LABORATORY MANUAL

THERMAL ENGINEERING LAB

III B.TECH -I Semester

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DEPARTMENT OF MECHANICAL ENGINEERING

CMR ENGINEERING COLEGE
(Approved by AICTE, New Delhi & Affiliated JNTU, Hyderabad)
Kandlakoya (V), Medchal Road, RR.Dist – 501401

VISION OF THE INSTITUTE

- To be recognized as a premier institution in offering value based and futuristic quality technical education to meet the technological needs of the society

MISSION OF THE INSTITUTE

1. To impart value based quality technical education through innovative teaching and learning methods
2. To continuously produce employable technical graduates with advanced technical skills to meet the current and future technological needs of the society
3. To prepare the graduates for higher learning with emphasis on academic and industrial research.

VISION OF THE DEPARTMENT

To be a center of excellence in offering value based and futuristic quality technical education in the field of mechanical engineering.

MISSION OF THE DEPARTMENT

M1. To impart quality technical education imbibed with values by providing state of the art laboratories and effective teaching and learning process.

M2. To produce industry ready mechanical engineering graduates with advanced technical and lifelong learning skills.

M3. To prepare graduates for higher learning and research in mechanical engineering and its allied areas.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS):

PEO 1: The Graduates will exhibit strong knowledge in mathematics, sciences and engineering for successful employment or higher education in mechanical engineering.

PEO 2: The Graduates will design and implement complex modeling systems, conduct research and work with multi disciplinary teams.

PEO 3: The Graduates will be capable of communicating effectively with lifelong learning attitude and function as responsible members of global society.

PROGRAM OUTCOMES (POS):

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

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PROGRAM SPECIFIC OUTCOMES(PSOS):

PSO.1 Design a Thermal system for efficiency improvement as per industrial needs.

PSO.2 Design and manufacture mechanical components using advanced manufacturing technology as per the industrial needs.

COURSE NAME: THERMAL ENGINERING LAB

Course Name: Thermal Engineering Lab (C318)

Course Code	CO No.	Course Outcome (CO's)
C318	CO1	Analyze the Performance of diesel engine, petrol engine and draw the performance curves by conducting load test.
C318	CO2	Prepare the heat balance sheet by experimenting with petrol/diesel engine.
C318	CO3	Examine the components of fire tube and water tube boilers and compare their working principles.
C318	CO4	Experiment with reciprocating air compressor to determine its volumetric efficiency.
C318	CO5	Examine the working of two stroke and four stroke IC engine and draw its port timing and valve timing diagrams.
C318	CO6	Experiment with diesel engine/petrol engine to determine engine friction.

<u>Course Outcome (CO) – Program Outcome (PO) Matrix:</u>

CO's/PO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	3	-	-	-	-	2
CO2	3	3	3	3	-	-	3	-	-	-	-	2
CO3	3	3	3	3	-	-	3	-	-	-	-	2
CO4	3	3	3	3	-	-	3	-	-	-	-	2
CO5	3	3	3	3	-	-	3	-	-	-	-	2
CO6	3	3	3	3	-	-	3	-	-	-	-	2

<u>Course Outcomes (CO) – Program Specific Outcomes (PSO) Matrix:</u>

CO's/PSO's	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-
CO6	3	-

GENERAL INSTRUCTIONS FOR LABORATORY CLASSES

1. All the students must follow the prescribed dress code (apron, formals, shoes) wear their ID cards
2. All the students should sign in login register.
3. All students must carry their observation books and records without fail.
4. Students must take the permission of the laboratory staff before handling the machines in order to avoid any injury.
5. The students must have basic understanding about the theory and procedure of the experiment to be conducted.
6. Power supply to the test table/test rig should be given in the presence of only through the lab technician.
7. Do not LEAN on and do not come CLOSE to the equipment.
8. Instruments like TOOLS, APPARATUS and GUAGE sets should be returned before leaving the lab.
9. Every student is required to handle the equipment with care and follow proper precautions
10. Students should ensure that their work areas are clean.
11. At the end of each experiment, the student must take initials from the staff on the data / observations taken after completing the necessary calculations.
12. The record should be properly written with following section in each experiment:
    a) Aim of the experiment
    b) Apparatus / Tools / Instruments required
    c) Procedure / Theory
    d) Model Calculations
    e) Schematic Diagram
    f) Specifications / Designs Details
    g) Tabulations.
    h) Graph
    i) Result and discussions.
13. Students should attend regularly to all lab classes.
14. Day- to- day evaluation of student performance is carried out and recorded for finalizing internal marks.

SCHEME OF EVALUATION FOR EXTERNAL LABS

Correctness of Write up and Precautions	Conduct Experiment & observations	Model Calculations	Results and Graphs	Viva
Marks: 5	**Marks: 15**	**Marks: 10**	**Marks: 10**	**Marks: 10**
Total Marks: 50 Marks				

SCHEME OF EVALUATION FOR INTERNAL LABS

Day to Day Evaluation ------15 Marks					**Internal Exam------10 Marks**				
Uniform	Observation &Record	Performance of experiment	Results	Viva Voce	Correctness of Write up and Precautions	Conduct Experiment & observations	Model Calculations	Results and Graphs	Viva Voce
Marks: 2	**Marks: 3**	**Marks: 3**	**Marks:4**	**Marks:3**	**Marks: 2**	**Marks:2**	**Marks: 2**	**Marks: 2**	**Marks: 2**
Total Marks: 15+10=25 Marks									

LIST OF EQUIPMENT

1. Single cylinder 2-Stroke petrol Engine
2. Single cylinder 4-stroke Diesel Engine
3. Multi cylinder Petrol Engine
4. Variable Compression Ratio Diesel Engine
5. Boiler Models
6. Multi stage Reciprocating Air Compressor Unit
7. 2-Stroke Petrol Engine Cut model
8. 4- Stroke Diesel Engine cut model
9. Parts of an IC Engine.

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VALVE TIMING DIAGRAM

❖ AIM:

The experiment is conducted to

- Determine the actual valve timing for a 4-stroke diesel engine and hence draw the diagram.

❖ PROCEDURE:

1. Keep the decompression lever in vertical position.
2. Bring the TDC mark to the pointer level closed.
3. Rotate the flywheel till the inlet valves moves down i.e., opened.
4. Draw a line on the flywheel in front of the pointer and take the reading.
5. Continue to rotate the flywheel till the inlet valve goes down and comes to horizontal position and take reading.
6. Continue to rotate the flywheel till the outlet valve opens, take the reading.
7. Continue to rotate the flywheel till the exhaust valve gets closed and take the reading.

❖ OBSERVATIONS:

Sl. No.	Valve Position	Arc Length, S		Angle ‘θ’ in degrees
		cm	mm	
1	TDC – Inlet Valve open	6	60	17.70
2	BDC – Inlet Valve Close	60	600	177.04
3	TDC – Exhaust Valve Open	122+61=183	1830	540.19
4	BDC – Exhaust Valve Close	122+133=235	2350	693.44

❖ Calculations

1. Diameter of the flywheel, D

$$D = \frac{\text{Circumference of the flywheel}}{\pi}$$

2. Angle ‘θ’ in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

Where,

S = Arc length, mm

1. $\theta = 6\times360/122/\pi^2 = 17.70$
2. $\theta = 6\times360/122/\pi^{2\,=}$ 177.4
3. $\theta = 183\times360/122/\pi^2 = 540.19$
4. $\theta = 235\times360/122/\pi^2 = 693.44$

❖**RESULTS:**

The Valve Timing diagram is plotted.

PORT TIMING DIAGRAM

❖ **AIM**:

- The experiment is conducted to determine the actual PORT timing for a 2-stroke Petrol engine and hence draw the diagram.

❖ **PROCEDURE**:

- Bring the Piston to Top and start as if from the spark.
- Rotate the flywheel till the Exhaust port opens and note the reading.
- Continue the same way and note the reading for the Transfer port.
- Continue to rotate the flywheel till the Piston moves from BDC to TDC and note down the closing of Transfer and Exhaust port readings.

❖ **Observations:**

Sl. No.	POort Position	Angle ‘θ’ in degrees
1	Transfer Port opens	120
2	Transfer Port Closes	240
3	Exhaust Port Opens	140
4	Exhaust Port Closes	230

❖ **Calculations:**

➢ Diameter of the flywheel, D

$$\mathbf{D} = \frac{\text{Circumference of the flywheel}}{\pi}$$

- Angle ‘θ’ in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

Where,

S = Arc length, mm

- **RESULT:**

The Port Timing diagram has been plotted.

I.C. ENGINES PERFORMANCE TEST FOR 4 STROKE SI ENGINES

AIM:

To study and understand the performance characteristics of the engine.

APPARATUS:

- Dynamometer
- Petrol engine
- Calorimeter
- Fuel
- Electrical connections

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.

DESCRIPTION OF THE APPARATUS:

<u>Hydraulic Dynamometer Loading</u>

- 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.

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

- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and Load cell arrangement.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained frame made of MS channels with A-Type anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Check the lubricating oil level.
- Check the fuel level.
- Check and Release the load on the dynamometer if loaded.
- Check the necessary electrical connections and switch on the panel.
- Provide the Battery Connections.
- Allow cooling water to engine and calorimeter and set the flow to 6 & 3 LPM respectively.
- Open the three-way cock so that fuel flows to the engine.
- Start the engine using the starter key.
- Set the speed of the engine. (Do not exceed 3000rpm)
- Now slowly load the engine using the loading wheel of the dynamometer.
- Set the engine speed to before rating.
- Note the following readings.
    a. Engine Speed.
    b. Time taken for ____cc of petrol consumption
    c. Rota meter readings.
    d. Manometer readings, in ‘m’ of water &
    e. Temperatures.

- Repeat the experiment for other loadings.
- After the completion release the load (while doing so release the accelerator) and then switch of the engine and the panel.
- Allow the water to flow for few minutes and then turn it off.
- Remove earthing connection of the battery and the starter key

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied kg	Manometer Reading			Time for 10 cc of fuel collected, t sec
			h1	h2	hw = (h1~h2)	
1	1500	4	1.6	1.8	0.2	16.35
2	1500	2	1.6	1.8	0.2	12.47

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate, LPM2
1	6	3

CALCULATIONS:

1. **MASS OF FUEL CONSUMED**

$M_{f1} = (10\times0.71) \div (1000\times16.35)$

$M_{f1} = 4.342\times10^{-4}$ kg /sec

2. **HEAT IN PUT**

$HI_1 = m_{f1}$ X CALORIFIC VALUE OF FUEL KW

$= 4.342\times10^{-4} \text{ X } 43120$

$=0.000228\times43120$

HI_1 = 18.722 KW

3. BRAKE POWER = $\frac{\mathbf{W \text{ X } N \text{ X } 0.805}}{\mathbf{2000}}$ **kW**

$= \frac{\mathbf{4 \text{ X } 1500 \text{ X } 0.80}}{\mathbf{2000}}$

B.P = 2.4 kW

4. Specific Fuel Consumption = $\frac{\mathbf{m_{f1} \text{ X } 3600}}{\mathbf{BP}}$ **Kg/kW-hr**

$= \frac{4.342 \times 10^{-4} \text{ X } 3600}{2.4}$

= 0.65 kg /KW-hr

5. Brake Thermal Efficiency

$\eta_{bth} = \frac{\mathbf{3600 \text{ x } 100}}{\mathbf{SFC \text{ x } CV}}$

$\eta_{bth} = \frac{\mathbf{3600 \text{ x } 100}}{\mathbf{0.65 \text{ x } 43120}}$

η_{bth} = 12.85 %

6. Mechanical Efficiency:

$\eta_{mech} = \frac{BP}{IP} \text{ x } 100$

IP is calculated using the Morse test facility

7. Calculation of head of air, Ha

$$Ha = \mathbf{h_w} \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m^3

ρ_{air} = 1.2 Kg/m^3 @ R.T.P

h_w is the head in water column in 'm' of water

$$Ha = 0.2 \times \frac{1000}{1.2}$$

Ha = 16.66 m

8. Volumetric efficiency

$$\eta_{vol} = \frac{Qa}{Qth} \times 100$$

Where,

Q_a = Actual volume of air taken

$= C_d \, a \sqrt{(2gHa)}$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = Area at the orifice,

$$a = \frac{\pi \times (0.025)^2}{4}$$

Ha = head in air column, m of air.

$$Q_a = 0.62 \times 4.9 \times 10^{-4} \times \sqrt{2 \times 9.8 \times 16.66}$$

$$Q_a = 5.49 \times 10^{-3}$$

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.084m

L = Length of the Stroke = 0.082m

N is speed of the engine in rpm.

$$Q_{th} = \frac{(\pi/4) \times 0.084^2 \times 0.082 \times 1500}{60 \times 2}$$

$$Q_{th} = 5.68 \times 10^{-3}$$

$$\eta_{vol} = \frac{5.49 \times 10^{-3}}{5.68 \times 10^{-3}}$$

$$\eta_{vol} = 96.65\ \%$$

PRECAUTIONS:

- ❖ Do not run the engine if supply voltage is less than 180V
- ❖ Do not run the engine without the supply of water.
- ❖ Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
- ❖ Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
- ❖ Always set the accelerator knob to the minimum condition and start the engine.
- ❖ Do not forget to give electrical earth and neutral connections correctly.

- ❖ Frequently, at least once in three months, grease all visual moving parts.
- ❖ At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
- ❖ It is recommended to run the engine below **3000rpm** otherwise the rotating parts and bearing of dynamometer may run out.
- ❖ In case of any major faults, Please write to the manufacturers and do not attempt to repair.

RESULT:

The performance characteristics of the multi cylinder engine are studied.

I.C. ENGINES MORSE, RETARDATION, MOTORING TESTS

AIM: To do the performance of Morse test on multi cylinder 4-s petrol engine

APPARATUS:

- Dynamometer
- Petrol Engine
- Calorimeter
- Fuel
- Electrical connections

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.

DESCRIPTION OF THE APPARATUS:

a. Hydraulic Dynamometer Loading

- 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.

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

- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and Load cell arrangement.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained frame made of MS channels with A-Type anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

1. Start the engine and set to one particular speed and note down the readings and calculate the B.P of the engine for the Particular load and speed.
2. Cut - off the 1st 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 1st cylinder.
3. Now, repeat the step 2 for other cylinders.

OBSERVATION:

Sl. No.	Speed	Initial Load	cylinder cut – off
1.	1493	8	No Cylinder
2.	1272	6.9	1st Cylinder
3.	1272	7.1	2nd Cylinder
4	1255	7.2	3rd Cylinder
5	1245	7.1	4th Cylinder

CALCULATION:

Brake Power , BP

$$BP = \frac{W \times N \times 0.8}{2000} \ kW$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

$$BP = \frac{W \times N \times 0.8}{2000} \ Kw$$

$$= \frac{1493 \times 8 \times 0.8}{2000} \ Kw$$

= 4.77 Kw

$$BP_1 = \frac{1272 \ X \ 6.9 \ X \ 0.8}{2000} \ Kw$$

= 3.51

$$BP_2 = \frac{1272 \ X \ 7.1 \ X \ 0.8}{2000} \ Kw$$

= 3.612

$$BP_2 = \frac{1255 \ X \ 7.2 \ X \ 0.8}{2000} \ Kw$$

= 3.614

$BP_2 = \frac{1245 \times 7.1 \times 0.8}{2000}$ Kw

= 3.535

Note: Calculate BP for full load as well as cut-off loads

Indicated Power , BP

IP = IP1 + IP2 + IP3 + IP4 kW

Where,

$IP_1 =$ BP – BP1

= 4.77 – 3.51

= 1.163

$IP_2 =$ BP – BP2

= 4.77 – 3.612

= 1.165

$IP_3 =$ BP – BP3

= 4.77 – 3.614

= 1.163

$IP_4 =$ BP – BP4

= 4.77 – 3.535

= 1.242

η = BP ÷ IP

= 4.777 ÷ 4.837

= 0.98 Or 98 %

η = 98 %

RESULT:

Morse test has been performed on 4-stroke multi cylinder petrol engine.

RETARDATION TEST OF SINGLE CYLINDER CI ENGINE

Aim: To do Retardation Test on Single Cylinder 4-Stroke Diesel Engine

Apparatus:

- Dynamometer
- Diesel engine
- Calorimeter
- Fuel
- Electrical connections

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. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

Mechanical Loading (Water cooled):

- The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.

- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Start the engine as given in the main procedure and allow it to attain steady state.
2. From the RPM controller set 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 its stops, means at the set speed.
4. Also, open the fuel flow when the timer stops.
5. Now, repeat steps 1 to 4 for different speeds (say 900,800.. upto 400rpm).
6. Next, Load the engine at 25% of the full load and repeat the steps 1 to 5.
7. Repeat the step 1 to 6 for different percentages of loading (say 50% & 75%)
8. Draw the graph of SPEED vs TIME OF SPEED DROP for different loading conditions.
9. From the graph note the time for given speed difference (Say 100, 200 or any rpm) for no load and load condition and do the calculations as mentioned below.

NOTE:

You can conduct above procedure for single speed also. That is, it is not necessary to repeat the step 5 and step7 for different speeds and loads.

CALCULATIONS:

- **Frictional Torque, Tf**

$$T_f = \left(\frac{t_3}{t_2 - t_3}\right) T_{given\ load} \qquad Nm$$

Where,

$T_{given\ load}$ = Torque at the given load, Nm.

T_f = Frictional Torque, Nm.

t3 = time for reduction of speed at given load.

t2 = time for reduction of speed at no load.

Friction Power, FP

$$FP = \frac{2\pi N T_f}{60000} \quad kW$$

SL NO	LOAD	RPM	TIME TAKEN TO STOP
1	0	1573	11.44
2	4	1546	8.94
3	6	1545	6.44

T = f X r X 9.81

T_1 = 4 X 0.51 X 9.81

T_1 = 5.88T_{f1} = (8.94) ÷ (11.44 – 8.94) X 5.88

T_{f1} = 21.02

RESULT:

Retardation Test on Single cylinder CI Engine is performed

I.C. ENGINE HEAT BALANCE - CI/SI ENGINES

AIM:

To prepare the heat Balance Sheet for single cylinder Petrol/diesel engine

Apparatus:

- Dynamometer
- Petrol engine
- Calorimeter
- Fuel
- Electrical connections

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.

DESCRIPTION OF THE APPARATUS:

<u>Hydraulic Dynamometer Loading</u>

- 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.
- The Engine is coupled to a Hydraulic Dynamometer for loading purposes. The coupling is done by a universal coupling in a bearing house.
- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.

- The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and Load cell arrangement.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained frame made of MS channels with A-Type anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Check the lubricating oil level.
- Check the fuel level.
- Check and Release the load on the dynamometer if loaded.
- Check the necessary electrical connections and switch on the panel.
- Provide the Battery Connections.
- Allow cooling water to engine and calorimeter and set the flow to 6 & 3 LPM respectively.
- Open the three-way cock so that fuel flows to the engine.
- Start the engine using the starter key.
- Set the speed of the engine. (Do not exceed 3000rpm)
- Now slowly load the engine using the loading wheel of the dynamometer.
- Set the engine speed to before rating.
- Note the following readings.
  a. Engine Speed.
  b. Time taken for ____cc of petrol consumption
  c. Rota meter readings.
  d. Manometer readings, in ‘m’ of water &
  e. Temperatures.
- Repeat the experiment for other loadings.
- After the completion release the load (while doing so release the accelerator) and then switch of the engine and the panel.

- Allow the water to flow for few minutes and then turn it off.
- Remove earthing connection of the battery and the starter key

Note: Allow water only to the calorimeter and not to the engine**.**

OBSERVATIONS

Sl. No.	Speed, rpm	Load Applied kg	Manometer Reading			Time for 10 cc of fuel collected, t sec
			h1	h2	hw = (h1~h2)	
1	1500	4	1.6	1.8	0.2	16.35
2	1500	2	1.6	1.8	0.2	12.47

Sl. No.	T1	T2	T3	T4	T5	T6
1	23	24	30	35	177	57
2	37	28	34	40	220	90

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate, LPM2
1	6	3

CALCULATIONS:

1) **MASS OF FUEL CONSUMED**

$\mathbf{M_{f1}} = (10\times0.71) \div (1000\times16.35)$

$\mathbf{M_{f1}} = 4.342\times10^{-4}$ kg /sec

2) **HEAT IN PUT**

$\mathbf{HI_1 = m_{f1}}$ **X CALORIFIC VALUE OF FUEL KW**

$= 4.342\times10^{-4}$ X 43120

$=0.000228\times43120$

$\mathbf{HI_1}$ = 18.722 KW

3) **BRAKE POWER** = $\frac{\mathbf{W \ X \ N \ X \ 0.805}}{\mathbf{2000}}$ **KW**

$= \frac{\mathbf{4 \ X \ 1500 \ X \ 0.80}}{\mathbf{2000}}$

B.P = 2.4 KW

Heat Balance Sheet Calculations IN SECONDS basis:

A. Heat Input A

A = m_f X Calorific Value KW

A = 18.722 KW

B. Heat to BP

BP = 2.4 Kw

C. Heat to cooling water

$$\mathbf{C = m_{we} \ X \ C_{pw} \ X \ (T_{ei} - T_{eo}) \ kW}$$

Where

m_{we} = cooling water flow rate to the engine from Rota meter

= LPM1/60 kg/sec

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

$C = 0.1 \times 4.18 \times (T_2 – T_3)$

$C = 0.1 \times 4.18 \times (24-30)$

C = - 2.508

D. Heat to exhaust gases

$$D = m_{wc} \times C_{pw} \times (T_{ci} – T_{co}) \times [(T_{gci} – T_a)/ (T_{co} – T_{ci})] \quad kW$$

Where

m_{wc} = water flow rate in kg/sec

= LPM2/60 kg/sec

C_{pw} = Specific Heat of water

T_a = Engine surrounding temperature.

T_{gci} = Gas inlet temp to calorimeter

T_{gco} = Gas outlet temp from calorimeter

T_{ci} = Water Inlet temp to calorimeter

T_{co} = Water outlet temp from calorimeter

D = 2.95

E. Heat Unaccounted

E = A – (B+C+D) kW

E = 18.437

HEAT BALANCE SHEET:

Sl. No.	Particulars	Heat Content kW	%
1	Heat Input -- A	18.722	100
2	Heat to BP -- B	2.4	B/A = 1.28
3	Heat to Cooling Water -- C	2.508	C/A = -1.33
4	Heat to Exhaust Gases -- D	2.95	D/A = 1.57
5	Heat Unaccounted -- E	18.437	E/A = 98.47

RESULT:

Heat Balance sheet has been prepare for single cylinder diesel engine

I.C. ENGINES PERFORMANCE TEST FOR SINGLE CYLINDER 2 STROKE SI ENGINES

AIM:

To study the performance characteristics of the single cylinder 2-stroke petrol engine

APPARATUS:

- Dynamometer
- Petrol engine
- Calorimeter
- Fuel
- Electrical connections

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.

DESCRIPTION OF THE APPARATUS:

Electrical Dynamometer Loading (AC):

- The equipment consists of a Brand new **BAJAJ** make 5 port model Petrol Engine (Kick Start) of **3hp(2.2kW)** capacity and is Air cooled The Engine is coupled to a **AC Alternator** for Loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven. The dynamometer is provided with load controller switches for varying the load.
- The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachment for varying the spark timing.
- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Engine Speed at various condition s is determined by a Digital RPM Indicator.
- Load on the engine is measured by means of Electrical Energy meter.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the

engine respectively.

- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board which houses all indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Give the necessary electrical connections to the panel.
- Check the lubricating oil level in the engine.
- Check the fuel level in the tank.
- Release the load if any on the dynamometer.
- Open the three-way cock so that fuel flows to the engine.
- Set the accelerator to the minimum condition.
- Start the engine by cranking.(KICK START)
- Allow to attain the steady state.
- Load the engine by switching on the Load controller switches provided. (Each loading is incremental of 0.5kW)
- Note the following readings for particular condition,
  a) Engine Speed
  b) Time taken for ____cc of petrol consumption
  c) Water meter readings.
  d) Manometer readings, in cms of water &
  e) Temperatures at different locations.
- Repeat the experiment for different loads and note down the above readings.
- 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 turnoff the panel.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied ‘F’ kW	Manometer Reading, cm of water			Time for 10cc of fuel collected, t sec	Time for 5 rev of Energy meter,
			h1	h2	hw = (h1+h2)		
1	1000	0	0	0.6	0	0	0
2	1000	0.5	0.6	0.7	1.3	31.06	8.91
3	1000	1.0	0.7	0.8	1.5	39.19	8.85
4	1000	1.5	0.8	0.8	1.6	31.19	8.55

CALCULATIONS:

- **Mass of fuel consumed, mf**

$$\mathbf{m_f} = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \text{ x t}}$$

Where,

Specific Gravity of Petrol is = 0.71

X cc is the volume of fuel consumed = 10ml

t is time taken in seconds

- **Heat Input, HI**

$$\mathbf{HI = m_f \text{ x Calorific Value of Fuel}} \quad \text{kW}$$

Where,

Calorific Value of Petrol = 43,120 KJ/Kg

- **Output or Brake Power, BP**

$$BP = \frac{n \times 3600}{K \times T \times \eta_m} \text{ kW}$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant = 750 revs/kW-hr

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 80%

- **Specific Fuel Consumption, SFC**

$$SFC = m_f \times \frac{3600}{BP} \quad \text{kg/kW – hr}$$

- **Brake Thermal Efficiency,**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

- **Calculation of head of air, Ha**

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m^3

ρ_{air} = 1.2 Kg/m^3 @ R.T.P

h_w is the head in water column in 'm' of water

- **Volumetric efficiency:**

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

Where,

A. Qa = Actual volume of air taken

$$Qa = Cd\, a \sqrt{(2gHa)}$$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $(\pi(0.015)^2/4)$

Ha = head in air column, m of air.

B. Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times Gr \times 0.5\, N}{60}$$

Where,

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N = Speed of the engine in rpm.

Gr = gear ratio

1^{st} gear = 14.47:1

2^{nd} gear = 10.28:1

3^{rd} gear = 7.31:1

4^{th} gear = 5.36:1

Calculations:

M_f = 10×0.71/1000×31.06=0.000228.

HI_1= 0.000228×43120=9.856

BP = 5×3600/750×8.91 0.8=3.36

SFC = 0.000288×3600/3.36=0.244

η_{bth} = 3600×100/0.244×43120=34.21

H_a = 0.012×1000/1.2=10

Q_a = 0.62×∏×0.015²/4×√2×9.81×10=0.00153

Q_{th} =0.0129.

η_{Vol} = 11.81%

TABLE:

Sl. No	Input Power	Output Power, BP	SFC	Brake Thermal Efficiency	Volumetric efficiency
1	0	0	0	0	0
2	9.856	3.36	0.244	34.21	11.81
3	7.811	3.389	0.192	43.38	12.75
4	7.8133	3.554	0.183	45.492	13.25

PRECAUTIONS:

- Do not run the engine if supply voltage is less than 180V
- Do not run the engine without the supply of water.
- Supply water free from dust to prevent blockage in rota meters, engine head and calorimeter.
- Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.

- ❖ Always set the accelerator knob to the minimum condition and start the engine.
- ❖ Switch off the ignition of AUXILLARY while doing in the engine arrangement.
- ❖ Do not forget to give electrical earth and neutral connections correctly.
- ❖ Frequently, at least once in three months, grease all visual moving parts.
- ❖ At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
- ❖ It is recommended to run the engine at **1000rpm** otherwise the rotating parts and bearing of engine may run out.
- ❖ In case of any major faults, Please write to the manufacturers and do not attempt to repair.

RESULT:

Performance of the single cylinder, 2 – stroke petrol engine has been studied.

I.C. ENGINES ECONOMICAL SPEED TEST ON A SI ENGINE

AIM:

To performance the economical speed test on a single cylinder 2-stroke petrol engine

APPARATUS:

- Dynamometer
- Petrol engine
- Calorimeter
- Fuel
- Electrical connections

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.

DESCRIPTION OF THE APPARATUS:

Electrical Dynamometer Loading (AC):

- The equipment consists of a Brand new **BAJAJ** make 5 port model Petrol Engine (Kick Start) of **3hp(2.2kW)** capacity and is Air cooled The Engine is coupled to a **AC Alternator** for Loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven. The dynamometer is provided with load controller switches for varying the load.
- The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachment for varying the spark timing.
- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Engine Speed at various condition s is determined by a Digital RPM Indicator.
- Load on the engine is measured by means of Electrical Energy meter.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.

- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board which houses all indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Give the necessary electrical connections to the panel.
- Check the lubricating oil level in the engine.
- Check the fuel level in the tank.
- Release the load if any on the dynamometer.
- Open the three-way cock so that fuel flows to the engine.
- Set the accelerator to the minimum condition.
- Start the engine by cranking.(KICK START)
- Allow to attain the steady state.
- Load the engine by switching on the Load controller switches provided. (Each loading is incremental of 0.5kW)
- Note the following readings for particular condition,
  - f) Engine Speed
  - g) Time taken for ____cc of petrol consumption
  - h) Water meter readings.
  - i) Manometer readings, in cms of water &
  - j) Temperatures at different locations.
- Repeat the experiment for different loads and note down the above readings.
- 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 turnoff the panel.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied 'F' kW	Manometer Reading, cm of water			Time for 10cc of fuel collected, t sec	Time for 5 rev of Energy meter,
			h1	h2	hw = (h1+h2)		
1	600	1	0.7	0.5	1.2	30.5	76
2	800	1	0.7	0.5	1.2	24.5	65
3	1000	1	0.7	0.5	1.2	19.5	55

CALCULATIONS:

- **Mass of fuel consumed, mf**

$$m_f = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \text{ x t}}$$

Where,

Specific Gravity of Petrol is = 0.71

X cc is the volume of fuel consumed = 10ml

t is time taken in seconds

1. $m_{f1} = 0.934\times10^{-4}$
2. $m_{f2} = 1.09\times10^{-4}$
3. $m_{f3} = 1.29\times10^{-4}$

- **Heat Input, HI**

HI = mf x Calorific Value of Fuel kW

Where,

Calorific **Value o**f Petrol = 43,120 KJ/Kg

1. **HI_1 =4.027 kW**
2. **HI $_2$=4.70 kW**
3. **HI_3 =5056 kW**

- **Output or Brake Power, BP**

$$BP = \frac{n \times 3600}{K \times T \times \eta_m} \quad kW$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant = 750 revs/kW-hr

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 80%

1. BP_1 =1 kW
2. BP_2 =1.25 kW
3. BP_3 =1.57 kW

- **Specific Fuel Consumption, SFC**

$$SFC = m_f \times \frac{3600}{BP} \quad kg/kW - hr$$

1. SFC_1 =1.33 kg/kW – hr
2. SFC_2 =0.31 kg/kW – hr
3. SFC_3 =0.29 kg/kW – hr

- **Brake Thermal Efficiency,**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

1. η_{bth1} **=25.29 %**
2. η_{bth2} **=26.93 %**
3. η_{bth3} **=28.78 %**

- **Calculation of head of air, Ha**

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m^3

ρ_{air} = 1.2 Kg/m^3 @ R.T.P

h_w is the head in water column in 'm' of water

H_a **=1000 Cm**

- **Volumetric efficiency:**

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

Where,

C. **Qa = Actual volume of air taken**

Qa = Cd a √ (2gHa)

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $(\prod(0.015)^2/4)$

Ha = head in air column, m of air.

Qa =1.53×10^{-3}

D. Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times Gr \times 0.5\, N}{60}$$

Where,

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N = Speed of the engine in rpm.

Gr = gear ratio

1^{st} gear = 14.47:1

2^{nd} gear = 10.28:1

3^{rd} gear = 7.31:1

4^{th} gear = 5.36:1

Theoretical volume of air taken

1. Q_{th1} =5.31×10^{-3}
2. Q_{th2} =7.08×10^{-3}
3. Q_{th3} =8.86×10^{-3}

Volumetric efficiency:

1. $\eta_{vol\,1}$ = 28.81 %
2. $\eta_{vol\,2}$ = 21.61 %
3. $\eta_{vol\,3}$ = 17.26 %

TABLE:

Sl. No	Output Power, BP	SFC	Brake Thermal Efficiency	Volumetric efficiency
1	1	0.33	25.29 %	28.81 %
2	1.25	0.31	26.93 %	21.61 %
3	1.57	0.29	28.78 %	17.26 %

PRECAUTIONS:

- ❖ Do not run the engine if supply voltage is less than 180V
- ❖ Do not run the engine without the supply of water.
- ❖ Supply water free from dust to prevent blockage in rota meters, engine head and calorimeter.
- ❖ Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
- ❖ Always set the accelerator knob to the minimum condition and start the engine.
- ❖ Switch off the ignition of AUXILLARY while doing in the engine arrangement.
- ❖ Do not forget to give electrical earth and neutral connections correctly.
- ❖ Frequently, at least once in three months, grease all visual moving parts.
- ❖ At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
- ❖ It is recommended to run the engine at **1000rpm** otherwise the rotating parts and bearing of engine may run out.
- ❖ In case of any major faults, Please write to the manufacturers and do not attempt to repair.

RESULT:

Performance of the single cylinder, 2 – stroke petrol engine has been studied.

PERFORMANCE TEST ON VARIABLE COMPRESSION RATIO DIESEL ENGINE

AIM:

The experiment is conducted to

- To study and understand the performance characteristics of the engine.
- To draw Performance curves and compare with standards.

APPARATUS:

- Dynamometer
- Diesel engine
- Calorimeter
- Fuel
- Electrical connections

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. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

Eddy Current Dynamometer Loading:

- The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled.

- The Engine is coupled to a Eddy Current Dynamometer for Loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the Load Cell with digital load indication.
- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Give the necessary electrical connections to the panel.
- Check the lubricating oil level in the engine.
- Check the fuel level in the tank.
- Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
- Release the load if any on the dynamometer.
- Open the three-way cock so that fuel flows to the engine.
- Start the engine by cranking.
- Allow to attain the steady state.
- Set the compression Ratio – see Annexure I for detail
- Switch on the Load controller and slowly load the engine by rotating the knob clockwise.
- Note the following readings for particular condition,

1. Engine Speed
2. Time taken for ____cc of diesel consumption
3. Rota meter reading.
4. Manometer readings, in cms of water &
5. Temperatures at different locations.

- Repeat the experiment for different loads and note down the above readings.
- After the completion release the load and then switch of the engine.
- Allow the water to flow for few minutes and then turn it off.

SETTING THE COMPRESSION RATIO

Follow the procedure below to set the compression ratio:

- Start the engine at higher compression Ratio.
- Allow the engine to attain the steady speed.
- Rotate the Wheel provided on the head to vary the *Compression Ratio.(See the below Table for Compression Ratio Reading scale)
- Continue doing till the required compression ratio is set.

NOTE:

1. You can change the compression ratio when the engine is running.
2. Compression ratio from **12.2 to 23.1** can be set.
3. Lower compression ratio has to be set from the maximum compression ratio only.
4. Engine cannot be started instantaneously at lower compression ratio.

SCALE FOR VARIABLE COMPRESSION RATIO:

Reading on Scale, 'mm'	Compression Ratio
0.0	23.12
0.5	21.10
1.0	19.43
1.5	18.00
2.0	16.77
2.5	15.72
3.0	14.80
3.5	14.00
4.0	13.25
4.5	12.61
5.0	12.02

OBSERVATIONS:

Sl. No.	Compression Ratio	Speed, rpm 'N'	Load Applied 'F'	Manometer Reading			Time for 10cc of fuel collected, t sec
				h_1	h_2	hw = (h1+h2)	
1	23.12	1529	3	0.6	0.7	1.3	40.48
2	23.12	1522	5	0.6	0.6	1.2	37.81
3	12.02	1515	3	0.6	0.7	1.2	33.38
4	12.02	1501	5	0.5	0.6	1.1	30.35

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate, LPM2
1	6	3

CALCULATIONS:

- **Mass of fuel consumed, mf**

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

Specific Gravity of Diesel = 0.827

X cc is the volume of fuel consumed = 10ml

t is time taken in seconds

1. **m_{f1} =0.00020 kg/s**
2. **m_{f2}=0.00021 kg/s**
3. **m_{f3}=0.00024 kg/s**
4. **m_{f4}=0.00027 kg/s**

- **Heat Input, HI**

HI = m_f x Calorific Value of Fuel kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

1. **HI_1=8.9263 kW**
2. **HI_2=9.37 kW**
3. **HI_3=10.7116 kW**
4. **HI_4=12.0506 kW**

➢ **Output or Brake Power, BP**

Engine output **BP =** $\frac{2\Pi NT}{60000}$ **kW**

Where,

N = Speed in rpm

T = Torque on the load indicator

T = F x r x 9.81 N-m

r = Torque arm radius = 0.15m

1. BP_1 =0.7068 kW
2. BP_2 =1.17805 kW
3. BP_3 =0.7003 kW
4. BP_4 =1.15648 Kw

➢ **Specific Fuel Consumption, SFC**

SFC = m_f x $\frac{3600}{BP}$ kg/kW – hr

1. **SFC_1 =1.0186**
2. **SFC_2 =0.6417**
3. **SFC_3 =1.237**
4. **SFC_4 =0.8404**

➢ **Brake Thermal Efficiency, η_{bth}%**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

1. **η_{bth1} =7.91**
2. **η_{bth2} =12.56**
3. **η_{bth3} =6.53**
4. **η_{bth4} =9.59**

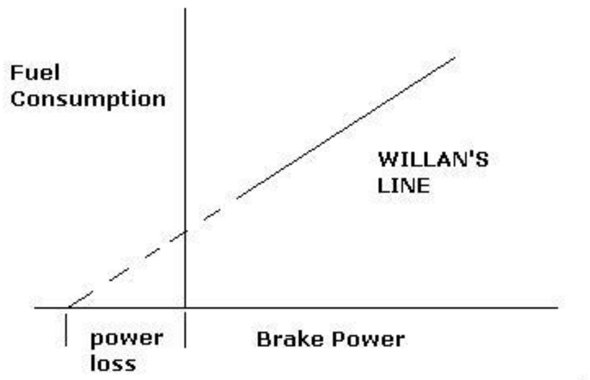
- **Mechanical Efficiency, η_{mech}%**

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

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

  IP = BP + FP



1. η_{mech1} =26.11%
2. η_{mech2} =54.00%
3. η_{mech3}=28.00%
4. η_{mech4} =39.11%

- **Calculation of head of air, Ha**

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m³

ρ_{air} = 1.2 Kg/m³ @ R.T.P

h_w is the head in water column in 'm' of water

- **Volumetric efficiency**

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

Where,

Q_a = Actual volume of air taken = Cd a √ (2gHa) m^3/s

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.02)²/4)

Ha = head in air column, m of air.

1. **Q_{a1} =0.0028** m^3/s
2. **Q_{a2} =0.0026** m^3/s
3. **Q_{a3} =0.0028** m^3/s
4. **Q_{a4} =0.0025** m^3/s

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2} \quad m^3/s$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

1. $\mathbf{Q_{th}}$ = 0.00704 m^3/s
2. $\mathbf{Q_{th}}$ = 0.00701 m^3/s
3. $\mathbf{Q_{th}}$ = 0.00698 m^3/s
4. $\mathbf{Q_{th}}$ = 0.00691 m^3/s

Volumetric efficiency

a) η_{vol1} = 40%

b) η_{vol2} = 37.14%

c) η_{vol3} = 40.57%

d) η_{vol4} = 36.23%

PRECAUTIONS:

- Do not run the engine if supply voltage is less than 180V
- Do not run the engine without the supply of water.
- Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
- Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
- Do not forget to give electrical earth and neutral connections correctly.
- Frequently, at least once in three months, grease all visual moving parts.
- At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
- It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.
- In case of any major faults, Please write to the manufacturers and do not attempt to repair.

TABULATION:

Sl No	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1	8.9263	0.707	10.18	7.9	26.11	40
2	9.373	1.178	0.6417	12.6	54	37.14
3	10.711	0.7003	1.233	6.5	28	40.57
4	12.05	1.156	0.8405	9.6	39.11	36.23

RESULT:

The performance of variable compression ratio diesel engine has been studied.

IC ENGINE PERFORMANCE TEST ON A 4S CI ENGINE AT CONSTANT SPEED

AIM:

To study and understand the performance characteristics of the 4s diesel engine.

APPARATUS:

- Dynamometer
- Diesel engine
- Calorimeter
- Fuel
- Electrical connections

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. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS

Mechanical Loading (Water cooled):

- The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.

- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Give the necessary electrical connections to the panel.
- Check the lubricating oil level in the engine.
- Check the fuel level in the tank.
- Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
- Release the load if any on the dynamometer.
- Open the three-way cock so that fuel flows to the engine.
- Start the engine by cranking.
- Allow to attain the steady state.
- Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
- Note the following readings for particular condition,
    a) Engine Speed
    b) Time taken for ____cc of diesel consumption
    c) Rota meter reading.
    d) Manometer readings, in cm of water &
    e) Temperatures at different locations.

- Repeat the experiment for different loads and note down the above readings.
- After the completion release the load and then switch of the engine.
- Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No	Speed, rpm	Load Applied kg			Manometer Reading			Time for 10 cc of fuel collected, t sec
		F_1	F_2	$F= F_1-F_2$	h_1	h_2	$hw = h_1-h_2$	
1	1563	4	0.5	4.5	2	2.2	4.2	58.35
2	1544	6	1	5	2	2.2	4.2	49.19

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate, LPM2
1	6	3

CALCULATIONS:

1. **MASS OF FUEL CONSUMED**

   $M_f = 1.41\times10^{-4}$ kg /sec

2. **HEAT IN PUT**

   $HI_1 = m_{f1}$ X CALORIFIC VALUE OF FUEL KW

   $= 1.41\times10^{-4}$ X 43120

   HI_1 = 6.29 KW

3. **BRAKE POWER** = $\frac{\mathbf{W \times N \times 0.80}}{\mathbf{2000}}$ **kW**

B.P = 0.96 kW

4. SPECIFIC FUEL CONSUMPTION = $\frac{\mathbf{m_{f1} \times 3600}}{\mathbf{BP}}$ **Kg/kW-hr**

$$= \frac{1.41 \times 10^{-4} \times 3600}{0.96}$$

= 0.52 kg /KW-hr

5. **Brake Thermal Efficiency**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

$$\eta_{bth} = \frac{3600 \times 100}{0.52 \times 43120}$$

$$\eta_{bth} = 15.51\ \%$$

6. Mechanical Efficiency:

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

IP = BP+ FP

= .0.96 + 0.4

= 1.36

$$\eta_{mech} = \frac{0.96}{1.36} \times 100$$

η_{mech} **= 70.58 %**

- **Calculation of head of air, Ha**

$$Ha = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m^3

ρ_{air} = 1.2 Kg/m^3 @ R.T.P

h_w is the head in water column in 'm' of water

$$H_a = 0.2 \times \frac{1000}{1.2}$$

H_a = 16.66 m

- **Volumetric efficiency:**

$$\eta_{vol} = \frac{Qa}{Qth} \times 100$$

Where,

Q_a = Actual volume of air taken

$= C_d\, a \sqrt{(2gHa)}$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = Area at the orifice,

$$a = \pi \times (0.025)^2$$

4

Ha = head in air column, m of air.

$$Q_a = 0.62 \times 3.14 \times 10^{-4} \times \sqrt{(2 \times 9.8 \times 35)}$$

$$Q_a = 5.10 \times 10^{-3}$$

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.084m

L = Length of the Stroke = 0.082m

N = speed of the engine in rpm.

$$Q_{th} = \frac{(\pi/4) \times 0.084^2 \times 0.11 \times 1563}{60 \times 2}$$

$$Q_{th} = 7.20 \times 10^{-3}$$

$$\eta_{vol} = \frac{5.10 \times 10^{-3}}{7.20 \times 10^{-3}}$$

$$\eta_{vol} = 70.83\ \%$$

RESULT:

Performance of the single cylinder 4 stroke diesel engine has been studied.

VOLUMETRIC EFFICIENCY OF AIR - COMPRESSOR UNIT

AIM:

Determine the Volumetric efficiency of reciprocating air compressor

APPARATUS:

- Two stage reciprocating air compressor unit
- Motor
- Pressure gauges
- Stop watch

INTRODUCTION:

A compressor is a device, which sucks in air at atmospheric pressure & increases its pressure by compressing it. If the air is compressed in a single cylinder it is called as a Single Stage Compressor. If the air is compressed in two or more cylinders it is called as a Multi Stage Compressor.

In a Two Stage Compressor the air is sucked from atmosphere & compressed in the first cylinder called the low-pressure cylinder. The compressed air then passes 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.

DESCRIPTION OF THE APPARATUS:

- Consists of Two Stage ELGI make Reciprocating air compressor of 3hp capacity. The compressor is fitted with similar capacity Motor as a driver and 160lt capacity reservoir tank.
- Air tank with orifice plate assembly is provided to measure the volume of air taken and is done using the Acrylic Manometer provided.
- Compressed air is stored in an air reservoir, which is provided with a pressure gauge and automatic cut-off.
- Necessary Pressure and Temperature tappings are made on the compressor for making different measurements
- Temperature is read using the Digital temperature indicator and speed by Digital RPM indicator.

- All the measurements and controls are placed in a separate NOVAPAN board control panel unit with all necessary instrumentations.

PROCEDURE:

- Check the necessary electrical connections and also for the direction of the motor.
- Check the lubricating oil level in the compressor.
- Start the compressor by switching on the motor.
- The slow increase of the pressure inside the air reservoir in observed.
- Maintain the required pressure by slowly operating the discharge valve (open/close). (Note there may be slight variations in the pressure readings since it is a dynamic process and the reservoir will be filled continuously till the cut-off.)
- Now note down the following readings in the respective units

    a) Speed of the compressor.
    b) Manometer readings.
    c) Delivery pressure.
    d) Temperatures.
    e) Energy meter reading.

- Repeat the experiment for different delivery pressures.
- Once the set of readings are taken switch of the compressor.
- 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 a air jet which may damage you or your surroundings.
- Repeat the above two steps after every experiment.

OBSERVATIONS:

Sl. No.	Compressor Speed, N rpm	Delivery Pressure, 'P' kg/cm^2			Time for 'n' revolutions of energy meter, 'T' sec	Manometer meter reading in 'm'		
		P_1	P_2	P_3		h_1	h_2	h_W
1	921	1.2	1.8	1.5	5.72	1	1	2
2	914	2.4	3.1	2.5	4.94	1	1	2
3	9.2	3.9	5.1	4.5	4.37	1	1	2

CALCULATIONS:

1) **Air head causing flow, ha**

$$h_a = h_w \frac{\rho_{water}}{\rho_{air}} \quad \text{m of air}$$

=2/100×1000/1.293=15.46

Where,

h_w is Water column reading in **m** of water.

ρ_{water} is density of the water = 1000 kg/m³

ρ_{air} is the density of the air = 1.293 kg/m³

2) **Actual vol. of air compressed air**

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

Where, $=0.62\times3.14\times10^{-4}\sqrt{(2\times9.81\times15.46}$

$=3.39\times10^{-3}$

h_a = air head causing the flow in **m** of air.

C_d = co efficient of discharge of orifice = 0.62

a = Area of orifice = $(\prod d^2) / 4$

Where, **d** = diameter of orifice = 0.02m

3) Theoritical volume of air compressed

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60} \quad m^3/s$$

$Q_{th} = 5.02\times10^{-3}\ m^3/sec$

D = diameter of the LP cylinder = 0.07m.

L = Stroke Length = 0.085m

N = Speed of the compressor in rpm

Where

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant revs/kW-hr

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 75%

4) **Volumetric efficiency,**

$\eta_{vol} = (Qa) \div (Qth)$

$= 3039\times10^{-3}/5.02\times10^{-3}\times100$

$=0.53\div 1.47$

TABULATIONS

Sl. No	Head of air h_a, m	Act. Vol. of air compressed Q_a m³/s	Theo. Vol. of air compressed Q_{th}, m³/s	Isothermal work done kW	Iso Thermal Efficiency η_{iso}, %	Volumetric Efficiency, η_{vol}, %
1	15.46	3.14×10^{-4}	5.02×10^{-3}	0.53	36.07	67.52
2	15.46	3.14×10^{-4}	4.9×10^{-3}	0.89	57.88	68.52
3	15.46	3.14×10^{-4}	5.35×10^{-3}	1.608	82.04	68.36

PRECAUTIONS:

- Do not run the blower if supply voltage is less than 380V
- Check the direction of the motor, if the motor runs in opposite direction change the phase line of the motor to run in appropriate direction.
- Do not forget to give electrical earth and neutral connections correctly.
- Frequently, at least once in three months, grease all visual moving parts.
- At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
- In case of any major faults, Please write to the manufacturers and do not attempt to repair.

RESULT:

Volumetric efficiency of the reciprocating air compressor has been studied

DIS-ASSEMBLY / ASSEMBLY OF I.C. ENGINE

AIM:

Dismantling and reassembling of a 4 stroke petrol engine.

Apparatus:

- Spanner set
- Work bench
- screw driver,
- spark plug spanner
- Spark plug cleaner
- Tray
- Kerosene oil
- Cotton waste
- Hammer
- Oil can

THEORY:

In 1878, a British engineer introduced a cycle which could be completed in two strokes of piston rather than four strokes as is the case with the four-stroke cycle engines. In this engine suction and exhaust strokes are eliminated. Here instead of valves, ports are used. The exhaust gases are driven out from engine cylinder by the fresh charge of fuel entering the cylinder nearly at the end of the working stroke .A two-stroke petrol engine is generally used in scooters, motor cycles etc. The cylinder L is connected to a closed crank chamber C.C. During the upward stroke of the piston M, the gases in L are compressed and at the same time fresh air and fuel (petrol) mixture enters the crank chamber through the valve.

Different Parts of an I.C. Engine

1) Cylinder
2) Cylinder head
3) Piston
4) Piston rings
5) Gudgeon pin
6) Connecting rod
7) Crankshaft
8) Engine bearing
9) Crank case
10) Flywheel.

Parts of a 2 Stroke Petrol Engine

Cylinder Head:

It is also referred to as the top end; the cylinder head houses the pistons, valves, rocker arms and camshafts.

Valves:

A pair of valves, used for controlling fuel intake and exhaust, is controlled by a set of fingers on the camshaft called lobes. As the intake valve opens, a mixture of fuel and air from the carburetor is pulled into the cylinder. The exhaust valve expels the spent air/fuel mixture after combustion.

Camshaft:

Usually chain or gear-driven, the camshaft spins, using its lobes to actuate the rocker arms. These open the intake and exhaust valves at preset intervals.

Piston:

The piston travels up and down within the cylinder and compresses the air/fuel mixture to be ignited by a spark plug. The combustive force propels the piston downward. The piston is attached to a connecting rod by a wristpin.

Piston rings:

These are circular rings which seal the gaps made between the piston and the cylinder, their object being to prevent gas escaping and to control the amount of lubricant which is allowed to reach the top of the cylinder.

Gudgeon-pin:

This pin transfers the thrust from the piston to the connecting-rod small- end while permitting the rod rock to and fro as the crankshaft rotates.

Connecting-rod:

This acts as both a strut and a tie link-rod. It transmits the linear pressure impulses acting on the piston to the crankshaft big-end journal, where they are converted into turning-effort.

Crankshaft:

The crankshaft is made up of a left and right flywheel connected to the piston's connecting rod by a crank pin, which rotates to create the piston's up-and-down motion. The cam chain sprocket is mounted on the crankshaft, which controls the chain that drives the camshaft.

Carburetor:

The carburetor is the control for the engine. It feeds the engine with a mixture of air and petrol in a controlled volume that determines the speed, acceleration and deceleration of the engine. The carburetor is controlled by a slide connected to the throttle cable from the handlebar twist grip which adjusts the volume of air drawn into the engine.

Procedure:

- Dismantle the following system
  1) Fuel supply system
  2) Electrical system
- Remove the spark plug from the cylinder head.
- Remove the cylinder head nut and bolts.
- Separate the cylinder head from the engine block.
- Remove the carburetor from the engine.
- Open the crankcase.
- Remove piston rings from the piston.
- Clean the combustion chamber.
- Reassemble the components vice versa.

Precautions:

* Don't use loose handle of hammer.
* Care must be taken while removing the components.

Result:

A 2 – stroke petrol engine has been dismantled and reassembled.

STUDY OF BOILERS

STUDY OF BABCOCK-WILCOX BOILER

Aim: To study the Babcock-Wilcox boiler.

Theory:

Evaporating the water at appropriate temperatures and pressures in boilers does the generation of steam. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Babcock- Wilcox boiler.

Observation:

In thermal powerhouses, Babcock Wilcox boilers degeneration of steam in large quantities.

The boiler consists essentially of three parts.

1. **A number of inclined water tubes**: They extend all over the furnace. Water circulates through them and is heated.
2. **A horizontal stream and water drum**: Here steam separate from the water which is kept circulating through the tubes and drum.
3. **Combustion chambers**: The whole of space where water tubes are laid is divided into three separate chambers, connected to each other so that hot gases pass from one to the other and give out heat in each chamber gradually. Thus the first chamber is the hottest and the last one is at the lowest temperature. All of these constituents have been shown as in fig.

The Water tubes 76.2 to 109 mm in diameter are connected with each other and with the drum by vertical passages at each end called Headers. Tubes are inclined in such a way that they slope down towards the back. The rear header is called the down-take header and the front header is called the uptake header has been represented in the fig as DC and VH respectively.

Whole of the assembly of tubes is hung along with the drum in a room made of masonry work, lined with fire bricks. This room is divided into three compartments A, B, and C as shown in fig, so that first of all, the hot gases rise in A and go down in B, again rises up in C, and then the led to the chimney through the smoke chamber C. A mud collector M is attached to the rear and lowest point of the boiler into which the sediment

I.e. suspended impurities of water are collected due to gravity, during its passage through the down take header. Below the front uptake header is situated the grate of the furnace either automatically or manually fired depending upon the size of the boiler. The direction of hot gases is maintained upwards by the baffles L.

In the steam and water drum the steam is separated from the water and the remaining water travels to the back end of the drum and descends through the down take header where it is subjected to the action of fire of which the temperature goes on increasing towards the uptake header. Then it enters the drum where the separation occurs and similar process continuous further.

For the purpose of super heating the stream addition sets of tubes of U-shape fixed horizontally, are fitted in the chamber between the water tubes and the drum. The steam passes from the steam face of the drum downwards into the super heater entering at its upper part, and spreads towards the bottom .Finally the steam enters the water box W, at the bottom in a super-heated condition from where it is taken out through the outlet pipes.

The boiler is fitted with the usual mountings like main stop valve M, safety valve S, and feed valve F, and pressure gauge P.

Main stop valve is used to regulate flow of steam from the boiler, to steam pipe or from one steam one steam pipe to other.

The function of safety valve is used to safe guard the boiler from the hazard of pressures higher than the design value. They automatically discharge steam from the boiler if inside pressure exceeds design-specified limit.

Feed check valve is used to control the supply of water to the boiler and to prevent the escaping of water from boiler due to high pressure inside.

Pressure gauge is an instrument, which record the inside pressure of the boiler.

When steam is raised from a cold boiler, an arrangement is provided for flooding the super heater. By this arrangement the super heater is filled with the water up to the level. Any steam is formed while the super heater is flooded is delivered to the drum ultimately when it is raised to the working pressure. Now the water is drained off from the super heater through the cock provided for this purpose, and then steam is let in for super heating purposes.

Result:

The Babcock – Wilcox boiler is studied

STUDY OF LANCASHIRE BOILER

AIM: To study the Lancashire boiler.

Theory:

Evaporating the water at appropriate temperatures and pressures in boilers does the generation of system. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Lancashire boiler.

Observation:

Lancashire boiler has two large diameter tubes called **flues**, through which the hot gases pass. The water filled in the main shell is heated from within around the flues and also from bottom and sides of the shell, with the help of other masonry ducts constructed in the boiler as described below.

The main boiler shell is of about 1.85 to 2.75 m in diameter and about 8 m long. Two large tubes of 75 to 105 cm diameter pass from end to end through this shell. These are called **flues.** Each flue is proved with a **fire door** and a **grate** on the front end. The shell is placed in a placed in a masonry structure which forms the external flues through which, also, hot gases pass and thus the boiler shell also forms a part of the heating surface. The whole arrangement of the brickwork and placing of boiler shell and flues is as shown in fig.

SS is the boiler **shell** enclosing the main **flue tubes**. SF is the **side flues** running along the length of the shell and BF is the **bottom flue**. Side and bottom flues are the ducts, which are provided in masonry itself.

The draught in this boiler is produced by chimney. The hot gases starting from the grate travel all along the flues tubes; and thus transmits heat through the surface of the flues. On reaching at the back end of the boiler they go down through a passage, they heat water through the lower portion of the main water shell. On reaching again at front end they bifurcate to the side flues and travel in the forward direction till finally they reach in the smoke chamber from where they pass onto chimney.

During passage through the side flues also they provide heat to the water through a part of the main shell. Thus it will be seen that sufficient amount of area is provided as heating surface by the flue tubes and by a large portion of the shell. Operating the dampers L placed at the exit of the flues may regulate the flow of the gases. Suitable firebricks line the flues. The boiler is equipped with suitable Firebricks line the flues. The boiler is equipped with suitable mountings and accessories.

There is a special advantage possessed by such types of boilers. The products of combustion are carried through the bottom flues only after they have passed through the main flue tubes, hence the hottest portion does not lie in the bottom of the boiler, where the sediment contained in water as impurities is likely to fall. Therefore there are less chances of unduly heating the plates at the bottom due to these sediments.

Result: The Lancashire boiler has been studied.

LEAD EXPERIMENT

SINGLE CYLINDER 4 STROKE BIO DIESEL ENGINE TEST RIG WITH VARIABLE COMPRESSION RATIO ATTACHMENT

AIM:

To study and understand the performance characteristics of the engine.

Apparatus:

- Dynamometer
- Diesel engine
- Calorimeter
- Bio Diesel
- Electrical connections

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. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

Eddy Current Dynamometer Loading

- The equipment consists of a Brand new KIRLOSKAR make AV1 model Diesel Engine (Crank started) of 5hp (3.7kW) capacity and is Water cooled.
- The Engine is coupled to a Eddy Current Dynamometer for Loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the Load Cell with digital load indication**.**
- Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
- Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
- Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
- A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
- A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
- The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
- The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

- Give the necessary electrical connections to the panel.
- Check the lubricating oil level in the engine.
- Check the fuel level in the tank.
- Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6 lpm & 3lpm respectively.
- Release the load if any on the dynamometer.

- Open the three-way cock so that fuel flows to the engine.
- Start the engine by cranking.
- Allow to attain the steady state.
- Set the compression Ratio – see Annexure I for detail
- Switch on the Load controller and slowly load the engine by rotating the knob clockwise.
- Note the following readings for particular condition,
    1. Engine Speed
    2. Time taken for ____cc of diesel consumption
    3. Rota meter reading.
    4. Manometer readings, in cms of water &
    5. Temperatures at different locations.
- Repeat the experiment for different loads and note down the above readings.
- After the completion release the load and then switch of the engine.
- Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	**Compression Ratio**	**Speed, rpm**	**Load Applied**	**Manometer Reading**			**Time for 10cc of fuel collected, t sec**
				h_1	**h_2**	**h_w**	
1	**23.12**	**1542**	**2**	**1**	**0.7**	**1.7**	**56**
2	**23.12**	**1532**	**4**	**1**	**0.8**	**1.8**	**46**
3	**12.02**	**1522**	**2**	**0.5**	**0.5**	**1**	**37**
4	**12.02**	**1505**	**4**	**0.5**	**0.5**	**1**	**30**

CALCULATIONS:

1) **Mass of fuel consumed, mf**

$$m_f = \frac{X_{cc} \text{ x Specific gravity of the fuel}}{1000 \text{ x } t}$$

Where,

Specific Gravity of Bio Diesel is = 0.88

X cc is the volume of fuel consumed = 10ml

t is time taken in seconds

1. $m_f = \frac{\times 0.88}{\times 1000}$ $=1.57\text{x}10^{-4}$ kg/s
2. m_f= 1.913 10^{-4} kg/s
3. m_f = 2.378 10^{-4} kg/s
4. m_f = 2.933 10^{-4} kg/s

2) **Heat Input, HI**

$$\textbf{HI} = \mathbf{m_f} \textbf{ x Calorific Value of Fuel} \quad \textbf{kW}$$

Where,

Calorific Value of Bio Diesel = 37270 KJ/Kg

1. HI = m_f x C.V =5.851kW
2. HI =m_f x C.V =7.129kW
3. HI =m_f x C.V =8.862kW

4. HI $= m_f \times C.V = 10.931$ kW

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

Engine output BP = $\frac{2\Pi NT}{60000}$ **kW**

Where,

N is speed in rpm

T = Torque on the load indicator

T = F x r x 9.81 N-m

r = Torque arm radius = 0.15m

a) BP $= \frac{\times 1542 \times 2.943}{60000}$ = 0.4752 kW

b) BP=0.944 kW

c) BP=0.469 kW

d) BP=0.9276kW

4) **Specific Fuel Consumption, SFC**

SFC = $\frac{m_f \times 3600}{BP}$ **kg/kW – hr**

1. SFC = 1.189 kg/kW – hr

2. SFC= 0.7295 kg/kW – hr

3. SFC= 1.825 kg/kW – hr

4. SFC= 1.138 kg/kW – hr

5) **Brake Thermal Efficiency, η_{bth}**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

η_{bth} = **8.123**

η_{bth} = **13.24**

η_{bth} = **5.29**

η_{bth} = **8.48**

6) Mechanical Efficiency, η_{mech}

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

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

IP = BP ÷ FP

From the Willan's Graph Frictional Power is obtained.

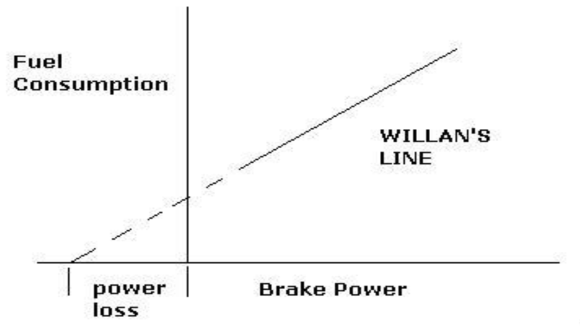
IP = 0.4752+1.2

= 1.67 kW

IP = 2.14 kW

IP = 1.77 kW

IP = 2.22 kW



1.η_{mech} = 28%

2.η_{mech} =44%

3.η_{mech} =26%

4.η_{mech} =41.65%

7) Calculation of head of air, H_a

$$H_a = h_w \frac{\rho_{water}}{\rho_{air}}$$

Where,

ρ_{water} = 1000 Kg/m³

ρ_{air} = 1.2 Kg/m³ @ R.T.P

h_w is the head in water column in 'm' of water

H_a = 14.166 m

H_a = 15 m

H_a = 8.33 m

H_a = 8.33 m

8) **Volumetric efficiency, η_{vol}**

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

Where,

Q_a = Actual volume of air taken = Cd a √ (2gHa)

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.02)²/4)

Ha = head in air column, m of air.

5. **Q_a = 0.003306** m^3/s
6. **Q_a = 0.003344** m^3/s
7. **Q_a = 0.00249** m^3/s
8. **Q_a = 0.00249** m^3/s

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\pi/4) \times D^2 \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

I. **Q_{th}** = 0.007105 m^3/s

II. **Q_{th}** = 0.007058 m^3/s

III. **Q_{th}** = 0.00701 m^3/s

IV. **Q_{th}** = 0.00693 m^3/s

a) **η_{vol} = 46.53%**

b) **η_{vol} = 47.38%**

c) **η_{vol} = 35.55%**

d) **η_{vol} = 35.95%**

PRECAUTIONS:

- Do not run the engine if supply voltage is less than 180V
- Do not run the engine without the supply of water.
- Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
- Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
- Do not forget to give electrical earth and neutral connections correctly.
- Frequently, at least once in three months, grease all visual moving parts.
- At least once in week, operate the unit for five minutes to prevent any clogging of moving parts
- It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.
- In case of any major faults, Please write to the manufacturers and do not attempt to repair.

SETTING THE COMPRESSION RATIO

Follow the procedure below to set the compression ratio:

- Start the engine at higher compression Ratio.
- Allow the engine to attain the steady speed.
- Rotate the Wheel provided on the head to vary the *Compression Ratio.(See the below Table for Compression Ratio Reading scale)
- Continue doing till the required compression ratio is set.

NOTE:

5. You can change the compression ratio when the engine is running.
6. Compression ratio from **12.2 to 23.1** can be set.
7. Lower compression ratio has to be set from the maximum compression ratio only.
8. Engine cannot be started instantaneously at lower compression ratio.

SCALE FOR VARIABLE COMPRESSION RATIO:

Reading on Scale, ‘mm’	**Compression Ratio**
0.0	23.12
0.5	21.10
1.0	19.43
1.5	18.00
2.0	16.77
2.5	15.72
3.0	14.80
3.5	14.00
4.0	13.25
4.5	12.61
5.0	12.02

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1	1.67	0.4752	1.189	8.123	28	46
2	2.14	0.944	0.7295	13.24	44	47
3	1.77	0.469	1.825	5.29	26	35
4	2.22	0.9276	1.138	8.48	41	36

Result:

The performance of variable compression ratio with Bio Diesel has been performed