PORT TIMING DIAGRAM

AIM : To determine the timings of port opening and closing for the given 2 – stroke engine and to draw PTD.

APPARATUS: Scale, thread and chalk.

SPECIFICATIONS:

Two stroke, Single cylinder, Horizontal Petrol engine,
Rated Power - 2.5 HP, Speed – 2800 rpm

THEORY AND DEFINITIONS:

The two stroke petrol (SI) engine works on Otto cycle (constant volume cycle). In two stroke engines the cycle is completed in two strokes i.e. in one revolution of the crank shaft as against two revolutions of four stroke cycle. The fresh charge is sucked through spring loaded inlet valve when the pressure in the crankcase reduces due to forward motion of the piston i.e. from ODC to IDC (from BDC to TDC incase of vertical engines) during compression stroke.

Transfer and exhaust port timings: In case of 2 – stroke engine the exhaust port is opened first, near the end of the expansion stroke i.e. From IDC to ODC. With piston controlled exhaust and transfer port arrangement the lower part of the piston stroke is always waste so, as far as the useful power output is concerned (about 15 % to 40 % of the expansion stroke is ineffective). This early opening of the exhaust port during the last part of the expansion stroke is necessary to permit blow down of the exhaust gases and also to reduce the cylinder pressure so that when the transfer port opens at the end of the blow down process, fresh charge can enter the cylinder. The fresh charge which comes from the crank case enters the cylinder at a pressure slightly higher than the atmospheric pressure. This will assist in forcing out (scavenging) the remaining exhaust gases through the exhaust port with the help of piston projection. During forward motion i.e. from ODC to IDC, the piston covers first the transfer port and then the exhaust port. It is to avoid the fresh charge to escape through the exhaust port.

PROCEDURE:

1. Identify the transfer and exhaust ports and their operation.
2. Identify outer dead centre (ODC) from the movement of the piston i.e. the piston moves towards crankcase. The piston remains stationary at dead cenres before it reverses its direction of motion. Mark a line on the flywheel taking a reference point on the engine body, corresponding to the outer dead centre. The diametrically opposite point on the flywheel will be the inner dead centre (IDC).
3. Fix up the correct direction of rotation of flywheel to get the proper sequencing of port opening and closing.
4. Identify the various port openings and closings. Mark the corresponding operations on the flywheel.

5. Recheck the markings on the flywheel to ascertain the correctness of valve openings and closings and measure the corresponding distances with the help of given thread and scale and tabulate the results.
6. Draw the flywheel diagram indicating valve events and their distances from dead centers.
7. Draw the valve timing diagram indicating the valve openings and closings in a spiral form. Identify all the four strokes in terms of angles and show the valve overlap.

OBSERVATIONS :

Circumference of Flywheel = π D =

Sl.No	Valve events	Distance in "cm" from dead centre ("L" cm)				Crank angle θ =360 X L / (π.D)
		Before TDC	After TDC	Before BDC	After BDC	
1	IVO					
2	IVC					
3	EVO					
4	EVC					

GRAPHS / DIAGRAMS:

1. Draw the fly wheel diagram indicating various valves operations and the direction of rotation.
2. Draw the valve timing diagram indicating the valve openings and closing in a spiral form. Identify all the four strokes in terms of crank angles and show the valve overlap.

PRECAUTIONS:

i) The valve opening should be taken as the point where it first begins to open
ii) The valve closing should be taken as the point where valve closes completely
iii) The flywheel should be rotated in proper direction.

SAMPLE CALCULATIONS :

RESULTS/ INFERENCE / CONCLUSIONS / RECOMMENDATIONS:

MALLA REDDY ENGINEERING COLLEGE
(AUTONOMOUS)

RETARDATION TEST ON DIESEL ENGINE

AIM:

To conduct retardation test on single cylinder four stroke diesel engine and to calculate frictional power and mechanical efficiency.

APPARATUS:

a. 4 Stroke Single Cylinder Diesel engine
b. Stop watch

SPECIFICATIONS:

a. Make – Kirloskar
b. Bore (D) – 0.080 m
c. Stroke (L) – 0.110 m
d. Speed (N) – 1500 rpm
e. Max. B.P – 5 H.P
f. Loading radius – 0.158 m
g. Compression ratio – 165:1
h. Calorific value – 45350 Kj/Kg

THEORY:

The engine is supplied with certain quantity of heat energy in the form of fuel. Only a part of this energy is converted into useful mechanical work, which is available at the engine crank shaft and rest is wasted in engine jacket cooling water, exhaust gases and in overcoming the friction. The non-useful energy levelling the system should be as small as possible in order to maximize the rated power. If the purpose of energy balance to trace the energy distribution i.e.

to determine how the input energy is distributed where the energy leaves and how much it during a test is revealed that at certain loading condition a certain form of energy loss in excessive a careful examination of that form is needed in order to have the better performance of the engine. A statement of the heat supplied, useful energy available and losses is called the heat balance sheet.

PROCEDURE:

1. Start the engine as given in the main procedure and allow it to attain steady state.
2. Decide the speed (say 1000rpm) and cut - off the fuel flow to the engine by the valve provided near the fuel filter.
3. Immediately trigger the timer and note the time when the rpm comes to decided value or nearest to it. **(Time: t_2)**
4. Also, open the fuel flow when the timer is stopped.
5. Next, Load the engine at 50% of the full load and repeat the steps 1 to 4 and note time. **(Time: t_3)**
6. Repeat the procedure for steps 1 to 4 and grade the values.

CALCULATIONS:

1. Frictional Torque, Tf

$T_f = [t_3 / (t_2 - t_3)] \times T_L$

Where,

T_L = load torque on drum.

= mxrxg where m = mass in kg of spring balance

r = radius of torque arm = 0.158m

T_f= Frictional Torque, Nm.

t_2 = time for reduction of speed at no load.

t_3 = time for reduction of speed at given that is at 50% load.

2. Friction Power, FP

$FP = (2\pi N T_f)/60000$ KW

IP = BP+FP

3. Brake Power, BP

$$BP = \frac{2\pi NT}{60000} \text{ Kw}$$

4. Mechanical Efficiency η_{mech} $= \frac{B.P}{I.P} \times 100$

TABULATION:

Sl.	Drop in speed (rpm)	Time for loss of speed at no load, t_2 (sec)	Time for loss of speed at 7.6 Kg load, t_3 (sec)	Frictional Torque, Tf (N-m)	Frictional Power, FP (w)	Indicated Power (w)	Mechanical Efficiency (η_{mech})
1							

PRECAUTIONS:

1. Do not start or stop the engine
2. Do not run the engine without the supply of water.
3. After starting the engine, remove the handle carefully fron the shaft
4. Take the time carefully for dropping the speed

Result: Retardation test is conducted on four stroke single cylinder diesel engine.

FP =

BP =

Mechanical Efficiency =

MALLA REDDY ENGINEERING COLLEGE
(AUTONOMOUS)

PERFORMANCE TEST OF IC ENGINE

AIM:

a. To conduct performance test on single cylinder four stroke diesel engine.
b. To calculate brake power, specific fuel consumption, brake thermal efficiency and volumetric efficiency

APPARATUS:

a. 4 Stroke Single Cylinder Diesel engine
b. Stop watch

SPECIFICATIONS:

a. Make – Kirloskar
b. Bore (D) – 0.080 m
c. Stroke (L) – 0.110 m
d. Speed (N) – 1500 rpm
e. Max. B.P – 5 H.P
f. Loading radius – 0.158 m

INTRODUCTION:

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 60 Lph & 40 Lph respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. * Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular Load condition,
    a. Engine Speed
    b. Initial and Final reading of the fuel w.r.t 60 sec.

c. Rotameter reading.

d. Manometer readings, in cms of water &

e. Temperatures at different locations.

11. Repeat the experiment for different loads and note down the above readings.

12. After the completion release the load and then switch of the engine.

13. Allow the water to flow for few minutes and then turn it off.

* It is to be noted that due to friction heat, load on the engine will be reduced slightly hence required to maintain the load to its original position by continuously operating the Yoke rod.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied			Air flow rate (mm of WC)	Fuel reading		
		F1	F2	F= (F1~F2)	H	IR	FR	TIME

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate (LPM1)	Calorimeter water flowrate (LPM2)

CALCULATIONS:

1. **Mass of fuel consumed, m_f**

$$m_f = \frac{(IR-FR)}{(t*1000)} \quad kg/sec$$

Where,

IR & FR are intial and final reading from the indicator

t is time taken in seconds

2. **Heat Input, HI**

HI = m_f x Calorific Value of Fuel kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

$$BP = \frac{2\pi N T}{60000} \quad kW$$

Where,

N is speed in rpm

T =Torque = (F1 ~ F2) x r x 9.81 N-m

r = 0.158m

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{(3600*m_f)}{BP} \quad Kg/kW-hr$$

5. **Brake Thermal Efficiency, η_{bth}%**

$$\eta_{bth} = \frac{(BP*100)}{(m_f*C_v)} \quad \%$$

Indicated power = BP + FP

Mechanical Efficiency = (BP/IP)X100

Fuel Air Ratio = m_a/m_f

Indicated Thermal Efficiency = (3600XIP)/m_fXCV

8

6. Calculation of head of air, Ha

$$h_a = \frac{h \times \rho_w}{\rho_a} \text{ m of air}$$

Where,

ρw = density of water = 1000 Kg/m3

ρa = density of air = 1.2 Kg/m3 @ R.T.P

h = head in water column in 'm' of water

7. Volumetric efficiency, $\eta vol\%$

$$\eta_{vol} = \frac{Q_a}{Q_{th}} \times 100 \ \%$$

where,

Qa = Actual volume of air taken =

$$Q_a = C_d \, a \sqrt{2gh_a} \qquad m^3/s$$

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $a = \frac{\pi d^2}{4} \quad m^2$ Where d = 0.017m

Ha = head in air column, m of air.

$$Q_{th} = \frac{A \, L \, N \, n}{n_c \, 60} \quad m^3/s$$

Qth = Theoretical volume of air taken

Where,

A = Area of the Bore = $A = \frac{\pi D^2}{4} \quad m^2$

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

n = no of cylinders

nc = no. of revolution of the flywheel to complete the cycle

TABULATION:

Sl.	Indicated Power (Kw)	Brake Power (Kw)	SFC (Kg/Kw-hr)	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						
5						

PRECAUTIONS:

1. Do not start or stop the engine
2. Do not run the engine without the supply of water.
3. After starting the engine, remove the handle carefully fron the shaft
4. Take the time carefully for dropping the speed

Result: The performance test on single cylinder four stroke diesel engine is conducted and the brake power, specific fuel consumption, brake thermal efficiency and volumetric efficiency are ,

Brake power =

Specific fuel consumption =

Brake thermal efficiency =

Volumetric efficiency =

Graphs to be plotted:

1) SFC v/s BP
2) η_{bth} v/s BP
3) η_{mech} v/s BP
4) η_{vol} v/s BP

MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS)

HEAT BALANCE TEST ON DIESEL ENGINE

AIM:

To conduct heat balance test on single cylinder four stroke diesel engine and to draw performance curves.

APPARATUS:

a. 4 Stroke Single Cylinder Diesel engine
b. Stop watch

SPECIFICATIONS:

a. Make – Kirloskar
b. Bore (D) – 0.080 m
c. Stroke (L) – 0.110 m
d. Speed (N) – 1500 rpm
e. Max. B.P – 5 H.P
f. Loading radius – 0.158 m

THEORY:

The engine is supplied with certain quantity of heat energy in the form of fuel. Only a part of this energy is converted into useful mechanical work, which is available at the engine crank shaft and rest is wasted in engine jacket cooling water, exhaust gases and in overcoming the friction. The non-useful energy levelling the system should be as small as possible in order to maximize the rated power. If the purpose of energy balance to trace the energy distribution i.e. to determine how the input energy is distributed where the energy leaves and how much it during a test is revealed that at certain loading condition a certain form of energy loss in excessive a careful examination of that form is needed in order to have the better performance of the engine. A statement of the heat supplied, useful energy available and losses is called the heat balance sheet.

PROCEDURE:

1. Note down the engine specification and ambient temperature
2. Give the necessary electrical connections to the panel.
3. Check the lubricating oil level in the engine.
4. Check the fuel level in the tank.
5. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 60 Lph & 40 Lph respectively.
6. Release the load if any on the dynamometer.
7. Open the three-way cock so that fuel flows to the engine.
8. Start the engine by cranking.
9. Allow to attain the steady state.
10. * Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
11. Note the following readings for particular Load condition,
    i. Engine Speed
    ii. Initial and Final reading of the fuel w.r.t 60 sec.
    iii. Rotameter reading.
    iv. Manometer readings, in cms of water &
    v. Temperatures at different locations.
12. Repeat the experiment for different loads and note down the above readings.

13. After the completion release the load and then switch of the engine.
14. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied			Air flow rate (mm of WC)	Fuel reading		
		F1	F2	F= (F1~F2)	H	IR	FR	TIME

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate (LPM1)	Calorimeter water flowrate (LPM2)

CALCULATIONS:

Heat Balance Sheet Calculations IN SECONDS basis:

Mass of fuel consumed, mf

$$m_f = \frac{(IR - FR)}{(t*1000)} \quad kg/sec$$

Where,

IR & FR are intial and final reading from the indicator

t is time taken in seconds

1. Heat Input --- A

$$A = m_f CV_f \quad kW$$

CV_f = Calorific Value of Diesel = 44631.96 KJ/Kg

2. Heat to BP --- B

$$BP = \frac{2 \pi N T}{60000} \quad kW$$

Where,

N is speed in rpm

T =Torque = (F1 ~ F2) x r x 9.81 N-m

r = 0.158m

3. Heat to cooling water --- C

$$C = \{m_{we} C_{pw} (T_{ewo} - T_{ewi})\} \quad kW$$

Where,

m_{wc} = Mass of the water to exchange heat from engine head in kg/s
= LPM1/60

C_{pw} = Specific heat of water = 4.18kJ/kg

T_{Ewi} = Water inlet temperature to Engine Head, °C T1

T_{Ewo} = Water outlet temperature from Engine Cooling , °C T3

1-5

T_{eic} = Exhaust Gas inlet to Calorimeter, °C

T_{ecc} = Exhaust Gas outlet from Calorimeter, °C

4. Heat to exhaust gases --- D

$$D = \frac{\{m_{wg} C_{pw} (T_{ewo} - T_{ewi})\} * (T_{eic} - T_{eoc})\}}{(T_{eie} - T_1)} \quad kW$$

Where,

m_w = Mass of the water to exchange heat from calorimeter in kg/s LPM2/60

C_{pg} = Specific heat of exhaust gases = 1. 005 kJ/kg.

C_{pw} = Specific heat of water = 4.18kJ/kg

T_{ewi} = Water inlet temperature to Calorimeter, °C 2

T_{ewo} = Water outlet temperature from Calorimeter, °C 4

T_{eic} = Exhaust Gas inlet to Calorimeter, °C 5

T_{eoc} = Exhaust Gas outlet from Calorimeter, °C 6

T_1 = Ambient Temperature

5. Heat Unaccounted

E = A – (B+C+D) kW

HEAT BALANCE SHEET:

Sl. No.	Particulars	Heat Content (kW)	%
1	Heat Input – A		100
2	Heat to BP – B		B/A =
3	Heat to Cooling Water – C		C/A =
4	Heat to Exhaust Gases – D		D/A =
5	Heat Unaccounted – E		E/A =

PRECAUTIONS:

1. Do not start or stop the engine
2. Do not run the engine without the supply of water.
3. After starting the engine, remove the handle carefully fron the shaft
4. Take the time carefully for dropping the speed

Result: The heat balance test has been conducted on four stroke single cylinder diesel engine

MALLAREDDY ENGINEERING COLLEGE (AUTONOMOUS)
THERMAL ENGINEERING LAB
MORSETEST

Aim: To conduct Morse test on Four cylinder four stroke engine and to calculate Indicated power and Brake power.

Apparatus:

a) Four cylinder four stroke petrol engine
b) Hydraulic dynamometer.

Specifications:

Make	: Isuzu
Bore (D)	: 82 mm
Stroke (L)	: 84 mm
Capacity	: 10 HP

Theory: The Indicated power and the Mechanical efficiency of a multi cylinder engine is found out in a very short time by this test.

During the test the engine is run at a constant speed and at same throttle opening. First the Brake power of the engine with all cylinders operative is measured by means of dynamometer. Next the brake power of the engine is measured with each cylinder rendered inoperative one by one by shorting the spark plug in case of petrol engine or cutting off the fuel supply in case of diesel engine.

When any cylinder is rendered inoperative, the speed abruptly goes down. Before taking any reading the initial speed must be restored by adjusting the load. It is assumed that the friction power of the inoperative cylinder remains the same as it when the cylinder was operative.

Procedure:

1. Start the engine and set to one particular speed and note down the readings and calculate the Brake power of the engine for the particular load and speed.
2. Cut-off the 1^{st} cylinder, now the speed reduces, so set the speed to the before value by releasing the load and subtract the previous value to get the IP of 1^{st} cylinder.
3. Now repeat the step 2 for other cylinders.

Observation:

S.No.	Speed	Initial Load	Final load after cylinder cut-off			
			1^{st} cylinder	2^{nd} cylinder	3^{rd} cylinder	4^{th} cylinder

Calculation:

1. Brake power, BP

$$BP = \frac{(W \times N \times 0.8)}{2000} \quad KW$$

Where W = Load carried by the dynamometer
= Load indicator reading in Kg
N = Speed of the engine in RPM

2. Indicated power, IP

IP = IP1 + IP2 + IP3 + IP4

Where,
IP! = BP – BP1
IP2 = BP - BP2
IP3 = BP – BP3
IP4 = BP – BP4

BP1, BP2, BP3 and BP4 are calculated for each cylinder cut – off.

Precautions:

1. Make sure that water flow is there in the dynamometer and in the engine
2. Make sure that the lever is disengaged while starting the engine.
3. Apply the load with hydraulic dynamometer carefully.

Result: The Morse test is conducted on a Four stroke four cylinder petrol engine

Indicated power =

Brake power =

MALLAREDDY ENGINEERING COLLEGE (AUTONOMOUS)
THERMAL ENGINEERING LAB
TWO STAGE RECIPROCATING AIR COMPRESSOR

Aim: To conduct air compressor test on a two stage reciprocating air compressor and to calculate volumetric efficiency, adiabatic efficiency and isothermal efficiency at different delivery pressures.

Apparatus:

a) Two stage reciprocating air compressor
b) Stop watch

Introduction:

A compressor is device, which sucks in air at atmospheric pressure and increases its pressure by compressing. If the air is compressed in a single cylinder it is called single stage compressor and if the air is compressed in two or more cylinders it is called multistage compressor.

In a two stage compressor the air is sucked from atmosphere and compressed in the first cylinder called low pressure cylinder. The compressed air is then passed through an inter cooler where its temperature is reduced. The air is then passed into the second cylinder where it is further compressed. The air further goes to the air reservoir where it is stored.

Procedure:

1) Check the necessary electrical connections and also for direction of the motor.
2) Check the lubricating oil level in the compressor.
3) Start the compressor by switching the motor starter.
4) The slow increase of the pressure inside the air reservoir is observed.
5) Maintain the required pressure by slowly operating the discharge valve.
6) Now note down the following readings in respective units
   a) Speed of the compressor
   b) Differential head in mm of water column.
   c) Pressure after 1^{st} stage,
   d) Pressure after 2^{nd} stage.
   e) Temperatures at different points.
   f) Energy meter reading.
7) Repeat the experiment for different delivery pressures.
8) Once the set of readings are taken switch off the compressor.

9) The air stored in the tank is discharged. Be careful while doing so, because the compressed air passing through the small area also acts as an air jet which may damage you and your surroundings.
10) Repeat the above two steps after every experiment.

Observations:

S.No.	Compressor speed, N rpm	Pressure after 1st stage P_1 kgf/cm^2	Delivery pressure P_2 kgf/cm^2	Time for 5 revolutions of energy meter 'T' sec	Air flow rate in mm of water column H

S.No.	Temperatures ^0c			
	T_1	T_2	T_3	T_4

Calculations:

1) Air head causing flow, H_a

$$H_a = (Hw \times \rho_w) / \rho_a$$

Where

Hw = water column reading in m of water

ρ_w = density of water = 1000 kg/m^3

ρ_a = density of the air = 1.293 kg/m^3

2) Actual volume of air compressed at RTP, Q_a

$$Q_a = C_d \times A \times \sqrt{2gHa} \quad m^3/s$$

Where,

H_a	=	Head causing the flow in m of air
C_d	=	Coefficient of discharge of orifice = 0.62
A	=	Area of orifice = $(\Pi d^2)/4$ m^2
D	=	Diameter of the orifice = 0.012m

3) Theoretical volume of compressed air

$$Q_{th} = (\Pi D^2 LN) / 240 \quad m^3/s$$

Where

D	=	Diameter of the LP cylinder = 0.08 m
L	=	Stroke length = 0.085 m
N	=	Speed of the compressor in RPM

4) Input power, IP

$$IP = (3600 \times n \times \eta_T) / (K \times T)$$

Where,

n	=	No. of revolutions of energy meter = 5
K	=	Energy meter constant = 1600 revs/ Kw-hr
T	=	Time for 5 revolutions of energy meter in seconds
η_T	=	Efficiency of belt transmission = 75% = 0.75

5) Pressure ratio, r

$$r = (P_2+P_{atm}) / P_{atm}$$

Where,

P_2	=	Delivery pressure in bar
P_{atm}	=	Atmospheric pressure = 1.01325 bar

6) Volumetric efficiency, η_{vol}

$$\eta_{vol} = (Q_a \times 100) / Q_{th}$$

7) Adiabatic efficiency $\eta_{adiabatic}$ = [(Adiabatic work)/Actual work)]X100

Adiabatic work = $(\gamma/\gamma-1)mR[(T_2-T_1)+(T_4-T_3)]$

Where m = mass flow rate of air in kg/sec = P_1V_1/RT_1

P_1 = Inlet pressure in N/m^2
T_1 = Inlet temperature of air in^0K

8) Isothermal Efficiency η_{iso} =$\{ \ln(P2/ P_1)/[(n/(n-1))(P2/ P_1)^{(n-1/n)} -1)]\}$X100

n = 1.4

P2 = Delivery pressure

P1 = Pressure after first stage

Tabulations

S.No.	Head of air H_a, mm of WC	Actual volume of air compressed $Q_a\ m^3/s$	Theoritical volume of air compressed $Q_{th}\ m^3/s$	Pressure ratio R	Indicated power KW	Volumetric efficiency η_{vol}

S.N0.	Indicated power	Adiabatic work	Adiabatic efficiency	Isothermal Efficiency

Precautions: 1) Do not run the compressor when supply voltgage<30V
2) Remove the stored air from the compressor
3) Do not forget to give electrical earth and neutral connections correctly.

Graph: Delivery pressure VS η_{vol},

Delivery pressure VS $\eta_{adiabatic}$

Delivery pressure VS $\eta_{isothermal}$

Result: The volumetric efficiency of two stage reciprocating air compressor is
The adiabatic efficiency of two stage reciprocating air compressor is
The isothermal efficiency of two stage reciprocating air compressor is

STUDY OF BOILERS

Aim: To study the details and operation of boilers.

Theory: Boiler is a device in which steam is generated from the water by the application of heat.

The details of the boiler are listed below:

Shell: The shell of the boiler is the main container usually of cylindrical shape, which contains water and steam.

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.

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.

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.

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 though steam separators, in the case of large boilers.

Fittings or Mountings: 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.

Accessories: Some equipment like economizer, air pre-heater and superheater are attached to the boiler to improve over all efficiency. The economizer and air pre-heater are used to extract maximum heat from of the flue gases and super heater is used to increase the temperature of steam above saturation temperature.

LANCASHIRE BOILER

It is a stationary fire tube, internally fired, horizontal, natural circulation boiler. This is 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 m in diameter and its length varies from 8 m to 10 m. It has two large internal fire tubes having 80 cm to 100 cm in

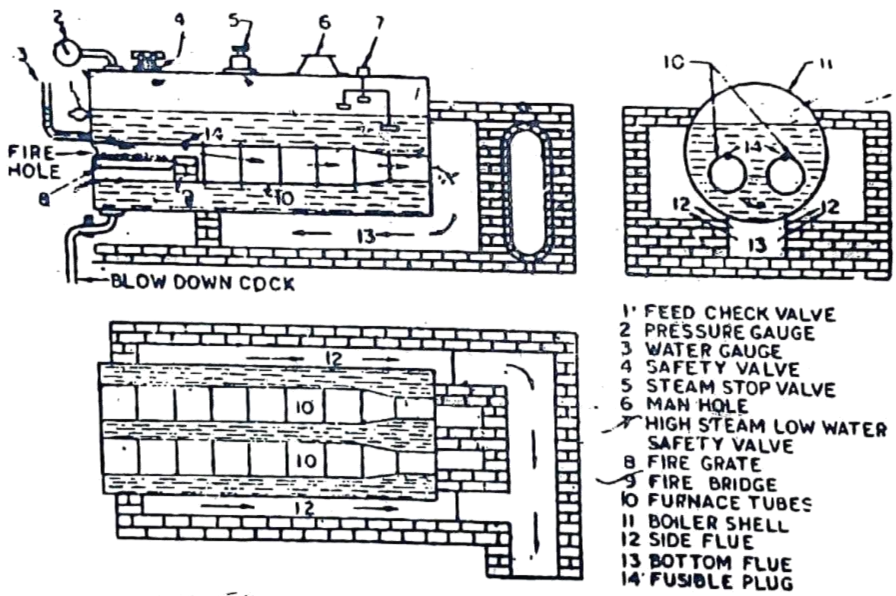


Figure 4 ; Lancashire boiler and its brick-work setting.

which the grate is situated. The boiler is set in a brick work forming external flue so that external part of the shell forms part of heating surface.

The main feature of Lancashire boiler with its brick work shown in figure1. The boiler consists of a cylindrical shell and two big surface tubes passing right through this, one bottom and two side flues arc formed by the brick setting. Both the flue gases which carry hot gases lay below the water level as shown in the figure1.

The seats are providing at the front end of the grates through the fire tubes. A low fire brick bridge is provided at the end of the grate, to prevent the flow of coal and ash particles in to interior of the furnace tubes.

The hot gases leaving the grate and pass up to the back end of the tubes and then in the downward direction. They move through the bottom flue to the front of the boiler where they are divided into two and pass to the side flues. Then they move along the two side flues and come to the chimney.

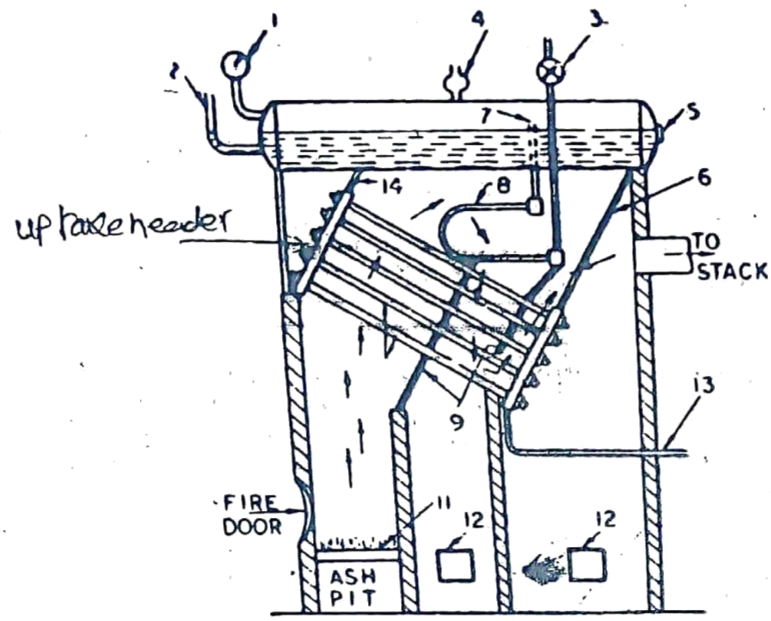
Dampers in the form of sliding doors are provided at the end of side flues to control the flow of gases, this regulates the combustion rate as well as steam generation rate. These dampers are operated by chains passing over a pully at the front of the boiler. The pressure gauge and water level indicator are provided at the front where as steam stop valve, safety valve, low water and high steam safety valve and manhole are provided on the top of the shell. The blow off cock is set beneath the front of the boiler shell for the removal of sediments and mud.

The outstanding features of this boiler are listed below.

a) Its heating surface 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 this boiler due to the large reserve capacity.
d) Super heater and economizer can be easily incorporated into the system; therefore, over all efficiency of the boiler can be considerably large (80-85%).

BABCOCK AND WILCOX BOILER

This is a horizontal, externally fired, water tube, natural circulation type of stationary boiler. It consists of a welded steel high pressure drum mounted at the top. From each end of the drum connections are made with the uptake header and a down take header. The headers are joined to each other by a large number of water tubes which are kept inclined at an angle of about 15^0 to the horizontal. The water tubes are straight, solid drawn steel tubes about 10 cm in diameter and are expanded into the bored boles of the headers. Due to serpentine (sinusoidal) form of headers, the tubes are staggered and this exposes the complete heating surface to flue gases. The heating surface of the unit forms the outer surface of the tubes and half of the cylindrical surface of the water drum which is exposed to flue gases.



1	PRESSURE GAUGE	2	WATER GAUGK
3	NON RETURN VALVE	4	SAFETY VALVE
5	MANHOLE	6	DOWN COMER
7	ANTIPRIMING PIPE	8	SUPER HEATER
9	BAFFLES	10	WATER TUBES
11	FIRE GRATE	12	CLEANOUT DOORS
13	BLOWOFF PIPE	14	RISER

Fig : Babcock and Wilcox Boiler,

The furnace is arranged below the uptake header. The coal is fed to the chain gate stoker through the fire door. The chain speed is so adjusted that by the time coal reaches the other end of the grate, its combustion has been complete. Baffles are provided across the water tubes to act as deflectors to the flue gases and to provide them with gas passes. The hot gases rise upwards, go down and then rise up again and finally escape to chimney through the smoke chamber. For maintaining equal gas velocity throughout its travel, the volumetric size of these passes tends to decrease from furnace to exit. If cross-sectional area of passes is kept equal, then cooled and consequently contracted gases would tend to go slow. The slow moving gases are then likely to form an insulating film around the tube surface and consequently hamper the heat transfer rate.

The circulation of water is maintained by convective currents. The hottest water and steam rise from the tubes to the uptake header and then through riser enter the boiler drum. The steam vapors escape though water to the upper half of the drum. The cold water flows from the drum to the rear header and thus the cycle is completed.

For getting superheated steam, the steam accumulated in the steam space is sent to the superheater tubes which are arranged above the water tubes. The superheated steam is finally supplied to the user through a steam pipe and steam stop valve. When the steam is being raised from a cold boiler, the superheater is filled with water to the drum water level. The superheater remains flooded until the steam reaches the working pressure. The superheater is then drained and steam is fed to it for superheating purposes.

At the bottom of the rear header is a mud box. The foreign matter held in suspension in water gets collected in it and can be blown off from time to time. The access to the interior of the boiler is provided by the doors. This is necessary to clean the tubes and remove the soot. The draught is regulated by a damper which is provided in the back chamber.

Vents are also provided for other mountings and accessories.

Evaporative capacity for such boilers ranges from 20,000 to 40,000 kg/hour and operating pressures of 11.5 to 17.5 kgf/cm^2 are quite common. The inspection of the boiler can be carried even when the boiler is in operation; draught loss is minimum and replacement of the defective tubes can be made readily., Further since the boiler unit (except furnace) is suspended, any expansion or contraction of the boiler has no harmful effect on the masonry work enclosing the furnace and the boiler.

24

Assembly and Disassembly of Engine

Aim: To identify the Parts of the engine and know the procedure for Disassembly and assembly of an Engine

a) Remove and Replace Cylinder Head – Block assembly only:
   i) Remove the spark plugs and place them in order in the spark-plugs rack.
   ii) Remove the intake and exhaust manifolds
   iii) Remove the rocker covers, rocker arm, and shaft assembly or rocker arms frm the pivot studs.
   iv) Remove the push- rod covers and push rods, placing the rods in the proper order in a push rod rack.
   v) Remove cylinder head bolts or nuts.
   vi) Lift off the cylinder head. Do not pry between the cylinder head and block, as parts could be damaged. Remove and discard the used gasket.
   vii) Clean the cylinder head and cylinder block gasket surfaces,
   viii) Place a little oil around the piston in each cylinder.
   ix) Make sure that the new gasket is in proper alignment and place it over the cylinder head studs or guide pins which have been temporarily installed in the cylinder head bolt holes.
   x) Install the cylinder head bolts or nuts finger tight. Using a torque wrench, tighten the nuts or bolts in several steps to proper tightening sequence.
   xi) Install the push rods, making sure that they are properly seated in the valve lifters: install rocker arms and shaft assembly or rocker arms on pivot studs.
   xii) Tighten the rocker arm shaft, attaching bolts to torque specifications.
   xiii) Adjust valve clearance.

b) Remove and replace valves:
   i) Remove the cylinder head as outlined in the preceding article
   ii) Using the correct valve spring compressor, compress the valve spring and remove the valve spring lock or keeper.
   iii) Release the valve - spring compressor. and remove the valve spring and retaining washer.
   iv) On I head engines remove the valve from the underside of the head.
   v) Place the valve you have removed in the valve rack.
   vi) Repeat steps 2 to 5 for the remaining valves.
   vii) Identify all the parts.
   viii) Reassemble all the valves, springs, retaining washers, and retaining locks or keepers.
   ix) Have the instructor inspect your work.

✓ c) Adjust Valves on Engines with Solid Lifters.

Procedure:

Start the engine and allow it to run at a fast idle until it reaches its normal operating temperature. After the engine reaches normal operating temperature, run it at a slow idle and then proceed with the checking and adjusting of the valves. You may set valves with the engine stopped by turning the crankshaft until the valve lifter is on the low point of the cam. Check and adjust the exhaust valves first.

"Assembly and Disassembly of Engine"

d

i. Insert a feeler gauge of the proper thickness between the valve stem and the end of the rocker arm. If the gauge will not slide in, use a screwdriver to prevent the adjusting screw from turning and, with a wrench, loosen the lock nut. Back out the screw sufficiently to allow the gauge to slip in between the valve stem and the end of the rocker arm.

ii. To adjust the valve clearance, tighten the screw (the lock nut must be loosened) until the feeler gauge is gripped firmly between the valve stem and the rocker arm. Then loosen the screw until the feeler gauge can be moved in and out with a slight drag. Hold the screw in this position and tighten the lock nut. Then, recheck the clearance to make sure that tightening the lock nut has not changed the adjustment.

iii. Adjust the remaining valves in the same manner.

iv. Have the instructor inspect your work..

e)Adjust Hydraulic valve Lifters.

Hydraulic valve lifters must not be adjusted while in service. After the lifters have been cleaned, it is necessary to make a basic initial adjustment.

Procedure:

i) Crank the engine until the valve lifter is on the top point of the cam.
ii) Back off the adjusting nut (rocker – arm stud nut) until there is play in the valve push rod.
iii) Tighten the adjusting nut to just barely remove the clearance between the push rod and rocker arm. This is accomplished by rocking the push rod as the nut is tightened. When the rod does not move readily in relation to the rocker arm, the clearance has been eliminated.
iv) Tighten the adjusting nut an additional three – quarters of a turn to place the hydraulic lifter plunger in the centre of its travel.
v) Have the instructor inspect your work.

f) Remove and Replace Oil Pan -- Block Assembly Only.

Procedure:
i) Remove the drain plug and allow the engine oil to drain from the engine.
ii) Remove the screws holding the pan to the block. To prevent the pan from dropping, steady it before taking out the last two screws.
iii) If the pan sticks, pry it loose. Proceed carefully to avoid distorting the pan.
iv) If the pan does not clear the crankshaft, turn the crankshaft a few degrees, so that the 'counterweights' move out of the way.
v) Clean the pan by washing it with cleaning solvent. and remove all traces of gasket materials from the pan and block.
vi) Have the instructor inspect your work.
vii) Coat the new gasket (or gaskets) with grease and place it in position, aligning the gasket with the pan bolt holes.
viii) Lift the pan into position and attach it with two screws, one on each side. Examine the gaskets to make sure that they are still in alignment. Install the remainder of the screws, tightening them uniformly so that the gaskets are compressed evenly.
ix) Replace the oil plug and add the proper grade and amount of engine oil.
x) Have the instructor inspect your work.

g) Remove and Replace Piston and Connecting Rod Assembly.
Procedure:

i) Remove cylinder head as outlined in practical assignment b.
ii) Remove the oil pan as outlined in practical assignment f.
iii) Examine the rod and cap for cylinder number identifying marks. These marks assure replacement of the rod and piston assembly in the cylinder from which it was removed. The marks are usually on the camshaft side of the rod and the cap.
iv) If the rod and cap are not marked, stamp numbers on them. This should be done before the assembly is removed, to avoid distorting the cap and the rod. Likewise, the piston should have an identifying mark.
v) Remove the connecting -- rod nuts and caps from one connecting rod.
vi) Slide the rod and piston assembly up in the cylinder and away from the crankshaft.
vii) Push the assembly out through the top of the cylinder and remove it. Replace the cap on the connecting rod. Tighten the nuts(finger tight only).
viii) Repeat for the other pistons. It will be necessary to turn the crankshaft in order to remove the remaining pistons.
ix) Have the instructor inspect your work.
x) To replace a rod and piston assembly, first check the markings to make sure that they match and that the assembly is going back into the same cylinder from which it was removed. Take off the cap nuts and the cap.
xi) Position the piston rings so that their gaps are uniformly spaced around the piston.
xii) Put the piston -- ring compressor in place so that the rings are compressor into their grooves.
xiii) After installing the rod bolt guide sleeves, if specified, place the assembly on the cylinder block, with the rod in the cylinder. Make sure that the rod markings are on the correct side.
xiv) Push the piston down into the cylinder. It should slip down without a great deal of used to tap the piston into place. If the piston does not go down easily, remove the assembly to see what is holding the piston up. Do not use heavy pressure or hard blows.
xv) Lubricate the crankpin and pull the rod assembly down until it rests in a normal position on the crankpin. Remove the rod bolt guide sleeves (where used) and replace the cap and nuts, tightening them to torque specifications.
xvi) Repeat for the remaining connecting – rod assemblies.
xvii) Install new cotter pins or palnuts on the connecting – rod bolts.
xviii) Have the instructor inspect your work.

6-1

MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS)

PERFORMANCE TEST OF 2-STROKE PETROL ENGINE

AIM:

a. To conduct performance test on two stroke petrol engine.
b. To calculate brake power, specific fuel consumption, brake thermal efficiency and volumetric efficiency

APPARATUS:

a. 2 Stroke Petrol engine
b. Load bank
c. DC Motors
d. Stop watch

SPECIFICATIONS:

a. Make – Bajaj
b. Bore (D) – 0.057 m
c. Stroke (L) – 0.057 m
d. Speed (N) – 2800 rpm
e. B.P – 2.5H.P

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Release the load, if any, on the dynamometer
5. Open the fuel valve so that fuel flows to the engine.
6. Set the accelerator to the minimum condition
7. Start the engine by cranking (KICK START)
8. Allow to attain the steady state.

9. Load the engine by switching on the load controller switches provided. (Each loading is incremental of 0.5 kW)
10. Note the following readings for particular Load condition,
    a. Engine Speed
    b. Initial and Final reading of the fuel for30 sec.
    c. Air flow rate or Manometer reading
    d. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings from the digital data logger.
12. After the completion release the load (while doing so release the accelerator) and then switch of the engine by pressing the ignition cut-off switch and then turn off the panel.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied	Air flow rate (mm of WC)	Time for 10cc of Fuel collected, t (sec)			Voltage	Current
		'F' Kw	h_w	IR	FR	TIME	V	I

Sl. No.	Temperature,	
	T1	T2

CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{(IR - FR)}{(t * 1000)} \quad kg/sec$$

Where,

IR & FR are intial and final reading from the indicator

t is time taken in seconds

2. Heat Input, HI

HI = m_f xCalorific Value of Fuel kW

Where,

Calorific Value of Petrol = 43,200 KJ/Kg

3. Output or Brake Power, BP

$$BP = \frac{V \, x \, I}{\eta_m \, x \, 1000} \quad kW$$

Where,

V=Voltage in Volts

I =Current in Amps

η_m = Motor efficiency = 0.8

4. Specific Fuel Consumption, SFC

$$SFC = \frac{(3600 * m_f)}{BP} \quad Kg/kW - hr$$

5. Brake Thermal Efficiency, η_{bth}%

$$\eta_{bth} = \frac{(BP * 100)}{(m_f * C_v)} \quad \%$$

6. Calculation of head of air, H_a

$$h_a = \frac{h \, x \, \rho_w}{\rho_a} \; m \, of \, air$$

Where,

ρ_w = density of water = 1000 Kg/m3

ρ_a = density of air = 1.2 Kg/m3 @ R.T.P h= head in water column in 'm' of water

7. Volumetric efficiency, ηvol%

$$\eta_{vol} = \frac{Q_a}{Q_{th}} x\ 100\ \ \%$$

where,

Qa = Actual volume of air taken =

$$Q_a = C_d\ a \sqrt{2gh_a}\, m^3/s$$

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $a = \frac{\pi d^2}{4} m^2$ Where d = 0.020m

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Q_{th} = \frac{A\,L\,N\,n}{n_c\ 60} m^3/s$$

Where,

A = Area of the Bore = $A = \frac{\pi D^2}{4} m^2$

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N is speed of the engine in rpm.

n = no of cylinders

nc = no. of revolution of the flywheel to complete the cycle

CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{(IR - FR)}{(t * 1000)} \quad kg/sec$$

Where,

IR & FR are intial and final reading from the indicator

t is time taken in seconds

2. Heat Input, HI

HI = m_f xCalorific Value of Fuel kW

Where,

Calorific Value of Petrol = 43,200 KJ/Kg

3. Output or Brake Power, BP

$$BP = \frac{V \, x \, I}{\eta_m \, x \, 1000} \quad kW$$

Where,

V=Voltage in Volts

I =Current in Amps

η_m = Motor efficiency = 0.8

4. Specific Fuel Consumption, SFC

$$SFC = \frac{(3600 * m_f)}{BP} \quad Kg/kW - hr$$

5. Brake Thermal Efficiency, η_{bth}%

$$\eta_{bth} = \frac{(BP * 100)}{(m_f * C_v)} \quad \%$$

6. Calculation of head of air, H_a

$$h_a = \frac{h \times \rho_w}{\rho_a} \quad m \, of \, air$$

Where,

ρ_w = density of water = 1000 Kg/m3

ρ_a = density of air = 1.2 Kg/m3 @ R.T.P

TABULATION:

Sl.	Input Power (Kw)	Brake power (Kw)	SFC (Kg/Kw-hr)	Brake Thermal Efficiency	Volumetric efficiency
1					
2					
3					
4					
5					

PRECAUTIONS:

1. Do not start or stop the engine
2. Make sure that fuel level is above minimum level
3. Apply the load carefully on the engine
4. Take the time carefully for dropping the speed

RESULT: The performance test on single cylinder Two stroke petrol engine is conducted and the brake power, specific fuel consumption, brake thermal efficiency and volumetric efficiency are

Brake power =

Specific fuel consumption =

Brake thermal efficiency =

Volumetric efficiency =

Graphs to be plotted:

1) SFC v/s BP
2) η_{bth} v/s BP
3) η_{vol} v/s BP

MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS)

OPTIMUM COOLING TEMPERATURE TEST OF IC ENGINE

AIM:

To conduct Optimum coolingwater temperature test on the IC engine at agiven load.

APPARATUS:

a. 4 Stroke Single Cylinder Diesel engine
b. Stop watch

SPECIFICATIONS:

a. Make – Kirloskar
b. Bore (D) – 0.080 m
c. Stroke (L) – 0.110 m
d. Speed (N) – 1500 rpm
e. Max. B.P – 5 H.P
f. Loading radius – 0.158 m

INTRODUCTION:

During the process of converting thermal energy to mechanical energy, high temperatures are produced in the cylinder of the engine as a result of the combustion process.

A large portion of the heat from the gases of combustion is transferred to the cylinder head and walls, pistons and valves. Unless this excess heat is carried away and these parts are adequately cooled, the engine will be damaged. A cooling system must be provided not only to prevent damage to vital parts of the engine, but the temperature of these components must be maintained within certain limits in order to obtain maximum performance from the engine.

In this system water is used for cooling and made to circulate through the jacket provided around the cylinder, cylinder-head, valve ports and seats where it extracts most of the heat.

Optimum cooling water temperature test is conducted in order to verify the performance of the engine at given load for different cooling water flow rates.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter.Adjust the flow rates to 60 cc/sec .
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow the engine to run for few minutes at no load.
9. Load the engine to half full load and maintain constant speed.
10. Wait for few minutes till the engine jacket water temperature becomes steady.
11. Note the following readings for half Load condition,
    i. Engine Speed
    ii. Initial and Final reading of the fuel w.r.t 60 sec.
    iii. Rotameter reading.
    iv. Engine jacket water temperature –Inlet & Outlet
12. Repeat the experiment for different rates of cooling water circulationto the engine (50,40,30& 20 cc/sec), keeping the load constant and note down the above readings.

13. After the completion, release the load and then switch of the engine.
14. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied (Kg)	Engine jacket rotameter reading (cc/sec)	Fuel consumption for 60 sec		Engine jacket water temperature (^oC)	
		F1	H	IR	FR	Inlet	Outlet
1			60				
2			50				
3			40				
4			30				
5			20				

CALCULATIONS:

1. Mass of fuel consumed, mf

$$m_f = \frac{(IR - FR)}{(t * 1000)} \quad kg/sec$$

Where,

IR & FR are initial and final reading from the indicator

t is time taken in seconds = 60 sec

2. Output or Brake Power, BP

$$BP = \frac{2\,\pi\,N\,T}{60000} \quad kW$$

Where,

N is speed in rpm

T =Torque = (F1) x r x 9.81 N-m

r = 0.158m

3. Specific Fuel Consumption, SFC

$$SFC = \frac{(3600 * m_f)}{BP} \quad Kg/kW - hr$$

RESULT:

Optimum cooling water temperature (from graph):

Graph to be plotted:

1) SFC v/s Engine jacket cooling water temperature

VARIABLE COMPRESSION RATIO COMPUTERIZED 4 STROKE SINGLE CYLINDER ENGINE TEST RIG

Aim: To conduct a performance test on the engine by changing the cylinder heads for different compression ratios to determine the following

1) Brake Power,
2) Indicated Power
3) Frictional Power
4) BSFC
5) Mechanical Efficiency
6) Brake Thermal Efficiency
7) Indicated Thermal Efficiency
8) Volumetric Efficiency
9) Graphs.

Computer (software) operating system:

1. Initially, with no load on engine, it is started by hand cranking
2. Run the software.
3. Press the button for "Get Pressure" to get the Mean effective Pressure, and note that reading
4. Fill the burette by petrol, on the fuel supply line and measure time required for 50 cc.
5. On computer, press the "Start Data Acquisition" button to get the various data.
6. Manually note down the various readings such as Temperatures, water flow rate, air pressure, speed
7. Now On computer save the each reading.
8. By increasing the torque on the engine again take readings.
9. Maximum 5 readings will have to be taken in the torque range of 0-5 N-m.
10. Calculate brake power, indicated power, various efficiencies and prepare a heat balance sheet.

Observation Table:

Sr. No.	Temperature				Air Pressure	Load	Speed	Water flow rate	Time for 50 cm^3 of fuel	m.e.f.
	T_1	T_2	T_3	T_4						P_m
	°c	°c	°c	°c	mm	kg	Rpm	lit/hr	Sec	
1.										

Calculations:

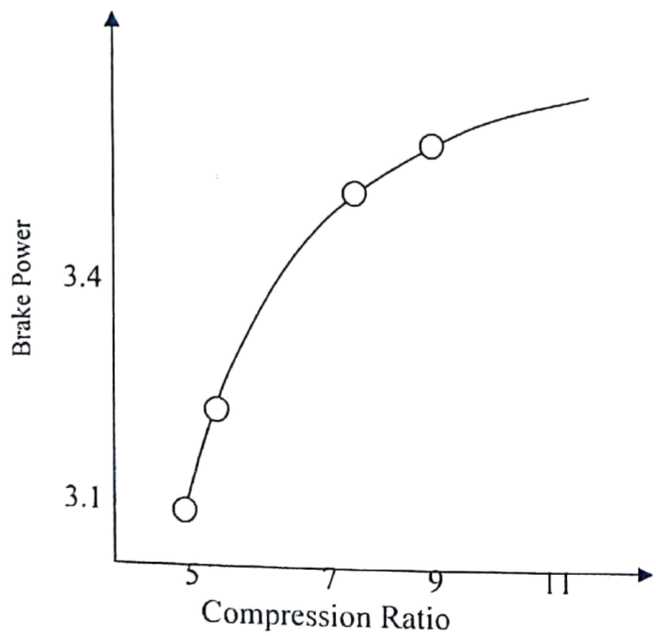
1. Torque T = 9.81 x Load x R = ____ N-m, where R = Length of Torque arm = 0.15 m
2. Brake Power, B.P. = $\dfrac{2\pi NT}{60\times1000}$ kW
3. Indicated Power, IP = $\dfrac{P_m\cdot 9.81\times10^4\cdot L\cdot A\cdot N/2}{60\times1000}$ KW
4. Frictional Power, FP = IP – BP = ___ KW
5. Fuel Consumption, M_f = $\dfrac{V}{10^6}\times\dfrac{1}{t}\times\rho_f$ Where, v = 50 cm^3, t =__ s, ρ_f=_ kg/m^3
6. Brake Specific Fuel Consumption B.S.F.C.= $\dfrac{m_f}{B.P.}$ kg/kWh
7. Mechanical Efficiency, $\eta_{mech} = \dfrac{B.P.}{I.P.}\times100 =$ ___%
8. Brake Thermal Efficiency η_{Bth} = $\dfrac{B.P.}{m_f\times C.V.}\times100 =$ ___%
9. Indicated Thermal Efficiency, η_{Ith} = $\dfrac{I.P.}{m_f\times C.V.}\times100 =$ ___%
10. Volumetric Efficiency $\eta_{vol} = \dfrac{v_a}{v_s} = \dfrac{Cd_o A_o\sqrt{2gH_a}}{\frac{\pi}{4}d^2L\times\frac{N}{60\times2}\times K} =$ ___%

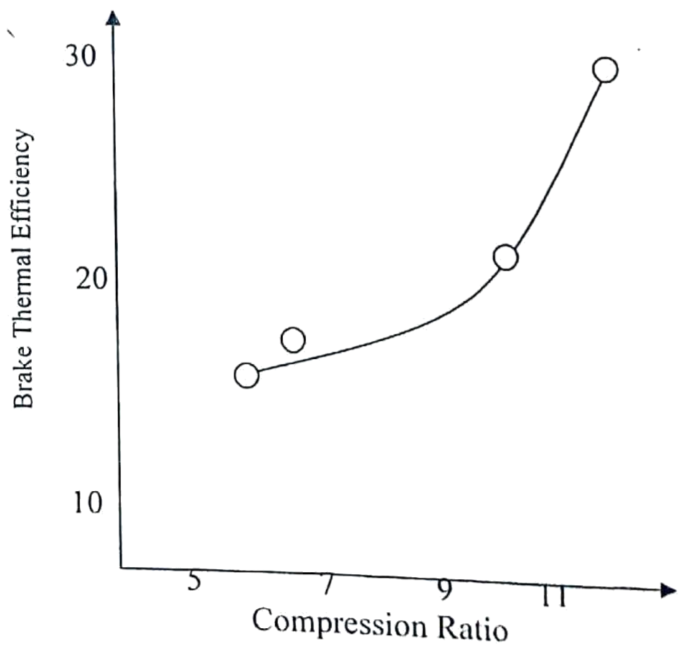
RESULT:

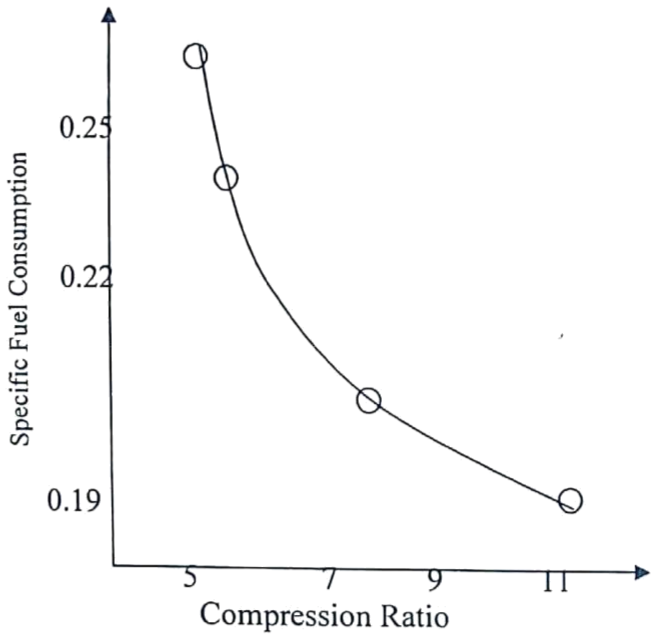
Sr. No.	Load	Brake Power	Indicated Power	Frictional Power	B.S.F.C.	Mechanical Efficiency	Brake Thermal Efficiency	Indicated Thermal Efficiency	Volumetric Efficiency
	W N	B.P. kW	I.P. kW	F. P. kW	kg/kWh	η_{mech} %	η_{bth} %	η_{Ith} %	$\eta_{vol.}$ %
1.									

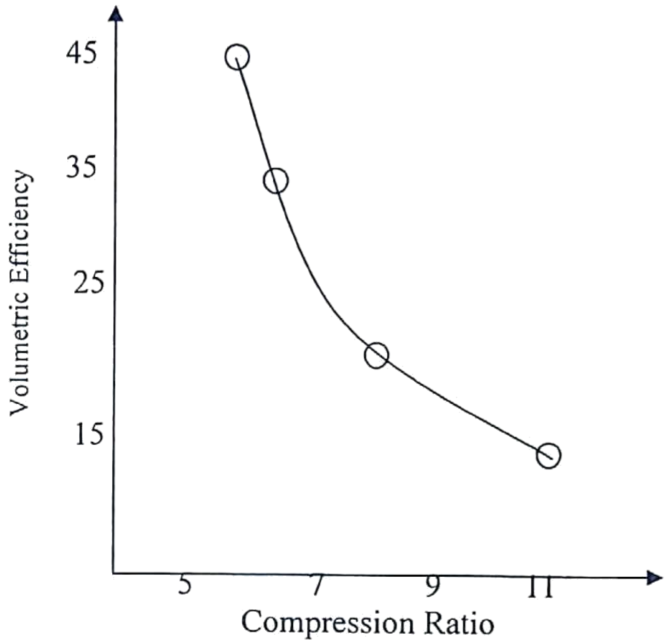
GRAPHS:

1. Compression Ratio Vs. Brake Power
2. Compression Ratio Vs. Brake Thermal Efficiency
3. Compression Ratio Vs. Specific Fuel Consumption
4. Compression Ratio Vs. Volumetric Efficiency






Specific Fuel Consumption
0.25
0.22
0.19
5
7
9
11
Compression Ratio


Volumetric Efficiency
45
35
25
15
5
7
9
11
Compression Ratio

MALLAREDDY ENGINEERING COLLEGE (AUTONOMOUS)

THERMAL ENGINEERING LAB

ECONOMICAL SPEED TEST

AIM: To determine the economical speed of four cylinder four stroke petrol Engine at half of the full load.

APPARATUS: Tachometer, Stopwatch, Petrol engine test rig.

ENGINE SPECIFICATIONS:

Max Horse Power = 10 HP

Speed = 1500 rpm

No of cylinders = 4

THEORY: The economical speed test is conducted to obtain the optimum operating speed of the engine optimum operating speed means it is the speed at which specific fuel consumption is minimum at a constant applied load. Test is conducted at a load of 12.5kg on the engine. The specific fuel consumption at different speeds of 1000 ,1200, 1400, 1600, 1800, 2000rpm , etc is measured. By keeping the load constant. A graph is plotted with engine speed on X-axis and specific fuel consumption on y-axis, from the graph the economical speed of the engine is determined.

PROCEDURE:

1. No load condition is ensured before starting the engine.
2. Fuel oil and lubricating oil level are checked.
3. Engine is started and cooling water supply is ensured.
4. The engine is nun at 1000 rpm by adjusting the load to 12.5 kg. Then the fuel consumption in 60 seconds is noted. The adjustment of the load and speed is to be done carefully by adjustment of accelerator.
5. The above procedure is repeated at speeds of 1000 ,1200, 1400, 1600, 1800, 2000rpm .

GRAPH: A graph is drawn such that BSFC is taken on Y-axis and speed on X-axis. From the graph the economical speed of the engine is found out, where BSFC is minimum

OBDERVATIONS:

S.No.	Speed N RPM	Load W Kg	IR (grams)	FR (grams)	Brake Power (KW)	Fuel Consumption (Kg/hr)	BSFC Kg/Kw-hr

MODEL CALCULATIONS:

1. Brake power = WXN/2000 KW

2. Fuel consumed per hour = (IR-FR)X60/1000 Kg/kr

3. Brake specific fuel consumption = (Fuel consumption)/BP

PRECUTIONS:

1. Make sure that the lever is in disengaged position while starting the engine.
2. Check supply of cooling water for engine and dynamometer.
3. Adjustment of load and speed to be carried carefully.

RESULT:

S.No.	Speed (RPM)	BSFC(Kg/Kw-hr

The economical speed of the four cylinder four stroke petrol engine is

4 – CYLINDER, 4 - STROKE PETROL ENGINE TEST RIG

1. INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

2. DESCRIPTION OF THE APPARATUS:

a. Hydraulic Dynamometer Loading

1. The equipment consists of a Brand new **ISUZU (Ambassador) make Carburetor Version Engine** (Self started) of capacity **30kW at the charsy and 7.5kW at the crankshaft.**

2. The Engine is coupled to a Hydraulic Dynamometer for loading purposes. The coupling is done by a **universal coupling** in a bearing house.

3. Rot meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.

4. Thermocouples are provided at appropriate positions, RPM SENSOR for measuring the sped of the engine, fuel load cell for measuring fuel rate, Differential air flow sensor for measuring the air flow rate, load cell used for loading purpose finally all are connected to the **Digital data logger.**

5. Note down all the values from the digital data logger at different load conditions.

3. EXPERIMENTATION:

i. AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves and compare with standards.

ii. PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 8Lpm & 5Lpm respectively.
5. Allow the water to run through the dynamometer.
6. Release the load if any on the dynamometer.
7. Open the three-way cock so that fuel flows to the engine.
8. Start the engine by Key start.
9. Allow to attain the steady state.
10. Release the clutch so the engine is engaged to dynamometer.
11. Set the speed of the engine. (Do not exceed 2000rpm)
12. *Now slowly load the engine using the loading wheel of the dynamometer.
13. Set the engine speed to before rating.

14. Note the following readings for particular Load condition,
    a. Engine Speed
    b. Initial and Final reading of the fuel w.r.t 30 sec.
    c. Rotameter reading.
    d. Manometer readings, in cms of water &
    e. Temperatures at different locations.
15. Repeat the experiment for different loads and note down the above readings.
16. After the completion release the load and then switch of the engine.
17. Allow the water to flow for few minutes and then turn it off.

* It is to be noted that due to friction heat, load on the engine will be reduced slightly hence required to maintain the load.

iii. PROCEDURE: COMPUTERIZED

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 8Lpm & 5Lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the Computer.
8. Open the Thermal Engineering Software.
9. Dialogue box for "MORSE TEST & PERFORMANCE" will be displayed on the screen
10. Select according and Press "NEXT" button to continue

11. If MORSE TEST is selected, Go to ANNEXURE – 1 for procedure, else if PERFORMANCE is selected continue below.
12. Start the engine by Key start.
13. Allow to attain the steady state.
14. Release the clutch so the engine is engaged to dynamometer.
15. Set the speed of the engine. (Do not exceed 2000rpm)
16. *Now slowly load the engine using the loading wheel of the dynamometer.
17. Set the engine speed to before rating.
18. Now, Press the "FUEL BUTTON" a dialogue box asking to wait for 30secs will appear. Click "OK" to continue.

Note at this stage maintain the load accordingly so there will be no effect on fuel reading.

19. If the fuel reading is not satisfied, repeat Step 15 until satisfied.

Note due to vibration a small variation may occur, you can change the value if needed when you convert to excel after completion of the experiment.

20. Press the **STORE** button to store the values.
21. Repeat **STEP 14 to STEP 20** for different loadings.
22. After the completion release the load and then switch of the engine.
23. Allow the water to flow for few minutes and then turn it off.
24. Press the ***"STOP"*** button to stop the process in the screen but however the mechanical cycle of operation will be running until the ENGINE is switched off.
25. Switch off the ENGINE after completion.

26. Next click on the ***"REPORT"*** button, **select date, time and username** appropriately so the reading taken are displayed.
27. Select ***"PRINT, PDF or EXCEL"*** as per the choice.

* It is to be noted that due to friction heat, load on the engine will be reduced slightly hence required to maintain the load to its original position by continuously operating the Yoke rod.

IMPORTANT:

MORSE TEST done will display the IP only for that particular load and cannot be combined with other loading conditioning.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Air flow rate in mm of WC	Time for 10cc of fuel collected, t sec		
		W, kg	h	IR	FR	TIME

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

iv. CALCULATIONS:

1. Mass of fuel consumed, mf

$$m_f = \frac{(IR - FR)}{(t * 1000)} \quad kg/sec$$

Where,

IR & FR are intial and final reading from the indicator

t is time taken in seconds

2. Heat Input, HI

HI = mf x Calorific Value of Fuel kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. Output or Brake Power, BP

$$BP = \frac{W * N * 0.8}{C} \quad kW$$

Where,

N is speed in rpm

W =Load in Kg

C = Dynamometer constant = 2000

4. Specific Fuel Consumption, SFC

$$SFC = \frac{(3600 * m_f)}{BP} \quad Kg/kW - hr$$

5. Brake Thermal Efficiency, ηbth%

$$\eta_{bth} = \frac{(BP * 100)}{(m_f * C_v)} \quad \%$$

6. Calculation of head of air, H_a

$$h_a = \frac{h \times \rho_w}{\rho_a} \; m \, of \, air$$

Where,

ρ_w = density of water = 1000 Kg/m3

ρ_a = density of air = 1.2 Kg/m3 @ R.T.P

h = head in water column in 'm' of water

7. Volumetric efficiency, η_{vol}%

$$\eta_{vol} = \frac{Q_a}{Q_{th}} \, x \, 100 \;\; \%$$

where,

Qa = Actual volume of air taken =

$$Q_a = C_d \, a \sqrt{2gh_a} \qquad m^3/s$$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $a = \frac{\pi d^2}{4} \quad m^2$ Where d = 0.028m

H_a = head in air column, m of air.

$$Q_{th} = \frac{A \, L \, N \, n}{n_c \, 60} \quad m^3/s$$

Qth = Theoretical volume of air taken

Where,

A = Area of the Bore = $A = \frac{\pi D^2}{4} \quad m^2$

D = Bore diameter of the engine = 0.082m

L = Length of the Stroke = 0.084m

N is speed of the engine in rpm.

n = no of cylinders = 4

nc = no. of revolution of the flywheel to complete the cycle

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						
5						

VALVE TIMING DIAGRAM

AIM : To determine the timings of valve opening and closing for the given 4-stroke diesel engine and to draw VTD.

APPARATUS : Scale , chalk and thread.

SPECIFICATIONS :

Make	: Kirloskar	No. of Stroke / Cycle:	: Four
Fuel	: Diesel	No. of Cylinders	: Single
Rated Output	: 80 mm	Rated Speed	: 1500 RPM
Bore	: 80 mm	Stroke	: 110 mm

THEORY AND DEFINITIONS :

A four stroke diesel engine works on diesel cycle which involve suction stroke, compression stroke, power stroke (expansion) and exhaust stroke. During the suction stroke fresh air is drawn into the cylinder by the movement of piston from Top Dead Centre (TDC) to Bottom Dead Centre (BDC). During this period the exhaust valve should remain closed theoretically. As the piston reaches BDC, the suction stroke is completed and air drawn must be compressed during the movement of piston from BDC to TDC. The air present in the cylinder must undergo compression. Both inlet valve and exhaust valve will remain closed during compression stroke. Diesel fuel is injected into the cylinder nearly at the end of compression stroke and it will get ignited due to high pressure and temperature in the cylinder. The piston starts moving from TDC to BDC due to high pressure inside the cylinder resulting in power stroke (expansion strike). During power stroke both the valves are closed. The expanded gases must be expelled from the cylinder after completion of expansion stroke so that fresh air can be drawn during the suction stroke. During the movement of piston from BDC to TDC, the exhaust valve is kept opened, while inlet valve is closed so that gases will escape from the cylinder through exhaust valve. The movement of piston from BDC to TDC is called exhaust stroke. After completion of exhaust stroke, suction stroke starts and the cycle is repeated..

Theoretically the inlet and exhaust valves are assumed to open (or) close instantaneously exactly at dead centers. But the valves to function need time to opening (or) closing. Thus the inlet valve opens even before piston reaches TDC and it will fully closed after the piston crosses BDC.

The following definitions are useful in the study of valve timings.

Lead : A valve is said to given "lead" when it opens before the piston has reached dead centers.

Lag : A valve is said to have lag when it closes after the piston reached dead centers.

Overlap: Overlap is the period during which both inlet and exhaust valves are open.

Inlet valve period: Inlet valve opens before top dead centre [TDC] and closes after bottom dead centre [BDC] with reference to a vertical engine. The reason for giving lead to inlet valve [generally 10 – 20 degrees of crank angle] is to provide sufficient time for full opening of the valve and avoid throttling of in coming air. Also, the depression in the cylinder at the end of the exhaust stroke caused by the momentum of the out going gases assist the fresh charge to be drawn into the cylinder overcoming its inertia. But the valve can't be opened too clearly as otherwise the higher pressure inside may blow back the incoming charge. For some period, known as 'overlap' both inlet and exhaust valves are open, that help in scavenging the cylinder of burnt gases. The piston moves from TDC to BDC to facilitate drawing of air in to cylinder. However the inlet valve is not closed at BDC, but after crosses BDC and is moving up there is a lag in the closing of the inlet valve The inlet valve is closed after BDC, the lag is given about 30 – 40 degrees. This is done so as to induce as large a fresh charge as possible.
Due to high speed of piston, the air does not keep pace with the speed of the piston and if the inlet valve is closed at BDC the cylinder would not be completely filled with fresh air. Advantage is taken of the high momentum of lair due to witch the suction continues even induces more charge in to the cylinder as the piston is relatively stationary and the crank can swing through a wide angle with little motion of the piston. The compression will take place inside the cylinder when both valves are closed.

Exhaust valve period: After the power stroke the combustion gases are to be exhausted the exhaust valve opens with a lead of 40 – 50 degrees i.e. before piston reaches BDC in the power stroke. This will facilitate escape of large quantities of exhaust gases to leave the cylinder even before BDC is reached. The exhaust valve is not closed at the end of exhaust stroke (though piston reaches TDC position) but closes 15 degrees of crank angle after TDC. The early opening of exhaust valve is associated with loss of power due to shortening of power stroke but is compensated by better scavenging and less negative work in expelling the exhaust gases. Even after the piston has reached TDC, some exhaust gases left in the combustion chamber are allowed to escape under the influence of momentum of incoming air.

PROCEDURE:

1. Identify the inlet and exhaust valves, decompression lever and the mechanism of valve operation. The decompression lever helps in cranking with ease.
2. Identify the bottom dead centre [BDC] from the movement of the piston i.e. piston moves towards crank case. The piston remains stationary at dead centers before it reverses its direction of motion. Mark a reference line on the engine body corresponding to the bottom dead centre. The diametrically opposite point on the fly wheel will be the TDC.
3. Fix up the "correct direction of the rotation" of fly wheel to get the proper sequencing of valve operation.'
4. Identify the various valve openings and closings. Mark the corresponding operations on the fly wheel.

PORT TIMING DIAGRAM

AIM : To determine the timings of port opening and closing for the given 2 – stroke engine and to draw PTD.

APPARATUS: Scale, thread and chalk.

SPECIFICATIONS:

Two stroke, Single cylinder, Horizontal Petrol engine,
Rated Power - 2.5 HP, Speed – 2800 rpm

THEORY AND DEFINITIONS:

The two stroke petrol (SI) engine works on Otto cycle (constant volume cycle). In two stroke engines the cycle is completed in two strokes i.e. in one revolution of the crank shaft as against two revolutions of four stroke cycle. The fresh charge is sucked through spring loaded inlet valve when the pressure in the crankcase reduces due to forward motion of the piston i.e. from ODC to IDC (from BDC to TDC incase of vertical engines) during compression stroke.

Transfer and exhaust port timings: In case of 2 – stroke engine the exhaust port is opened first, near the end of the expansion stroke i.e. From IDC to ODC. With piston controlled exhaust and transfer port arrangement the lower part of the piston stroke is always waste so, as far as the useful power output is concerned (about 15 % to 40 % of the expansion stroke is ineffective). This early opening of the exhaust port during the last part of the expansion stroke is necessary to permit blow down of the exhaust gases and also to reduce the cylinder pressure so that when the transfer port opens at the end of the blow down process, fresh charge can enter the cylinder. The fresh charge which comes from the crank case enters the cylinder at a pressure slightly higher than the atmospheric pressure. This will assist in forcing out (scavenging) the remaining exhaust gases through the exhaust port with the help of piston projection. During forward motion i.e. from ODC to IDC, the piston covers first the transfer port and then the exhaust port. It is to avoid the fresh charge to escape through the exhaust port.

PROCEDURE:

1. Identify the transfer and exhaust ports and their operation.
2. Identify outer dead centre (ODC) from the movement of the piston i.e. the piston moves towards crankcase. The piston remains stationary at dead cenres before it reverses its direction of motion. Mark a line on the flywheel taking a reference point on the engine body, corresponding to the outer dead centre. The diametrically opposite point on the flywheel will be the inner dead centre (IDC).
3. Fix up the correct direction of rotation of flywheel to get the proper sequencing of port opening and closing.
4. Identify the various port openings and closings. Mark the corresponding operations on the flywheel.

5. Recheck the markings on the flywheel to ascertain the correctness of valve openings and closings and measure the corresponding distances with the help of given thread and scale and tabulate the results.
6. Draw the flywheel diagram indicating valve events and their distances from dead centers.
7. Draw the valve timing diagram indicating the valve openings and closings in a spiral form. Identify all the four strokes in terms of angles and show the valve overlap.

OBSERVATIONS :

Circumference of Flywheel = π D =

Sl.No	Valve events	Distance in "cm" from dead centre ("L" cm)				Crank angle $\theta = 360 \times L / (\pi.D)$
		Before TDC	After TDC	Before BDC	After BDC	
1	IVO					
2	IVC					
3	EVO					
4	EVC					

GRAPHS / DIAGRAMS:

1. Draw the fly wheel diagram indicating various valves operations and the direction of rotation.
2. Draw the valve timing diagram indicating the valve openings and closing in a spiral form. Identify all the four strokes in terms of crank angles and show the valve overlap.

PRECAUTIONS:

i) The valve opening should be taken as the point where it first begins to open
ii) The valve closing should be taken as the point where valve closes completely
iii) The flywheel should be rotated in proper direction.

SAMPLE CALCULATIONS :

RESULTS/ INFERENCE / CONCLUSIONS / RECOMMENDATIONS: