LAB MANUAL

III Year B. Tech I - Semester

MECHANICAL ENGINEERING

AY: 2025-26

THERMAL ENGINEERING LAB

R22A0386

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

(Autonomous Institution-UGC, Govt. of India)
Secunderabad-500100, Telangana State, India.
www.mrcet.ac.in

MRCET CAMPUS

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(AUTONOMOUS INSTITUTION - UGC, GOVT. OF INDIA)

Affiliated to JNTUH; Approved by AICTE, NBA-Tier 1 & NAAC with A-GRADE | ISO 9001:2015

Maisammaguda, Dhulapally, Komaplly, Secunderabad - 500100, Telangana State, India

LABORATORY MANUAL & RECORD

Name:...

Roll No:.......... Branch:..

Year:........... Sem:...

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Certificate

Certified that this is the Bonafide Record of the Work Done by Mr./Ms...Roll.No...................of B.Tech year .... Semester for Academic year 2025-2026 in...Laboratory.

Date: Faculty Incharge HOD

Internal Examiner External Examiner

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- To become a model institution in the fields of Engineering, Technology and Management.
- To impart holistic education to the students to render them as industry ready engineers.
- To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- To provide state of art infrastructure and expertise to impart quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never – ending ladder of **SUCCESS** year after year.

For more information: www.mrcet.ac.in

VISION

To become an innovative knowledge center in mechanical engineering through state-of-the-art teaching-learning and research practices, promoting creative thinking professionals.

MISSION

The Department of Mechanical Engineering is dedicated for transforming the students into highly competent Mechanical engineers to meet the needs of the industry, in a changing and challenging technical environment, by strongly focusing in the fundamentals of engineering sciences for achieving excellent results in their professional pursuits.

Quality Policy

- ✓ To pursuit global Standards of excellence in all our endeavors namely teaching, research and continuing education and to remain accountable in our core and support functions, through processes of self-evaluation and continuous improvement.
- ✓ To create a midst of excellence for imparting state of art education, industry-oriented training research in the field of technical education.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

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Department of Mechanical Engineering

PROGRAM OUTCOMES

Engineering Graduates will be able to:

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 teamwork**: 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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Ability to analyze, design and develop Machine learning systems to solve the Engineering problems by integrating design and manufacturing Domains.

PSO2 Ability to succeed in competitive examinations or to pursue higher studies or research.

PSO3 Ability to apply the learned Mechanical Engineering knowledge for the Development of society and self.

Program Educational Objectives (PEOs)

The Program Educational Objectives of the program offered by the department are broadly listed below:

PEO1: PREPARATION

To provide sound foundation in mathematical, scientific and engineering fundamentals necessary to analyze, formulate and solve engineering problems.

PEO2: CORE COMPETANCE

To provide thorough knowledge in Mechanical Engineering subjects including theoretical knowledge and practical training for preparing Artificial models pertaining to Automobile Engineering, Element Analysis, Production Technology, Mechatronics etc.,

PEO3: INVENTION, INNOVATION AND CREATIVITY

To make the students to design, experiment, analyze, interpret in the core field with the help of other inter disciplinary concepts wherever applicable.

PEO4: CAREER DEVELOPMENT

To inculcate the habit of lifelong learning for career development through successful completion of advanced degrees, professional development courses, industrial training etc.

PEO5: PROFESSIONALISM

To impart technical knowledge, ethical values for professional development of the student to solve complex problems and to work in multi-disciplinary ambience, whose solutions lead to significant societal benefits.

CODE OF CONDUCT

1. Students should bring lab Manual/Record for every laboratory session and should enter the readings/observations in the manual while performing the experiment.
2. The group- wise division made in the beginning should be adhered to, and no mix up of students among different groups will be permitted later.
3. The components required pertaining to the experiment should be collected from stores in –charge after duly filling in the requisition form.
4. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
5. Any damage to the apparatus that occurs during the experiment should be brought to the notice of lab in-charge, consequently, the cost of repair or new apparatus should be brought by the students.
6. After completion of the experiment, certification of the concerned staff in –charge in the observation book is necessary.
7. Students should be present in the labs for the total scheduled duration.
8. Students should not carry any food items inside the laboratory.
9. Use of cell phones and IPODs are forbidden.
10. Students should not write on or deface any lab desks, computers, or any equipment provided to them during the experiment.
11. Every student should keep his/her work area properly before leaving the laboratory.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

III Year B. TECH - I- SEM **L/T/P/C**
-/-/2/1

(R22A0386) THERMAL ENGINEERING LAB

COURSE OBJECTIVES:

1. To study procedure to draw the valve and port timing diagram of CI/SI engines.
2. To understand the performance characteristics of CI/SI engines in terms of heat balancing, economical speed variations, air fuel ratio influence on the engine
3. To demonstrate and understand Morse test on multi cylinder SI engine
4. To understand working and performance of Reciprocating air compressor
5. To Study Design and working of the different types of boilers.

LIST OF EXPERIMENTS

1. Dis-assembly / Assembly of Engines
2. I.C. Engine Valve / Port Timing Diagrams
3. I.C. Engine Performance Test for 4 Stroke SI engines
4. I.C. Engine Performance Test for 2 Stroke SI engines
5. I.C. Engine Morse/ Retardation/ Motoring Tests
6. I.C. Engine Heat Balance - CI/SI Engines
7. I.C. Engine Economical speed Test on a SI engine
8. I.C. Engine Effect of A/F Ratio in a SI engine
9. Performance Test on Variable Compression Ratio of IC Engine
10. IC Engine Performance Test on a 4S CI Engine at constant speed
11. Volumetric efficiency of Air - Compressor Unit
12. Study of Boilers

NOTE: Minimum a total of 10 experiments are to be conducted.

COURSE OUTCOMES:

1. To draw the valve and port timing diagram of CI/SI engines.
2. Calculate & compare the performance characteristics of Diesel and Petro engines.
3. Apply the concept of Morse test on multi cylinder SI engine.
4. Analyze the efficiency of reciprocating air compressor.
5. Understand the working of boilers.

Experiment No: I **Date:**

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 etc.

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 I.C. Engine

Cylinder, Cylinder head, Piston, Piston rings, Gudgeon pin, Connecting rod, Crankshaft, Crank, Engine bearing, Crank case, Flywheel etc.

Parts of a 4- Stroke Petrol Engine

Cylinder Head

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 wrist pin.

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 to 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:

1) Dismantle the following system
   a) Fuel supply system
   b) Electrical system
2) Remove the spark plug from the cylinder head.
3) Remove the cylinder head nut and bolts.
4) Separate the cylinder head from the engine block.
5) Remove the carburetor from the engine.
6) Open the crank case.
7) Remove piston rings from the piston.
8) Clean the combustion chamber.
9) Reassemble the components vice versa.

Precautions:

* Don"t use loose handle of hammer.
* Care must be taken while removing the components.

Result:

A 4 – stroke petrol engine has been dismantled and reassembled.

Experiment No: II **Date:**

I.C. ENGINES VALVE TIMING DIAGRAM

AIM: The experiment is conducted to

- Determine the actual valve timing for a 4-stroke diesel engine and hence draw the 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 IN DEGREES
		cm	mm	
1	TDC – Inlet Valve Open			
2	BDC – Inlet Valve Open			
3	TDC – Exhaust Valve Close			
4	BDC – Exhaust Valve Close			

CALCULATIONS:

1. Diameter of the flywheel, D $= \dfrac{\text{Circumference of the flywheel}}{\pi}$

2. Angle (θ) in degrees,

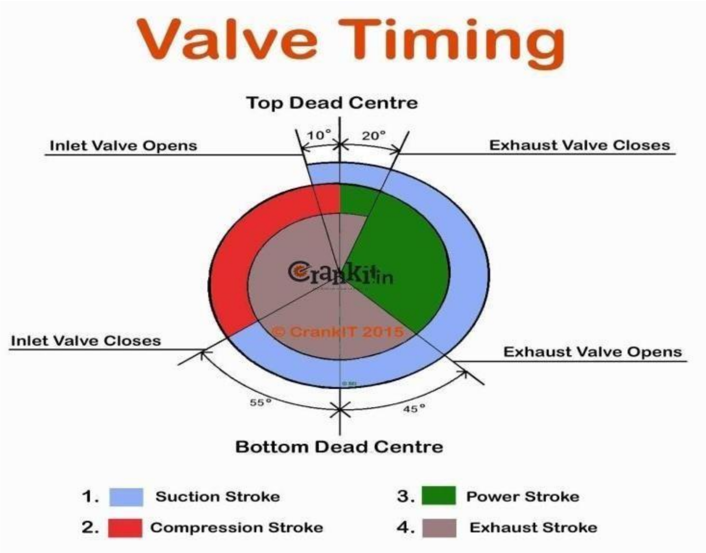
$$\theta = \frac{S\ X\ 360}{\mathrm{D\ X\ \pi}}$$

Where,

S = Arc length, mm

RESULT:

Valve Timing diagram is drawn



PORT TIMING DIAGRAM

AIM: The experiment is conducted to

- Determine the actual PORT timing for a 2-stroke Petrol engine and hencedraw the diagram.

PROCEDURE:

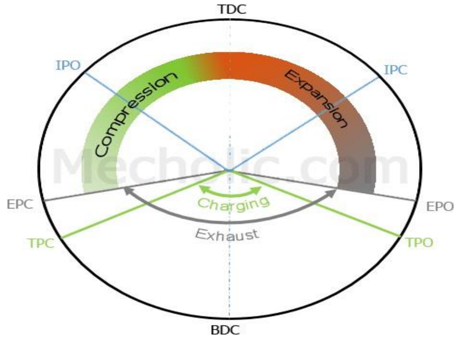
1) Bring the Piston to Top and start as if from the spark.
2) Rotate the flywheel till the Exhaust port opens and note the reading.
3) Continue the same way and note the reading for the Transfer port.
4) Continue to rotate the flywheel till the Piston moves from BDC to TDC and note down the closing of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

OBSERVATIONS:

Sl. No.	Valve Position	Angle 'θ' in degrees
1	Transfer Port open	
2	Transfer Port Close	
3	Exhaust Port Open	
4	Exhaust Port Close	

RESULT:

Port Timing diagram is drawn.



Experiment No: III **Date:**

PERFORMANCE TEST ON SINGLE CYLINDER FOUR STROKE PETROLENGINE

AIM

To conduct a performance test on four stroke single cylinder petrol engine.

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, thermodynamiccycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

INSTRUMENTATION

Digital RPM indicator to measure the speed of the engine.
Digital temperature indicator to measure various temperatures.
Differential manometer to measure quantity of air sucked into cylinder.
Burette with manifold to measure the rate of fuel consumed during test.

ENGINE SPECIFICATION

ENGINE	:	YAMAHA
BHP	:	3 HP
RPM	:	3000 RPM
FUEL	:	PETROL
NUMBER OF CYLINDERS	:	SINGLE
BORE	:	70 mm
STROKE LENGTH	:	66.7 mm
STARTING	:	ROPE & PULLEY STARTING
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	AIR COOLED
METHOD OF IGNITION	:	SPARK IGNITION
ORIFICE DIAMETER	:	20 mm

COMPRESSION RATIO	:	4.67
SPARK PLUG	:	MICO W 160Z2
CARBURATOR	:	YAMAHA 1320
GOVERNOR SYSTEM	:	MECHANICAL GOVERNOR
TYPE	:	SELF EXCITED, DC SHUNT GENERATOR
POWER	:	1.5 KW
SPEED	:	3000 RPM (Max. speed to run as dc motor: 2600 RPM)
RATED VOLTAGE	:	220 v DC

RESISTANCE LAMP BANK SPECIFICATION:

RATING	:	2.5 Kw, 1Φ(single phase)
VARIATION	:	In 10 steps, by dc switches.
COOLING	:	Air cooled

DESCRIPTION:

This engine is a four stroke single cylinder, air – cooled, spark ignition type petrol engine. It is coupled to a loading system which is in this case is a DC GENERATOR, having a resistive lamp bank which will take load with the help of dc switches and also providing motoring test facility to find out frictional power of the engine.

FUEL MEASUREMENT:

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel engine (Burette) with 3 – way cock. To measure the fuel consumption of the engine, fill the burette by opening the cock. By starting a stop clock, measure the time taken to consume X cc of fuel by the engine.

AIR INTAKE MEASUREMENT:

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

LUBRICATION:

The engine is lubricated by mechanical lubrication.
Lubricating oil recommended – SAE – 40 OR Equivalent.

TEMPERATURE MEASUREMENT:

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

THERMOCOUPLE DETAILS:

T1 = INLET WATER TEMPERATURE OF ENGINE JACKET & CALORIMETER.
T2 = OUTLET WATER TEMPERATURE OF ENGINE JACKET.
T3 = TEMPERATURE OF WATER OUTLET FROM CALORIMETER.
T4 = TEMPERATURE OF EXHAUST GAS INLET TO CALORIMETER.
T5 = TEMPERAUTRE OF EXHAUST GAS OUTLET FROM CALORIMETER.
T6 = AMBIENT TEMPERATURE.

LOADING SYSTEM:

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

PROCEDURE:

1. Connect the instrumentation power input plug to a 230v, 50 Hz AC single phase AC supply. Now all the digital meters namely, RPM indicator, temperature indicator display the respective readings.
2. Fill up the petrol to the fuel tank mounted behind the panel.
3. Check the lubricating oil level in the oil sump with the dipstick provided.
4. Start the engine with the help of rope and pulley arrangement.
5. Allow the engine to stabilize the speed i.e. 2800 RPM by adjusting the accelerator knob.
6. Keep the changeover switch in the generator direction.
7. Apply ¼ load (1.9 Amps).
8. Note down all the required parameters mentioned below.
   a. Speed of the engine in RPM.
   b. Load from ammeter in amps.
   c. Burette reading in cc.
   d. Manometer reading in mm.
   e. Time take for consumption of Xcc petrol.
   f. Exhaust gas temperature in degree C.

9. Load the engine step by step with the use of dc switches provided on the load bank such as,
   1/2 load = 3.2 A / 3.8 A
   3/4 load = 4.7 A / 5.7 A
   Full load = 6.3 A / 7.6 A
10. Note down all required readings.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied	Manometer Reading (cm of water)			Time collected for 10cc of fuel, (t sec)
		'F' kW	h1	h2	hw =(h1+h2)	

ENGINE PERFORMANCE:

1. **BRAKE POWER**

$$BP = \frac{VI}{1000 \text{ x } \eta g} \text{ KW}$$

Where, V = DC voltage in volts.
I = DC current in amps.
η_g = efficiency of generator = 85%

2. **MASS OF FUEL CONSUMED.**

$$m_f = \frac{X \text{ x } 0.72 \text{ x } 3600}{1000 \text{ x } t} \text{ kg/hr}$$

Where, X = burette reading in cc
Density of petrol = 0.72 gram / cc
t = time taken in seconds.

3. **SPECIFIC FUEL CONSUMPTION.**

$$SFC = \frac{m_f}{BP} \text{ Kg/kWh}$$

4. **ACTUAL VOLUME OF AIR SUCKED IN TO THE CYLINDER.**

$$V_a = C_d \text{ x A x 2 x g x H x 3600} \quad m^3/hr$$

Where, $H = \frac{h \text{ x } \rho_w}{1000 \text{ x } \rho_a}$ meter of water

A = area of orifice = $\Pi d^2 / 4$
h = manometer reading in mm
ρ_w= density of water=1000 kg/m^3
ρ_a = density of air = 1.193 kg/ m^3
C_d = co-efficient of discharge = 0.62

5. SWEPT VOLUME:

$$V_s = \frac{\pi}{4} \text{ x } d^2 \text{ x L} \qquad m^3$$

Where, d = diameter of bore = 70 mm
L = length of stroke = 66.7 mm

6. VOLUMETRIC EFFICIENCY:

$$\eta_v = \frac{V_a}{V_s} \text{X}100 \qquad \%$$

7. BRAKE THERMAL OR OVER ALL EFFICIENCY

$$\eta_{bth} = \frac{\text{BP x 3600 x 100}}{m_f \text{ x CV}} \qquad \%$$

Where, CV = Calorific value of petrol = 43500 kJ / kg.
BP = Brake Power in kW.

8. INDICATED THERMAL EFFICIENCY:

$$\eta_{ith} = \frac{\text{IP x 3600 x 100}}{m_f \text{ x CV}} \qquad \%$$

9. MECHANICAL EFFICIENCY:

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

Where, BP = Brake Power in kW.
IP = Indicated power in kW.

RESULT:

Experiment No: IV **Date:**

I.C. ENGINES PERFORMANCE TEST ON 2-STROKE PETROL ENGINE

AIM:

The experiment is conducted to

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

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:

The test rig is built for loading mentioned below:

a. <u>Electrical Dynamometer Loading (AC)</u>

1) The equipment consists of a **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.
2) The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachment for varying the spark timing
3) Thermocouples are provided at appropriate positions and are read by digital temperature indicator with channel selector to select the position.
4) Engine Speed at various condition s is determined by a Digital RPM Indicator.
5) Load on the engine is measured by means of Electrical Energy meter.
6) 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 a Manometer.
7) A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

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 three-way cock 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 0.5kW)
10. 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.
11. Repeat the experiment for different loads and note down the abovereadings.
12. After the completion release the load (while doing so release theaccelerator) 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	Manometer Reading (cm of water)			Time collected for 10cc of fuel (t sec)	Time for 5 rev of Energy meter (T in secs)
		'F' kW	h1	h2	hw =(h1+h2)		

Sl. No.	Temperature, °C	
	T1	T2

CALCULATIONS:

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

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

Where,

SG of Petrol = 0.71

X_{cc} is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

HI = m_f x Calorific Value of Fuel, **kW**

Where,

Calorific Value of Petrol = 43,120 KJ/Kg

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

$$\text{BP} = \frac{\text{n x 3600}}{\text{K x T x } \eta\text{m}} \text{ KW}$$

Where,

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

K = Energy meter constant

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

η_m = efficiency of belt transmission = 80%

4. Specific Fuel Consumption, SFC

$$SFC = \frac{m_f \text{ x } 3600}{BP} \text{ Kg/kWh}$$

5. Brake Thermal Efficiency, η_{bth}

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

6. Calculation of head of air, Ha

$$H = \frac{h_w \text{ x } \rho_{water}}{1000 \text{ x } \rho_a} \text{ meter of water}$$

Where,

ρ_{water} = 1000 Kg/m

ρ_{air} = 1.2 Kg/m @ R.T.P

h_w is the head in water column in meter of water

7. Volumetric efficiency, η_v

$$\eta_v = \frac{Q_a}{Q_{the}} \text{ x } 100 \quad \%$$

Where,

Q_a = Actual volume of air taken

$$Q_a = C_d \text{ x a x } \sqrt{2 \text{ x g x } H_a}$$

Where,

Cd = Coefficient of discharge of orifice = 0.62

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

Ha = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{\pi/4 \text{ x } D^2 \text{ x L x GR x 0.5 x N}}{60}$$

Where,

D = Bore diameter of the engine =

0.057mL = Length of the Stroke =

0.057m

N = speed of the engine in rpm.

GR = gear ratio

1st gear = 14.47:1
2nd gear = 10.28:1
3rd gear = 7.31:1
4th gear = 5.36:1

TABULATION:

Sl.	Input Power	Output Power, BP	SFC	Brake Thermal Efficiency	Volumetric efficiency
1					
2					
3					
4					

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameter, engine head and calorimeter.
4. 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.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Switch off the ignition of AUXILLARY while doing in the engine arrangement.
7. Do not forget to give electrical earth and neutral connections correctly.
8. It is recommended to run the engine at **1000rpm** otherwise the rotating parts and bearing of engine may run out.

RESULT: Graphs to be plotted:

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

Experiment No: V **Date:**

DETERMINATION OF FHP BY MORSE/ RETARDATION/ MOTORING TEST ON IC ENGINE

AIM:

To measure the FP of the given 4-stroke single cylinder petrol engine by motoring test

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.

INSTRUMENTATION:

Digital RPM indicator to measure the speed of the engine.

Digital temperature indicator to measure various temperatures.

.Differentialmanometer to measure quantity of air sucked into cylinder.

Burettewith manifold to measure the rate of fuel consumed during test.

ENGINE SPECIFICATION:

ENGINE	:	YAMAHA
BHP	:	3 HP
RPM	:	3000 RPM
FUEL	:	PETROL
No. of CYLINDERS:		SINGLE
BORE	:	70 mm
STROKE LENGTH	:	66.7 mm
STARTING	:	ROPE & PULLEY STARTING
WORKING CYCLE	:	FOUR STROKE

METHOD OF COOLING	:	AIR COOLED
METHOD OF IGNITION	:	SPARK IGNITION
ORIFICE DIA.	:	20 mm
COMPRESSION RATIO	:	4.67
SPARK PLUG	:	MICO W 160Z2
CARBURATOR	:	YAMAHA 1320
GOVERNOR SYSTEM	:	MECHANICAL GOVERNOR
TYPE	:	SELF EXCITED, DC SHUNT GENERATOR
POWER	:	1.5 KW
SPEED	:	3000 RPM RATED
VOLTAGE	:	220 v DC

(Max. speed to run as dc motor : 2600 RPM)

RESISTANCE LAMP BANK SPECIFICATION:

RATING	:	2.5 Kw, 1Φ (single phase)
VARIATION	:	In 10 steps, by dc switches.
COOLING	:	Air cooled

DESCRIPTION:

This engine is a four stroke single cylinder, air – cooled, spark ignition type petrol engine. It is coupled to a loading system which is in this case is a DC GENERATOR, having a resistive lamp bank which will take load with the help of dc switches and also providing motoring test facility to find out frictional power of the engine.

FUEL MEASUREMENT:

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel engine (Burette) with 3 – way cock. To measure the fuel consumption of the engine, fill the burette by opening the cock. By starting a stop clock, measure the time taken to consume X ccof fuel by the engine.

AIR INTAKE MEASUREMENT:

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

LUBRICATION:

The engine is lubricated by mechanical lubrication.
Lubricating oil recommended – SAE – 40 OR Equivalent.

TEMPERATURE MEASUREMENT:

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

LOADING SYSTEM:

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

PROCEDURE:

1. To conduct the motoring test, first connect the rectifier to the panel board.
2. Remove the spark plug connection from the engine & switch off the ignition switch.
3. Keep the changeover switch in the motoring direction.
4. Now slowly increase the power using variac provided in the rectifier circuit.
5. Increase the speed up to 2800 rpm and note down the armature current and voltage.
6. Now slowly decrease the power and turn the changeover switch to off condition.

OBSERVATIONS:

S.No	Speed(N)	Voltage (V)	Current(I)	F.P
1				
2				
3				

CALCULATIONS:

FRICTIONAL POWER OF THE ENGINE (FP)

$$FP = \frac{V \times I}{1000 \times \eta} \text{ KW}$$

Where,

η engine efficiency = 55 % (0.55)

Result: Hence the Total FP has been determined by conducting motoring test.

Experiment No: VI **Date:**

I.C. ENGINES HEAT BALANCE ON DIESEL ENGINES

AIM:

The experiment is conducted to

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

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:

The test rig is built for loading mentioned below:

b. <u>Mechanical Loading (Water cooled)</u>

1. The equipment consists of **KIRLOSKAR** 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.
2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water

flow rate to the engine and calorimeter respectively.

4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. 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 Manometer.
6. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

THERMOCOUPLE DETAILS:

T1 = INLET WATER TEMPERATURE OF ENGINE JACKET & CALORIMETER.

T2 = OUTLET WATER TEMPERATURE OF ENGINE JACKET.

T3 = TEMPERATURE OF WATER OUTLET FROM CALORIMETER.

T4 = TEMPERATURE OF EXHAUST GAS INLET TO CALORIMETER.

T5 = TEMPERAUTRE OF EXHAUST GAS OUTLET FROM CALORIMETER.

T6 = AMBIENT TEMPERATURE.

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 6lpm & 3lpm 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 condition,
    a. Engine Speed
    b. Time taken for_____cc of diesel consumption
    c. Rotameter reading.
    d. Manometer readings, in cm 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.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied			Manometer Reading (cm of water)			Time collected for 10cc of fuel (t sec)
		F1	F2	F =F1 – F2	h1	h2	hw =(h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate,LPM2

CALCULATIONS:

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

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

Where,

SG of Diesel = 0.827

X_{cc} is the volume of fuel consumed = 10ml

t is time taken in seconds

2. Heat Input, HI

HI = $\boldsymbol{m_f}$ x Calorific Value of Fuel, kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. Output or Brake Power, BP

$$\mathrm{BP} = \frac{2\mathrm{x}\pi\mathrm{xNxT}}{60000}\ \mathrm{KW}$$

Where,

N = speed in rpm

T = F x r x 9.81 N-m

r = 0.15 m

4. Specific Fuel Consumption, SFC

$$\mathrm{SFC} = \frac{m_f \mathrm{x3600}}{\mathrm{BP}}\ \mathrm{Kg/kWh}$$

5. Brake Thermal Efficiency, $\boldsymbol{\eta_{bth}}$

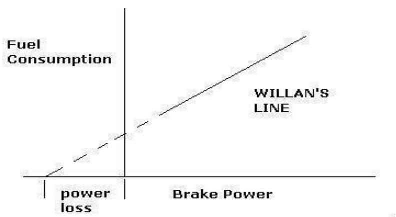
$$\eta_{bth} = \frac{\mathrm{BP\ x\ 3600\ x\ 100}}{m_f\ \mathrm{x\ \ CV}} \qquad \%$$

6. Mechanical Efficiency, $\boldsymbol{\eta_{mech}}$

$$\eta_{mech} = \frac{\mathrm{BP\ x\ 100}}{\mathrm{IP}} \qquad \%$$

Determine the IP = Indicated Power, using WILLAN"S LINE method and theprocedure 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 givethe Power losses (Friction Power loss)
- With this the IP can be found using the relation:



- IP = BP + FP

HEAT BALANCE:

1. **Heat Input (A)**

$$A = m_f \text{ x Calorific Value of Fuel, KW}$$

2. **Heat to BP (out put) (B)**

$$BP = \frac{2x\pi xNxT}{60000} \text{ KW}$$

3. **Heat to colling water (C)**

$$C = m_{we} \text{ x } C_{pw} \text{ x } (T_{ei} - T_{eo}) \text{ KW}$$

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

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

= LPM / 60 kg/sec

4. **Heat to Exhaust gases (D)**

$$D = m_{wc} \text{ x } C_{pw} \text{ x } (T_{ci} - T_{co}) \text{ x } [(T_{gci} - T_a)/ (T_{gco} - T_{gci})] \text{ kW}$$

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

Tgco = Gas outlet temp from calorimeter

Tci = Water Inlet temp to calorimeter

Tco = Water outlet temp from calorimeter

5. **Heat Unaccounted (E)**

$$E = A - (B + C + D) \text{ kW}$$

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameter, engine head and calorimeter.
4. 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.
5. Do not forget to give electrical earth and neutral connections correctly.
6. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

RESULT:

Graphs to be plotted:

4) SFC v/s BP
5) η_{bth} v/s BP
6) η_{mech} v/s BP
4) η_{vol} v/s BP

Experiment No:VII **Date:**

ECONOMICAL SPEED TEST ON 4-STROKE, MULTI CYLINDER PETROL ENGINE TEST RIG

AIM: To conduct an economical speed test on 4-stroke 4-cylinder petrol engine at various loads, for a given output.

EQUIPMENT REQUIRED:

1. 4-stroke, 4 -cylinder petrol engine with a hydraulic dynamometer.
2. Tachometer (0-2000 rpm)
3. Stop watch

SPECIFICATIONS:

Make	:	Ambassador
No. of cylinders	:	4
Bore	:	73 mm
Stroke	:	90 mm
Rated Speed	:	1500 rpm
B. P.	:	7.35 KW (10 HP)
Orifice Diameter	:	35mm
Fuel	:	Petrol
Specific Gravity of petrol	:	0.716
Density of petrol	:	716 kg/m3
Caloric value of petrol	:	47100 KJ/kg

DESCRIPTION:

The test rig consists of a multi cylinder petrol engine coupled to a hydraulic Dynamometer. The engine is Ambassador Brand and is 4-cylinder 4-stroke vertical engine developing 7.35 KW (10HP) at 1500 rpm. This type of engine is best suited for automobiles which operate at varying speed. The engine is fitted on a rigid bed and is coupled through a flexible coupling to a hydraulic dynamometer, acts as the loading device. All the instruments are mounted on a suitable panel board. Fuel consumption is measured with a burette and a 3-way cock which regulates the flow of fuel from the tank to the engine.

Air consumption is measured by using a M.S. tank, which is fitted with a standard orifice and a U-tube water manometer that measures the pressures inside the tank.

STARTING THE ENGINE:

1. Disengage the clutch and start the engine using the ignition key.
2. Engage the clutch slowly.
3. Adjust the throttle valve, so that the engine attains rated speed.

PROCEDURE:

1. Before stating the engine, calculate the net load to be applied on hydraulic dynamometer at different speeds for maintaining constant B.P of the engine
2. Open the three way cock so that fuel flows to the engine directly from the tank.
3. Open the cooling water valves and ensure water flows through the engine.
4. Open the water line to the hydraulic dynamometer.
5. Start the engine and allow it to run on no load for a few minutes.
6. Operate the throttle valve so that the engine picks up the speed to the required level.
7. The engine is loaded to the calculated value with hydraulic dynamometer is done by turning the handle in the direction marked. If sufficient loaded is not absorbed by the dynamometer at the required speed, the outlet valve in the dynamometer can be closed to increase the pressure (as indicated by the pressure gauge) and hence the load.
8. Regulate the speed to the desired value by controlling the fuel supply to the engine
9. Note down the time taken for 10cc fuel consumption
10. Repeat the above procedure at different speeds under constant B.P of the engine
11. Repeat the above procedure for another constant B.P

PRECAUTIONS:

1. Before stating the engine check all the systems such as cooling , lubrication and fuel system
2. Ensure oil level is maintained in the engine upto recommended level always. Never run the engine with insufficient oil.
3. Never run the engine with insufficient engine cooling water and exhaust gas calorimeter cooling water.
4. For stopping the engine, load on the engine should be removed.

GRAPHS:

1. T.F.C Vs Speed

TFC ,Kg/hr

Speed

OBSERVATIONS:

Sl. No.	Load on the Dynamometer, W Kg	Speed, Rpm	Time for 10cc of fuel (sec)	T.F.C Kg/hr
1				
2				
3				
4				
5				
6				

SAMPLE CALCULATIONS:

$$\text{Brake Power } (BP_{max}) = \frac{W_{max} \text{ x N}}{2000 \text{ x } 1.36} \text{ KW}$$

Where,

N= rated speed …… rpm,

W_{max}= Full load on the Dynamometer.... Kg

$$\text{Full Load } (W_{max}) = \frac{BP \text{ x } 2000 \text{ x } 1.36}{N} \text{ KW}$$

If Output power, B.P = I/2 $B.P_{max}$

Load on Dynamometer, W = B.P x 2000 x 1.36 x N x N

Time for 10 cc of fuel consumption, t = sec

$$Mass\ of\ fuel\ consumption\ per\ min, m_f = \frac{10 \text{ x density of diesel x } 60}{1000 \text{ x t}} \text{ kg/min}$$

Total Fuel Consumption, TFC = m_f x 60….kg / hr.

RESULT:

Experiment No: VIII **Date:**

DETERMINATION OF AIR/FUEL RATIO AND VOLUMETRIC EFFICIENCY ON 4-STROKE DIESEL ENGINE

AIM: To determine A/F Ratio and Volumetric Efficiency on the four stroke twin cylinder diesel engine

DESCRIPTION: The A.C. generator is fixed to the Engine shaft and is mounted on a M.S. Channel Frame. Panel board is used to fix burette with 3-way cock, digital RPM indicator and "U" tube manometer.

INSTRUMENTATION:

1. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
2. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
3. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
4. 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 a Manometer.
5. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

PROCEDURE:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. 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.
5. Do not forget to give electrical earth and neutral connections correctly.
6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging ofmoving parts.
8. It is recommended to run the engine at **1500rpm** otherwise the rotatingparts and bearing of engine may run out.

FUEL MEASUREMENT

The fuel supplied from the main fuel tank through a measuring burette with 3 way manifold system. To measure the fuel consumption of the engine fill the burette by opening the cock measure the time taken to consume X cc of fuel.

AIR INTAKE MEASUREMENT:

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

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied			Manometer Reading (cm of water)			Time collected for 10cc of fuel (t sec)
		F1	F2	F =F1 – F2	h1	h2	hw =(h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flow rate, LPM1	Calorimeter water flow rate,LPM2

CALCULATIONS:

1. **Mass of fuel consumed, $\boldsymbol{m_f}$**

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

Where,

SG of Diesel = 0.827

X_{cc} is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

HI = $\boldsymbol{m_f}$ x Calorific Value of Fuel, kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

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

$$BP = \frac{2x\pi xNxT}{60000} \text{ KW}$$

Where,

N = speed in rpm

T = F x r x 9.81 N-m

r = 0.15 m

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{m_f x3600}{BP} \text{ Kg/kWh}$$

5. **Brake Thermal Efficiency, $\boldsymbol{\eta_{bth}}$**

$$\eta_{bth} = \frac{BP \text{ x } 3600 \text{ x } 100}{m_f \text{ x CV}} \quad \%$$

6. **Mechanical Efficiency, $\boldsymbol{\eta_{mech}}$**

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

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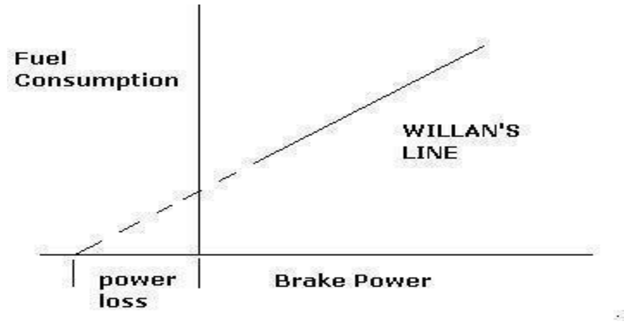
Determine the IP = Indicated Power, using WILLAN"S LINE method and theprocedure is as below:

- 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 givethe Power losses (Friction Power loss)
- With this the IP can be found using the relation:



- IP = BP + FP

7. Calculation of head of air, Ha

$$H_a = \frac{h_w \times \rho_{water}}{1000 \times \rho_a} \text{ meter of water}$$

Where,

ρwater = 1000 Kg/m

ρair = 1.2 Kg/m @ R.T.P

hw is the head in water column in meter of water

Where, **Q_a = Actual volume of air taken = $C_d \times a \times \sqrt{2 \times g \times H_a}$**

Cd = Coefficient of discharge of orifice = 0.62

a =area at the orifice, = $(\pi \times (0.02)^2)/4$

Ha = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

Where, $Q_{th} = \frac{\pi/4 \times D^2 \times L \times x \times N}{60}$

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

Air Fuel Ratio:

M_a/M_f =

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameter, engine head and calorimeter.
4. 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.
5. Do not forget to give electrical earth and neutral connections correctly.
6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
8. It is recommended to run the engine at 1500rpm otherwise the rotating parts and bearing of engine may run out.

Result :

Experiment No: IX **Date:**

LOAD TEST ON 4- STROKE, SINGLE CYLINDER PETROL ENGINE TEST RIG WITH VARIABLE COMPRESSION RATIO

AIM: To conduct a load test on a single cylinder, 4-stroke variable compression ratio petrol engine and study its performance under various compression ratios.

INTRODUCTION:

Internal combustion engines develop varying brake power depending on the compression ratio, while the other parameters held constant. For compression ignition engines, the compression ratio is brought to be above certain value for ignition to take place, but the spark ignition engines can be operated at lower compression ratios. The ignition being controlled by spark strength and advance. The effect of compression ratio, which of present concern is studied in the present test rig.

EQUIPMENT REQUIRED:

1. Single cylinder petrol engine with electrical loading.
2. Stop watch

SPECIFICATIONS:

Make	:	Crompton Greaves
Stroke, L	:	66.7mm
Bore, D	:	70mm
Swept volume, V	:	256 cm^3
Rated R.P.M	:	3000rpm
Output	:	2.2KW
Compression ratio, CR	:	4.67:1
Orifice Diameter	:	15mm Fuel :
Petrol Sp. Gr. Of petrol	:	0.716
Calorific Value of petrol	:	47100 KJ/Kg
Staring	:	By rope
Loading	:	Electrical, Air heater connected to AC Generator
Cooling	:	Air cooling

DESCRIPTION:

The Test Rig consists of Four-Stroke Petrol Engine (Air Cooled) to be tested for performance is coupled to AC Generator .To facilitate the change in compression ratio, an auxiliary head-piston assembly above the main head has been provided.

The auxiliary piston is operated up-down by hand wheel-screw rod assembly to fix the required compression ratio. When the piston is in the bottom most position, the compression ratio is at its maximum value, and in the top most position it is at minimum value of 2s. The minimum clearance volume is 35 cc when the piston it is at bottom most position. The charge from this initial volume of clearance is determined by the displacement of the piston and thus used for calculation of the compression ratio.

Compression Ratio = SweptVolume/ClearenceVolume

Swept Volume : 250 cc (fixed)

Clearance Volume : Initial clearance volume + Additional clearance volume due to auxiliary piston movement

Clearance Volume : $\frac{35\,cc \text{ x } d^2 \text{ x l}}{4\,cc}$

Where, d is the diameter of auxiliary piston = 70 mm, l is the axial movement of piston.

The hand wheel which operates the screw holding the auxiliary piston is provided with holes circumferentially along the locking plate. The bolts used for locking the movement of screw are loosened and the hand wheel is operated. A scale with the compression ratio directly marked is provided for indicating this. After adjusting to the required compression ratio, all the bolts are tightened well before conducting experiment. The rate of fuel Consumption is measured by using Volumetric Pipette. Air Flow is measured by Manometer, connected to air box.

The different electrical loading are achieved by loading the Electrical generator in steps which is connected to the Air Heaters (Resistance Load)The engine speed & AC Alternator speed are measured by electronic digital counter. Temperatures at air inlet and engine exhaust gas are measured by electronic digital temperature indicator with thermocouple.

The whole instrumentation is mounted on a self-contained unit ready for operation.

PROCEDURE:

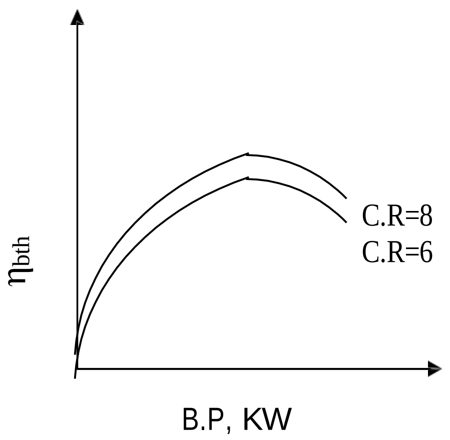
1. Loosen the locking bolt of the auxiliary piston screw rod assembly
2. Rotate the hand wheel and bring the indicator to the required compression ratio
3. Lock the screw rod assembly before conducting the experiment for the compression ratio selected.
4. Open the 3-way cock. So that fuel flows into the engine.
5. Supply the cooling water to engine head.
6. Start the engine and allow it to run on no load condition for few minutes.
7. Apply the load on the engine by switching ON the heater switch which is provided on the control panel loading the AC generator by switching
8. Allow the engine to run at this load for few minutes.
9. Note the following readings.
10. Engine Speed
11. Energy meter
12. Manometer
13. Time for 10cc of fuel consumption
14. Repeat the procedures 8 & 9 at different loads. 11.Stop the engine after removing load on the engine
15. Change the compression ratio and repeat the above procedure.

PRECAUTIONS:

1. Before stating the engine check all the systems such as cooling , lubrication and fuel system
2.
3. Ensure oil level is maintained in the engine upto recommended level always. Never run the engine with insufficient oil.
4.
5. Never run the engine with insufficient engine cooling water and exhaust gas calorimeter cooling water.
6. For stopping the engine, load on the engine should be removed
7. Don’t increase the compression ratio beyond 8.0

GRAPHS

1. η_{bth} Vs B .P



OBSERVATIONS:

Compression Ratio =6

S.NO	Loading Switches	Speed rpm	Time for 10 cc fuel consumption, Sec	Energy meter reading for 'n' number of revolutions Sec	mf Kg/min	T.F.C, Kg/hr	H.I KW	B.P (elec) KW	B.P (eng), KW	$\eta_{thermal}$

Compression Ratio =8

S.NO	Loading Switches	Speed rpm	Time for 10 cc fuel consumption, Sec	Energy meter reading for 'n' number of revolutions Sec	mf Kg/min	T.F.C, Kg/hr	H.I KW	B.P (elec) KW	B.P (eng), KW	$\eta_{thermal}$

SAMPLE CALCULATIONS:

Engine output (Brake Power):

$$\text{Engine Output, } BP_{elec} = \frac{\text{nx60x60}}{E_m \text{ x t}} \text{ KW}$$

$$\text{Engine Output, } BP_{eng} = \frac{BP_{elec}}{\eta_{trans}} \text{ KW}$$

Where,

n = No. of revolution of energy meter

Em = Energy meter constant = rev / Kw – hr

t= time for 'n' revolutions of energy meter in sec

η_{trans} = transmission efficiency = 0.7

Time for 10cc of fuel consumption, t = 19.66…. Sec,

$$m_f = \frac{\text{Specific gravity of the fuel x 60}}{\text{1000 x t}} \text{ kg/min}$$

Total Fuel Consumption, TFC = m_f x 60….kg / hr.

$$\text{Heat Input, HI} = \frac{\text{TFC x CV}}{60\ x\ 60} \quad \text{KW}$$

Where CV is calorific value of given fuel = 47,100 KJ/kg

$$\text{Brake Thermal Efficiency, } \eta_{bth} = \frac{B.P}{HI}\ x\ 100 \quad (\%)$$

Result:

1. What is the significance of clearance volume?
2. What is a stroke?
3. Difference between SI and CI ?
4. Difference between four stroke and two stroke
5. Why four stroke is mostly preferred ?
6. What is the function of piston rings
7. What are functions of camshaft and crankshaft?
8. What is volumetric efficiency? And it's significance
9. What is indicated power, brake power?
10. What is pin connecting the piston and connecting rod?
11. Types of lubrication in an IC engine?
12. Difference between CI and SI engine.?

Experiment No: X **Date:**

I.C. ENGINES PERFORMANCE TEST ON 4 -STROKE DIESEL ENGINE AT CONSTANT SPEED

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.

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:

The test rig is built for loading mentioned below:

b. Mechanical Loading (Water cooled)

1. The equipment consists of KIRLOSKAR 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.

2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. 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 Manometer.
6. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

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 6lpm & 3lpm 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 condition,
11. Engine Speed
12. Time taken for cc of diesel consumption
13. Rotameter reading.
14. Manometer readings, in cm of water &
15. Temperatures at different locations.
16. Repeat the experiment for different loads and note down the above readings.
17. After the completion release the load and then switch of the engine.
18. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed (rpm)	Load Applied			Manometer Reading (cm of water)			Time collected for 10cc of fuel (t sec)
		F1	F2	F =F1 – F2	h1	h2	hw =(h1+h2)	

CALCULATIONS:

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

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

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10 cc

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**

$$\text{BP} = \frac{2\text{x}\pi\text{xNxT}}{60000} \text{ KW}$$

Where,

N = speed in rpm

T = F x r x 9.81 N-m

r = 0.15 m

4. **<u>Specific Fuel Consumption, SFC</u>**

$$\text{SFC} = \frac{m_f\text{x}3600}{\text{BP}} \text{ Kg/kWh}$$

5. Brake Thermal Efficiency, η_{bth}

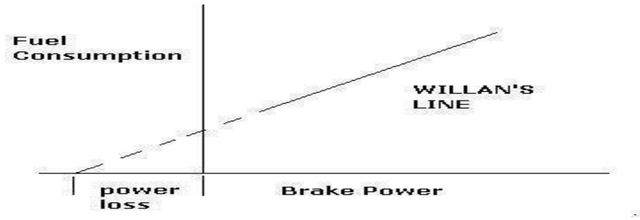
$$\eta_{bth} = \frac{BP \times 3600 \times 100}{m_f \times CV} \quad \%$$

6. Mechanical Efficiency, η_{mech}

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

Determine the IP = Indicated Power, using WILLAN"S LINE method and theprocedure 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

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency
1					
2					
3					

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameter, engine head and calorimeter.
4. 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.
5. Do not forget to give electrical earth and neutral connections correctly.
6. It is recommended to run the engine at 1500 rpm otherwise the rotating parts and bearing of engine may run out.

RESULT:

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

Experiment No: XI **Date:**

PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR

AIM:

The experiment is conducted at various pressures to

1. Determine the Volumetric efficiency.
2. Determine the Isothermal efficiency.

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:

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

PROCEDURE:

1. Check the necessary electrical connections and also for the direction of the motor.
2. Check the lubricating oil level in the compressor.
3. Start the compressor by switching on the motor.
4. The slow increase of the pressure inside the air reservoir in observed.
5. 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.)
6. Now note down the following readings in the respective units, speed of compressor, Manometer readings.
7. Delivery pressure. Temperatures.
8. Energy meter reading.
9. Repeat the experiment for different delivery pressures.
10. Once the set of readings are taken switch of the compressor.
11. 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.
12. Repeat the above two steps after every experiment.

OBSERVATIONS:

S. No.	Compressor Speed, N rpm	Delivery Pressure, P Kg/cm^2	Time for n revolutions of energy meter, T Sec	Manometer meter reading in meters		
				h1	h2	H_w

CALCULATIONS:

1. Air head causing flow, h_a

$$h_a = \frac{h_w \times \rho_{water}}{1000 \times \rho_a} \text{ meter of water}$$

Where,

h_w is Water column reading in m of water.

ρ_{water} is density of the water = 1000 kg/m^3

$\boldsymbol{\rho_{air}}$ is the density of the air = 1.293 kg/m^3

2. Actual vol. of air compressed at RTP, Qa

$$Q_a = C_d \text{ x a x } \sqrt{2 \text{ x g x } h_a}$$

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (π x (0.02)^2)/4

ha = head in air column, m of air.

3. Theoretical volume of air compressed Q_{th},

$$Q_{th} = \frac{\pi/4 \text{ x } D^2 \text{ x L x GR x 0.5 x N}}{60}$$

Where, D is the diameter of the LP cylinder = 0.07m.

L is Stroke Length = 0.085m

N is speed of the compressor in rpm

4. Input Power, IP

$$Input\ Power = \frac{3600 \text{ x n x } \eta_m \text{x K}}{T}\ KW$$

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%

5. Isothermal Workdone, WD

$$\boldsymbol{WD} = \boldsymbol{\rho_a} \text{x } Q_a \text{ x} \ln r \qquad KW$$

Where,

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

Qa = Actual volume of air compressed.

r = Compression ratio

$$r = \frac{\text{Delivery gauge pressure} + \text{Atmospheric pressure}}{\text{Atmospheric pressure}}$$

Where Atmospheric pressure = 101.325 kPa

NOTE: To convert delivery pressure from kg/cm to kPa multiply by 98.1

6. Volumetric efficiency, η_{vol}

$$\eta_{vol} = \frac{Q_a}{Q_{th}} x100 \quad \%$$

7. Isothermal efficiency, η_{iso}

$$\eta_{iso} = \frac{Isothermal\ work\ done}{IP} x100 \quad \%$$

TABULATIONS:

S. No.	Head of air H_a, m	Actual volume of compressed air, $Q_a(m^3/s)$	Theoretical volume of compressed air, $Q_{th}(m^3/s)$	Isothermal work done KW	Isothermal Efficiency $\eta_{iso}(\%)$	Volumetric Efficiency, $\eta_{vol}(\%)$
1						
2						
3						
4						
5						
6						

PRECAUTIONS:

1. Do not run the blower if supply voltage is less than 380V
2. 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.
3. Do not forget to give electrical earth and neutral connections correctly.

RESULT:

Volumetric efficiency, η_{vol} = ---------

Isothermal efficiency, η_{iso} = -----------

GRAPHS TO BE PLOTTED:

- Delivery Pressure vs. ηvol
- Delivery Pressure v

Experiment No:XII **Date:**

STUDY OF BOILERS

STUDY OF BABCOCK-WILCOX BOILER

AIM:

To study 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 do generation of steam in large quantities. The boiler consists essentially of three parts.

A number of inclined water tubes:

They extend all over the furnace. Water circulates through them and is heated.

A horizontal stream and water drum:

Here steam separate from the water which is kept circulating through the tubes and drum.

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 thedown 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.

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 , 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, safety valve, and feed valve, and pressure gauge.

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 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 are 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.