LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

STUDENT MANUAL

THERMAL ENGINEERING LAB

B.Tech -
Mechanical Engineering

Department of Mechanical Engineering

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

DEGREE	B. Tech (U.G)
PROGRAM	MECHANICAL ENGINEERING
REGULATION	R20
YEAR & SEMESTER	III B. TECH I SEM
SUBJECT/LAB WITH CODE	ENGINEERING MECHANICS LAB
CREDITS	1.5
NUMBER OF EXPERIMENTS	10

INSTITUTE

VISION

- Producing globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behaviour of students towards employment and higher studies.

- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.

- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Envisions Mechanical Engineers of globally competent and skilled professionals to meet the needs of Industry and society.

MISSION

- Providing state of art facilities with inspiring learning environment to develop skill and ethical values of students towards higher studies and employment.
- Creating a conducive environment for technological development, research and entrepreneurship to fulfil the evolving needs of Industry and Society.
- Transforming the graduates to contribute towards wellbeing of society and sustainable development goals turn value based and sustainable engineering education.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1 Graduate shall have strong knowledge, skills and professional aptitude towards employment, higher studies and research.

PEO2 Graduates shall comprehend latest tools and rapidly changing technologies to analyze, design and develop sustainable systems for real life applications.

PEO3 Graduates shall develop multidisciplinary approach, ethics, good communication, teamwork to become competent technocrats and entrepreneurs.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1 Capable of design, develop and implement sustainable mechanical environmental systems.

PSO2 Quality in national and international competitive examinations for successful higher studies and employment.

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DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: 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.

PO3: 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.

PO4: 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.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6: 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.

P07: 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.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

P09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: 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.

PO12: 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

Subject code	Subject Name	L	T	P	C
R20MEC-PC3105	Thermal Engineering Lab	0	0	3	1.5

Course Objectives:

The students completing the course are expected to:

- Familiarize students with the working principles of internal combustion (I.C.) engines and compressors by analyzing valve and port timing diagrams.
- Enable students to conduct performance tests on different engine types and evaluate parameters such as frictional power, heat balance, and efficiency.
- Develop students' ability to analyze experimental data from engine tests and apply the findings for optimizing engine performance and fuel economy.

Course Outcomes:

At the end of the course, the student will be able to

CO1: **Draw** the valve and port timing diagrams of 4-stroke CI engine and 2-stroke SI engines

CO2: **Analyse** the performance parameters of engines and compressors using load tests

CO3: **Determine** friction power of engines through retardation, motoring and Morse tests.

CO4: **Evaluate** performance, fuel economy and heat balance sheet for engines

CO5: **Demonstrate** experimental techniques in the thermal engineering lab

COURSE INFORMATION SHEET-2024-25

PROGRAM: Mechanical Engineering	**DEGREE**: B. Tech.
COURSE: THERMAL ENGINEERING LAB	**SEMESTER**: III-I CREDITS: 1.5
COURSE CODE: REGULATION:R23 Academic Year: (2024-25)	COURSE TYPE: Lab
COURSE AREA/DOMAIN: Core	CONTACT HOURS: 3 hours/Week.

List of Experiments

S.NO	Title
1	I.C. engines valve timing diagram.
2	I.C. engines port timing diagram
3	Load test on twin cylinder compression ignition engine
4	Determination of frictional power by retardation test
5	I.C engine heat balance sheet.
6	Motoring test on 4-stroke,single cylinder SI engine test rig
7	Load test on variable compression ratio on 4-stroke, single cylinder petrol engine test rig
8	Performance test on two stage reciprocating air compressor
9	Economical speed test on multi cylinder SI engine
10	Morse test on multi cylinder SI engine

Practical Schedule

Week	Date	Expt. No.	Description	Remarks
		Cycle1		
Week 1		-	Introduction class- Course objectives, outcomes , applications etc.	
Week 2		Cycle 1- demonstration		
Week 3		Exp- 1	I.C. engines valve timing diagram.	
Week 4		Exp- 2	I.C. engines port timing diagram	
Week 5		Ext- 3	Load test on twin cylinder compression ignition engine	
Week 6		Exp- 4	Determination of frictional power by retardation test	
Week 7		Exp- 5	I.C engine heat balance sheet.	

Week 8		Repetition class		
		Cycle 2		
Week 9		-	Demonstration of cycle 2 experiments	
Week 10		Exp- 6	Motoring test on 4-stroke,single cylinder SI engine test rig	
Week 11		Exp- 7	Load test on variable compression ratio on 4-stroke, single cylinder petrol engine test rig	
Week 12		Exp- 8	Performance test on two stage reciprocating air compressor	
Week 13		Exp- 9	Economical speed test on multi cylinder SI engine	
Week 14		Exp- 10	Morse test on multi cylinder SI engine	
Week 15		Repetition class		
Week 16		Internal test -practical		

COURSE OBJECTIVES:

1. Familiarize students with the working principles of internal combustion (I.C.) engines and compressors by analyzing valve and port timing diagrams.
2. Enable students to conduct performance tests on different engine types and evaluate parameters such as frictional power, heat balance, and efficiency.
3. Develop students' ability to analyze experimental data from engine tests and apply the findings for optimizing engine performance and fuel economy.

COURSE OUTCOMES:

After completion of this lab the student will be able to

CO1: **Draw** the valve and port timing diagrams of 4-stroke CI engine and 2-stroke SI engines

CO2: **Analyse** the performance parameters of engines and compressors using load tests

CO3: **Determine** friction power of engines through retardation, motoring and Morse tests.

CO4: **Evaluate** performance, fuel economy and heat balance sheet for engines

CO5: **Demonstrate** experimental techniques in the thermal engineering lab

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

S.NO.	CO No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1.	**CO1**	3	3	2	1		1	1	1	1	1	1	2	1	1
2.	**CO2**	3	3	2			1	1	1	1	1	1	1	1	2
3.	**CO3**	3	3	2	1		1	1	1	1	1	1	2	2	2
4.	**CO4**	3	3	2			1	1	1	1	1	1	1	1	1
5.	**CO5**	3	3	2			1	1	1	1	1	1	1	1	1
Overall Mapping		**3**	**3**	**2**	1		**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

** For Entire Course, PO & PSO Mapping*

PO & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop and implement sustainable mechanical and environmental systems
PO2	Problem Analysis	PO8	Ethics	PSO2	Qualify in national and international competitive examinations for successful higher studies and employment
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R1	I.C Engine, by V. Ganeshan, Tata McGraw Hill Publishers
R2	A Course in International Combustion Engines, by Mathur &Sharma, Dhanpat Rai & Sons.

WEB SOURCE REFERENCES:

1	Welcome to Virtual Labs - A MHRD Govt of india Initiative (vlabs.ac.in)

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☑ Practical	☐ WEB RESOURCES	☐ NPTEL/OTHERS
☑LCD/SMART BOARDS	☐ STUD. SEMINARS	☑ ADD-ON experiments	☐ WEBNIARS

ASSESSMENT METHODOLOGIES-DIRECT:

☑ Practical class evaluation	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ END SEMESTER PRACTICAL EXAMINATION

Prepared by

Signature of the PAC Member **Head of the Department**

List of Experiments

Students have to perform any 10 of the following Experiments:

1. I.C. engines valve timing diagram.
2. I.C. engines port timing diagram
3. Load test on twin cylinder compression ignition engine
4. Determination of frictional power by retardation test
5. I.C engine heat balance sheet.
6. Motoring test on 4-stroke,single cylinder SI engine test rig
7. Load test on variable compression ratio on 4-stroke, single cylinder petrol engine test rig
8. Performance test on two stage reciprocating air compressor
9. Economical speed test on multi cylinder SI engine
10. Morse test on multi cylinder SI engine

INDEX

Exp. No.	Name Of The Experiment	CO	CO-PO, PSO Mapping
Introduction to lab			
01	I.C. engines valve timing diagram.	CO1, CO5	PO1, PO2, PO3, PO4, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
02	I.C. engines port timing diagram	CO1, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
03	Load test on twin cylinder compression ignition engine	CO2, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
04	Determination of frictional power by retardation test	CO3, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
05	I.C engine heat balance sheet.	CO4, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
06	Motoring test on 4-stroke,single cylinder SI engine test rig	CO3, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
07	Load test on variable compression ratio on 4-stroke, single cylinder petrol engine test rig	CO2, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
08	Performance test on two stage reciprocating air compressor	CO2, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
09	Economical speed test on multi cylinder SI engine	CO4, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2
10	Morse test on multi cylinder SI engine	CO3, CO5	PO1, PO2, PO3, PO4,PO6,PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2

Signature of lab I/C

EXPERIMENT-01

I.C. ENGINES VALVE TIMING DIAGRAM

Aim:

To construct and analyse the valve timing diagram of a given four-stroke compression ignition (CI) engine, illustrating the sequence and timing of valve operations in relation to the piston movement and crankshaft rotation.

Equipment:

1. Four-Stroke CI Engine Cut-Section – To observe and analyze the valve mechanism and timing sequence.
2. Measuring Tape – For measuring relevant dimensions needed for diagram representation.
3. Chalk – To mark reference points on the flywheel or other engine components for timing analysis.

Theory:

A valve timing diagram provides a graphical representation of the sequence and timing of valve operations in an engine cycle. It helps in understanding how the various strokes—suction, compression, power, and exhaust—are carried out in relation to the movement of the piston and crankshaft rotation.

In a four-stroke diesel engine, the combustion process relies on precise valve timing for efficient performance. The engine has an inlet valve, which allows fresh air to enter the cylinder during the suction stroke, and an exhaust valve, which expels burnt gases after combustion. Unlike petrol engines, where a carburettor mixes fuel with air before intake, a diesel engine injects fuel directly into the cylinder using a fuel injector.

The opening and closing of valves are controlled by a cam-follower-rocker arm mechanism that synchronizes their operation with the piston's movement. As the piston moves between Top Dead Centre (TDC) and Bottom Dead Centre (BDC), the valves open and close at specific crankshaft positions. Since a four-stroke cycle is completed in two revolutions of the crankshaft (720° of crank rotation), valve timing is carefully adjusted to optimize engine efficiency.

In an ideal scenario, the suction, compression, power, and exhaust strokes should occur precisely within their designated phases. However, in practical applications, the valves do not open or close exactly at TDC or BDC.

The valve timing diagram is typically illustrated using a spiral representation, showing the precise angular positions at which valve events occur. Since valve timing significantly influences engine efficiency, power output, and fuel consumption, studying these timing events is essential for optimizing engine performance.

Understanding the valve timing diagram helps engineers diagnose issues, make necessary adjustments, and enhance engine efficiency in practical applications.

PROCEDURE:

1. Mark the direction of rotation of the fly wheel. Always rotate only in clockwise direction viewing in front of the flywheel
2. Mark the Bottom Dead Centre (BDC) position on the flywheel with the reference point when the piston reaches the lowermost position during rotation of the flywheel
3. Mark the Top Dead Centre (TDC) position on the flywheel with the reference point when the piston reaches the top most position during the rotation of flywheel
4. Identify the four strokes by the rotation of the flywheel and observe he movement of inlet and exhaust valves
5. Mark the opening and closing events of the inlet and exhaust valves on the flywheel
6. Measure the circumferential distance of the above events either from TDC or from BDC whichever is nearer and calculate their respective angles
7. Draw the valve timing diagram and indicate the valve opening and closing periods.

PRECAUTIONS:

1. Avoid applying excessive force when rotating the flywheel to prevent damage to the camshaft and valves.
2. Use chalk or markers carefully to ensure precise marking of TDC, BDC, and valve events for accurate readings.
3. Manually rotate the flywheel at a steady and slow pace to accurately observe the valve movements and avoid missing critical events.
4. Ensure that no foreign objects obstruct the movement of the crankshaft, camshaft, or rocker arms.

Result:

Model valve timing diagram:

Observation Table:1

S. No	DESCRIPTION	DISTANCE	ANGLE IN DEGREES
1	IVO Before TDC		
2	IVC After BDC		
3	EVO Before BDC		
4	EVC After TDC		

CALCULATION:

Angle in degrees = $\frac{\text{distance}}{\text{circumference}} \times 360^0$

Circumference of the fly wheel = 125cm=1250mm

1) IVO Before TDC =
2) IVC After BDC =
3) EVO Before BDC =
4) EVC After TDC =

Experiment No: 02

I.C. ENGINES PORT TIMING DIAGRAM

Aim:

To construct and analyse the port-timing diagram for the given 2-stroke Spark Ignition (SI) engine, illustrating the precise timing of the inlet, exhaust, and transfer ports throughout the engine cycle.

Equipment:

1. Two-Stroke SI Engine Cut-Section – To observe and analyse the port mechanism and timing sequence.
2. Measuring Tape – For measuring relevant dimensions needed for diagram representation.
3. Chalk – To mark reference points on the flywheel or other engine components for timing analysis.

Theory:

The port timing diagram represents the timing of various events in the cycle of an internal combustion engine in terms of crank angles, with respect to the dead centre positions. This diagram is particularly important for understanding the operation of a crankcase scavenging engine, which has three primary ports: inlet, exhaust, and transfer**.**

In a crankcase scavenging engine, the piston plays a critical role in the intake, compression, and exhaust processes. As the piston moves from Bottom Dead Centre (BDC**)** to Top Dead Center (TDC)**,** it creates a vacuum in the crankcase. During this upward movement, the inlet port is opened, allowing the air-fuel mixture to flow into the crankcase from the carburettor. This process continues as the piston moves upward.

At the same time, the piston begins to close the transfer port, which is the first port to be sealed off as the piston moves toward TDC. Following this, the exhaust port is also closed. By the time the piston reaches TDC, the air-fuel mixture in the crankcase is fully compressed. Just before reaching TDC, the spark plug ignites the mixture, initiating combustion.

After combustion, the piston moves downward from TDC to BDC. During this phase, the piston first opens the exhaust port, allowing the high-pressure exhaust gases to escape into the atmosphere. Once the exhaust gases are expelled, the piston opens the transfer port, through which the fresh air-fuel mixture from the crankcase enters the combustion chamber.

Meanwhile, the piston closes the inlet port, preventing the mixture from flowing back into the carburettor.

This process is known as scavenging, where the fresh air-fuel mixture entering through the transfer port replaces the exhaust gases that were left in the cylinder. The effective scavenging of exhaust gases is crucial for improving the efficiency and power output of the engine. By clearing out the old exhaust gases, the engine is able to intake a fresh mixture, thus ensuring that the combustion process is as clean and efficient as possible.

PROCEDURE:

1. Mark the direction of rotation of the flywheel. Always rotate only in Clockwise direction when viewing in front of the flywheel
2. Mark the Bottom Dead centre (BDC) position on the flywheel with the reference point when the piston reaches the lowermost position during rotation of the flywheel
3. Mark the Top Dead centre (TDC) position on the flywheel with the reference point when the piston reaches the top most position during the rotation of flywheel
4. Mark the IPO, IPC, EPO, EPC, TPO, and TPC on the Flywheel observing the following conditions
5. Inlet port pen (IPO) when the bottom edge of the piston kit just opens the lowermost part of the inlet port during its upward movement
6. Port close IPC when the bottom edge of the piston Fully reaches the Lower most part of the inlet port during its down ward Movement
7. Transfer port open (TPO) when the top Edge of the is ton just open the topmost part of the transfer port during its down ward movement
8. Transfer port close (TPC)when the top edge of the piston fully reaches the upper most part of the transfer port during its upward movement
9. Exhaust port open (EPO) when the top edge of the piston just open the top most part of the exhaust port during its downward movement
10. Exhaust port close (EPC) when the top edge of the piston fully reaches the upper most part of the exhaust port during its upward movement
11. Measure the circumferential distance of the above events either From TDC or from BDC whichever is nearer and calculate their respective angles
12. Draw a circle and mark the angles

PRECAUTIONS:

1. Ensure that the engine is properly mounted and secured to prevent any unintended movement during operation.
2. Wear appropriate personal protective equipment (PPE), including safety goggles, gloves, and ear protection.
3. Maintain a steady engine speed throughout the experiment to ensure consistent timing results.
4. When marking the positions on the flywheel, ensure that timing marks are precise and clearly visible.
5. Use accurate measuring instruments, such as a protractor or timing disk, to measure the crank angle for the port events.
6. Calibrate the measuring devices, such as the protractor, to ensure the accuracy of your measurements. Any discrepancies in calibration could result in errors in the timing diagram.

Observation Table: 1

SI. No	DESCRIPTION	DISTANCE	ANGLE IN DEGREES
1	IPO Before TDC		
2	IPC After TDC		
3	EPC Before BDC		
4	EPC Before BDC		
5	TPO Before BDC		
6	TPC After BDC		

Circumference of the fly wheel = 52cm = 520mm

1. IPO Before TDC =
2. IPC After TDC =
3. EPO Before BDC =
4. EPC After BDC =
5. TPO Before BDC =
6. TPC After BDC =

Result:

Model Port timing diagram:

Experiment No: 03

LOAD TEST ON TWIN CYLINDER COMPRESSION IGNITION ENGINE

Aim:

To determine the performance characteristics of a Compression Ignition (CI) engine by conducting a load test and analyzing parameters such as power output, fuel consumption, and efficiency at various load conditions.

Equipment:

1. Twin Cylinder CI Engine Test Rig – To observe and analyze the engine's performance under varying load conditions and measure power output and fuel consumption.
2. Hydraulic Dynamometer – To apply load to the engine and measure torque and power at different operational loads.
3. Stopwatch – To accurately measure time intervals for fuel consumption and engine performance, aiding in the calculation of efficiency and specific fuel consumption.

Theory:

The purpose of this experiment is to determine the performance characteristics of a Compression Ignition (CI) engine by conducting a load test. This test helps evaluate critical parameters such as power output, fuel consumption, thermal efficiency, and specific fuel consumption under different loading conditions. By varying the load on the engine, this experiment simulates real-world operational conditions, allowing for the assessment of engine efficiency and performance across a range of scenarios. Understanding these characteristics is vital for optimizing engine operation, improving fuel efficiency, and reducing emissions in real-world applications.

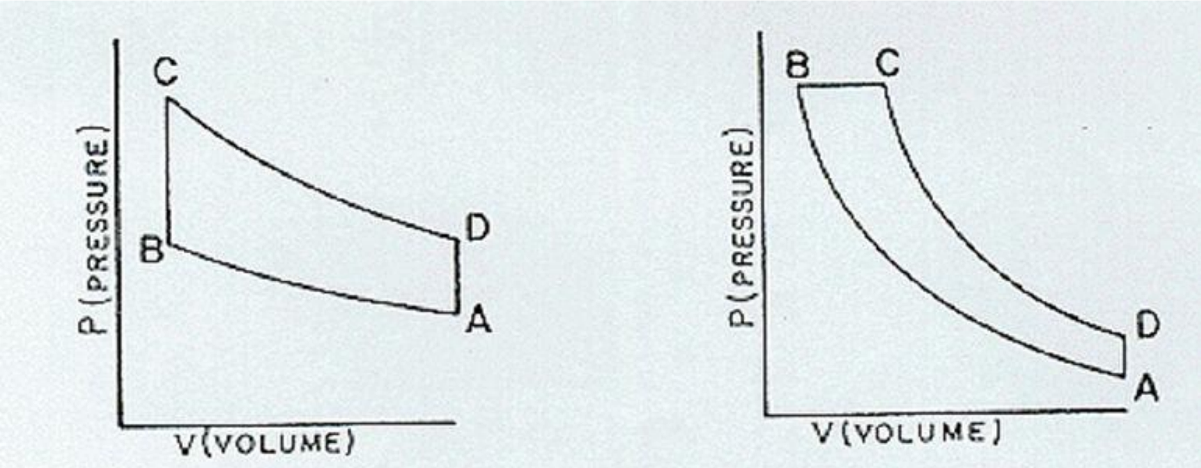
The Twin Cylinder CI Engine Test Rig is designed to conduct various performance tests on a Compression Ignition (CI) engine. The rig typically features a twin-cylinder engine, allowing for simultaneous observation and analysis of both cylinders during operation. This setup provides valuable data on how the engine performs under different load and speed conditions. The rig is equipped with sensors to measure key parameters such as torque, fuel consumption, and exhaust temperature, while a hydraulic dynamometer applies a variable load to the engine. The dynamometer measures the engine's output power and torque, helping to simulate different driving conditions and analyze the engine's performance. A stopwatch is used to record time intervals for fuel consumption and engine parameters, ensuring accurate data collection for performance calculations.

The results of the load test on the CI engine have several real-world applications. CI engines are commonly found in automobiles, trucks, marine vessels, and generators. By conducting this experiment, engineers can assess how an engine will perform under different load conditions, which is crucial for ensuring optimal performance in these applications. For example, in automotive industries, understanding engine performance under varying loads helps in fuel efficiency improvements, emission control, and designing engines that meet regulatory standards. Similarly, for marine vessels or industrial generators, load tests provide insights into reliability, operational costs, and maintenance schedules. This experiment is vital for improving engine designs and developing more efficient, eco-friendly, and cost-effective machines for diverse sectors.

Engine specifications:

Make:	Kirloskar
Bore:	89 mm
Stroke:	110mm
No of cylinders:	2
B.H.P:	14 hp at 1500rpm
Compression ratio:	16.5:1
Fuel:	HSD
Specific gravity:	0.8275
Calorific value:	42700 kJ/kg
Lubricant oil: SAE	30-40
Diameter of orifice:	20 mm
Rotameter in LPM:	4 lpm
Cooling type:	Water cooled
Loading:	Hydraulic dynamo meter

Starting: By Hand cranking



P-V and T-S diagram of Diesel cycle

All the load tests are generally conducted at constant speed of the engine that is at constant friction losses, which is determined from the William's curve. William curve is the graph drawn between specific fuel consumption (y-axis) and break power (x-axis) at constant speed is extrapolated on the negative axis of break power. The intercept of the negative axis is taken as the friction power of the engine at that speed.

Method to Determine the Maximum Load

Calculate the maximum load (full load) that can be applied on the engine using the formula

$$W_{max} = \frac{BP \times 60000}{2\pi R_e N}$$

Where W in Newton, N in RPM and Re in m. (R=0.358m)

Procedure:

- Ensure that the Twin Cylinder CI Engine Test Rig is properly installed and connected to the necessary measurement instruments, including the hydraulic dynamometer and stopwatch.
- Verify that the engine is well-lubricated and filled with the required fuel, and check for any leaks or issues before starting the experiment.
- Start the engine and allow it to warm up to its normal operating temperature. This ensures consistent performance during the test.

- Set the engine to its rated idle speed, which will be used for baseline measurements.
- Set the hydraulic dynamometer to apply an initial load to the engine. This is usually a low load to begin the test. The dynamometer should gradually apply a mechanical load to the engine to simulate real-world conditions.
- Note the torque and speed at this initial load using the dynamometer.
- As the engine runs under load, measure the torque and speed using the dynamometer.
- Record the engine's power output at each load setting.
- While the engine is operating under load, measure the fuel consumption using the fuel flow meter on the rig.
- Use the stopwatch to measure the amount of time taken to consume a known volume of fuel. This can be done by recording the time taken for the fuel meter to drop a set amount (e.g., 1 Liter).
- Calculate the fuel consumption rate (e.g., Liters per hour or grams per minute) for each load condition.
- Gradually increase the load applied by the hydraulic dynamometer in increments (e.g., 25%, 50%, 75%, and 100% of the maximum load capacity).
- For each load setting, repeat the measurements of torque, speed, and fuel consumption.
- Record the power output and fuel consumption at each load level to calculate the engine's efficiency and performance.
- Once all measurements are taken, gradually reduce the load on the engine and allow it to idle before shutting it down.
- Turn off the engine and clean the test rig, ensuring that all instruments, including the dynamometer and fuel system, are properly stored for future use.

Precautions:

1. Allow the engine to warm up to its normal operating temperature before starting the load test to ensure accurate and consistent performance measurements.
2. Gradually increase the load applied by the hydraulic dynamometer to avoid sudden changes in engine speed or torque, which could affect the accuracy of power and fuel consumption measurements.
3. Measure fuel consumption accurately by using the stopwatch and fuel flow meter, ensuring no fuel leaks or interruptions in the fuel supply during the experiment.
4. Before starting the test, inspect the engine and rig for any fuel, oil, or exhaust leaks. Ensure all components are securely fastened to prevent accidents or measurement errors during the experiment.

OBSERVATION TABLE:

S. No.	SPEED	LOAD(W)	MANOMTER READINGS (H_1)	MANOMETER READINGS (H_0)	TIME TAKEN FOR ‘X’ CC OF FUEL
1					
2					
3					
4		9			

Formulae:

1)Brake power (BP) = $\frac{2\pi NT}{60}$

T = 9.81×W×R

Where W = Load

R = 0.358 m

2)Fuel consumption = $\frac{X}{t} \times specificgravity\ of\ fuel \times \frac{3600}{1000}\ \frac{kg}{hr}$ $\frac{x}{t}$×sp.gr of fuel× $\frac{3600}{1000}$ Kg/hr

Where x = cc of the fuel taken

t = time taken for x cc of fuel

specific gravity of diesel = 0.82

3)Specific fuel consumption = $\frac{TFC}{BP}\ \frac{kg}{kwhr}$

4)Indicated power (IP) = BP+FP (Find FP from Willans line graph)

5) Mechanical efficiency $\eta_{mech} = \frac{BP}{IP} \times 100$

6) Indicated thermal efficiency $\eta_{ith} = \frac{IP\times 3600}{TFC\times C_v} \times 100$

Where C_v= calorific value of diesel = 42700 KJ/Kg

7) Brake thermal efficiency $\eta_{bth} = \frac{BP\times 3600}{TFC\times C_v} \times 100$

Where C_v= calorific value of diesel = 42700 KJ/Kg

8) Indicated mean effective pressure $Imep = (IP \times 3600)/LANK \times 100\ N/m^2$

9) Brake mean effective pressure $Bmep = (BP \times 3600)/LANK \times 100\ N/m^2$

Where L = length of the stroke = 0.110 m

A = Area of the diameter = 0.89 m

N = Speed in RPM

K = number of cylinders = 2

CALCULATION:

AT Load ‘0’

1) Brake Power (BP) = $\frac{2\pi NT}{60}$

T=9.81×W×R

2) Total fuel consumption (TFC)

$= \frac{x}{t}$ ×specific gravity of fuel× $\frac{3600}{1000}$

3) Specific fuel consumption (SFC) = $\frac{TFC}{BP}$ Kg/Kw.hr

4) Integrated power (IP) = BP+FP

[from Williams lines method (FP=4)]

5) Mechanical efficiency (η_{mech}) $= \frac{BP}{IP} \times 100$

6) Integrated thermal efficiency (η_{Ith}) $= \frac{IP \times 3600}{TFC \times CV} \times 100$

7)Brake thermal efficiency (η_{Bth}) = $\frac{BP \times 3600}{TFC \times CV} \times 100$

8)Indicated mean effective pressure (IMEP) = $\frac{IP \times 3600}{L \times A \times n \times k}$

Result Table:

S. NO	SPEED (N)	LOAD (W)	TFC (Kg/hr)	SFC (Kg/hwhr)	BP (Kw)	IP (Kw)	FP (Kw)	IMEP (N/m^2)	BMEP (N/m^2)	η_{Bth} (%)	η_{Tth} (%)	η_{mech} (%)
1												
2												
3												
4												

Experiment No: 04

DETERMINATION OF FRICTIONAL POWER BY RETARDATION TEST

AIM:

To conduct a retardation test on a constant speed CI engine to determine the frictional power by analysing the rate of deceleration when the fuel supply is cut off.

APPARATUS:

1. Constant Speed CI Engine Test Rig – To maintain a steady engine speed and perform the retardation test to analyze deceleration and determine frictional power.
2. Stopwatch – To accurately measure the time interval during the deceleration process, aiding in the calculation of frictional power.
3. Tachometer – To measure the engine's rotational speed (RPM) during the deceleration phase, helping to determine the rate of speed reduction.
4. Dynamometer or Crankshaft Pulley – To measure the torque and power during the deceleration, assisting in calculating the frictional losses in the engine.
5. Temperature Sensor – To monitor and maintain the engine’s operating temperature, ensuring consistent conditions during the test.

SPECIFICATIONS:

Type:	Vertical automotive
Brake power:	4.4 KW (6BHP)
Rated speed:	650RPM
Bore:	0.25m
Stroke:	0.11m
Diameter of orifice:	20 mm
Fuel:	HSD
Specific gravity:	0.8275
Calorific value:	42700 kJ/kg
Lubricant oil:	SAE 30-40
Diameter of orifice:	0.02 m
Rotameter in LPM:	4 lpm
Cooling type:	Water cooled
Loading:	Mechanical Rope brake
Drum diameter:	40 mm
Starting:	By Hand cranking

Theory:

The retardation test is a method used to determine the frictional power losses in an engine by observing the rate at which the engine decelerates when the fuel supply is cut off. The frictional power is the portion of the engine's total power that is consumed by the internal resistance within the engine components, such as the pistons, crankshaft, bearings, and cylinder walls. This power is not used for useful work but is dissipated as heat due to friction. In this experiment, the engine is run at a constant speed, and the fuel supply is suddenly shut off. As a result, the engine will gradually slow down due to internal frictional losses. The rate of deceleration is recorded over time, and from this data, the frictional power can be calculated. The frictional losses are mainly influenced by the engine's internal components, lubrication, and mechanical condition.

The procedure involves recording the engine speed (RPM) at various time intervals using a tachometer and a stopwatch. The time taken for the engine to decelerate from a higher speed to a lower speed is measured, and the dynamometer or crankshaft pulley is used to assess the torque. By analysing the deceleration curve and applying the principles of rotational dynamics, the frictional power can be determined.

This power is then used to evaluate engine performance and efficiency, as it represents the energy wasted due to internal mechanical friction. This test provides valuable information regarding the internal friction of the engine, which is crucial for understanding the overall efficiency of the engine. Minimizing frictional losses is essential for improving engine performance, fuel efficiency, and longevity.

Additionally, it helps in the optimization of engine components and lubrication systems to reduce wear and tear in the engine. In practical applications, reducing frictional losses can lead to improved fuel efficiency, better performance, and reduced operational costs in automotive, marine, and industrial engines. This experiment helps in the design and development of engines with lower frictional losses and better overall efficiency.

PROCEDURE:

1. Ensure the CI engine is properly mounted on the test bed.
2. Check for sufficient lubrication and coolant levels.

3. Connect the necessary measuring instruments, such as a tachometer, fuel flow meter, and temperature gauges.
4. Start the engine and allow it to run at a constant speed under normal operating conditions.
5. Let the engine reach steady-state temperature.
6. Note the initial speed (N_1) of the engine in RPM.
7. Ensure the engine is running without any load or with minimal load.
8. Shut off the fuel supply completely.
9. The engine will start decelerating due to frictional and other resistive forces.
10. Use the tachometer to record the speed of the engine at regular time intervals (e.g., every 2–5 seconds) as it slows down.
11. Continue recording until the engine comes to a complete stop or until the speed reduces significantly.
12. Use the recorded values to plot a speed (N) vs. time (t) graph.
13. The slope of the graph gives the rate of deceleration.
14. Perform multiple trials to ensure consistency and accuracy of the results.
15. Take the average value of frictional power from multiple trials.

PRECAUTIONS:

1. Ensure the engine is properly lubricated before starting the experiment.
2. Check the coolant levels to prevent overheating.
3. Secure all connections and fittings to avoid fuel or oil leakage.

Observation table: 6

S. No	Speed (N_1)	In RPM(N_2)	Load in Kgs	Time Take for Retardation N_1-N_2
1				
2				
3				
4				

Calculation:

For 500 RPM with Zero Load:

1) Load Torque (T1) = 9.81×10×R

Where R= BRAKE Radius

W=Weight (R=0.2m)

2) Fractional force (T_f) = $T_2[\frac{t_3}{t_2-t_2}]$ =

3) Fractional power (P_{fw}) = $\frac{2\pi N T_l}{60\times10^3}$ =

For 400rpm With Zero Load:

1) load Torque (T_2) = 9.8×W×R =

2) Frictional Power (Tf) = $T_L[\frac{t_3}{t_2-t_2}]$ =

3) Frictional power (Pfw) = $\frac{2\pi N T_f}{60\times10^3}$ =

For 500 rpm with 15Kgs load:

1) load torque (T_l) = 9.81×W×R

2) Frictional Torque (T_f) = $T_2[\frac{t_3}{t_2 - t_2}]$ =

3) Frictional Power (P_{fw}) = $\frac{2\pi N T_f}{60\times10^3}$

For 400 rpm with 15Kgs load:

1) Load torque (TL) = 9.86×W×R =

2) Frictional torque(T_f) = $T_L[\frac{t_3}{t_2 - t_2}]$

3) Frictional Power (Pfw) = $\frac{2\pi N T_f}{60\times10^3}$

RESULT TABLE:

S. No	Speed rpm		Load in Kgs	TIME taken for retardation (N_1toN_2)	LOAD TORQUE IN N-M	FRICTIONAL TORQUE IN N-M	FRICTIONAL TORQUE IN Kw
	N_1	N_2					
1							
2							
3							
4							

Experiment No: 05

I.C ENGINE HEAT BALANCE SHEET

AIM:

To prepare a heat balance sheet for a 4-stroke twin-cylinder CI engine by measuring the input energy and analysing its distribution into useful work, cooling water, exhaust gases, and unaccounted losses.

Equipment:

1. Twin-Cylinder CI Engine Test Rig – To perform the heat balance test by measuring the input fuel energy and analysing its distribution into useful work, cooling water, exhaust gases, and unaccounted losses.
2. Hydraulic Dynamometer – To measure the brake power (BP) of the engine by applying a controllable load.
3. Stopwatch – To measure the duration of the experiment for accurate data collection.

THEORY:

In an internal combustion (IC) engine, the chemical energy of the fuel is converted into mechanical work, but only a portion of this energy is effectively utilized. The rest is lost in various forms such as heat carried away by the cooling water, exhaust gases, and unaccounted losses like radiation and friction. A heat balance sheet is used to analyze the distribution of the input energy and assess the engine's thermal efficiency. This sheet provides a comprehensive view of how the energy supplied by the fuel is utilized or wasted, helping engineers identify potential areas for performance improvement.

During the heat balance test, the heat energy supplied to the engine is calculated using the mass flow rate of the fuel and its calorific value. The engine's brake power (BP) is measured using a hydraulic dynamometer, representing the useful work output. The heat lost through the cooling system is determined by measuring the temperature difference of the cooling water before and after it passes through the engine, along with the water flow rate. Similarly, the heat carried away by the exhaust gases is calculated by measuring the exhaust gas temperature and mass flow rate. The remaining energy, which cannot be directly accounted for, is categorized as unaccounted losses, caused by radiation, friction, and incomplete combustion.

Analyzing the heat balance sheet is essential for evaluating the engine's thermal efficiency and identifying areas for improvement. It helps in determining how efficiently the engine converts fuel energy into mechanical power and how much energy is wasted. This information is crucial for optimizing engine performance, improving fuel economy, and reducing unnecessary energy losses. It also provides insights into the effectiveness of the cooling system and the exhaust gas behavior, which are vital for ensuring safe and efficient engine operation.

SPECIFICATIONS:

Make:	Kirloskar
Bore:	89 mm
Stroke:	110mm
No of cylinders:	2
B.H.P:	14 hp at 1500rpm
Compression ratio:	16.5:1
Fuel:	HSD
Specific gravity:	0.8275
Calorific value:	42700 kJ/kg
Lubricant oil:	SAE 30-40
Diameter of orifice:	20 mm
Rotameter in LPM:	4 lpm
Cooling type:	Water cooled
Loading:	Hydraulic dynamo meter
Starting:	By Hand cranking

PROCEDURE:

1. Ensure the twin-cylinder CI engine test rig is properly mounted and all connections are secure.
2. Check the lubricant and coolant levels to prevent overheating and ensure smooth engine operation.
3. Start the engine and allow it to run at a constant speed until it reaches steady-state operating conditions.
4. Measure the fuel consumption rate using a fuel flow meter or measuring flask over a specific time interval.
5. Record the engine speed (RPM) using a tachometer.
6. Use the hydraulic dynamometer to apply load and measure the brake power (BP) of the engine.
7. Measure the cooling water temperature at the inlet and outlet using temperature sensors.
8. Record the flow rate of the cooling water to calculate the heat absorbed by the cooling system.
9. Measure the temperature of exhaust gases using thermocouples or temperature probes.
10. Use a calorimeter or flow meter to determine the mass flow rate of the exhaust gases.
11. Calculate the heat supplied to the engine using the fuel consumption rate and the calorific value of the fuel.
12. Determine the heat carried away by cooling water by using the water flow rate and temperature difference.
13. Calculate the heat lost in exhaust gases using the mass flow rate and temperature difference of the exhaust gases.
14. Identify the unaccounted losses by subtracting the utilized heat (useful work, cooling water, and exhaust gas heat) from the total heat supplied.
15. Prepare the heat balance sheet by listing the heat supplied and the distribution of heat in different forms.
16. Repeat the experiment multiple times to ensure consistent and accurate results.

PRECAUTIONS:

1. Ensure the engine is properly lubricated to prevent excessive friction and wear.
2. Check the coolant levels to avoid overheating during the experiment.
3. Secure all fuel and water connections to prevent leaks.
4. Use accurate measuring instruments for fuel flow, temperature, and speed readings.
5. Avoid touching hot surfaces such as the exhaust pipe and engine block during operation.

OBSERVATION TABLE:

S. No.	Speed in RPM	Load in kgs	Time taken for 100cc of fuel in sec	Manometric in H_1	Manometric in H_0	T_1	T_2	T_3	T_4	T_5
1										

Calculation:

1) Total fuel consumption;

$$TFC = \frac{x}{t} \times sp\ of\ fuel \times \frac{3600}{1000} =$$

2) Heat Input (HI) = TFC×CV

(CV=42700 Kj/Kg)

3) Brake power (BP) = $\frac{2\pi NT}{60\times10^3}$ =

4) Heat loss due to cooling water

$$Q_w = \text{m}\times\text{wCpw}\times(T_2 - T_1)$$

5) Heat Lost due to exhaust gases

$$\text{Qg} = \text{M}g \times \text{Cpg}\ (T_4 - T_1)$$

$$\text{Mwcpw}(T_3 - T_2) = \text{mgcpg}(T_4 - T_5)$$

$$\text{C}\rho\text{g} = \frac{\text{Mwcpw}(T_3 - T_2)}{\text{mg}(T_4 - T_5)}$$

Unaccounted losses = HI - (BP+Qw+Qg)

RESULT:

The heat balance is as follow:

Heat input	%	Heat output	%
TFC×CV=141.3	100	Heat lost due to BP= Heat lost due to cooling water= Heat lost due to exhaust gases= Unaccounted losses =	$\frac{BP}{HI}\times 100 =$ $\frac{QW}{HI}\times 100 =$ $\frac{Qg}{HI}\times 100 =$ 90.35%

Experiment No: 06

MOTORING TESTON 4-STROKE, SINGLE CYLINDER SI ENGINE TEST RIG

AIM:

To conduct a motoring test on a 4-stroke, single-cylinder SI engine and determine the frictional power by measuring the energy required to overcome internal engine losses.

EQUIPMENT/APPARATUS:

1. 4- Stroke, single cylinder SI engine with a swinging field type electrical dynamometer.
2. Stopwatch.

SPECIFICATIONS:

Type:	4 stroke single cylinder Variable compression SI engine
Capacity:	100cc
Bore:	80mm
Stroke:	110m m
Rated Speed:	2500-3000 rpm
Max. B.P:	3.7KW (5 H.P)
Compression Ratio:	16 .5:1
Diameter of orifice:	20 mm
Fuel used:	Petrol
Sp.gravity	0.72
Calorific Value:	46700 kJ/kg
Diameter of orifice:	0.02 m
Rotameter in LPM:	4 lpm
Cooling type:	air cooled, water cooled
Loading:	D.C machine with Swinging field arrangement
Starting:	By rope

DESCRIPTION:

The test rig consists of a 4-stroke, single-cylinder SI engine connected to a DC machine with a swinging field arrangement for conducting the motoring test. The fuel consumption rate is measured using a burette by recording the fuel volume consumed over a known time interval. The swinging field arrangement is used to determine the frictional power by measuring the power required to motor the engine. The water flow rate for engine cooling is measured separately using a water meter. The airflow rate is determined with an orifice and a manometer. Different electrical load conditions are applied by adjusting the dimmer stat of the dynamometer in steps. The engine speed (RPM) is monitored using an electronic digital counter. The temperature at various points is measured with an electronic digital temperature indicator equipped with thermocouples. The entire instrumentation is mounted on a self-contained unit, making it convenient and ready for operation.

THEORY:

The frictional power of an I.C. engine can be determined using various methods, including:

a) William’s line method

b) Indicator area method

c) Retardation test

d) Motoring test

e) Morse test

Motoring Test:

In this test, the engine is initially run at its rated speed under normal operating conditions using its own power. It is allowed to stabilize under a given speed and load until the temperature of the engine components, lubricating oil, and cooling water reaches a steady state. During this period, a swinging field type electric dynamometer is used to absorb the power generated by the engine.

Once the steady-state conditions are achieved, the ignition system is cut off, and the dynamometer is switched to act as a motor. This motor drives the engine at the same speed it was previously operating. The power supplied by the dynamometer during this motoring phase is measured, which represents the frictional power of the engine at that speed.

PROCEDURE:

1. Ensure the engine is properly lubricated to minimize wear and tear during the test.
2. Check the coolant levels to prevent overheating.
3. Verify all electrical connections of the dynamometer are secure and properly insulated.
4. Gradually apply and remove the load to avoid sudden shocks or fluctuations.
5. Use accurate measuring instruments for speed, temperature, and power readings.
6. Ensure the ignition is completely cut off during the motoring phase to prevent accidental firing.
7. Avoid touching hot engine parts or moving components during the test.
8. Ensure the work area is well-ventilated to prevent the accumulation of exhaust gases.
9. Wear safety gloves and goggles while handling the engine and electrical components.
10. Shut down the engine immediately in case of abnormal noise, vibration, or overheating.

PRECAUTIONS:

1. Ensure the engine is properly lubricated to reduce internal friction and prevent damage.
2. Check the coolant levels to avoid overheating during the test.
3. Verify that all electrical connections of the dynamometer are secure and properly insulated.
4. Ensure the ignition is completely cut off during the motoring phase to avoid accidental firing.
5. Use accurate measuring instruments for speed, temperature, and power readings.
6. Avoid touching hot surfaces or moving parts while the engine is running.

Observations:

S.NO	Speed	Ammeter Readings(I)	Voltmeter READINGS(v)
1			
2			
3			
4			

Formula: P = VICosϕ

Where Cosϕ (power factor) = 0.9

Calculation:

1) At speed 500 rpm

P =

2) At Speed = 700 rpm

P =

3) At speed 900 rpm;

P =

4) At speed 400 rpm;

P =

Result table: -

S.NO	SPEED	RPM	AMMETER READINGS(I)	VOLTMETER READINGS(R)	FRACTIONAL POWER(K_w)
1					
2					
3					
4					

Experiment No: 07

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

AIM:

To conduct a load test on a 4-stroke, single-cylinder petrol engine with a variable compression ratio (VCR) and evaluate its performance under different load conditions.

EQUIPMENT REQUIRED:

1. Single-Cylinder Petrol Engine with Variable Compression Ratio (VCR) Test Rig – To conduct the load test and evaluate the engine's performance under different compression ratios and load conditions.
2. Fuel Flow Meter or Burette – To measure the fuel consumption rate during the experiment.
3. Tachometer – To measure the engine speed (RPM) during the test.

SPECIFICATIONS:

Type:	4 stroke single cylinder Variable compression SI engine
Capacity:	100cc
Bore:	80mm
Stroke:	110m m
Rated Speed:	2500-3000 rpm
Max. B.P:	3.7KW (5 H.P)
Compression Ratio:	16 .5:1
Diameter of orifice:	20 mm
Fuel used:	Petrol
Sp.gravity	0.72
Calorific Value:	46700 kJ/kg
Diameter of orifice:	0.02 m
Rotameter in LPM:	4 lpm
Cooling type:	air cooled, water cooled
Loading:	D.C machine with Swinging field arrangement
Starting:	By rope

THEORY:

The performance of internal combustion (IC) engines varies with the compression ratio, while keeping other parameters constant. In compression ignition (CI) engines, the compression ratio must be sufficiently high to initiate ignition through heat generation during compression. However, in spark ignition (SI) engines, ignition is controlled by the spark strength and timing, allowing them to operate at lower compression ratios. The effect of varying the compression ratio on engine performance is studied using this test rig.

The test rig consists of a 4-stroke, air-cooled petrol engine coupled to an AC generator. To facilitate the change in compression ratio, an auxiliary head-piston assembly is mounted above the main cylinder head. The auxiliary piston is adjusted up or down using a handwheel-screw rod mechanism, allowing the compression ratio to be varied. When the auxiliary piston is in the bottommost position, the compression ratio is at its maximum value, while at the topmost position, it reaches the minimum value. The minimum clearance volume is 35 cc when the piston is at the bottommost position. The change in the clearance volume due to piston displacement is used to calculate the compression ratio.

The handwheel controlling the auxiliary piston has circumferential holes along the locking plate, allowing precise adjustments. To change the compression ratio, the locking bolts are loosened, the handwheel is rotated to the desired setting, and the bolts are tightened securely before starting the test. A scale with direct compression ratio markings is provided for easy reference.

The fuel consumption rate is measured using a volumetric pipette, while the airflow rate is recorded using a manometer connected to an airbox. The electrical loading is applied in steps by loading the AC generator, which is connected to air heaters (resistance load). The engine speed and generator speed are measured using an electronic digital counter. The temperature at the air inlet and engine exhaust is monitored with a digital temperature indicator equipped with thermocouples. The entire setup is mounted on a self-contained unit, making it ready for operation.

PRECAUTIONS:

1. Loosen the locking bolt of the auxiliary piston screw rod assembly.
2. Rotate the handwheel to adjust the indicator to the desired compression ratio.
3. Securely lock the screw rod assembly before starting the experiment at the selected compression ratio.
4. Open the 3-way cock to allow fuel to flow into the engine.
5. Supply cooling water to the engine head to prevent overheating.
6. Start the engine and let it run under no-load condition for a few minutes to reach a steady operating state.
7. Gradually apply load using the loading device, starting from no load and increasing it to full load in steps.
8. Allow the engine to run at each load condition for a few minutes.
9. Record the following readings:
    a. Engine speed (RPM) using a tachometer or digital counter.
    b. Energy meter reading to measure the power output.
    c. Manometer reading for airflow measurement.
    d. Time taken for the consumption of 10cc of fuel using the burette or pipette.
10. Repeat the steps of applying load and recording readings at different load conditions.
11. Once the readings are recorded, remove the load and stop the engine.
12. Repeat the entire procedure for different compression ratios, making the necessary adjustments with the handwheel.

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 up to recommended level always. Never run the engine with insufficient oil.
3. Don’t increase the compression ratio beyond 8.0.

OBSERVATION TABLE:

S. No	Compression ratio	Case	v	I	speed	Manometer readings N_1	N_2	N_m	Time taken for 10 of fuel consumption
1		No load							
		load							
2		No load							
		load							
3		No load							
		load							
4		No load							
		load							

FORMULAS:

1)Bp = $\frac{V \times I}{1000}$ Kw

2) mass of fuel consumed (mf) = $\frac{x}{t} \times \frac{SP.gravity\ of\ fuel}{1000}$

Where x = 10cc

Sp.gr = 0.72

3) Heat input (HI) = Mf×Cv

Where Cv = 47100Kj/Kg

4) $\eta_{b+h} = \frac{BP}{HI} \times 100\%$

5) $\eta_{vol} = \frac{Va}{Vs} \times 100$

Va = Cd×Aorific × $\sqrt{2gha}$

Where,

Cd= 0.69

A orifice =$\frac{\pi}{4} d^2$, d=0.017=2.269× $10^{-4} m^2$

V_s= $\frac{\frac{\pi}{4} d^2 \times \rho \times \frac{n}{2}}{60}$, where d=0.08m, ρ=0.11m

Calculation:

At 3.5(no load)

1) BP =

2) MF=

3) HI =

4) η_{bth} =

5) η_v= $\frac{V_a}{V_s} \times 100$ =

Va=

Vs=

Ha=

At 3.5(load)

1) Bp =

2) Mf =

3) HI =

4) η_{bth} =

5) $\eta_v = \frac{V_a}{V_s} \times 100$

$V_a =$

$V_s =$

ha =

RESULT TABLE:

S. No	Compression ratio	case	Voltage	current	speed	Time taken for 10cc of fuel consumption	Hm	η_{bh}	η_{vol}
1		No load							
		Load							
2		No load							
		Load							
3		No load							
		Load							
4		No load							
		load							

Experiment No: 08

PERFORMANCE TEST ON TWO STAGE RECIPROCATING AIR COMPRESSOR

AIM:

To conduct a performance test on a two-stage reciprocating air compressor and evaluate its efficiency, volumetric efficiency, and power consumption under different operating conditions.

APPARATUS:

1. Two-Stage Reciprocating Air Compressor Test Rig – To conduct the performance test and measure the compressor's efficiency under different operating conditions.
2. Pressure Gauges – To measure the suction and delivery pressures of the compressor at various stages.
3. Tachometer – To measure the rotational speed (RPM) of the compressor.
4. Air Receiver Tank – To store the compressed air and regulate the output pressure.

DESCRIPTION:

The test rig, as shown in Figure 1, consists of a two-stage reciprocating air compressor driven by a swinging field type electric motor through a V-belt drive. The input power to the compressor is directly measured using the swinging field motor and the spring scale readings. An air tank is connected to the system, equipped with an orifice and a differential manometer to measure the actual quantity of air sucked by the compressor. The air enters the low-pressure (L.P.) cylinder through an air filter, ensuring clean airflow into the system.

SPECIFICATIONS:

Type:	Two stage with Intermediate Cooler
Motor:	3 HP Motor
Diameter of L.P. cylinder:	70 mm
Diameter of H.P. cylinder:	50 mm
Stroke:	85 mm
Orifice Diameter:	15 mm
Stroke length in both cylinders:	85 mm

Diameter of orifice :20 mm

Rated speed of motor: 1440 RPM

Rated speed of compressor: 715 RPM

Mechanical efficiency of motor: 85%

Transmission efficiency: 95%

Energy meter constant: 1600imp/Kwhr

Tank volume :400mm X 400mm X 400mm

THEORY:

In a reciprocating air compressor, air is compressed by the positive displacement of a piston moving within a confined cylinder. This action increases the pressure and density of the air. The flow of air through the cylinder is regulated by valves that control the intake and exhaust.

When the motor is started, air is drawn from the atmosphere through the inlet air box and an orifice meter. The air is first compressed in the low-pressure (L.P.) cylinder, increasing its temperature and pressure. The hot, compressed air then passes through an intercooler, where it is cooled before entering the high-pressure (H.P.) cylinder for further compression. The high-pressure air is then delivered to the air receiver tank through an after-cooler and a non-return valve, ready for use.

The volumetric efficiency of the compressor is defined as the ratio of the actual quantity of air sucked by the compressor to the swept volume of the cylinder. In a multi-stage compressor, volumetric efficiency decreases as the back pressure increases, because the actual quantity of air intake reduces.

The mechanical efficiency of the compressor is the ratio of the compressor output (power utilized for compression) to the mechanical input power. The output power is determined based on the flow rate and the cylinder pressures. The compressor achieves maximum efficiency when perfect intercooling is provided between the L.P. and H.P. cylinders, as this reduces the work required for compression.

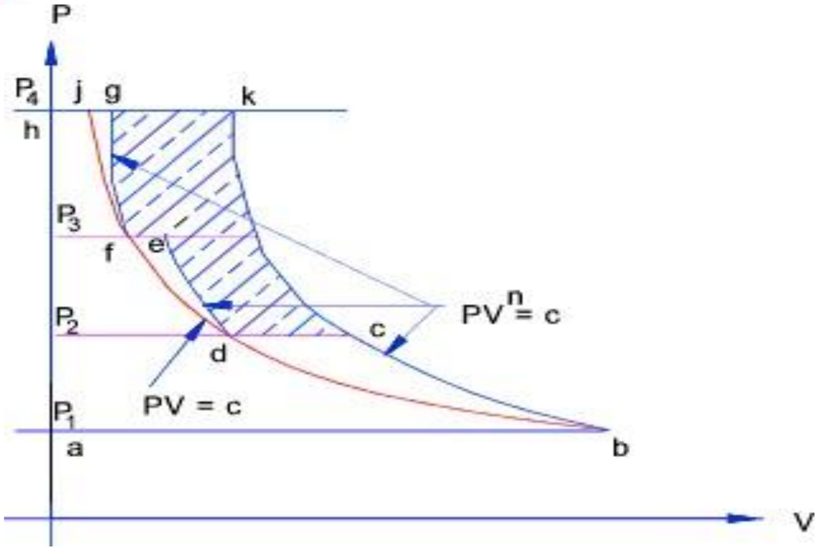


Figure: P-V Diagram of Multi stage compression

PROCEDURE:

1. Ensure all connections of the compressor test rig are secure and the cooling system is functioning properly.
2. Open the cooling water supply to the intercooler and after-cooler.
3. Check the lubrication level and ensure the compressor is properly lubricated.
4. Start the electric motor to run the compressor.
5. Gradually increase the load by adjusting the air receiver valve.
6. Allow the compressor to run until it reaches steady-state conditions.
7. Record the following readings:
    a. Suction and delivery pressures from the pressure gauges.
    b. Airflow rate using the orifice meter and manometer.
    c. Temperature readings at the inlet, intercooler, and outlet stages using thermocouples.
    d. Input power from the motor and spring scale readings.
    e. Time required to fill the air receiver tank to a specific pressure using a stopwatch.
8. Repeat the experiment by varying the load conditions and record the observations.

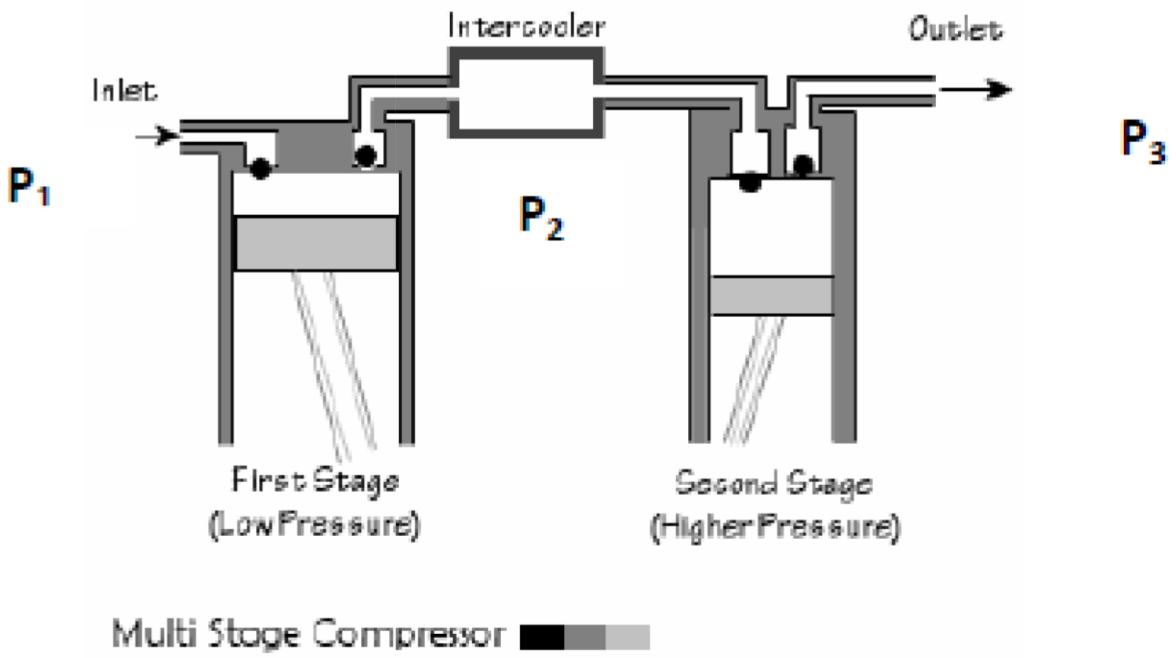
9. After completing the test, gradually reduce the load, stop the motor, and shut off the cooling water supply.

10. Allow the compressor to cool down before turning off the power supply.

PRECAUTIONS:

1. Ensure the compressor is properly lubricated to prevent wear and overheating.
2. Do not exceed the maximum pressure limit of the air receiver tank to avoid accidents.
3. Ensure the cooling system is functioning properly to prevent overheating of the compressed air.

Line diagram:



P_1 = Atmospheric pressure of air in Kg/cm2
T_1 = Air atmospheric Temperature in oC
P_2 = Intermediate Pressure of air in Kg/cm2
T_2 = Temperature of air before intercooler
P_3 = Pressure of air at Compressed air tank in Kg/cm2
T_3 = Exit temperature in oC

OBSERVATION TABLE:

S: No	P_1	P_2	P_3	SPEED	MANOMETRIC READINGS H_1	H_2	H_3	TIME TAKEN	TEMPEARATURE T_1	T_2	T_3
1											
2											
3											
4											
5											

FORMULAS:

1. Volume of free air delivery $V_a = C_d \times D_{orifice} \times \sqrt{2gh_a} m^3/s$

Where C_d = coefficient of discharge e = 0.62

$a_{orifice}$ = area of orifice = 0.00017 m^2

h_a = head of air = $\frac{\rho_w \times h_m}{\rho_a}$

where ρ_w = 1000 (density of water)

ρ_a = 1.169 (density of air)

$H_m = h_1 + h_2$ in meters

2. Compression index $\eta_{LP} = 1+\eta_{LP} [\frac{\log (\frac{T_2+273}{T_1+273})}{log\frac{P_2}{P_1}}]$ Let X

$\eta_{LP} = 1+\eta_{LP}X$

$\eta_{LP} - \eta_{LP}X = 1$

$\eta_{LP} = \frac{1}{(1-X)}$

$\eta = 1+\eta_{hP}[\frac{\log\left(\frac{T_3+273}{T_2+273}\right)}{\log\left(\frac{P_3}{P_2}\right)}]$ Let y

$\eta_{hP} - \eta_{hP}y = 1$

3. Swept volume $V_{LP} = \frac{\pi D_1^2}{4} \times l \times \frac{N}{60}$ m^3/s

   D_1 = diameter of LP cylinder = 70mm = 0.07m

   l = stroke length of LP cylinder = 85mm = 0.085mm

   N = speed

   $V_{HP} = \frac{\pi D_2^2}{4} \times l \times \frac{N}{60}$ m^3/s

   D_2 = Diameter of HP cyclinder = 50mm = 0.05m

4. Volumetric efficiency $\eta_{vol} = \frac{volume\ of\ free\ air\ delivered}{swept\ volume\ of\ LP\ cylinder} = \frac{V_a}{V_{LP}}$ %

5. Indicated power IP = $IP_{LP}+IP_{HP}$

$$IP_{LP} = \left(\frac{\eta_{LP}}{\eta_{LP}-1}\right)P_1V_{LP}\left[\left(\frac{P_2}{P_1}\right)^{\frac{\eta_{LP}-1}{\eta_{LP}}} - 1\right] \times 1000 \text{ KW}$$

$$IP_{HP} = \left(\frac{\eta_{LP}}{\eta_{LP}-1}\right)P_2V_{HP}[\left[\left(\frac{P_3}{P_2}\right)^{\frac{\eta_{HP}-1}{\eta_{HP}}} - 1\right] \times 1000 \text{ KW}$$

6. Isothermal efficiency $n_{iso} = P_1 \times V_a \times \ln\left(\frac{P_2}{P_1}\right) \times 1000$ KW

7. Isothermal efficiency $\eta_{iso} = \frac{P_{iso}}{IP}$ %

8. Compressor efficiency = $\frac{shaft\ power}{IP}$ %

   Where shaft power = $\frac{3600 \times no.of\ impulses \times \eta_{mech} \times \eta_{transmission}}{time \times energy\ meter\ const}$

   Where no of impulse = 10 (generally for 10 blinks)

   η_{mech} = 0.85 (mechanical efficiency)

   $\eta_{transmission}$ = 0.95 (transmission efficiency)

   Time = time taken for 10 blinks

   Energy meter constant = 1600 imp/kwhr

CALCULATIONS:

1) Va =

2) X =

3) $\eta_{cp} = \frac{1}{1-x} =$

   y =

   $\eta_{hp} = \frac{1}{1-y} =$

4) $V_{cp} =$

   $V_{hp} =$

5) $\eta_{vol} =$

6) $IP_{cp} =$

   $IP_{hp}=$

IP =

7) Pi_{so} =

8) η_{is} =

9) η_c =

RESULT TABLE:

S. No	P1	P2	P3	N	H_m	T	T_1	T_2	T_3	η_{CP}	η_{HP}	η_{VOL}	Ip Lp	Ip Hp	Pi Ip	η_{is}	η_i
1																	
2																	
3																	
4																	
5																	

Experiment No: 09

ECONOMICAL SPEED TEST ON MULTI CYLINDER SI ENGINE

AIM:

To determine the economical speed of a multi-cylinder spark ignition (SI) engine by evaluating its fuel consumption and performance under varying speed conditions.

OBJECTIVE:

• To know the effect of speed on fuel consumption

• To study the effect of load on fuel consumption

• To study the effect of load on economical speed

APPARATUS:

1. Multi-Cylinder SI Engine Test Rig – To conduct the economical speed test and measure the engine's performance under different speed conditions.
2. Fuel Flow Meter or Burette – To measure the fuel consumption rate accurately during the test.
3. Tachometer – To measure the engine speed (RPM) at different load conditions.
4. Dynamometer – To apply load on the engine and measure the brake power (BP).

DESCRIPTION:

The test rig, as shown, consists of a 3-cylinder, water-cooled petrol engine coupled to an eddy current dynamometer, which acts as the loading device. An air tank fitted with an orifice and a differential manometer is connected to the engine's inlet manifold to measure the quantity of air intake.

The rig is also equipped with a graduated burette, positioned between the fuel tank and the fuel pump, to accurately measure the fuel consumption. Additionally, the setup includes a provision to cut off the spark plugs of individual cylinders, allowing for flexible testing and performance evaluation.

TEST RIG SPECIFICATIONS

Make:	Maruti Suzuki
Bore:	68.5mm
Stroke:	55.1mm
No of cylinders:	3
Diameter of orifice:	20 mm
Fuel:	Petrol
Sp.gravity	0.72
Calorific Value:	46700 kJ/kg
Compression Ratio:	9:1
Loading by:	Eddy current dynamometer
Diameter of orifice:	0.02m
Capacity:	15-20 HP at 1500-2000RPM
Cooling type:	water cooled
Rated speed:	2000 to 2500 RPM
Starting by:	Battery ignition method

THEORY:

In an economical speed test on a multi-cylinder spark ignition (SI) engine, the objective is to determine the engine speed at which fuel consumption is minimized while maintaining optimal performance. The economical speed refers to the range of speeds where the engine operates with maximum fuel efficiency.

The multi-cylinder SI engine uses multiple cylinders to produce power, resulting in a smoother operation and enhanced performance. During the test, the engine is run at varying speeds under controlled load conditions. The fuel consumption is measured using a graduated burette, and the air intake is monitored through an orifice and manometer setup. The brake power (BP) and the specific fuel consumption (SFC) are calculated at each speed.

The test aims to identify the speed where the engine achieves the lowest specific fuel consumption (SFC), which indicates the most economical operating range. The brake specific fuel consumption (BSFC) is a key parameter, representing the amount of fuel consumed per unit of power output.

During the experiment, the eddy current dynamometer is used to apply varying loads, allowing the measurement of power output at different speeds. As the speed increases, the fuel consumption is recorded at each level. The relationship between fuel consumption and engine speed is plotted to identify the point of minimum SFC, which corresponds to the economical speed.

Economical speed testing is significant for optimizing engine performance and reducing fuel costs. It helps in determining the ideal operating speed for engines used in automobiles, generators, and industrial applications, thereby improving fuel efficiency and reducing operational expenses.

PRECAUTIONS:

1. Ensure all connections of the test rig are secure and the cooling system is properly functioning.
2. Check the fuel level and ensure there is no airlock in the fuel line.
3. Start the engine and allow it to run at no-load condition for a few minutes to reach a steady operating temperature.
4. Gradually apply load using the eddy current dynamometer.
5. Adjust the engine speed to the desired level using the throttle control.
6. Record the following readings:
7. Engine speed (RPM) using the tachometer.
8. Fuel consumption rate by measuring the time taken for a specific volume of fuel using the burette.
9. Air intake flow rate using the manometer.
10. Brake power (BP) from the dynamometer readings.
11. Repeat the test at different speeds by adjusting the throttle and applying varying loads.
12. For each speed, record the fuel consumption and calculate the specific fuel consumption (SFC).

13. Identify the speed where the SFC is the lowest, which indicates the economical speed of the engine.
14. After completing the test, gradually reduce the load, stop the engine, and turn off the cooling system.
15. Allow the engine to cool down before shutting off the power supply.

PRECAUTIONS:

1. The test readings of burette should be taken without parallax error.
2. The engine should be not be started or stopped under load.

Observation table:

S.No.	Load(W)	Speed(rpm)	Time taken for 'x'cc of fuel consumption
1			
2			
3			
4			
5			

Model calculations:

1) Total fuel consumption (TFC) = $\frac{x}{t} \times \frac{SP.gravity\ of\ fuel}{1000} \times 3600$

Where sp. gravity = 0.72

2) Brake(BP) = $\frac{2\pi NT}{60\times 10^3}$ Kw

Where T=W×0.25×9.81

3) specific fuel consumption (SFC) = $\frac{TFC}{BP}$

CALCULATIONS:

AT 1600 RPM

1) TFC =

2) BP =

3) SFC =

RESULT:

Experiment No: 10

MORSE TEST ON MULTI CYLINDER SI ENGINE

AIM:

To determine the Indicated Power (IP), Frictional Power (FP), and Mechanical Efficiency of a multi-cylinder spark ignition (SI) engine by performing the Morse test.

OBJECTIVE:

• To find friction power of the engine

• To find the indicated power of the engine

• To find mechanical efficiency of the engine

• To understand cut-off of cylinder

• To understand how eddy current loading is applied

APPARATUS:

1. Multi-Cylinder SI Engine Test Rig – To conduct the Morse test and measure the engine's performance parameters.
2. Tachometer – To measure the engine speed (RPM) during the test.
3. Fuel Flow Meter or Burette – To measure the fuel consumption rate accurately.
4. Dynamometer – To apply and measure the load on the engine and determine brake power

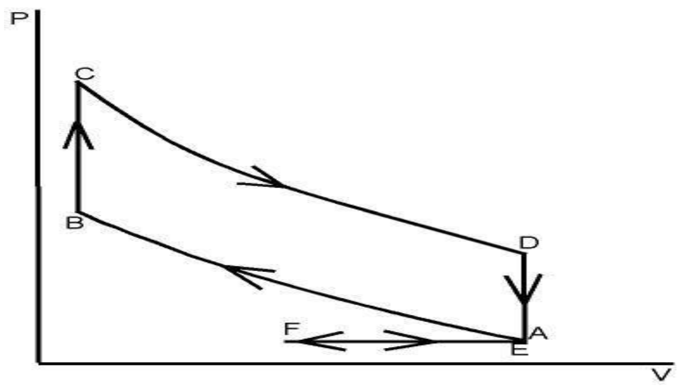
DESCRIPTION:

The test rig consists of a 3-cylinder, water-cooled petrol engine coupled to an eddy current dynamometer, which serves as the loading device. An air tank fitted with an orifice and a differential manometer is connected to the engine's inlet manifold to measure the air intake quantity. The rig is also equipped with a graduated burette, positioned between the fuel tank and fuel pump, to accurately measure the fuel consumption. Additionally, the setup includes a provision to cut off the spark plugs of individual cylinders, enabling the performance of the Morse test to determine the indicated power (IP) and frictional power (FP) of the engine.

TEST RIG SPECIFICATIONS:

Make:	Maruti Suzuki
Bore:	68.5mm
Stroke:	55.1mm
No of cylinders:	3
Fuel:	Petrol
Sp.gravity	0.72
Calorific Value:	46700 kJ/kg
Compression Ratio:	9:1
Loading by:	Eddy current dynamometer
Diameter of orifice:	0.02m
Capacity:	15-20 HP at 1500-2000RPM
Cooling type:	water cooled
Rated speed:	2000 to 2500 RPM
Starting by:	Battery ignition method

THEORY:



P-V diagram of Otto cycle

The Morse test is a widely used method for determining the Indicated Power (IP), Frictional Power (FP), and Mechanical Efficiency of a multi-cylinder spark ignition (SI) engine. This test is based on the principle of cutting off individual cylinders one at a time and measuring the resulting change in brake power (BP). By analyzing the drop in power, the IP of each cylinder can be calculated.

During the test, the engine is run under normal operating conditions at a constant speed and load. The brake power of the engine is recorded with all cylinders firing. One by one, the spark plugs are disconnected, cutting off combustion in each cylinder. The engine is then motored by the remaining active cylinders, and the new brake power is measured. The difference in brake power between the firing and non-firing conditions of each cylinder represents the IP of the cut-off cylinder.

The Morse test provides a reliable method for determining the frictional losses and mechanical efficiency of a multi-cylinder engine. It is particularly useful for evaluating the performance of individual cylinders and identifying imbalances or inefficiencies. This test is commonly used in automotive and mechanical laboratories for engine analysis and performance assessment.

PROCEDURE:

1. Check all connections of the test rig, including the fuel supply, cooling system, and ignition wiring.
2. Ensure the cooling water flow is adequate to prevent overheating during the test.
3. Start the multi-cylinder SI engine and allow it to run at no-load condition for a few minutes to reach a stable operating temperature.
4. Gradually apply load on the engine using the eddy current dynamometer and adjust the throttle to maintain a constant speed.
5. Measure and record the brake power (BP) with all cylinders firing.
6. Disconnect the spark plug of one cylinder, effectively cutting off its combustion.
7. Measure the new brake power (BP) with the remaining cylinders operating.
8. Reconnect the spark plug and repeat the process for each cylinder, cutting off one cylinder at a time.
9. Record the brake power for each configuration.
10. Calculate the indicated power (IP) of each cylinder using the difference in BP before and after disconnecting the cylinder.
11. Determine the frictional power (FP) by subtracting the total brake power from the total indicated power:

12. After completing the test, gradually reduce the load, stop the engine, and turn off the cooling system.
13. Allow the engine to cool down before shutting off the power supply.

PRECAUTIONS:

1. The test readings of burette and manometer should be taken without parallax error.
2. The engine should be neither be started nor stopped without load.
3. Note down the readings of temperatures only after attainment of steady state conditions.

Observation Table:

S.NO	EVENT	LOAD(W)	SPEED
1	All Cylinder are firing		
2	Firing cutoff of first cylinder		
3	Firing cutoff of second cylinder		
4	Firing cutoff to third cylinder		

Model Calculation:

Brake power (BP) = $\frac{2\pi NT}{60\times10^3}$

Torque (T) = 9.81×10×0.25

Frictional power (FP) = IP - BP

Mechanical efficiency (η_m) = $\frac{BP}{IP}\times 100$

Calculation:

At all cylinder firing

BP =

BP_1 =

BP_2 =

$BP_3 =$

IP_1 = BP-BP_1 =

IP_2 =

IP_3 =

Now,

IP= $IP_1 + IP_2 + IP_3$

=

FP = IP – BP

=

η_{mech}=

RESULT: