



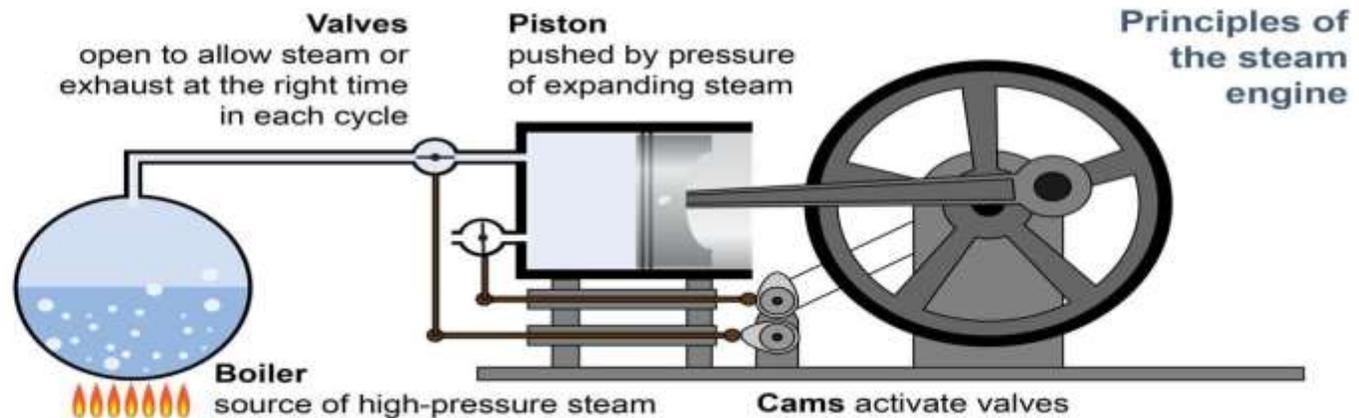
# LAB MANUAL

Heat Engine Lab  
Course Code: ME-418



## Heat engines

Real heat engines convert heat to mechanical work by manipulating the *pressure, volume, temperature and/or phase of a working fluid.*



**University of Global Village (UGV), Barishal**  
**Department of Mechanical Engineering**

**Prepared by**  
Md. Naeem Hosen Hredoy Lab  
Instructor Department of Mechanical

## COURSE INFORMATION

Course Title	<b>Heat Engine</b>	Lecture Contact Hours	85
Covered Lab	Internal Combustion Engine	Credit	01
		Total Marks	50
PRE-REQUISITE			CIE SEE 20 30
Course Code: ME-418		SEE exam time: 2 Hours	

UNIVERSITY OF GLOBAL VILLAGE

**Course Learning Outcomes (CLOs):** After completion of this course successfully, the students will be able to...

CLO1	<b>Understand</b> the principles of heat transfer.
CLO2	<b>Analyze</b> heat transfer systems and components.
CLO3	<b>Apply</b> heat engines are a prime example of a real-world application of heat transfer principles.
CLO4	<b>Evaluate</b> heat transfer rates and thermal performance.

Sl. No.	Course Content	Hrs	CLOs
1	<b>TO STUDY THE CUT MODELS OF I.C. ENGINE.</b>	05	CLO1
2	<b>TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE PETROL ENGINE.</b>	10	CLO2, CLO3, CLO 4
3	<b>TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE DIESEL ENGINE.</b>	15	CLO2, CLO3
4	<b>TO DETERMINE THE FLASH POINT &amp; FIRE POINT OF THE DIESEL ENGINE BY MEANS OF THE CLEVELAND APPARATUS.</b>	15	CLO2, CLO3, CLO 4
5	<b>TO DETERMINE THE CALORIFIC VALUE OF DIESEL BY BOMB CALORIMETER.</b>	10	CLO2, CLO3, CLO 4
6	<b>TO PREPARE THE HEAT BALANCE SHEET BY CONDUCTING PERFORMANCE TEST ON SINGLE CYLINDER 4-STROKE DIESEL ENGINE (WITH ELECTRICAL BRAKE DYNAMOMETER.</b>	10	CLO 2 CLO 4 CLO 3
7	<b>CYLINDER 4-STROKE DIESEL ENGINE (WITH ROPE BRAKE DYNAMOMETER.</b>	10	CLO 1
8	<b>TO DETERMINE THE MORSE TEST ON A MULTI CYLINDER PETROL ENGINE.</b>	10	CLO2, CLO3

## REFERENCE BOOKS

**1.Fundamentals of Heat Engines by Jamil Ghojel**

**2.Applied Second Law Analysis of Heat Engine Cycles by Rena  
C. Gulen**

**3.Principles of Thermodynamics by Myron Kaufman**

**4.Reflections on the Motive Power of Fire by Sadi Carnot**

**ASSESSMENT PATTERN**

**CIE- Continuous Internal Evaluation (20 Marks)**

**SEE- Semester**

**End Examination (30Marks)**

**SEE- Semester End Examination (50 Marks) (should be converted in actual marks (30))**

<b>Bloom's Category</b> Cognitive		<b>Tests (20)</b>	
		Remember	05
Understand	07		
Apply	08		
Analyze	07		
Evaluate	08		
Create	05		
<b>Bloom's Category</b> Psychomotor			
Imitation	10		
Manipulation	5		
Precision	5		
Articulation	5		
Naturalization	5		

**CIE- Continuous Internal Evaluation (40 Marks)  
(should be converted in actual marks (20))**

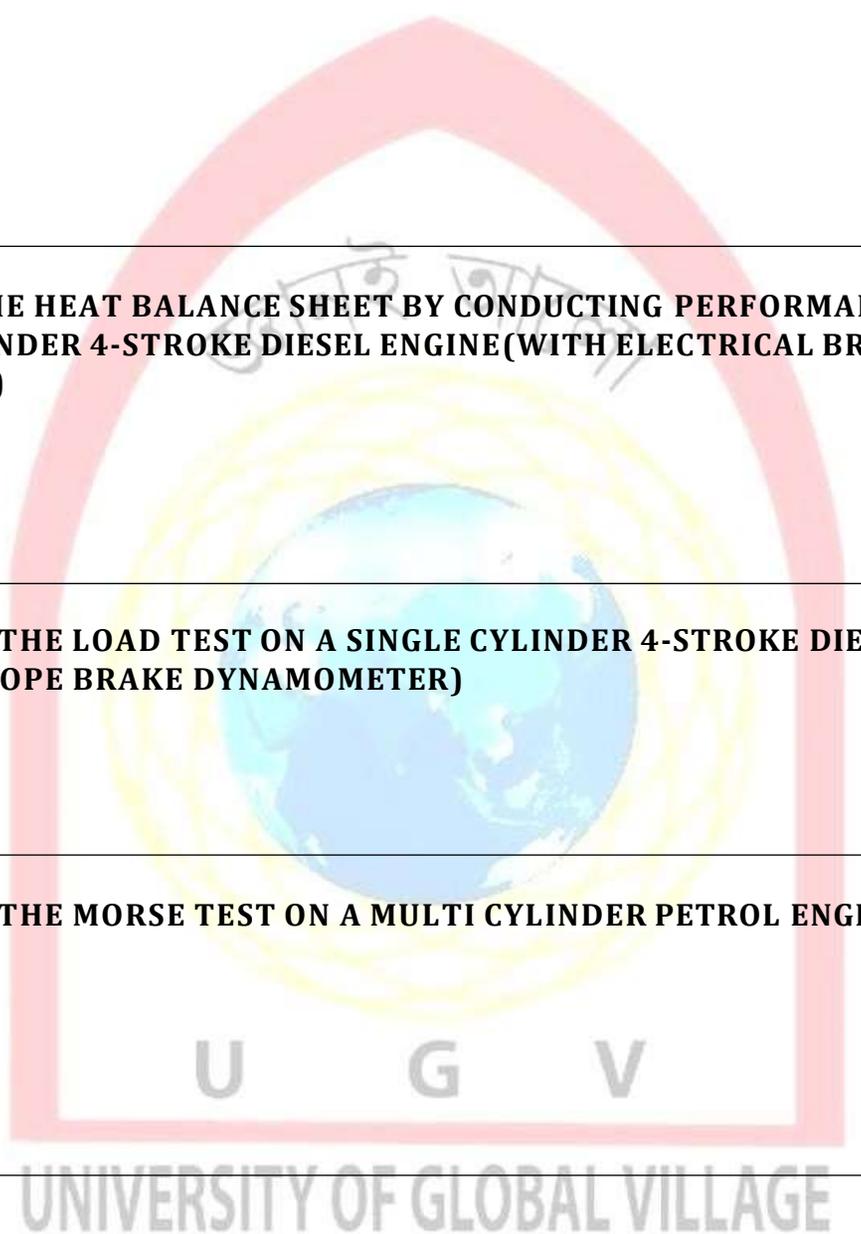
<b>Bloom's Category Marks (out of 60)</b>	<b>Lab Report (10)</b>	<b>Continuous lab performance (10)</b>	<b>Presentation &amp; Viva (10)</b>	<b>External Participation in Curricular/Co-Curricular Activities (10)</b>
Remember			02	Attendance 10
Understand	05	04	03	
Apply		02		
Analyze		02		
Evaluate	05	02		
Create			05	

<b>Course Plan Specifying Content, CLOs, Teaching Learning Strategy and Assessment Strategy</b>				
<b>Week</b>	<b>Topics</b>	<b>Teaching Learning Strategy</b>	<b>Assessment Strategy</b>	<b>Corresponding CLOs</b>
1,2	<b>TO STUDY THE CUT MODELS OF I.C. ENGINE.</b>	Lecture, Oral Presentation	Quiz	CLO1
3,4	<b>TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE PETROL ENGINE.</b>	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3, CLO 4
5,6	<b>TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE DIESEL ENGINE.</b>	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3, CLO 4
7,8	<b>TO DETERMINE THE FLASH POINT &amp; FIRE POINT OF THE DIESEL ENGINE BY MEANS OF THE CLEVELAND APPARATUS.</b>	Group Discussion, Experiment Practice	Skill Development Test	CLO2, CLO3, CLO 4
9,10	<b>TO DETERMINE THE CALORIFIC VALUE OF DIESEL BY BOMB CALORIMETER.</b>	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3
11,12	<b>TO PREPARE THE HEAT BALANCE SHEET BY CONDUCTING PERFORMANCE TEST ON SINGLE CYLINDER 4-STROKE DIESEL ENGINE(WITH ELECTRICAL BRAKE</b>	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test, Quiz	CLO2, CLO3

	DYNAMOMETER.			
13,14	TO DETERMINE THE LOAD TEST ON A SINGLE CYLINDER 4-STROKE DIESEL ENGINE(WITH ROPE BRAKE DYNAMOMETER.	Group Discussion, Experiment Practice	Skill Development Test	CLO2, CLO3
15,16,17	TO DETERMINE THE MORSE TEST ON A MULTI CYLINDER PETROL ENGINE.	Lecture, discussion, Video Presentation, Experiment	Lab Report Assessment, viva, Lab Test	CLO2, CLO3,

SL. NO	NAME OF THE EXPERIMENT
1	TO STUDY THE CUT MODELS OF I.C. ENGINE.
2	TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE PETROL ENGINE.
3	TO STUDY THE ACTUAL VALVE TIMING DIAGRAM OF 4-STROKE DIESEL ENGINE.
4	TO DETERMINE THE FLASH POINT & FIRE POINT OF THE DIESEL ENGINE BY MEANS OF THE CLEVELAND APPARATUS.

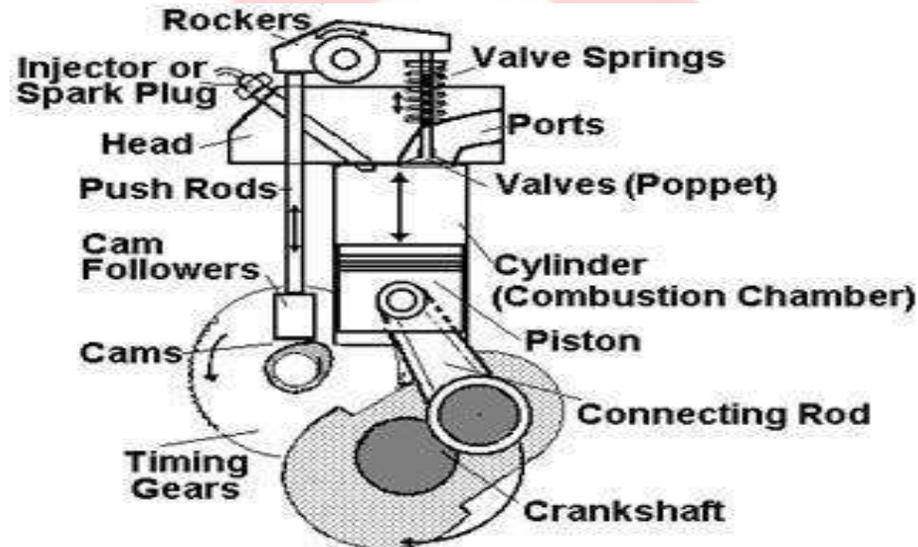
5	<b>TO DETERMINE THE CALORIFIC VALUE OF DIESEL BY BOMB CALORIMETER.</b>
6	<b>TO PREPARE THE HEAT BALANCE SHEET BY CONDUCTING PERFORMANCE TEST ON SINGLE CYLINDER 4-STROKE DIESEL ENGINE (WITH ELECTRICAL BRAKE DYNAMOMETER)</b>
7	<b>TO DETERMINE THE LOAD TEST ON A SINGLE CYLINDER 4-STROKE DIESEL ENGINE (WITH ROPE BRAKE DYNAMOMETER)</b>
8	<b>TO DETERMINE THE MORSE TEST ON A MULTI CYLINDER PETROL ENGINE.</b>



## EXPERIMENT NUMBER : 1(A)

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

### DIAGRAM:-

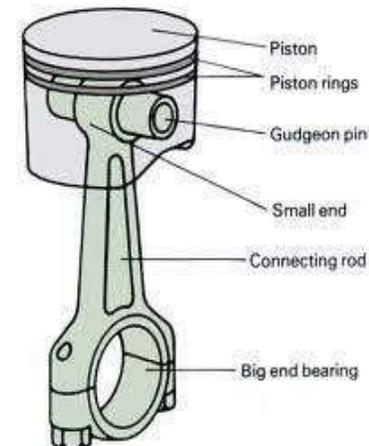


**Figure 1.A..1 Cut Model of 4 Stroke I.C Engine PARTS OF I.C ENGINE:-**

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

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

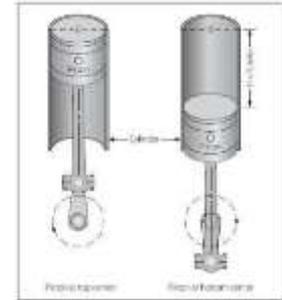
**Function:** Its purpose is to change the volume enclosed by the cylinder , to exert a force on a fluid inside the cylinder or to cover and uncover ports. In an engine, its purpose is to



**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.

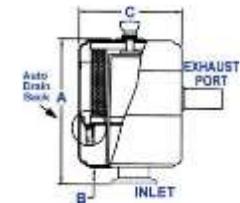
**Function :** Its help in converting reciprocating motion of piston into rotary motion.



**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.

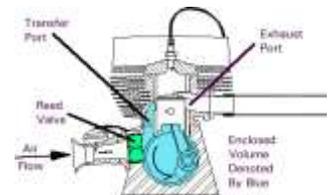
**Materials:** Special Alloy Steel.

**Function:** Its helps in the entry and exit of the fuel when ever 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 1.A.7. 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 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.

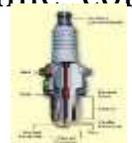
**Crankcase:** This is the part where crankshaft situated. The inlet port is also connected First charge enters into crankcase and send to combustion chamber through transfer port.



**Material:** Aluminium 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.



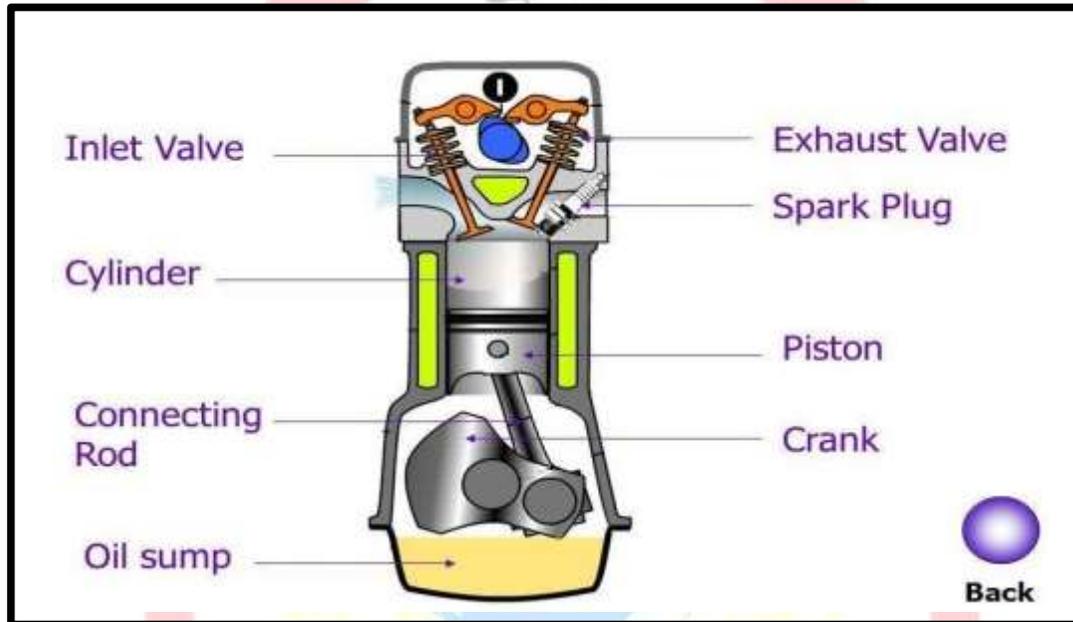
**Material:** Copper and Nickel Alloy.

**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

## EXPERIMENT NO. 1(B)

AIM:- To study the 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:

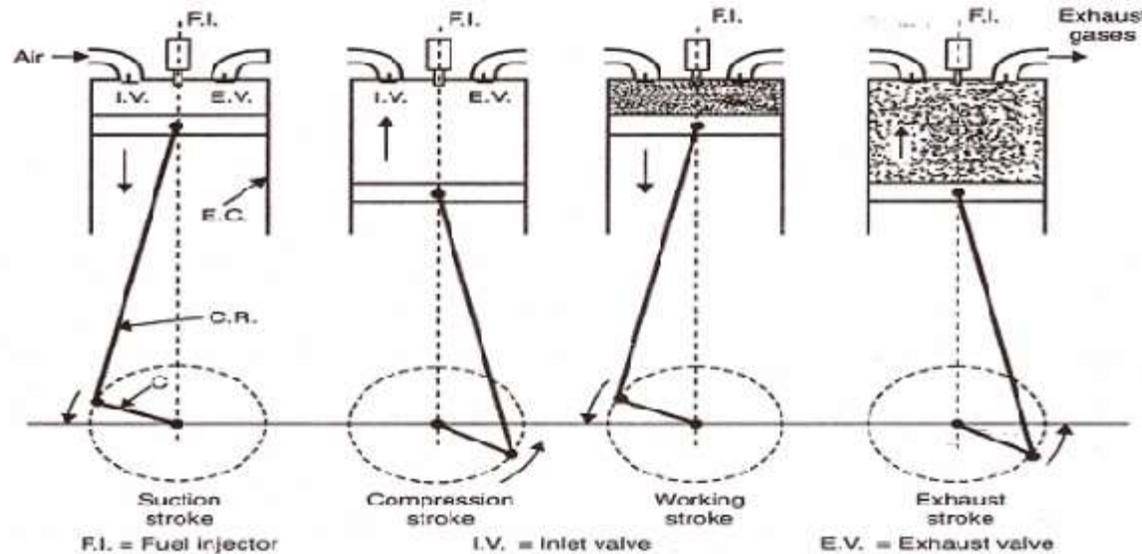
*i) Suction stroke*

*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 ( $180^\circ$ ) of the crank shaft, which means at the end of the suction stroke, piston reaches the bottom dead centre position.



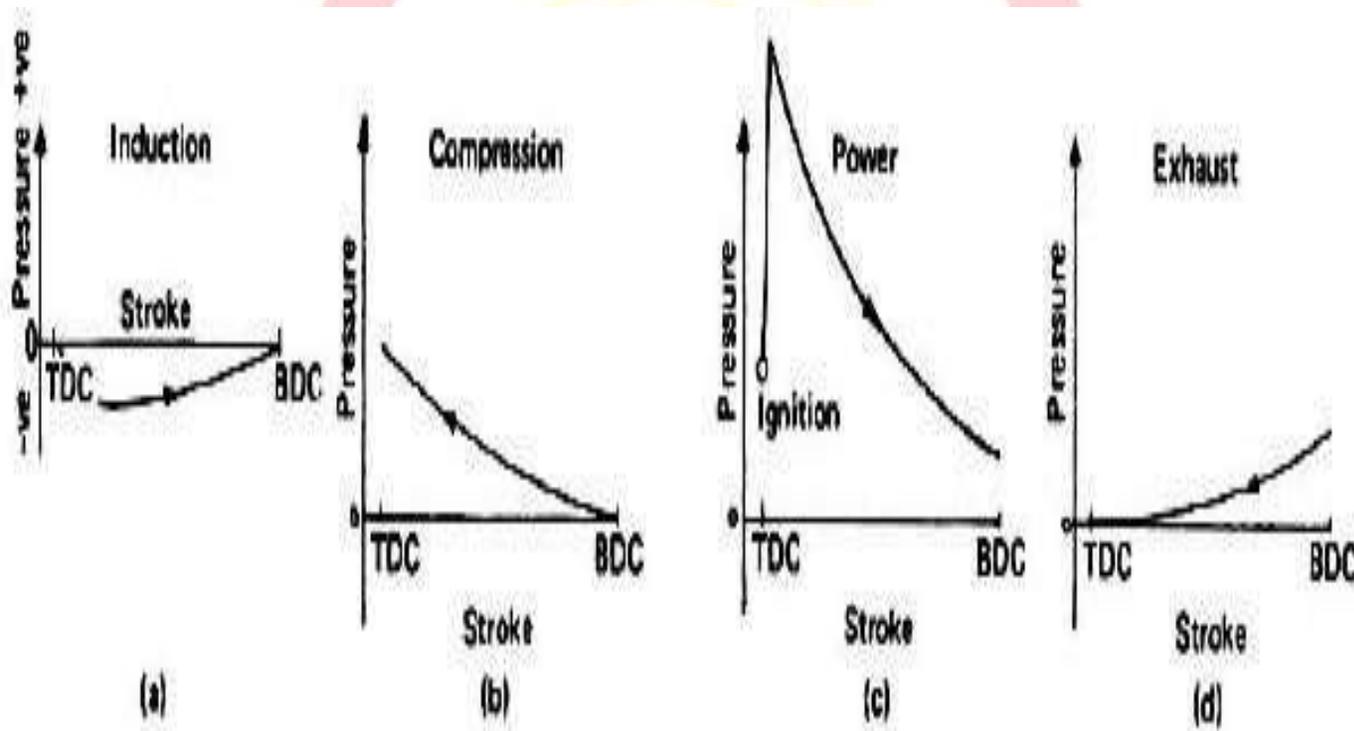
**Figure 1.B.2 suction, compression, power and exhaust stroke**

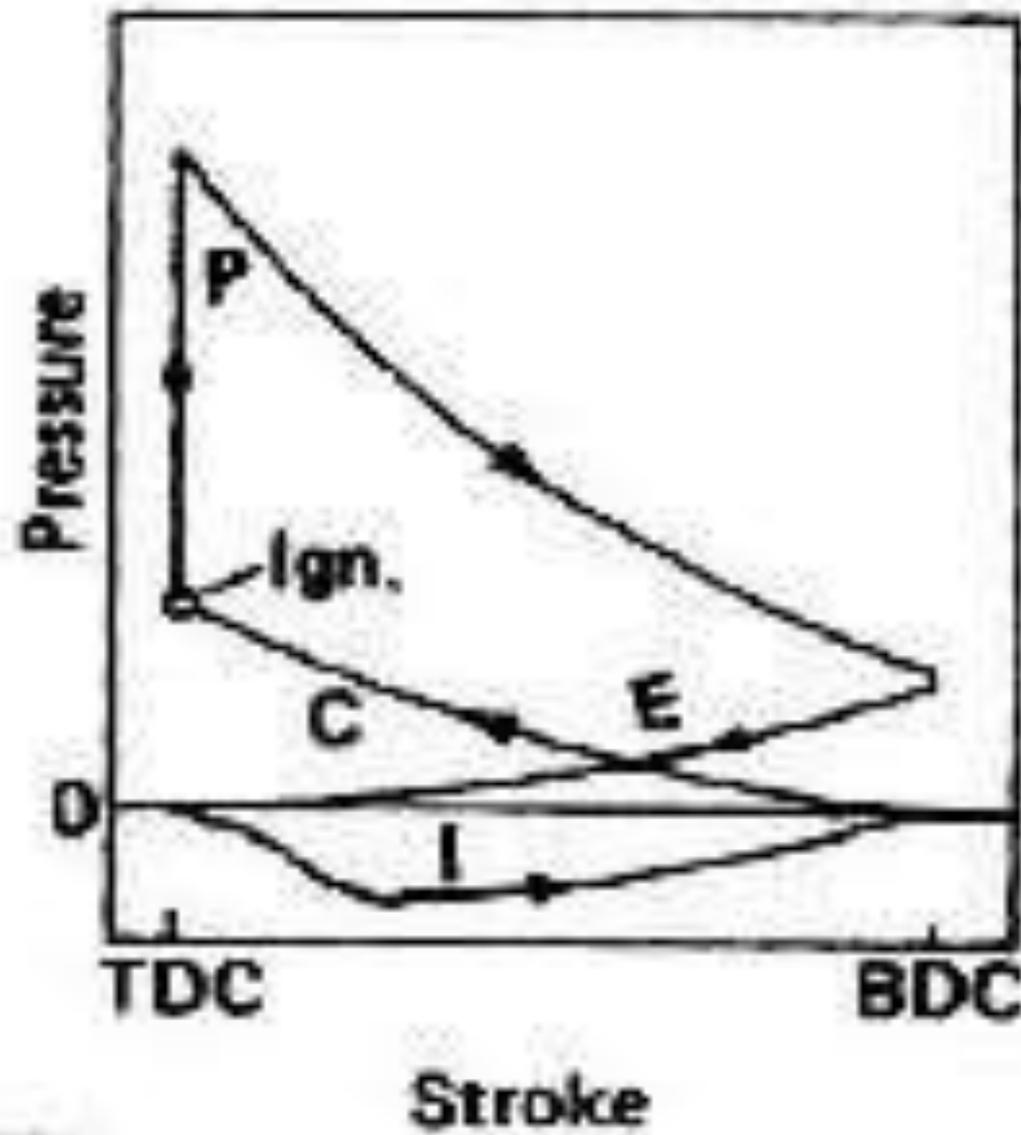
**ii) COMPRESSION STROKE:** During this stroke the inlet and exhaust valves are closed and the piston returns from bottom dead centre position. As the piston moves up, the charge is compressed. During compression the pressure and temperature rises. This rise in temperature and pressure depends upon the 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 remains 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





## EXPERIMENT NO: 2

AIM:- To study the Actual valve timing diagram of 4-stroke petrol engine

DIAGRAM:-

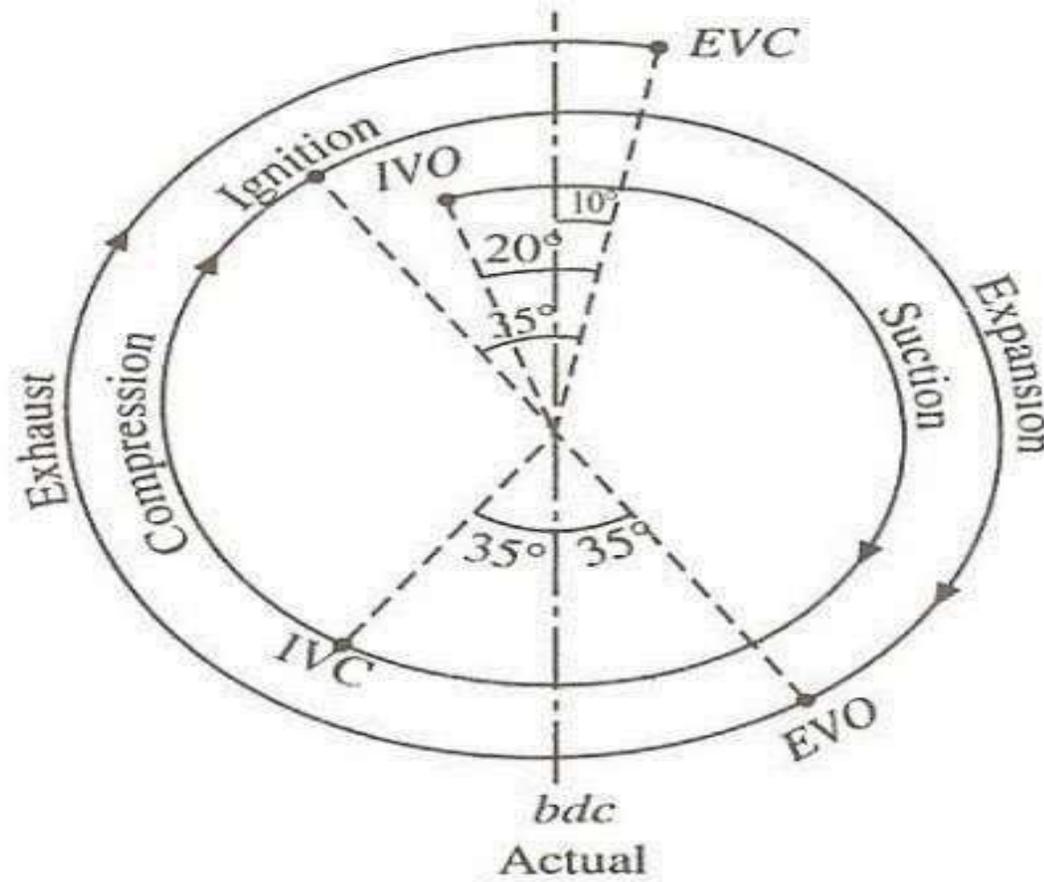


Figure 2.1 ACTUAL VALVE TIMEING DIAGRAM OF 4-STROKE PETROL ENGINE

**I.V.O**-INLET VALVE OPEN  $10^{\circ}$ --  $20^{\circ}$  BEFORE THE PISTON REACHES TDC  
**I.V.C**-INLET VALVE CLOSE  $30^{\circ}$ - $40^{\circ}$  AFTER THE  
PISTON REACHES BDC **E.V.O**-EXHAUST VALVE OPEN  $30^{\circ}$ -  
 $50^{\circ}$  BEFORE THE PISTON REACHES BDC **E.V.C**-EXHAUST  
VALVE CLOSE  $10^{\circ}$ - $15^{\circ}$  AFTER THE PISTON REACHES  
TDC

A valve timing diagram is a graphical representation of the opening and closing of the intake and exhaust valve of the engine, The opening and closing of the valves of the engine depend upon the movement of piston from TDC to BDC, This relation between piston and valves is controlled by setting a graphical representation between these two, which is known as valve timing diagram.

**I.V.O**-INLET VALVE OPEN  $10^{\circ}$ --  $20^{\circ}$  BEFORE THE PISTON REACHES TDC

**I.V.C**-INLET VALVE CLOSE  $30^{\circ}$ - $40^{\circ}$  AFTER THE

PISTON REACHES BDC **E.V.O**-EXHAUST VALVE OPEN  $30^{\circ}$ -

$50^{\circ}$  BEFORE THE PISTON REACHES BDC **E.V.C**-EXHAUST

VALVE CLOSE  $10^{\circ}$ - $15^{\circ}$  AFTER THE PISTON REACHES

TDC

A valve timing diagram is a graphical representation of the opening and closing of the intake and exhaust valve of the engine, The opening and closing of the valves of the engine depend upon the movement of piston from TDC to BDC, This relation between piston and valves is controlled by setting a graphical representation between these two, which is known as valve timing diagram.

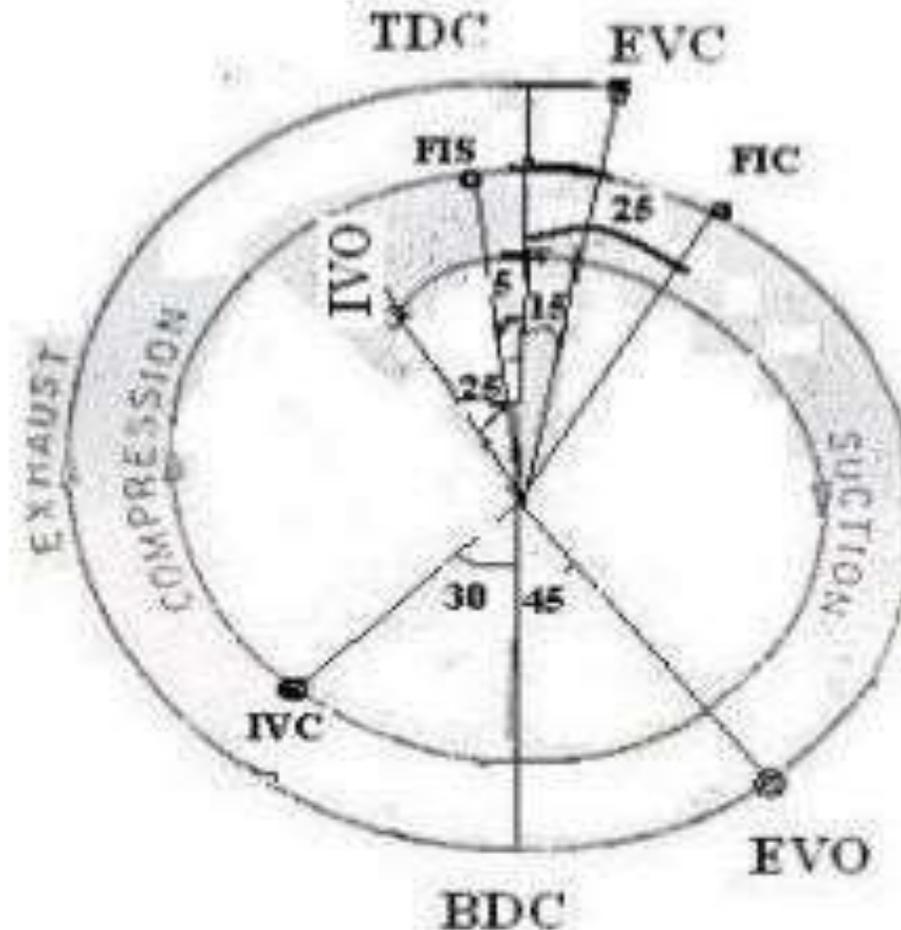
U G V

UNIVERSITY OF GLOBAL VILLAGE

## EXPERIMENT NO:-3

AIM:- To study the Actual valve timing diagram of 4 stroke diesel engine.

DIAGRAM:-



UNIVERSITY OF GLOBAL VILLAGE

Figure 3.1 ACTUAL VALVE TIMEING DIAGRAM OF 4-STROKE DIESEL ENGINE

## **ACTUAL VALVE TIMING DIAGRAM OF 4 STROKE DIESEL ENGINE**

**I.V.O**-INLET VALVE OPEN  $10^{\circ}$ - $20^{\circ}$  BEFORE TDC

**I.V.C**-INLET VALVE CLOSES  $25^{\circ}$ - $40^{\circ}$  AFTER BDC **F.V.O**-FUEL VALVE OPEN

$10^{\circ}$ - $20^{\circ}$  BEFORE TDC **F.V.C**-FUEL VALVE CLOSES  $15^{\circ}$ - $20^{\circ}$  AFTER TDC

**E.V.O**-EXHAUST VALVE OPEN  $39^{\circ}$ - $50^{\circ}$  BEFORE BDC

**E.V.C**-EXHAUST VALVE CLOSES  $10^{\circ}$ - $15^{\circ}$  AFTER TDC

In an ideal engine, the inlet valve opens at TDC and closes at BDC. The exhaust valve opens at BDC and closes at TDC. The fuel is injected into the cylinder when the piston is at TDC and at the end of compression stroke. But in actual practice it will differ.

### **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 opened at  $35^{\circ}$  to  $45^{\circ}$  before BDC and closes at  $10^{\circ}$  to  $20^{\circ}$  after the TDC. It is clear from the diagram, for certain period both inlet valve and exhaust valve remains in open condition. The crank angles 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.

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” [TDC]. In case of horizontal engine this is known as “inner dead centre “ [IDC].

Suction or inlet valve opens slightly before top dead center in vertical engine (or inner dead center in horizontal engines) so that the charge is not restricted at the dead center position. The valve continues to be opened. Well beyond the bottom dead center or outer dead center in horizontal engines to admit more charge due to high velocity at charge in the inlet manifold. The charge air from atmosphere enters the cylinder due to suction stroke. The angle between inlet valve opening and closing gives the suction process in crank angles in degrees. Exhaust valve opens considerably before the end of the working stroke that is before bottom dead center. This no doubt reduces the power output from the engine.

## EXPERIMENT NO: 4

**EXPERIMENT:** DETERMINATION OF FLASH POINT (OPEN) AND FIRE POINT OF THE SAMPLE OIL BY MEANS OF THE CLEVELAND APPARATUS.

**OBJECTS:** To find out the Flash point (open) and Fire point of the sample oil.

**APPARATUS:**

- Cleveland apparatus with a cup made of brass and flame exposure device.
- Gas cylinder (LPG with knob and pipe).
- Heating arrangement i.e, burner.
- Thermometer.

**THEORY:**

The temperature at which the vapour of oil flashes when subjected to an open flame is known as flash point of the oil and fire point is that temperature at which the oil vapour if once lit with flame, will burn steadily at least for 5 sec. Fire point is usually higher than the open flash point In case of open type test, the sample is placed in the cup of the apparatus with top and heated at a uniform rate. A small test flame is directed in to the cup regular and the flash point is taken as the lowest temperature at which intervals application of the test flame causes the vapour above the sample to ignite with a distinct flash inside the cup and also fire point is recorded as the minimum temperature at which the oil continuously burns.

**EXPERIMENTAL PROCEDURE:**

1. Thermometer shall be suspended or held in a vertical position. The bottom of the bulb shall be 1/4 inch (6.4 mm) from the bottom of the cup and half way between the center and wall of the cup.
2. The cap shall be filled with the sample oil so that the top of the meniscus is exactly at the filling line at room temperature. The surface of the sample shall be free from bubbles. There shall be no sample above the filling line on the out side of the apparatus.
3. The test flame shall be approximately 5/32 inch (4 mm) in diameter and it is placed at the bottom centre of the cup.
4. The test flame shall be applied as the temperature reading reaches each successive 5 °F mark. The flame shall pass in a straight line (or in the circumference of a circle having a radius of at least 6 inches across the center of the cup and at the right angle to the diameter passing through the thermometer. The test flame shall, while passing across the surface of the sample, be in the plane of upper edge of the cup. The time for the

the test flame across the cup shall be approximately 1 second. The operator shall avoid breathing over the surface of

5. The sample in temperature does not exceed 30 °F/minuit, The sample shall be heated so that rise till a point is reached approximately 100°F below probable flash point of the sample. Thereafter the rate should be decreased
6. When the flash first appears at point on the surface of the oil, note down the temperature with help of thermometer and it is the desired flash point of the sample oil.
7. More increasing in temperature causes continuously burn of oil at least for 5 sec and this temperature is the fire point of the oil.

### **OBSERVATION AND RESULT:**

Flash point:

Fire point:

### **SARETY AND PRECAUTION:**

- Check the regulator and connecting pipes to avoid any leakage problem.
- Temperature rising observed carefully.
- Keep safe distance from the apparatus during flash time.

### **CONCLUSION AND REMARKS:**

To be written by student

## EXPERIMENT NO: 5

**NAME OF EXPERIMENT:** DETERMINATION OF CALORIFIC VALUE OF GIVEN BY BOMB CALORIMETER.

**OBJECTIVE:**

1. To find the water equivalent of bomb calorimeter using benzoic acid.
2. To find out the calorific value of given fuel.

**APPARATUS:**

- Bomb calorimeter.
- Oxygen cylinder.
- Pressure pipe for flowing oxygen from cylinder to bomb.
- Temperature measuring device (Thermometer)
- Digital weight meter.
- Fuse wire.
- Crucible.
- Cotton.

**SUBSTANCES /CHEMICALS:**

- Pure Benzoic acid.
- Fuel whose calorific value is to be determined.

**THEORY:**

The bomb calorimeter is normally used to determine the higher calorific value of solid as well as liquids fuels. The combustion of fuels takes place at constant volume totally enclosed by vessel.

Thus the higher calorific value at constant volume of the supplied fuel is determined. The combustion leads to reduction in volume of product of combustion when reduced to initial temperature. The values obtained are the different from actual heat liberated.

Heat liberated by fuel and wire = Heat absorbed in the calorimeter Or,  $CX + C_1X_w = (W + w)(\theta_1 - \theta_2) C_p$

Where

- C= calorific value of burnt fuels.
- $C_1$ = calorific value of wire burnt.
- X = mass of fuel burnt.
- X W = mass of wire.
- $\theta_1$  = temperature after combustion.
- $\theta_2$  = temperature before combustion.
- W = water equivalent of water.
- w = weights of water in calorimeter.

- $C_p$  = specific heat of water.

Temperature rise for wire burnt is negligible,

$$C = (W + w) (\theta_1 - \theta_2) C_p / x \dots \dots \dots (1)$$

**EXPERIMENTAL PROCEDURE:**

1. At first measure the water equivalent of calorimeter using benzoic acid whose calorific value is known.
  - First measure empty crucible in gm.
  - Take the measurement of crucible filled with benzoic acid.
  - Set fuse wire & cotton in proper position of electrode.
  - Fill bomb with oxygen from oxygen cylinder at 25 atm.
  - Get the proper electrical connection to activate firing unit, stirrer system & temperature indicator.
  - Measure and note down the temperature raising of water every 60 Sec after firing till the temperature becomes steady.
2. Measure the calorific value of fuel by known water equivalent of calorimeter using the equation (1). The next procedure is same as above only the difference is that instead of Benzoic acid take the supplied fuel.

**OBSERVATION DATA:**

To find out the water equivalent of calorimeter bomb using benzoic acid.

Table-A1:

SL. No	Empty crucible Weight	Crucible +B.A Weight	Weight of B.A
Unit	In gm	In gm	In gm
1			

SL. No	Initial Temperature( $\theta_1^\circ$ C)	Time interval	Temperature	Final Temperature( $\theta_2^\circ$ C)	Temperature Rise( $\theta_1-\theta_2$ ) $^\circ$ C	Water equivalent

**CALCULATION:**

Calorific value of benzoic acid = 26 KJ/gm Calculate water equivalent of bomb

To find out the calorific value of given fuel: Table-B1:

SL. No	Empty crucible Weight	Crucible +sample Weight	Weight of sample
Unit	In gm	In gm	In gm
1			

Table-B2:

SL. No	Initial Temperature( $\theta_1^\circ$ C)	Time interval	Temperature	Final Temperature( $\theta_2^\circ$ C)	Temperature Rise( $\theta_1-\theta_2$ ) $^\circ$ C	Water equivalent

**CALCULATION:**

Calculate Calorific value of fuel using equation no (1).

**PRECAUTION:**

During the experiment the following measures should be taken:

- Benzoic acid should be pure.
- Weight should be taken very carefully.
- In every 15 sec, temperature should be recorded with correct and careful manner.
- Room temperature should be steady.
- Clean the bomb after every experiment.
- In calculation avoid round-off error

**CONCLUSION AND REMARKS:**

To be written by student.

## **EXPERIMENT NO: 6**

**NAME OF EXPERIMENT:** PREPARE A HEAT BALANCE SHEET BY CONDUCTING PERFORMANCE TEST ON A SINGLE CYLINDER 4 STROKE DIESEL ENGINE (WITH ELECTRICAL BRAKE DYNAMOMETER)

**OBJECT:**

To draw up a thermal energy distribution graph (heat balance) for the CI engine by performing load tests at the rated speed of the engine with Electrical brake dynamometer.

**APPARATUS WITH SPECIFICATION :**

1. Single cylinder water cooled diesel engine.
  - Make.
  - Rated Horsepower: 5 H.P. 1500 r.p.m.
  - Stroke: 110 mm.
2. Dynamometer
  - Make
  - Type: Electrical D.C type
3. Panel Board  
It consists of Amp meter, Voltmeter and Switch fuse carrier.
4. Fuel measuring tank.  
Mounted on a sturdy iron stand, burette tube three way cock with connecting tube.
5. Air intake measurement.
  - Make:
  - Size:
6. Stopwatch.

**THEORY:**

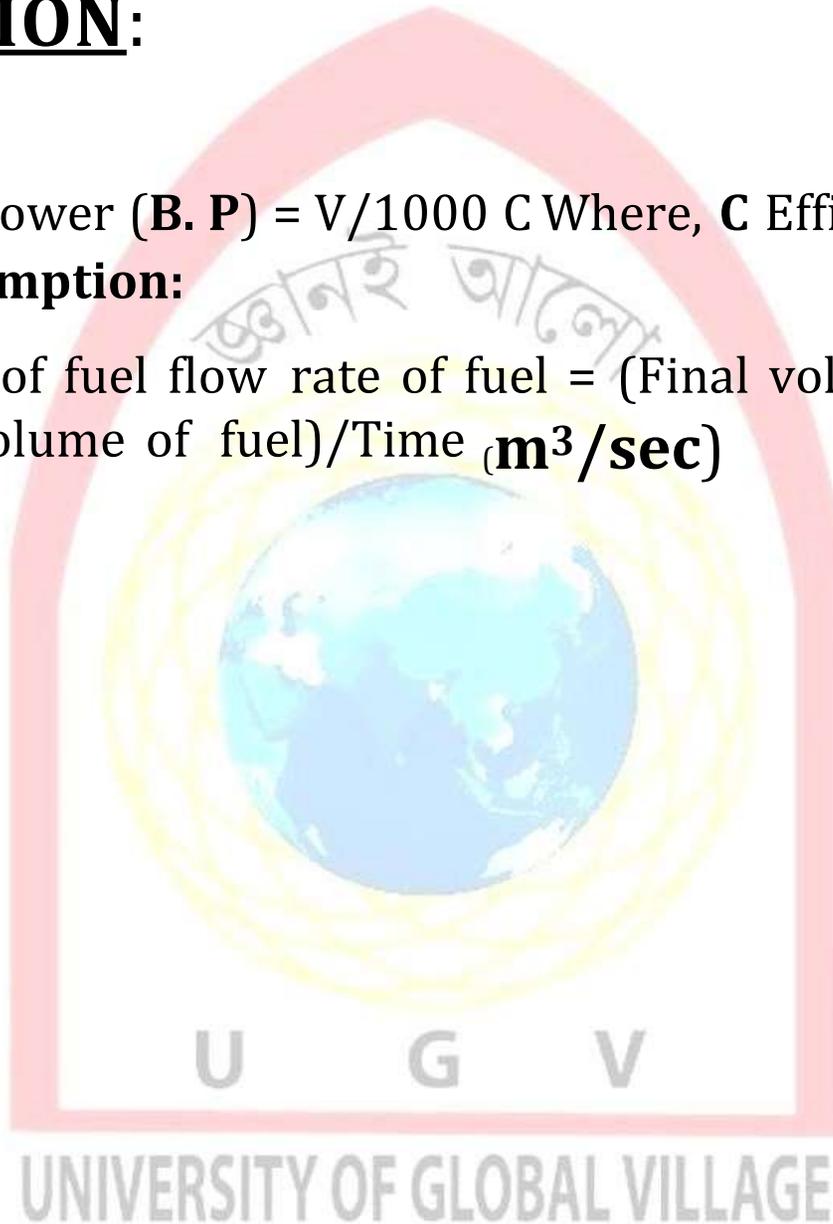
The performance of an engine is generally given by heat balance sheet. To draw the heat balance sheet for I.C. Engine, it is run at constant load. The quantity of fuel used in a given time and its calorific value, the amount, inlet and outlet temperature of cooling water, the temperature of exhaust gases, etc. are recorded. After that the heat used in



## CALCULATION:

Brake power (**B. P**) =  $V/1000 C$  Where, **C** Efficiency of generator. **KW**  
**Fuel Consumption:**

Volume of fuel flow rate of fuel = (Final volume of fuel - initial volume of fuel)/Time (**m<sup>3</sup>/sec**)



Mass flow rate of fuel ( $m_f$ ) = (Volume flow rate of fuel  $\times$  density of fuel). (Kg/hr)  
 Sp. Gravity of fuel = 0.86

**Sp. Fuel Consumption:**

$$\text{B.P s. f. c} = \frac{\text{Fuel used in kg/ hr}}{\text{B.P in k w.}} = \frac{m_f}{\text{B.P.}} \quad (\text{Kg/KW-h})$$

**Heat supplied by the fuel:**

Heat supplied by the fuel ( $Q_s$ ) =  $m_f \times C.V \times 3600$ . (KJ/hr)

**Heat equivalent to B.P:**

$$Q_{B.P} = \text{B.P} \times 3600 \text{ (KJ /hr)}$$

**Heat carried away by exhaust gas:**

The amount of heat carried away by exhaust gas  $Q_e = (m_a + m_f) \times C_{pg} \times (T_g - T_a)$ . (KJ/hr)

Where,  $T_g$  = Temperature of exhaust gas (K)  $T_a$  = Temperature of air.

(K)

$C_{pg}$  = Sp. Heat of exhaust gas. ( KJ/Kg-K)

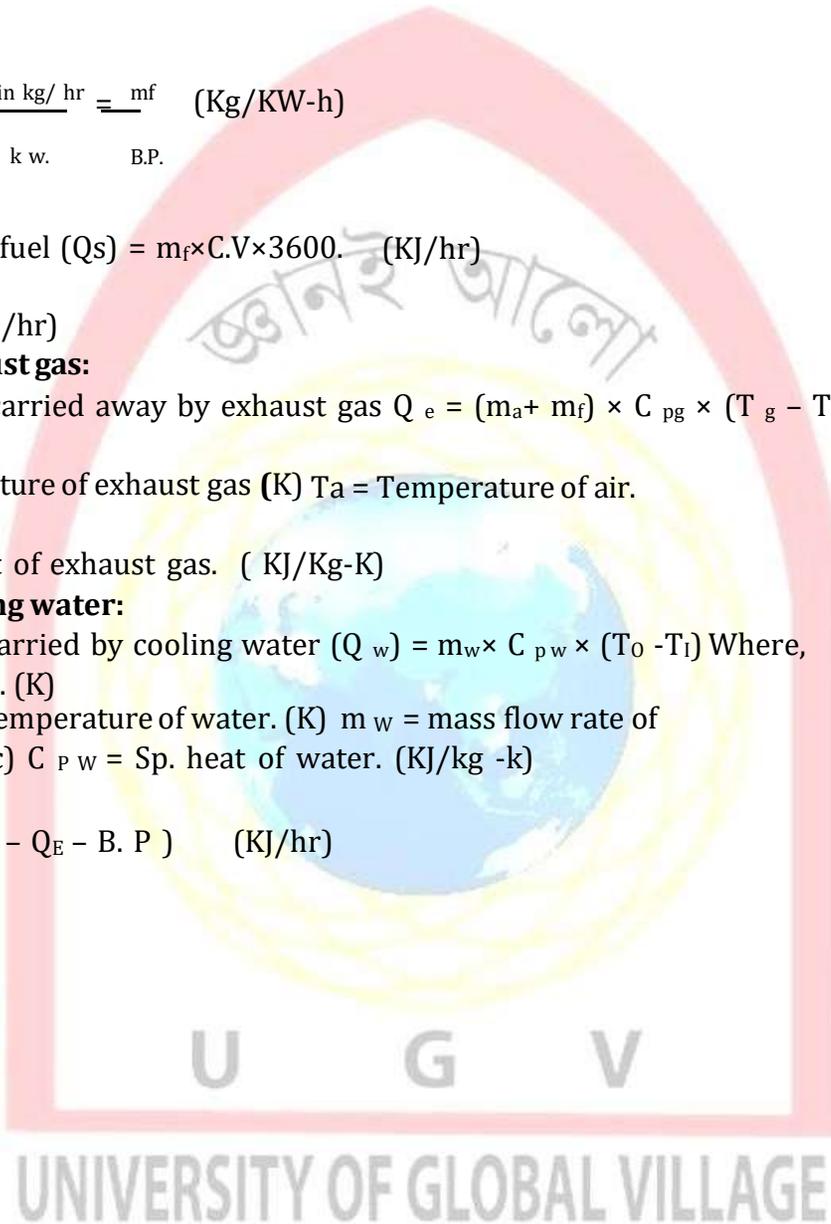
**Heat carried away by cooling water:**

The amount of heat carried by cooling water ( $Q_w$ ) =  $m_w \times C_{pw} \times (T_o - T_i)$  Where,  $T_o$  = outlet Temperature of water. (K)

$T_i$  = inlet Temperature of water. (K)  $m_w$  = mass flow rate of water (kg/sec)  $C_{pw}$  = Sp. heat of water. (KJ/kg -k)

**Unaccounted heat:**

$$Q_U = (Q_s - Q_w - Q_e - \text{B. P} ) \quad (\text{KJ/hr})$$



**RESULT:**

Heat balance sheet:

CREDIT		DEBIT		
	100%	1.Heating b .p		%
		2.Heating injacket water		%
		3.Heat in exhaust gas.		%
		4.Heat accounted		%
	100%	Total		100%

## **PRECAUTION:**

The following precautions should be taken during the experiment:

- Before starting engine, grease cups and lubricating oil should be checked.
- It should be checked that air is not present in the pump.
- The water line should also be checked.
- Do not tamper with any of engine settings without proper knowledge.
- Water supply should be stop after the experiment was stop.

## **CONCUUSION AND REMARKS:**

To be written by student.

## **EXPERIMENT NO: 7**

**NANIE OF EXPERIMENT:** LOAD TEST ON A SINGLE CYLINDER FOUR STROKE DESEL ENGINE (WITH ROPE BRAKE DYNAMOMETER)

**OBJECT:**

1. To determine the B.P, f. p. And I. p at different load.
2. To determine the fuel consumption, air consumption, air-fuel ratio and s .f .c at different load.
3. To calculate mechanical and thermal efficiency of the engine at different load.
4. To plot the graphs of fuel consumption in vs. B .P, and s. f. c vs. AFR.

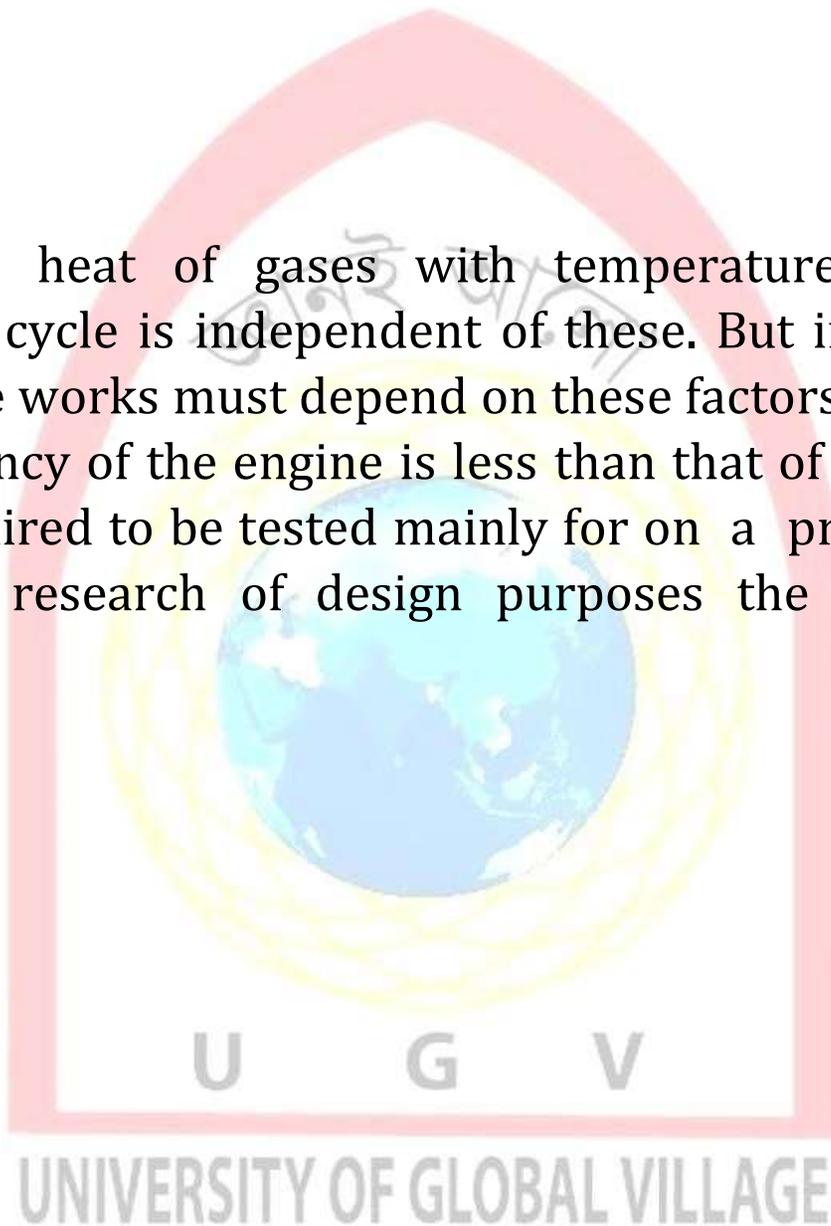
**APPARATUS WITH SPECIFICATION :**

1. Single cylinder water cooled diesel engine.
  - Make.
  - Rated Horsepower: 5 H P, 1500 r p.m.
  - Stroke: 110 mm.
2. Dynamometer
  - Make
  - Type: Mechanical (Rope Drum)type
3. Tachometer
  - Make
4. Fuel measuring tank.  
Mounted on a sturdy iron stand, burette tube three way cock with connecting tube.
5. Air intake measurement.
  - Make:
  - Size:
6. Stopwatch.

**THEORY:**

In theoretical cycle, we assume that there is no friction loss or exhaust gas loss, cooling water heat loss or there is no

variation of sp. heat of gases with temperature. Therefore the efficiency of the cycle is independent of these. But in actual cycle on which the engine works must depend on these factors and due to these losses the efficiency of the engine is less than that of theoretical cycle. Engines are required to be tested mainly for on a production line of engines and in research of design purposes the basic



measurements which usually should be undertaken to evaluate the performance of an engine are

- Speed
- Fuel and Air consumption.
- Air- Fuel ratio.
- B.P, f. p and I. p .
- Heat going to cooling water.
- Heat going to exhaust gases.
- Sp. Fuel consumption.
- Mechanical and Thermal efficiency.

**EXPERIMENT PROCEDURE:**

1. Check the level of the diesel in tank and lime up with the fuel pump through fuel measuring apparatus.
2. Start the engine by hand cranking with no load condition.
3. As the engine pick up speed, start water to the brake drum.
4. Put a light Load in the engine with loading screw.
5. Achieving steady state condition, note down all the necessary data (fuel consumption, cooling water flow rate, brake drum speed with tachometer, manometer difference, difference temperatures).
6. After noting down repeat the steps 4 and 5 for different load.
7. Before stop the Engine remove the load and run the engine on no-load for two minutes.
8. Stop the engine.
9. Turn off cooling water supply to engine after one minute.

**OBSERVATION DATA:**

Given, CV = 42630 KJ/Kg

Diameter of drum = 300 mm. Diameter of rope = 12mm.

Diameter of orifice meter = 15 mm Coefficient of discharge =

0.62

Table 1:

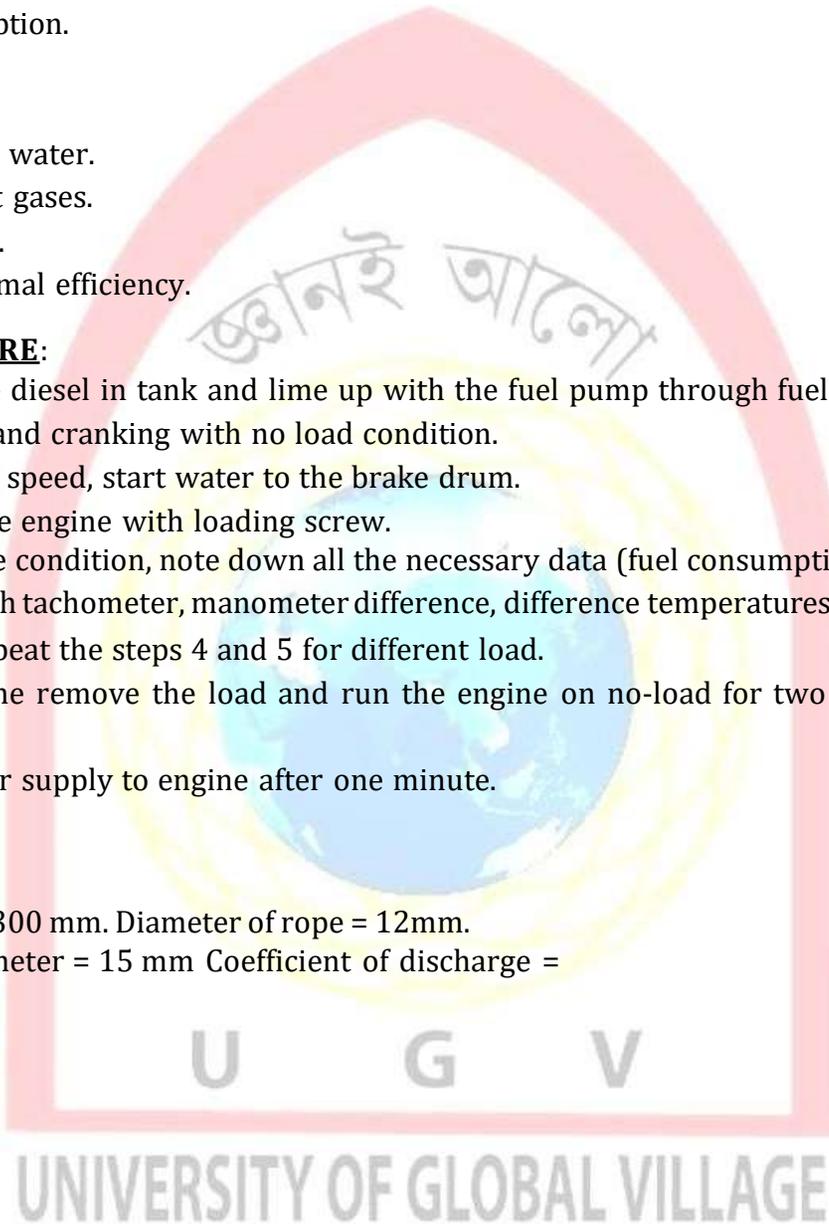


Table 1

SL. No	Fuel consumption in ml	Time taken in sec	Manometer reading	Water flow of cooling water in litre	Time taken in sec	Cooling water temperature in °C	Exhaust gas temperature in °C

			Left limb	Right limb		inlet	outlet	

Table 2:

Sl. No	Speed of crank shaft N = 2×cam shaft speed ( in R.P.M)	Load on break drum W=Applied load in kg ×g in m/sec <sup>2</sup>	Spring balance reading S = load show in kg ×g in m/sec <sup>2</sup>

**CALCULATION:**

**Fuel Consumption:**

Volume flow rate of fuel = (Final volume of fuel - Initial volume of fuel)/Time [m<sup>3</sup>/sec]

Mass flow rate of fuel (m<sub>f</sub>) = (volume flow rate of fuel × density of fuel) [kg /sec] Sp. gravity of fuel = 0.86

**Air Consumption:**

Mass flow rate of air (m<sub>a</sub>) = C<sub>d</sub> × Q × ρ<sub>a</sub> Where, C<sub>d</sub> = coefficient of discharge of orifice. Density of air ρ<sub>a</sub> = P<sub>atm</sub> /RT<sub>atm</sub> [kg /m<sup>3</sup>]

Q = Volume flow rate of air. Q = √2gHwρ<sub>w</sub> / ρ<sub>a</sub>

And H<sub>w</sub> = difference in manometric head in water column.

ρ<sub>w</sub> = density of water. A = Area of orifice.

d = Diameter of through. m<sub>a</sub> = C<sub>d</sub> × A × √2gHwρ<sub>w</sub> / ρ<sub>a</sub>

a × ρ<sub>a</sub>

$$= C_d \times A \times \sqrt{2gHw\rho_w} / \rho_a$$

**Air - fuel ratio:**

Air - Fuel ratio (AFR) = m<sub>a</sub>/m<sub>f</sub>

**Break power:**

$$B.P = \frac{2\pi NT}{1000 \times 60} \quad K.W$$

Where, N = brake speed in r.p.m. (Crank shaft)

T = [(W-S) × (radius of break drum + radius of rope)] Nm

**Friction power:**

Power  $m_f$  vs.  $b. p$  for different reading Extend the line to meet zero  $m_f$ . The power (on negative side) at which  $m_f$  is zero is  $f. p$ . The plot is known as Willian's Line.

**Indicated power:**

$$i. p = b. p + f. p. \text{ (KW)}$$

**Sp. Fuel Consumption:**

$$s. f. c = \text{Fuel used in kg/hr} / b. p \text{ in KW} = m_f / b. P \text{ (kg/KW - hr)}$$

**Heat supplied by the fuel:**

$$\text{Heat supplied by the fuel } (Q_s) = m_f \times CV \times 3600 \text{ (KJ/hr)}$$



### Heat equivalent to b. p:

$$Q_{b.p} = b.p \times 3600 \text{ (KJ/hr)}$$

### Efficiency:

Brake thermal efficiency ( $\eta_{b.t}$ ) =  $Q_{b.p} \times 100 / Q_S$  Indicated thermal efficiency ( $\eta_{i.t}$ )

=  $i.p \times 100 / Q_S$  Mechanical efficiency ( $\eta_m$ ) =  $Q_{b.p} \times 100 / Q_{i.p}$

### RESULTS:

Load	b. p	f. p	I. p	F.C	s f c	AFR	qs	q b p	$\eta_{b.t}$	$\eta_{i.t}$	$\eta_m$
Kg	KW	KW	KW	Kg/hr	Kg/KW-hr		KJ/hr	KJ/hr			

Plot the graphs of  $m_f$  vs. b. P and (s .f. c) vs AFR.

### PRECAUTION:

The following precautions should be taken during the experiment:

- Before starting engine, grease cups and lubricating oil should be checked.
- It should be checked that air is not present in the pump.
- The water line should also be checked.

### CONCLUSION AND REMARKS:

To be written by student.

## EXPERIMENT NO: 8

**NAME OF EXPERIMENT:** MORSE TEST ON A MULTI CYLINDER PETROLENGINE.

**OBJECTS:**

1. To perform "Morse Test" on a Multi cylinder petrol engine at different speed and determine i. p, b .p and f. p. Of engine at each speed.
2. To determine the mechanical efficiency of the engine.
3. To plot the characteristic curve f.p. vs Speed.

**APPARATUS WITH SPECIFICATION:**

- Multi cylinder water cooled petrol engine.
  1. Make:
  2. Rated Horsepower:
  3. No. of Cylinders:
  4. Capacity:
  5. Cylinder Bore:
  6. Stroke:
- Dynamometer:
  1. Type:
  2. Constant
- Tachometer.
- Others.

**THEORY:**

Morse Test, applicable only to multi cylinder engines use to find indicated power, break power frictional power and mechanical efficiency of the petrol engine as well as diesel engine for set positions of throttle, choke and for a selected speed by cutting each cylinder in succession. If the engine consists of 'k' cylinders then the break power of the engine should be measured k-times cutting each cylinder turn by turn The cylinder of petrol engine is made inoperative by shorting the spark plug. If all the 'k' cylinders of the engine are in working, then

$$i.P_1 + i.p.2 + i.p.3 \dots i.P_k = \sum_{n=1}^k b.p_n + f.p. \dots (1)$$

Where i.p, b .p. and f p. are respectively indicated, brake and frictional power and suffix stands for the cylinder number.

**OBSERVATION DATA:**

Sl. No	Speed in ( r.p.m.) / voltage in (V)	Shorted Cylinder	Load(in A)			
		Initial load (All cylinder in acting Condition)				
		With No 1 Cylinder Shorted				
		With No 2 Cylinder Shorted				
		With No 3 Cylinder Shorted				
		With No 4 Cylinder Shorted				

**RESULTS:**

Sl. No	Speed in (r.p.m) / voltage in (V)	I. p	b. p	f. p	Mech. Efficiency ( $\eta_m$ )

## **SAMPLE CALCULATIONS:**

Students have to show one set of calculation in details. Use the following formula to find out

$$\text{the b.p b.p} = \frac{2NW_r}{4500} \text{ (in hp)}$$

$$= \frac{2NWrg}{60} \text{ (inw)}$$

where  $W$  = Load indicated by the weighing device in kg  $N$  = Shaft speed in r.p.m.  $r$  = Arm length in m  $g = 9.81 \text{ m/s}$

## **PRECAUTION:**



**THANK YOU**

**University of Global Village (UGV), Barishal**  
**Department of Mechanical Engineering**

**Prepared by**  
Md. Naeem Hosen Hredoy  
Lab Instructor  
Department of Mechanical

**U G V**

**UNIVERSITY OF GLOBAL VILLAGE**