\text{kg/cm}^3$	Isothermal Power in kW	Indicated Power in kW	Isothermal Efficiency ( $\eta_{\text{iso}}$ ) %	Volumetric Efficiency ( $\eta_{\text{vol}}$ ) %





## **GRAPH**

Draw a representing delivery pressure on the X-axis, on Y-axis volumetric efficiency and isothermal efficiency.

## **RESULT**

Thus the volumetric efficiency, indicated power, Isothermal power efficiency were found out and relevant graph were drawn.

<b>EX.NO :</b>	<b>Assembly and Disassembly of Petrol and diesel Engine</b>
<b>DATE :</b>	

**Aim:**

To study the procedure for dis-assembly and assembly of a petrol engine by making a practical trail on it.

**Introduction:**

Due to use of engine continuously over period of time they may develop certain troubles. Such as loss of efficiency noise irrational, fluctuations manufacturing of fuel pump injector. As such there will be necessity of strip of all parts of the engine inspect then for visual detects provide packing and scaling whenever required for this purpose Disassembling and assembling of a petrol engine is done in a certain manner or correct sequence.

The main parts of any engine are,

**Cylinder Block:**

1. It forms the basic frame work of the engine.
2. It houses the engine cylinders.
3. Serves as bearing or support and guides the piston reciprocating in it.
4. Block contains passengers for circulation of cooling water and lubricating oil.

There are two types of rings

- a) Compression ring
- b) Oil control ring

**Connecting rod:** It connect the piston with the crank shaft thus facilitative the transmission of power combustion chamber to the crank shaft it also converts the reciprocating motion of the piston into rotary motion of crank shaft.

**Fly wheel:** The fly wheel absorbs the energy power source and gives out this energy the other 3-strokes keeping the crank shaft rotating at uniform speed through out.

**Cam shaft:** A shaft is responsible for opening the value on addition the crank shaft operates.

**Cylinder head:**

1. The head is a mono block casting.
2. It contains spark plug notes and cooling water Sackets, value opening mechanism is mounted.
3. Complete value opening mechanism is mounted on head.



**Procedure:**

The following proceeds to be followed while disassembling and assembling of a four stroke cylinder petrol engine.

- a) Study of the engine.
- b) Plan the method for disassembling and keep the tools ready
- c) Remove the rocker armies boxes.
- d) Remove the rocker armies and screw's to displace the covering plate on cylinder head
- e) Remove injector pipe end disconnect the injector
- f) Remove both the exhaust and inlet
- g) Remove the push rod cover
- h) Remove the petrol tank
- i) Remove fly wheel and fly wheel housing
- j) Remove fuel pump and curb wetter
- k) Remove the cylinder block
- l) Remove connecting rod big ends and bearing
- m) Remove side covers
- n) Remove the cam shaft from the bearing.
- o) Draw out all the lubricating oil from crank case
- p) Remove the oil filter.

The following procedure is to be followed broadly in the gives sequence for assembling the disassembled petrol engine.

- 1) After proper cleaning and checking of all parts assembling is carried out.
- 2) Position the piston along with rings to the small end of connecting rod, insert grudger pin for fixing the piston to small end of the connecting rod.
- 3) Position the crankshaft into the bearing in the proper way.
- 4) Fix the side covers and tighten properly.
- 5) Position the cylinder block clad fix it in a proper way.
- 6) Fix the fuel pump and contributor.
- 7) Position the fly wheel housing and fix the fly wheel correctly.
- 8) Fix both the inlet and the exhaust manifold.
- 9) Place the cylinder head block properly and fix the nuts properly.
- 10) Position the rocker worn and fix then correctly.
- 11) Tighten all the blocks with the help of nuts to make the engine fit.

**Precautions:**

All the nuts and bolts removed during the disassembling should place carefully. While dealing with rocker arms and crank shaft care must be taken. Use only the tools while disassembling and assembling.

**Result:**

Thus the procedure of the ASSEMBLING & DISASSEMBLING of a four-stroke four-cylinder Petrol engine studies and recorded.

<b>EX.NO :</b>	<b>PERFORMANCE TEST ON REFRIGERATION TEST RIG</b>
<b>DATE :</b>	

### AIM

To conduct a performance test on refrigeration test rig and determine the co-efficient of performance of refrigeration system.

### APPARATUS REQUIRED

- Thermometer
- Stop watch
- Measuring Jar

### FORMULA USED

1. **Heat lost by water,  $Q_w = \frac{m * C_p \Delta T}{\Delta t}$  in Kw**

Where, m = mass of the water in kg  
 $C_p$  = Specific heat of water in KJ/kg  
 $\Delta T$  = Change in water temperature  
 $\Delta t$  = Time taken for change in temperature

2. **Energy supplied to the compressor,  $Q_c = \frac{3000 * n}{t * N}$  in Kw**

Where, n = no of revolution in energy meter disc  
N = Energy meter constant 1200 rev/kW-hr  
t = Time taken for 'n' revolution

3. **Actual COP =  $\frac{\text{Heat lost by the water}}{\text{Energy supplied to the compressor}}$**

4. **Theoretical COP =  $(h_1 - h_4) / (h_2 - h_1)$**

## Tabulation

S · N OP <sub>1</sub>	Pressure in bar				Temperature in °C				Specific enthalpy in KJ/kg				Time taken for 10 revolution in energy meter in sec	Inlet temperature of water in °C	Final temperature in °C	Δt	Mass of water cooled in kg
	P <sub>2</sub>	P <sub>3</sub>	P <sub>4</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	h <sub>1</sub>	h <sub>2</sub>	h <sub>3</sub>	h <sub>4</sub>						

### DESCRIPTION

The test rig consists of compressor, condenser unit placed inside trolley and fitted with Freon-12 (CCl<sub>2</sub> F<sub>2</sub>) reciprocating compressor, Air cooled condenser, cooling fan for condenser and liquid receiver.

The chilled water calorimeter consisting of a refrigerated stainless steel vessel placed inside an insulated wooden box and provided with evaporative coil, Stirrer, Electric heater, Sensing bulb of a low temperature thermostat, A high temperature thermostat and a thermometer to measure the temperature of chilled water. The above unit is located on the trolley behind the front panel.

The front panel of the test rig consists of capillary expansion tube with isolation valve, thermostatic expansion valve and solenoid thermostat, solenoid switch, indicator, and isolating valve, drier cum strainer and sight glass, thermostat ay inlet and outlet of both evaporator and

condenser, main switch and compressor safety high pressure, low pressure (HP/LP) cut out, heat power regulator switch and regulator, energy meter to measure the power consumed either by heater or by compressor.

### **PROCEDURE**

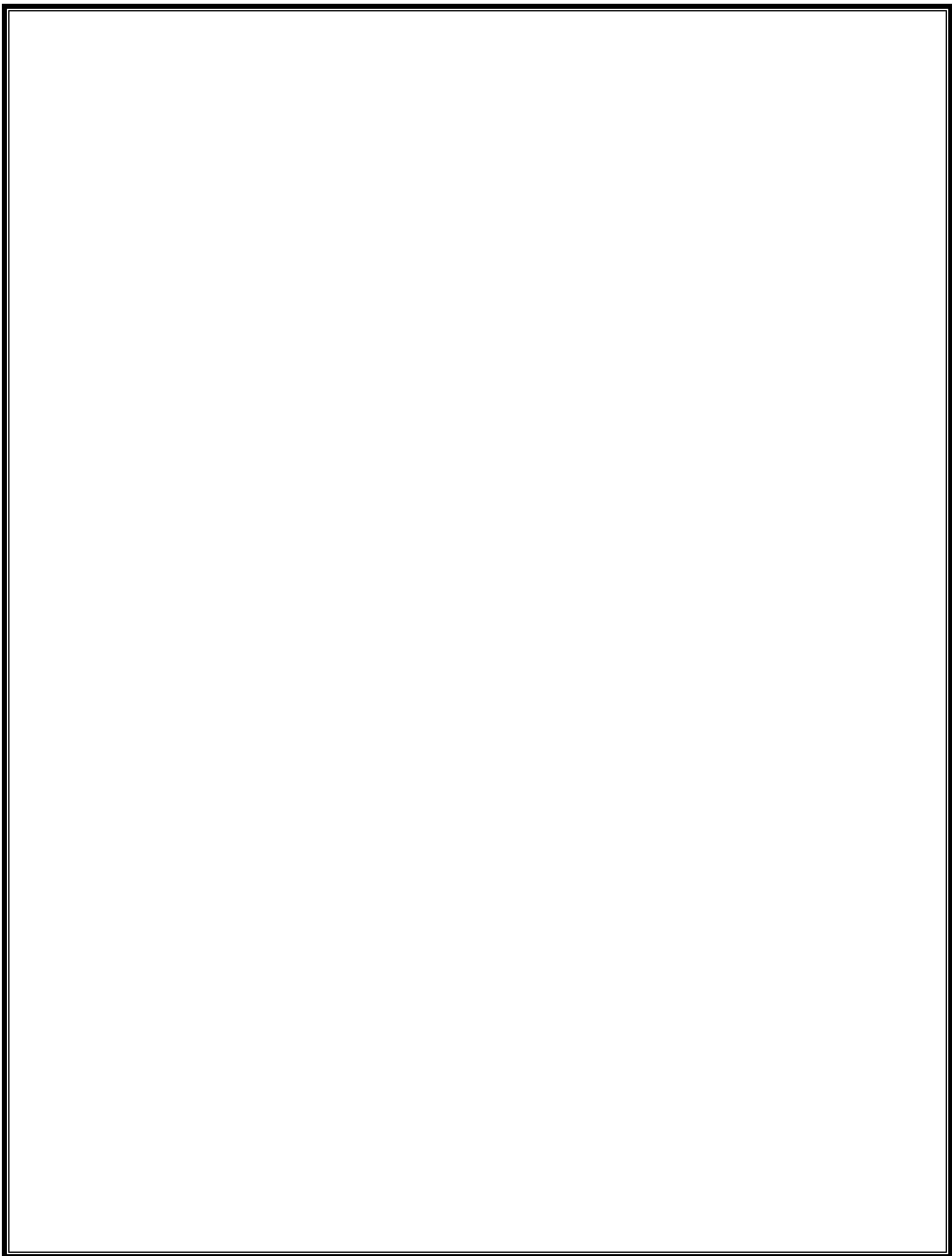
1. Fill the chilled water calorimeter with pure water so that the evaporative coils are fully immersed.
2. Select the capillary tube line by opening the shut-off valve in this line and closing the one on the thermostatic expansion valve line. The solenoid switch is switched off.
3. Start the compressor and run for some time so that the chilled water temperature is lowered to the given temperature.
4. Switch on the heater and slowly increase the power.
5. The temperature in water calorimeter is allowed to reach the equilibrium temperature.
6. Connect the energy meter to motor and heater by the selector switch one after another and note down the time taken for 5 revolutions of the energy meter disc.
7. Note down the pressure and temperature readings at locations 1,2,3,4 as mentioned.
8. Switch off the heater and mains.

$h_1$ =Specific enthalpy at  $P_e$  and  $T_1$

$h_2$ =Specific enthalpy at  $P_c$  and  $T_2$

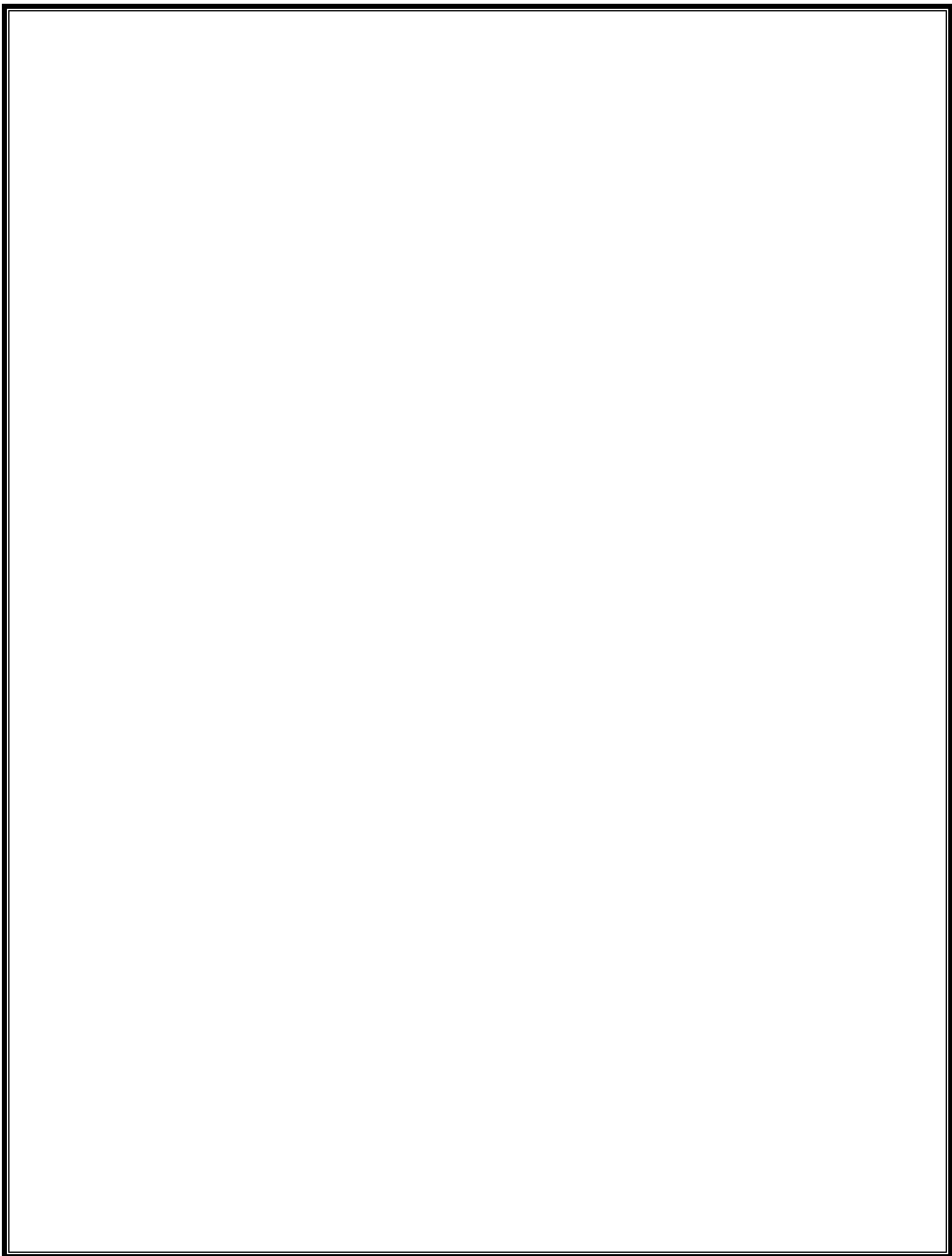
$h_3$ =Specific enthalpy at  $P_c$  and  $T_3$

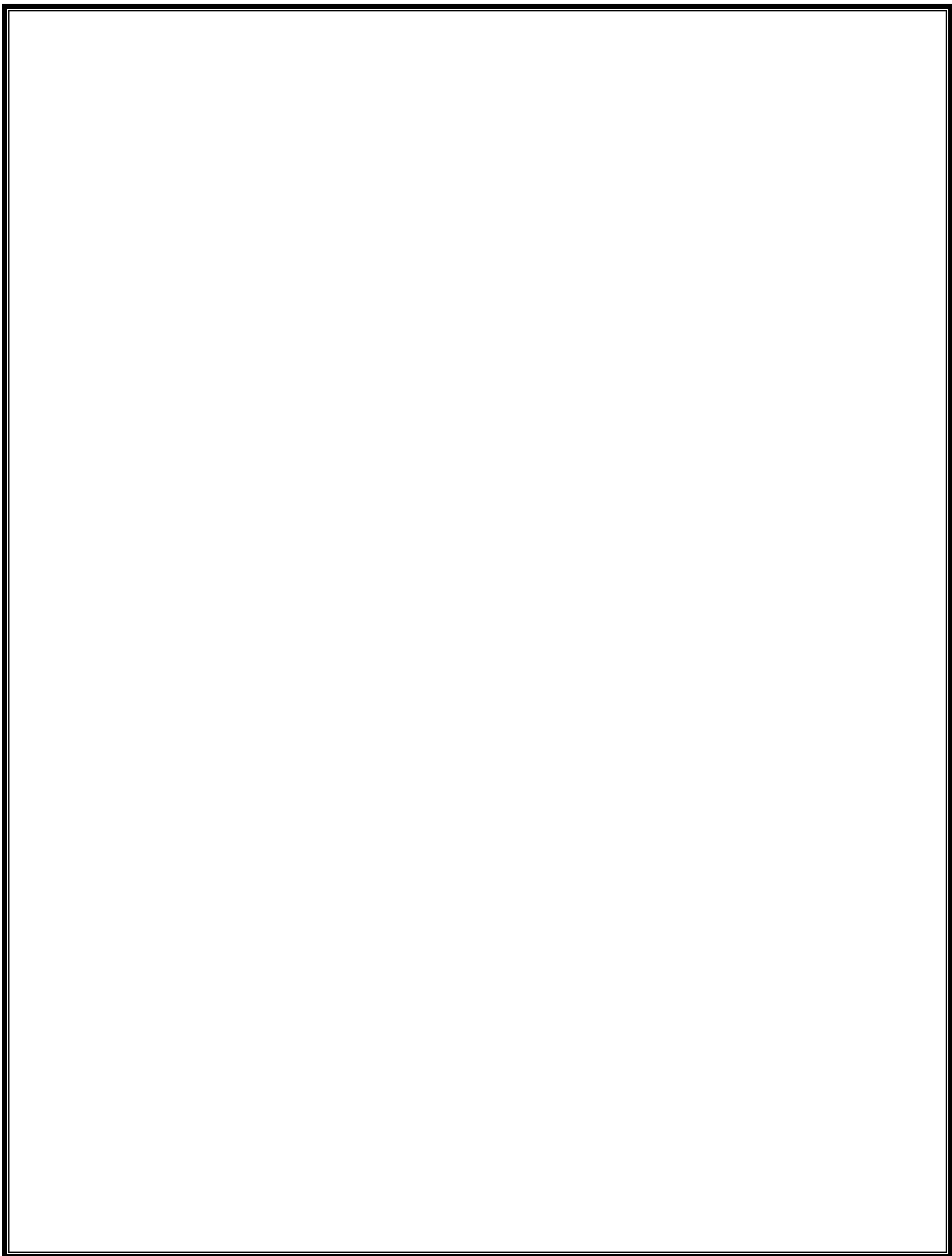
$$h_4 = h_3$$



**CALCULATION TABULATION**

<b>S.No</b>	<b>Heat loss by water <math>Q_w</math> in kW</b>	<b>Energy supplied to the compressor <math>Q_c</math></b>	<b>Actual COP</b>	<b>Theoretical COP</b>	<b>Tonne of refrigeration (<math>T_R</math>)</b>





## **RESULT**

The performance test on a refrigeration test rig was conducted and the results are as follows.

1. Actual C.O.P of the system = -----
2. Tonne of refrigeration = -----

<b>EX.NO :</b>	<b>PERFORMANCE TEST ON AIR CONDITIONING TEST RIG</b>
<b>DATE :</b>	

**AIM:**

To conduct a performance test on air conditioning test rig and determine the C.O.P of the system.

**APPARATUS REQUIRED**

- Digital anemometer
- Stopwatch
- Thermometer

**THEORY**

The properties of moist air are called psychometric properties. Moist air consists of two parts. One comprising dry air, considered as the fixed part and the other solely of water vapour, considered as the variable part. In air conditioning practice all calculations are based on the dry air part since the water vapour is continuously variable one need to know three properties to define the complete thermodynamic state of the air and water vapour mixture. The common processes involved in air conditioning illustrated by lines on a psychometric chart.



**Pictorial view of AC system**

Air conditioning is making the environment conditions suitable for various applications, like to produce comfortable conditions at home, or to make more complete control of manufacturing processes in industries etc. a complete air conditioning system cleans the air, cools in summer and heats in winter, humidifies in winter and dehumidifies in summer and circulates it through the space where it is required. All the systems may not be equipped with all these controls. This unit is designed to study the basic processes of heating, cooling dehumidification and humidification.

## **THE APPARATUS**

The unit consists of a duct, in which air flow is generated by an axial flow fan. A cooling coil, air heaters, and a steam injector are fitted in the duct. Adjustable flappers are provided in duct to control the air flow. At reduced flow rates of air, cooling coil can be used as dehumidifier. The condensing unit and steam generator is located below the air flow duct. The hermetic compressor compresses the refrigerant vapour and sends it to condenser, where it is liquefied. The liquid refrigerant is throttled by expansion valve to low pressure and temperature. This low temperature refrigerant goes to evaporator where it boils by collecting heat. The low pressure refrigerant vapour coming from the evaporator is sucked by the compressor and again circulated through the system.

A steam generator with electrical heater is provided below the duct, which connected to steam injector in the duct. The steam injection is controlled by a valve. Various measurements are provided so different processes of air conditioning can be studied.

## **SPECIFICATIONS**

- Compressor – 1.5 ton (approx.) capacity, hermetically sealed, using refrigerant R-22 (Monochlorodifluoromethane).
- Finned tube condenser with fan. Capillary tube.
- Finned tube direct expansion evaporator fitted in a duct of cross section of 250 x 250 mm. Fan to generate the air flow over the evaporator coil.
- Steam generator with electrical heater and steam injector. Heaters in the duct.
- Measurement and controls.
- Thermometers for cooling cycle and dry/wet bulb air temperatures.
- Energy meter's for compressor and heater input-02 nos.
- Pressure gauges to measure condensing and evaporating pressures. High/low pressure output.
- Necessary switches.
- Flow control flappers in the duct.

## ***TERMINOLOGY***

Dry air- It is a mixture of constituent gases which comprise the atmospheric air, excluding water vapour.

Moist air- It is the mixture of dry air and water vapour. Generally atmospheric air is moist air. Humidity – Water vapour that is mixed with atmospheric air is called humidity.

Specific Humidity- It is mass of water vapour in moist air, expresses in Kg / Kg of dry air. Absolute

Humidity – It is mass of ware vapour contained in a volume of air and is expressed in grams per m<sup>3</sup>of air.

Relative Humidity – It is the ratio of weight of water vapour contained in air at given temperature in a given space to the maximum amount (mass) of water vapour that the air would contain at the same temperature and volume, when fully saturated.

Saturated Vapour – When air – water vapour mixture contains maximum amount of water vapour it can hold, it is called saturated. When temperature of mixture is above saturation temperature, the vapour is supersaturatued.

Dalton's Low – In a mechanical mixture of gases, total pressure of the mixture is the sum of partial pressures of gases that each gas would exert when occupied the same volume at the same temperature as that of the mixture.

Dry Bulb Temperature – It is the temperature indicated by ordinary thermometer.

Wet Bulb Temperature – It is temperature indicated by a thermometer whose bulb is covered by a wet wick. The difference between Dry Bulb Temperature and Wet Bulb Temperature is called WET BULB DEPRESSION.

## **EXPERIMENTAL PROCEDURE**

### **A) COOLING OF AIR:**

- Fill up water in the wells of DB / WB thermometers. Adjust the flapper opening to a specific degrees. Say 10°C
- Put ON main switch. Start air flow through the duct, start the condenser fan and then start the compressor.
- Wait till steady temperatures are reached and note down the observations. Repeat the procedure by changing the air flow.

### **B) HEATING OF AIR:**

- Put ON the mains switch and start air flow through the duct.
- Put ON the heaters, as required.
- Wait till steady state conditions is reached note down the readings.
- Repeat the procedure at different air flow rates and changing the heat input.

### **C) HUMIDIFICATION OF AIR**

- Fill up sufficient water in steam generator, and start the steam heater.
- After some time, steam will be generated. Now start air flow through the duct, and slightly open the steam control valve so that steam will be injected in the stream of air.
- Note down the readings.

### **D) DEHUMIDIFICATION OF AIR**

- Start the air flow in the duct. Reduce the flow by partially closing the flap (close the flappers to

around half opening.)

- Start the condenser fan and then start the compressor. Cooling coil now works as dehumidifier. Condensed water will start collecting in collecting tray.
- Once steady temperatures are reached, drain all the condensed water. Then again start collecting the condensate.
- Collect the condensate for a period of 15 minutes.
- Note down the temperatures.
- Repeat the procedure by changing air flow.

### **OBSERVATIONS**

#### (A) COOLING OF AIR

Sr No	Inlet °C		Outlet °C		Flapper	Time for 10 rev. of compressor energy meter	Flow (LPH)
	DBT	WBT	DBT	WBT			

#### COOLING CYCLE OBSERVATIONS

##### TEMPERATURES

- (a) Condenser Inlet  $t_{ci}$  =                      °C  
 (b) Condenser Outlet  $t_{co}$  =                      °C  
 (c) Evaporator Inlet  $t_{ei}$  =                      °C  
 (d) Evaporator Outlet  $t_{eo}$  =                      °C

##### PRESSURES

- (a) Condensing pressure =                      kg / cm<sup>2</sup>  
 (b) Evaporating pressure =                      kg / cm<sup>2</sup>  
 (c) Flapper opening angle =                      °

#### COOLING OF AIR

Inlet – DBT = \_\_\_\_\_ °C, WBT = \_\_\_\_\_ °C

Therefore, from table of Dry / Wet Bulb temperatures, Relative humidity,

R H = \_\_\_\_\_ %

$$\text{Now, } RH = \frac{P_w}{P_{SAT}} \times 100$$

Where,  $P_w$  = Partial pressure of water vapour, Kgf / cm<sup>2</sup>

$P_{sat}$  = Partial pressure of water vapour Kg / cm<sup>2</sup>  
 At saturation at DBT (to be taken from chart)

$$\therefore P_w = \frac{R_H \times P_{sat}}{100} \quad \text{Kg / cm}^2$$

Now,

$$W = \frac{0.623 \times P_w}{(P - P_w)}$$

Where, W = weight of moisture Kg/Kg of dry air;

P = Atmospheric pressure Kg / cm<sup>2</sup>

(1) TOTAL ENTHALPY OF DRY AIR =  $H_t = h_a + h_s + h_l + h_{sh}$

Where,  $h_a$  = Enthalpy of dry air = 1 x (DBT) KJ / Kg

$h_s$  = Sensible heat of water vapour (up to WBT) = 4.2 x w x (WBT)

$h_l$  = Latent heat of evaporation of water vapour (at wbt) = w x l  
 (l is taken from chart)

$h_{sh}$  = Superheat of water vapour (from WBT to DBT)  
 = w x 1.9 x (DBT-WBT)

Thus, calculate total heat of air at inlet and outlet ie,  $h_{ti}$  and  $h_{to}$  respectively.

(2) AIR FLOW

(See table-2, showing air velocity 'V<sub>a</sub>' at a corresponding flapper opening) Cross sectional area of duct 0.0529 m<sup>2</sup>

$$\text{Density of air, } \rho_a = \frac{1.293 \times 273}{273 + DBT_{out}}$$

So, mass flow rate of air

$$m_a = (0.0529 - 0.0188) \times V_a \times \rho_a \times 3600 \quad \text{Kg/hr}$$

(3) HEAT RECOVERED BY COOLING COIL

$$H = m_a \cdot (h_{ti} - h_{to}) \quad \text{Kg/hr}$$

(4) COOLING CYCLE PERFORMANCE (i) Evaporating Pressure,  $P_{eg} = \underline{\hspace{2cm}}$  kg / cm<sup>2</sup> ab

so absolute evaporating pressure,  $P_{ea} = P_{eg} + 1.033$  kg / cm<sup>2</sup> ab

(ii) Condensing Pressure,  $P_{cg} = \underline{\hspace{2cm}}$  kg / cm<sup>2</sup> ab

so Absolute Condensing pressure,  $P_{ca} = P_{cg} + 1.033$  kg / cm<sup>2</sup> ab

From the temperatures, plot the cycle on P-H chart and find out enthalpy values.

$$H_{ci} = \underline{\hspace{2cm}} \text{Kj/Kg}$$

$$H_{co} = H_{ei} = \underline{\hspace{2cm}} \text{Kj/Kg}$$

$$H_{eo} = \underline{\hspace{2cm}} \text{Kj/kg}$$

(vi) Refrigerating effect =  $H_{eo} - H_{ei} = \underline{\hspace{2cm}}$  Kj/Kg

(v) Compressor work =  $H_{ci} - H_{eo} = \text{_____} \text{Kj/Kg}$

(vi) COP theo =  $(H_{eo} - H_{ei}) / (H_{ci} - H_{eo})$

(vii) If time required for 10 rev of compressor energy meter is

$t_{com}$  sec. Compressor work,

$$C_w = \frac{3600 \times 10}{t_{com} \times EMCC} \text{ Kw}$$

Where, EMCC = Compressor energy meter constant = 3200 imp/kwh

(viii) COP act =  $H / C_w$

Table 1: Thermodynamic properties of R-22

TEMP °C	SPECIFIC VOLUME m <sup>3</sup> / kg	
	Sat. liquid	Sat. vapour
-10	0.00075876	0.0653399
-5	0.00076831	0.0553394
0	0.00077834	0.0471354
4	0.00078673	0.0416124
8	0.00079549	0.0368493
12	0.00080465	0.0327239
16	0.00081424	0.0291361
20	0.00082431	0.0260032
24	0.00083491	0.0232572
26	0.00084043	0.0220111
28	0.00084610	0.0208411
30	0.00085193	0.0197417
32	0.00085793	0.0187076
34	0.00086412	0.0177341
36	0.00087051	0.0168168
38	0.00087710	0.0159517
40	0.00088394	0.0151351

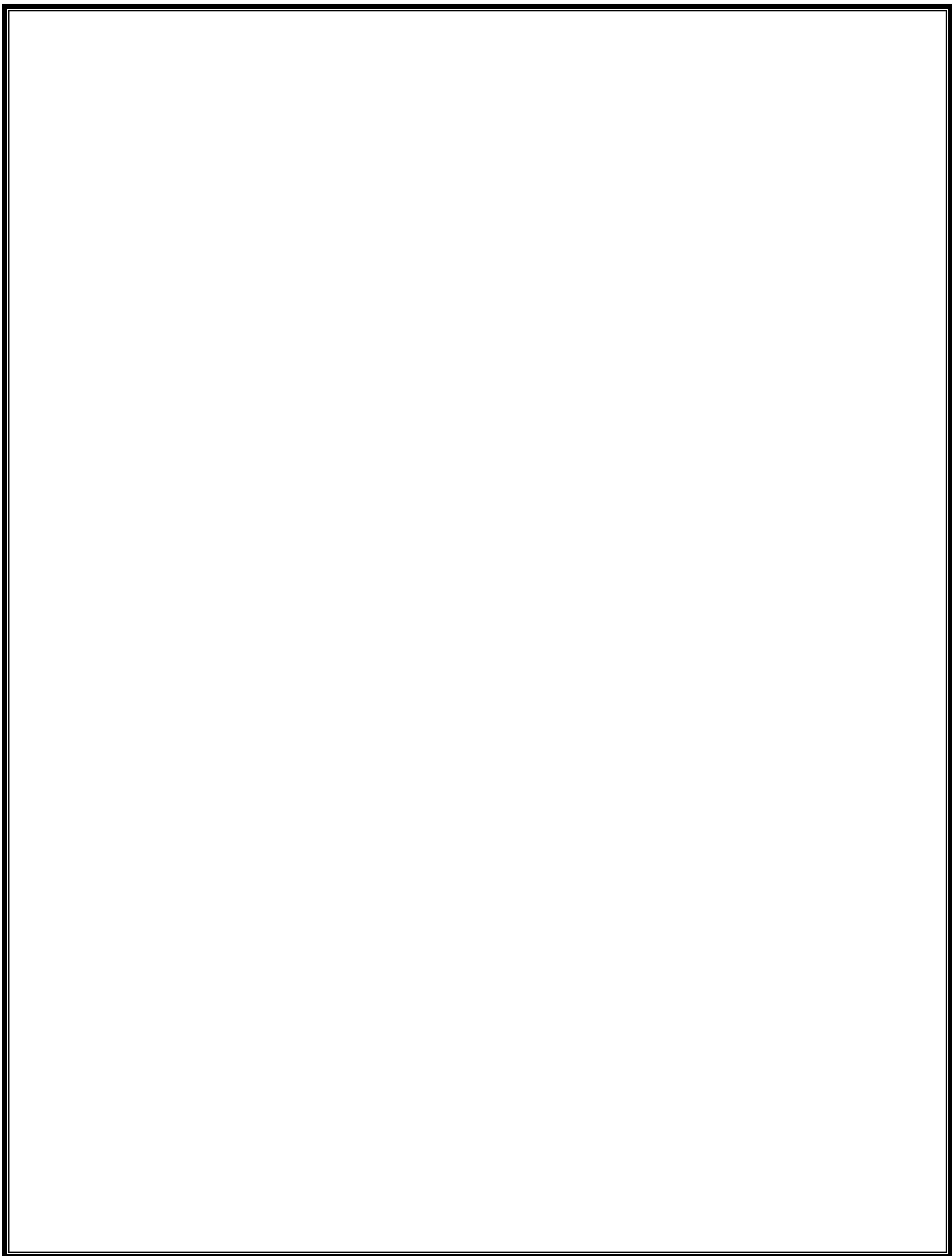
Table-2

FLAPPER CLOSING (DEGREES)	AIR VELOCITY ( m/s)
0 (fully open)	5.0
10	1.5
20	2.7
30	3.2
40	3.6
60	4.3
70	4.4
80	4.8

## Procedure

1. Fill the water in the wet bulb temperature.
2. Start the main.
3. Start the blower and run it at the required speed.
4. Start the spray pump and open the gate valve suitably.
5. Start the heater.
6. Select the expansion device (Capillary tube / thermostatic expansion valve)
7. Start the compressor.
8. Note down the following readings.
9. Dry bulb temperatures  $t_{db1}$ ,  $t_{db2}$ ,  $t_{db3}$ ,  $t_{db4}$
10. Wet bulb temperatures  $t_{wb1}$ ,  $t_{wb2}$ ,  $t_{wb3}$ ,  $t_{wb4}$
11. Time taken for 10 revolutions of energy meter disc for compressor.
12. Mean velocity of air at outlet duct using digital anemometer.

Switch off all the mains



**Result:**

The performance characteristics of air conditioning equipment were calculated.

<b>EX.NO :</b>	<b>PERFORMANCE TEST ON VARIABLE COMPRESSION RATIO PETROL ENGINE</b>
<b>DATE :</b>	

**Aim:** To Determine the performance characteristics and to draw Heat balance sheet at different compression ratios.

**Apparatus:** Petrol Engine, Test Rig, Stop watch etc.

**Theory:**

The basic task of the development engineer is to reduce the cost and improve the power output and reliability of the engine. To find the effect of a particular has to resort to testing the basic performance parameters are as follows.

1. Power and mechanical efficiency
2. Specific out put
3. Volumetric efficiency
4. Air fuel ratio
5. Specific fuel consumption
6. Theoretical efficiency and Heat balance
7. Exhaust smoke and other emission

**Procedure:**

1. Check the petrol level in the tank and ensure that it is up to the required mark.
2. Keep the loading in minimum position.
3. Turn on the petrol knob and start the engine by using rope pull starter
4. Increase the engine speed by disengaging the clutch and run the engine at rated speed of the engine.
5. Load the engine through electrical loading method and maintain the required speed by Adjusting the throttling valve.
6. Petrol tank valve in to the pipette portion and note down the time required for Particular quantity of the petrol consumed by the engine.
7. Note down the temperature reading at different portion by turning the temperature knob.

8. Note down the temperature readings at different air consumption from the U – tube manometer and also rotameter readings.
9. Repeat the steps 5 and 8 for different loads and tabulate readings
10. The graphs of BP Vs mf is plotted to find F.P.

**Observations :**

Density of the petrol ( $\rho_p$ ) = 750 Kg/m<sup>3</sup>

Diameter of Orifice  $d_o$  = 0.012m

Density of the water( $\rho_{water}$ ) = 1000 Kg/m<sup>3</sup>

Density of air ( $\rho_{air}$ ) = 1.29 Kg/m<sup>3</sup>

**Tabular column:**

Sl. No.	Compression ratio	Load	Torque	Speed	T sec For 10cc Fuel consume	$h_w$	$m_w$	Volt	I	$T_1$ °C	$T_2$ C	$T_3$ C	$T_4$ C	$T_5$ °C
1														
2														
1														
2														

Where  $T_1$  = Air inlet

$T_2$  = Exhaust gas calorimeter water inlet

$T_3$  = Exhaust gas calorimeter water outlet

$T_4$  = Exhaust gas inlet

$T_5$  = Exhaust gas outlet

Sl. No.	$m_f$ (kg/s)	BP (Kw)	FP (Kw)	IP (Kw)	$\eta_m$ (%)	$\eta_{bth}$ (%)	BSFC (Kg/kw-hr)	$V_a$ (m <sup>3</sup> /Sec)	$V_{th}$ (m <sup>3</sup> /Sec)	$\eta_v$ (%)	$m_a$ (Kg/Sec)	A:F
1												
2												
1												
2												

### Formulas for calculations:

$$1. \text{ Mass of fuel (mf)} = \frac{V_f \times 10^{-6} \times \rho}{T} \text{ fuel Kg/Sec}$$

$$2. \text{ Break Power (B.P)} = \frac{2\pi NT}{60 \times 10^3} \text{ Kw}$$

$$\text{Where } T = V \times I \times R \times 9.81$$

$$3. \text{ Frictional Power (F.P)} = \frac{2\pi NT}{60 \times 10^3} \times 9.81 \text{ Kw}$$

$$4. \text{ Indicated Power (IP)} = \text{BP} + \text{FP Kw}$$

$$5. \text{ Mechanical efficiency } (\eta_m) = (\text{BP/IP}) \times 100$$

$$6. \text{ Break Thermal Efficiency } (\eta_{bth}) = [\text{BP}/(m_f \times C_v)] \times 100$$

$$7. \text{ Break Specific Fuel Consumption (BSFC)} = \frac{m_f}{\text{BP}} \times 3600$$

### Calculations:

$$1. \text{ Actual Volume of air } (V_a) = C_d \times A_o \times \sqrt{2gh_a} \text{ where}$$

$$h_a = \frac{\rho_w}{\rho_a} \times h_w = \frac{1000}{1.283} [h_1 \sim h_2]$$

$$\text{Theoretical volume } (V_{th}) = \frac{\pi D^2 L N}{60 \times 4 \times 2} \text{ m}^3/\text{sec}$$

$$2. \text{ Volumetric Efficiency } (\eta_v) = \frac{V_a}{V_{th}} \times 100$$

$$3. \text{ Mass of the air } (m_a) = V_a \times \rho_a \text{ kg/s}$$

$$4. \text{ Air fuel Ratio (A/F)} = m_a/m_f$$

### Graphs :

BSFC vs BP

$\eta_{bth}$  vs BP

$\dot{\eta}_{\text{mech}}$  vs BP

$\dot{\eta}_v$  vs A:F

### Heat Balance Sheet:

1. Heat Supplied =  $m_f \times C_v \times 60$
2. Heat equivalent to brake power of the engine.
3. Heat carried away by the cooling water
4. Heat carried away by the exhaust gases
5. Unaccounted heat losses

### Formulae Used:

#### Heat equivalent to B.P:

The brake power in KW is converted into KJ/min

$$Q_{\text{B.P}} = \text{B.P} \times 60 = \text{_____ KJ/min}$$

#### Heat carried away by the cooling water : ( $Q_w$ )

$$Q_w = m_w \times C_{P_w} (T_{w_o} - T_{w_i}) \text{ in KJ/min}$$

Where,

$m_w$  = mass of cooling water circulated in kg/min

$C_{P_w}$  = Specific heat of cooling water = 4.186 KJ/kgK

$T_{w_i}$  = Temperature of cooling water at inlet in °C

$T_{w_o}$  = Temperature of cooling water at outlet of the engine  
in °C

#### Heat carried away by the exhaust gases : ( $Q_g$ )

$$Q_g = m_g C_{p_g} (T_g - T_R)$$

$m_g$  = mass of the exhaust gases (  $m_a + m_f$  ) x 60 in kg/min

$m_a$  = mass of air consumed in kg/min

$m_f$  = mass of fuel consumed in kg/min

$C_{p_g}$  = Specific heat of exhaust gases = 1.005 KJ/kg K

$T_g$  = Temperature of exhaust gases in °C

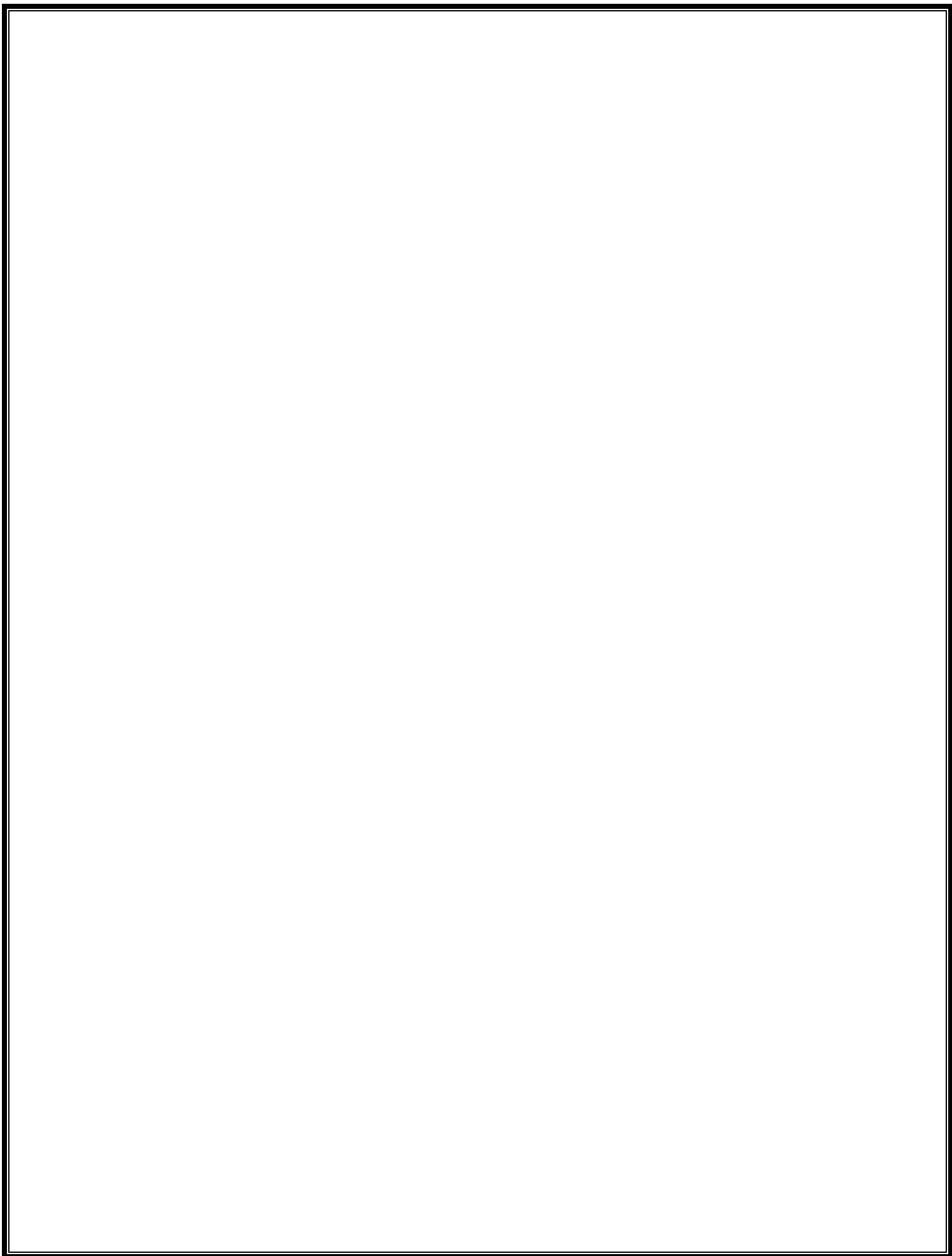
$T_R$  = Room temperature in °C

#### Unaccounted heat losses:

$$Q_{\text{un}} = Q_s - (Q_{\text{B.P}} + Q_w + Q_g) \text{ in KJ / min}$$

**Heat Balance Sheet :**

Sl.No	Particulars	Heat	
		KJ/min	Percentage
1			
2			
3			



**Result:**

The performance characteristics and to draw Heat balance sheet at different compression ratios were calculated.

<b>EX.NO :</b>	<b>STUDY OF STEAM BOILERS</b>
<b>DATE :</b>	

**Aim:** To study the working of various types of steam boilers

**Study of steam generators:**

**Introduction:**

A steam boiler is a closed vessel which boiler generator steam by transferring heat produced by burning of fuel to water. The steam boiler produced is used for power generation or process heating.

**Boiler details:**

The details of the Boilers are listed below:

- a. **SHELL:** The shell of the boiler is the main container usually of cylindrical shape, which contains water and steam
- b. **FURNACE:** A furnace is another important part of the boiler. This may be a grate to burn coal or a burner to atomize and burn liquid fuel. Suitable area and volume should be provided for efficient combustion.
- c. **WATER FLOW PATH:** Water flow path is followed by the water in the boiler during the process of absorption of heat from hot gases and conversion into steam. The water should be free from dissolved material in order to reduce the scaling of the heating surface.
- d. **GAS FLOW PATH:** The hot gas flow path either in fire tube or in water tube should be arranged in such a way that maximum heat of hot gases should be transferred to the water for steam generation. The boiler efficiency mainly depends upon the gas flow path
- e. **STEAM PATH:** In most of the boilers, the steam is taken out preferably at the top of the shell to avoid water particles being carried with the steam. To reduce the water particles carried by the steam, it is generally taken out through steam separators, in the case of large boilers.
- f. **FITTINGS:** The valves and gauges which are necessary for the safety of the boiler, are known as mountings. Water level indicator, safety valve, blow off cock, and fusible plug are some of the mountings.
- g. **ACCESSORIES:** Some equipments like economizer air pre-heater and super heater are attached to the boiler to improve overall efficiency. The economizer and air pre-heater are

used to extract heat from, the flue gases and superheater used to increase the temperature of steam above saturation temperature.

### **Selection of steam generators:**

The selection of type & size of a steam generator depends on the following factors.

1. The power required & working pressure.
2. The geographical position of power house.
3. The fuel & water available.
4. The probable load factor.

### **Classification of Boilers:**

The steam boilers are classified according to the following basic:

1. Flow of water & heat gases
  - a. Fire tube boiler
  - b. Water Tube boiler
2. Method of firing
  - a. Internally fired
  - b. Externally fired
3. Method of water circulation
  - a. Natural circulation
  - b. Forced circulation
4. Pressure developed
  - a. Low pressure boiler
  - b. High pressure boiler
5. Nature of service
  - a. Stationary boiler
  - b. Mobile boiler
6. Design of gas passage
  - a. Single phase
  - b. Multi phase

### **High Pressure Boilers:**

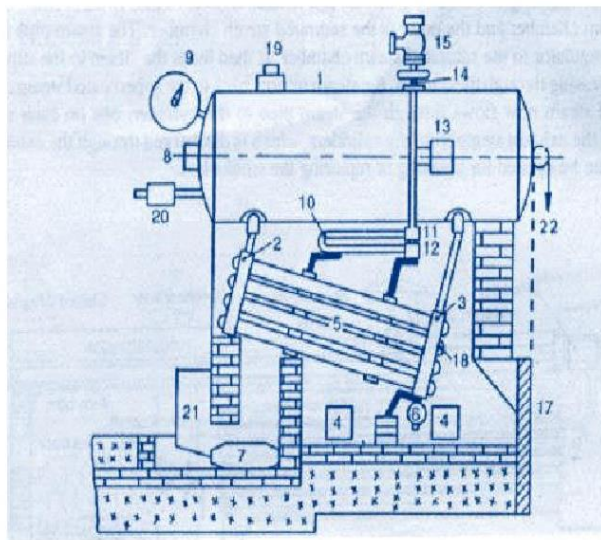
Modern high pressure boilers generate steam at a pressure more than 75 bar.

Example: Babcock & Wilcox boiler, Lamont boiler, BHEL boiler.

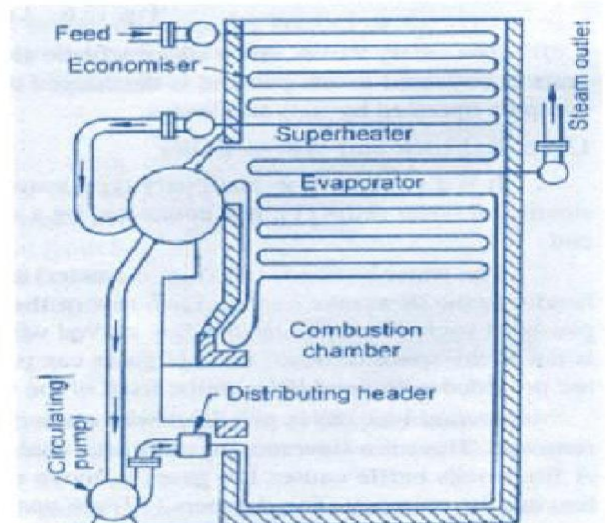
### Lamont Boiler:

A forced circulating boiler was first introduced in 1725 by Lamont. The arrangement is shown in the figure. The most of sensible heat is supplied to the feed water passing through the Economizer. A centrifugal pump circulates the water equal to 8 to 10 times the weight of steam evaporated tubes and the part of water supplied drum. The large quantity of water circulated prevents the tubes from being overheated.

To secure the uniform flow of feed water through each of parallel boilers circuits a choke is fitted all the enhance to each circuits



Babcock and Wilcox boiler.



La-Mont boiler.

### Shell Boilers:

It consists of feed pump, a economizer a boiler drum, radiant & connective super heaters, FD fan, air pre heaters 1 & 2 .Electro static precipitator 1D fan & chimney.

The feed water from the hot well is pumped with the help of a feed pump to boiler from the through economy .In boiler drawn the fed water is circulated to number of valves in the furnaces with fuel is burnt. The feed water is evaporated into wet steam and the wet steam flows back to boiler drawn. In this its supplied to prime mover through steam outlet.

The hot blue gases from the furnace pars over radiant & connective super heaters to super heat the steam, Then it passes through the pre heaters economizer and pre heater .Then the blue gases passes through the electrostatic precipitator.

## **2. Lancashire Boiler**

It is stationary fire tube, internally fired, horizontal, natural circulation boiler. This is a widely used boiler because of its good steaming quality and its ability to burn coal of inferior quality. These boilers have a cylindrical shell 2.1 m in diameter and its length varies from 8 m to 10 m. It has two large internal flue tubes having diameter between 80 cm to 100 cm in which the grate is situated. This boiler is set in a brick work forming external flue so that the external part of the shell forms part of the heating surface.

The main features of the Lancashire boiler with its brick work shelling are shown in Fig.10.0. The boiler consists of a cylindrical shell and two big furnace tubes pass right through this. One bottom flue and two side flues are formed by the brick setting. Both the flue tubes which carry hot gases lay below the water level as shown in the figure.

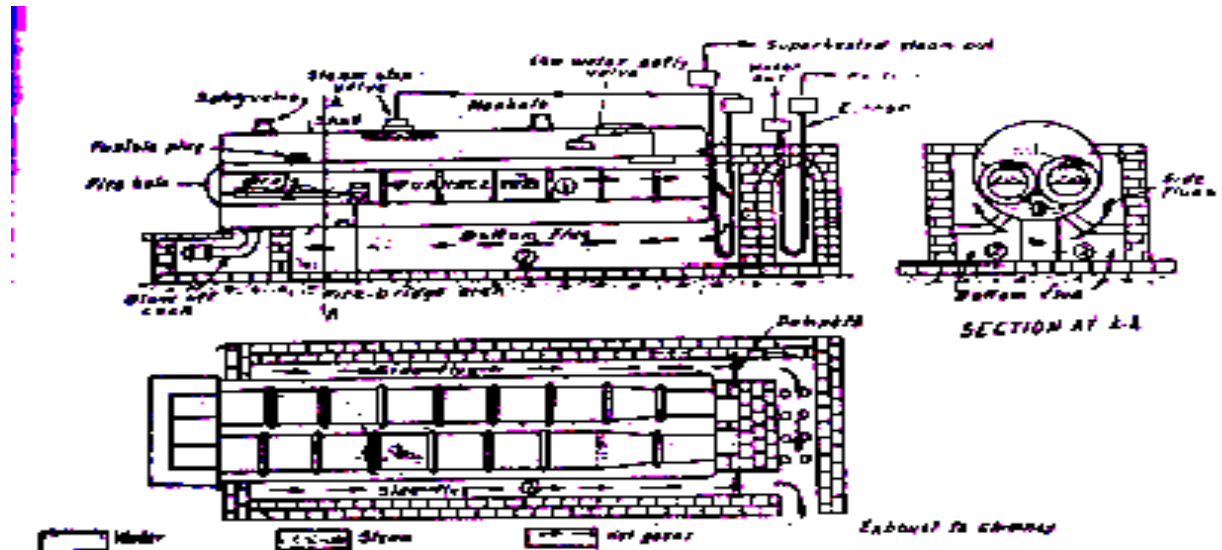
**The outstanding features of this boiler are listed below:**

- A. Its heating space area per unit volume of the boiler is considerably large.
- B. Its maintenance is easy
- C. It is suitable where a large reserve of hot water is needed. Load fluctuations can be easily met by the boiler due to the large reserve capacity.
- D. Superheater and economizer can be easily incorporated into the system, therefore overall efficiency of the boiler can be considerably large (80-85%)

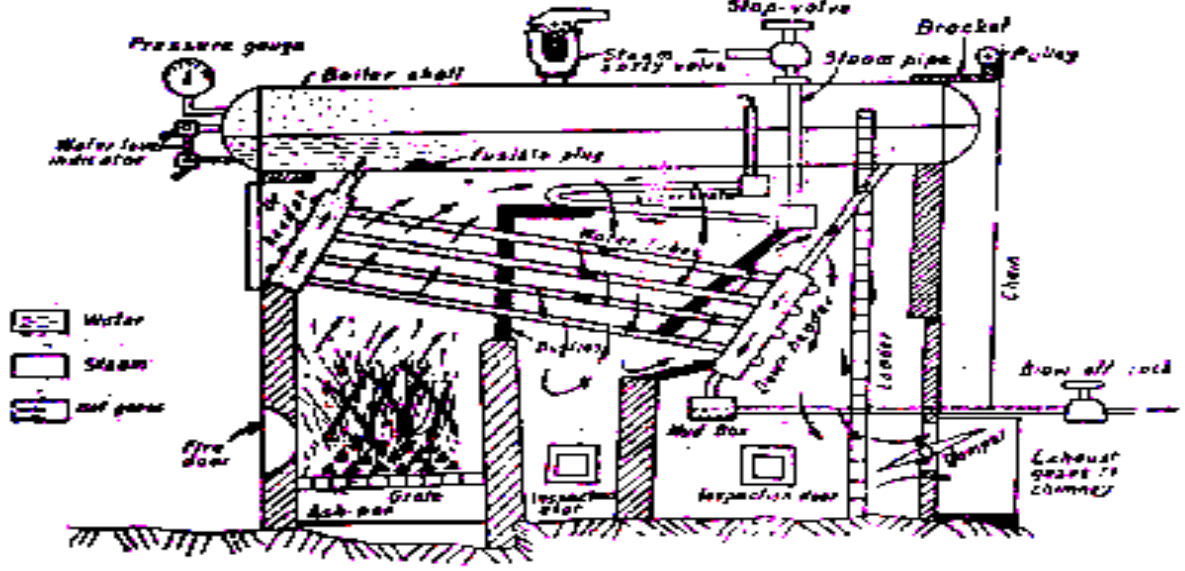
## **3. Babcock & Wilcox Boiler**

It is a water tube boiler, the water is inside the tubes and hot gases flow over the tubes. The boiler with its parts is shown Fig.10.1. The boiler shell known as water and steam drum is made of high quality steel. It is connected by short tubes with the uptake header of riser and by longer tubes to the downtake header. The water level in the drum is slightly above the center. The water tubes are connected to the top and bottom header and are kept inclined at an angle of  $15^\circ$  to the horizontal. The furnace is arranged below the uptake header. Coal is fed to the grate through the fire door. First the hot gases rise upward and then go down and then rise up again and finally escape to the chimney through the smoke chamber. The outer surface of the water tubes and half of the bottom cylindrical surface of the drum form the heating surface through which heat is transferred from the hot gases to the water.

The evaporative capacity of this boiler is high compared with other boiler (20,000 to 40,000 kg/hr.). The operating pressure lies between 11.5 to 17.5 kg /cm<sup>2</sup>



Lancashire Boiler (Fig. 10.0)



Babcock & Wilcox Boiler (Fig. 10.1)

**Result:**

The working of various types of steam boilers were studied.