GOVT CO-ED POLYTECHNIC

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LAB MANUAL

Branch:Mechanical Engineering

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Thermal Engineering Lab (2037363(037))
(Lab)

CONTENTS

Practical No. 01: Determination of thermal conductivity of metallic rod.

I Practical Significance

Conduction is dominant phenomenon of heat transfer in various applications. Value of thermal conductivity of different materials helps us to separate conductors from insulators. After doing this experiment students can determine experimentally thermal conductivity of any solid metallic rod.

II Relevant Program Outcomes (POs)

POl - **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based Mechanical engineering problems.
P02 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad-based mechanical engineering related problems.
P08 - **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.
P09 - **Communication:** Communicate effectively in oral and written form.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.':**

- Follow safety practices.
- Practice energy conservation.

IV Relevant Course Outcome(s)

- Use suitable modes of heat transfer.

V Practical Outcome

- Conduct a trial on conduction setup for a metallic rod and calculate thermal conductivity.

VI Minimum Theoretical Background

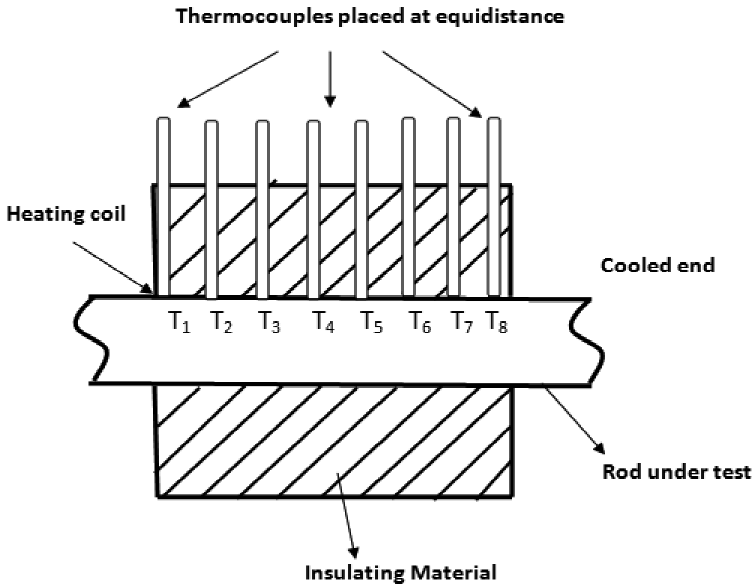
Fourier's law of conduction states that rate of heat transfer through a material is proportional to negative temperature gradient and to the area, at right angle to the gradient through which heat is flowing. Mathematically

Q *a* - (dT / dx)

QaA

Steady state is condition when properties at a location do not change with respect to time.

VII Setup (Models) -



Experimental setup

VIII Resources Required

S.No	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental set up for determination of thermal conductivity of a metallic rod.	Metallic rod of suitable length, Adequately insulated with heating arrangements at one end. Voltage regulator. Six thermocouples on metallic rod. Two thermocouples for water temperature. Arrangement for cooling other end of rod.	1 No.
2	Stop watch	----	1 No.
3	Measuring jar	1 litre	1 No.

IX Precautions to be Followed

- Do not touch heater end by bare hand.
- Use recommended voltage and amperage for heating rod.

X Procedure

1. Switch on Mains
2. Start cooling water supply and measure it. Note it.
3. Switch on the heater.
4. Adjust voltage regulator to get constant voltage and amperage. Note it.
5. Wait till steady state is reached.
6. Measure and note temperatures of thermocouples on given metallic rod. (T_1 to T_6)
7. Measure inlet & outlet temperatures of water. Note them. (T_7 & T_8)

XI Resources Used

S. No	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		

Actual Procedure Followed

Precautions Followed

Observations and Calculations

mw = Cooling water flow rate ....Kg/s

r = radius of given metallic rod = ...m

Distance between two thermocouples = ... m

S.No.	V	I					Ts			Ts

(Note - Multiple reading are required to reach steady state. Use final reading for the calculations once steady state is achieved).

Calculation -

Q = -kA (dT/dx)

Also neglecting any heat loss through insulating material we can

write Q = V *I= ....Watts (where Vis voltage & I is current set)

A = cross sectional area of rod = $n * r^2$

dT/dx = Temperature gradient can be calculated by plotting a graph of temperature Vs distance at which thermocouples are positioned and then finding slope of curve obtained.

K = ... **W/m K**

Result

Interpretation of Results (Giving meaning to results)

Conclusions (Actions to be taken based on the interpretations.)

Practical Related Questions

Note: Below given are few sample questions for reference. Teachers <u>must design</u> more such questions so as to ensure the achievement of identified CO.

1. Define thermal conductivity. State it's unit.
2. List thermal conductivity of commonly used engineering materials.
3. Discuss effects of chemical composition, state on thermal conductivity.
4. Discuss effect of temperature on thermal conductivity of metals and gases.
5. Discuss effect of pressure on thermal conductivity of liquids and gases.
6. If you want to calculate heat lost to insulating powder how will you calculate?

(Space for Answer)

Practical No. 02: Verification of Stefan Boltzmann law of radiation

I Practical Significance

Experiment is used to verify value of Stefan Boltzmann constant. The law is widely used law of radiation. This law is useful in calculating the energy transferred by radiation from emitting surface to receiving surface such as heat transferred by solar radiation, radiation heat from furnace walls, induction heating coils etc.

II Relevant Program Outcomes (POs)

PO2 - **Discipline knowledge:** Apply Mechanical engineering knowledge to solve broad- based mechanical engineering related problems.
PO3 - **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.
PO8 - **Individual and team work:** Function effectively as a leader and team member in diverse / multidisciplinary teams.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.':**

- Apply Stefan Boltzmann law to given situations.
- Calculate heat transfer by radiation.

IV Relevant Course Outcome(s)

- Use suitable modes of heat transfer

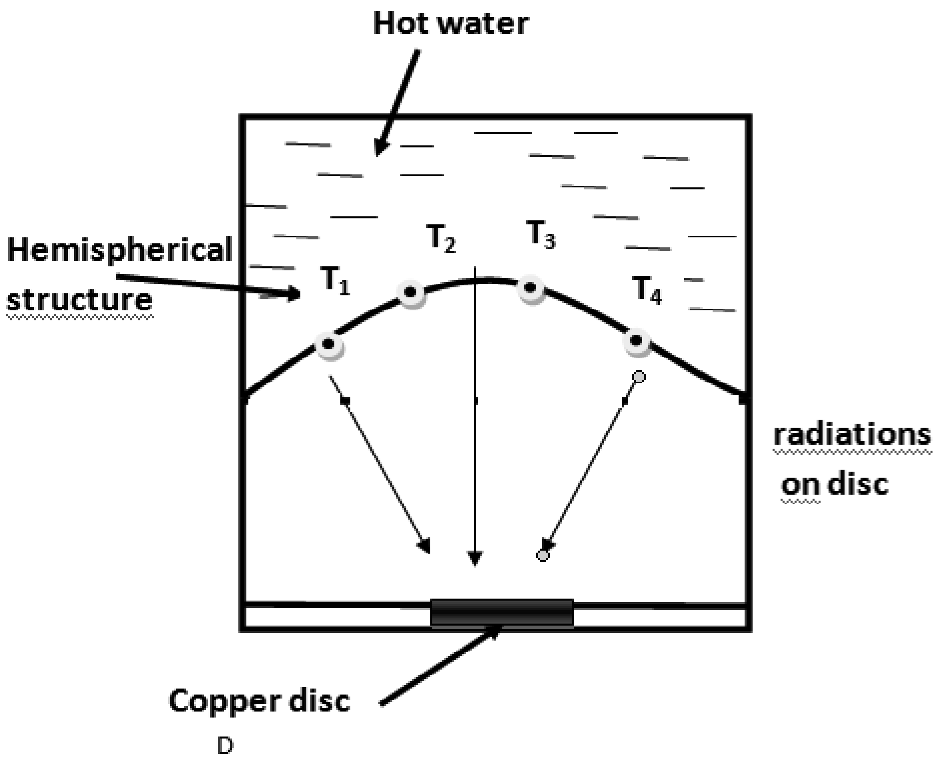
V Practical Outcome

- Verify of Stefan-Boltzmann constant for radiation.

VI Minimum Theoretical Background

Stefan-Boltzmann law, statement that the total radiant heat energy emitted from a surface is proportional to the fourth power of its absolute temperature. Black body is a body having absorptivity and emissivity both are 1. The value of Stefan Boltzmann constant is
$5.67 * 10^{-8} W/m^2 K^4$

VII Setup (Models) -



Experimental setup for Stefan Boltzmann law

VIII Resources Required

S.No.	Name of Resource	Suggested Broad Specification	Quantity
1	Stefan-Boltzmann apparatus.	Hemispherical enclosure with water jacket, base plate, Sleeve, test disc, thermocouples.	1 each
2			
3			
4			

IX Precautions to be Followed

- Use safety shoes.
- Do not touch heated surface with bare hand.

X Procedure

1. The water in the tank is heated by immersion heater up to a temperature of about 90 °C.
2. The disc Dis removed before pouring the hot water in the jacket.
3. The hot water is poured in the water jacket.
4. The hemispherical enclosure will come to some uniform temperature Tin short time after filling the hot water in jacket.
5. The enclosure will soon come to thermal equilibrium conditions.
6. The disc Dis now inserted back at a time when its temperature is say T_5 (to be sensed by separate thermocouple).
7. As soon as disc is inserted timer is started and temperature of disc is recorded af

After every 5 seconds

XI Resources Used

S. No	**Name of Resource**	**Broad Specifications**		**Quantity**	**Remarks** (If **any)**
		Ma	**Details**		

XII Actual Procedure Followed

XIII Precautions Followed

XIV Observations and Calculations

Calculate average temperature of hemisphere using four thermocouples located on it.

Themocouple	T_1 **(K)**	**T2(K)**	**T3(K)**	**T4(K)**
Temperature °C				

Average temperature of hemisphere = **T** = **(**$T_1 + T_2 + T_3 + T_4$**) /4**

1. Temperature to which water is heated= ....°C
2. Mass of disc (mo) =........... kg
3. Radius of disc = ...m
4. Specific heat of disc material (Cpn) = 0.4186 KJ/kg °C (for copper)

Time, sec	0	5		15	20	25	30
Temperature, oc							

Plot a graph of temperature of disc taking on y axis and time on x

axis. Find slope of graph at $(dT/dt)_{t=o}$ = . K/sec

Now heat radiated by hemisphere is equal to heat absorbed by copper disc.

$_0$ $*Ao*(T^4 - To^4) = m * Cpo * (dT/dt)_{t=o}$

TD = Temperature of disc at the instant when it is inserted.

Ao = Area of disc = ... m^2

$_0$ =(mo* Cpo * (dT/dt) $_{t=o}$) /(Ao* (T^4 -To ^{4})) = ...

$_0$ =......................... W/m^2K^4

XV Results

XVI Interpretation of Results (Giving meaning to results)

XVII Conclusions (Actions to be taken based on the interpretations.)

XVIII Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define radiation heat transfer.
2. Give practical examples where radiation heat transfer is dominant.
3. Define black body and emissivity.
4. State the applications where Stefan Boltzmann constant can be used.

(Space for Answer)

Practical No. 3: Determination of Dryness Fraction Of Steam

Practical Significance

In industries who use steam for various purposes need to find out dryness fraction for determining condition of steam. Particles of water in steam can have greater impact on various devices. In steam turbines the presence of water particle can result in erosion as well as corrosion of blades of turbine. Wet steam is economical in certain cases.

I. Relevant Program Outcomes (POs)

P02 - **Discipline knowledge:** Apply Meehanical engineering knowledge to solve broad-based mechanical engineering related problems.

P03 - **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based Mechanical engineering problems.

P06 - **Environment and sustainability:** Apply Mechanical engineering solutions also for sustainable development practices in societal and environmental contexts.

II. Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use principles of thermal engineering to maintain thermal related equipment.':**

- Follow safety practices.
- Practice energy conservation.

III. Relevant Course Outcome(s)

- Use relevant steam boilers.

IV. Practical Outcome

- Determination of dryness fraction of a given sample of steam by using separating calorimeter.

V. Minimum Theoretical Background

The steam containing water particles is called as wet steam. Steam calorimeters are devices used to find dryness fraction of the steam. In separating calorimeters water particle are separated mechanically. The steam is allowed to strike on hard surface due to which water particles falls down. The steam is separately collected in another chamber. The weight s of water particles and steam are measured.

VI. Setup (Models) - (Label the sketch)

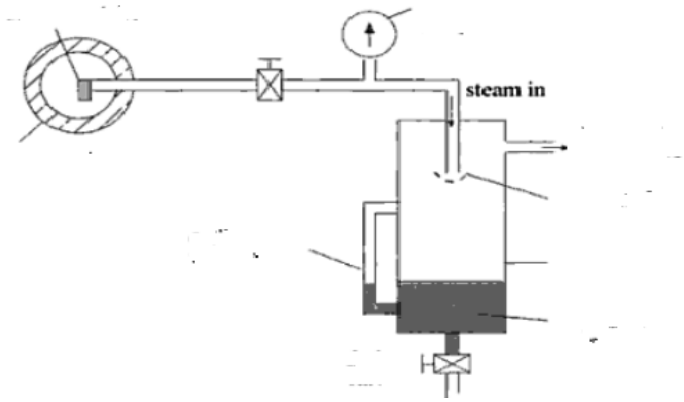


Figure – Seperating Calorimeter

VII. Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Experimental setup to find dryness fraction of steam.	Steam generator with separating calorimeter. Steam generator equipped with pressure and temperature gauges.	1 No.
2			
3			

VIII. Precautions to be Followed

1. Use safety shoes.
2. Monitor pressure gauge for safe operation of steam generator.

IX. Procedure

1. Start the steam generator.
2. Note the pressure and temperature of steam generator.
3. Open the steam valve for few seconds and send the sample to calorimeter.
4. Measure mass of condensate collected.
5. Measure mass of dry steam separately.

X. Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
1.					
2.					
3.					

XI. Actual Procedure Followed

XII. Precautions Followed

XIII. Observations and Calculations

S.No.	Pressure bar	Mass of water (Mw) kg	Mass of dry steam (Ms) kg	Dryness fraction
1				
2				

Dryness fraction is calculated by formula (Calculate at different pressures)

$$X = M_s / (M_s + M_w)$$

XIV. Results

XV. Interpretation of Results (Giving meaning to results)

XVI. Conclusions (Actions to be taken based on the interpretations.)

XVII. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State limitation of separating calorimeter.
2. Explain principle of separating and throttling calorimeter.
3. State formula to determine enthalpy of steam when it contain water particles.
4. List applications where wet steam is used.
5. Calculate dryness fraction for different pressures.

(Space for Answer)

Practical 4: I.C. Engine Performance Test Single Cylinder 4 Stroke Diesel 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, 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:

a. *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 springload 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 anddirecting the fuel to the engine respectively.

EXPERIMENTATION:

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.

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 adjustthe 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 Ropebrake 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			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	h_w = (h1+h2)	

Sl. No.	T 1	T 2	T 3	T 4	T 5	T 6

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

CALCULATIONS:

1. *Mass of fuel consumed, m_f*

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

Where,

SG of Diesel is = 0.827

Xcc 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 Diesel = 44631.96 KJ/

3. Output or Brake Power, BP

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

Where,

N = speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

4. Specific Fuel Consumption, SFC

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

5. Brake Thermal Efficiency, ηbth%

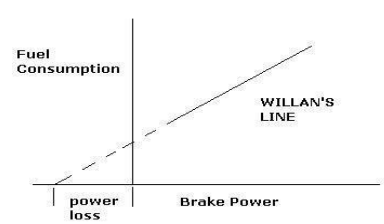
$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

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

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

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

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zeropoint 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					
4					
5					

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

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 rotameters, enginehead and calorimeter.
4. Note that the range for water supply provided is an approximate standardvalues, 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 therotating parts and bearing of engine may run out.

PRECAUTIONS:

7. Do not run the engine if supply voltage is less than 180V
8. Do not run the engine without the supply of water.
9. Supply water free from dust to prevent blockage in rotameters, enginehead and calorimeter.
10. Note that the range for water supply provided is an approximate standardvalues, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.

11. Do not forget to give electrical earth and neutral connections correctly.
12. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

Practical-05: PERFORMANCE TEST ON SINGLE CYLINDER 2 – STROKE 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, 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. *Electrical Dynamometer Loading (AC)*

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 byan 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 bydigital 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 ismeasured by means of a Manometer.

7) A volumetric flask with a fuel distributor is provided for measurementand directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to

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

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 switchesprovided. (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 above readings.
12. After the completion release the load (while doing so release the accelerator) and then switch of the engine by pressing the ignition cut – off switch and then turnoff the panel.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading, cm of water			Time for 10cc of fuel collected,	Time for 5 rev of Energy meter,
		'F' kW	h1	h2	h_w = (h1+h2)	t sec	

Sl. No.	Temperature, °C	
	T1	T2

CALCULATIONS:

1. *Mass of fuel consumed, m_f*

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

Where,

SG of Petrol is = 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*

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

Where,

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

K = Energy meter constant

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

η_m = efficiency of belt transmission = 80%

4. Specific Fuel Consumption, SFC

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

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

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

6. Calculation of head of air, Ha

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

Where,

ρ_{water} = 1000 Kg/m

ρ_{air} = 1.2 Kg/m @ R.T.P

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

7. Volumetric efficiency, $\eta_{vol\%}$

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

where,

Q_a = Actual volume of air taken

$$\mathbf{Qa} = C_d\ a \sqrt{(2gH_a)}$$

Where,

C_d = Coefficient of discharge of orifice = 0.62

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

H_a = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

$$\mathbf{Q_{th}} = \frac{(\prod/4) \times D^2 \times L \times GR \times 0.5 \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N = speed of the engine in rpm.

GR = gear ratio

1^{st} gear = 14.47:1

2^{nd} gear = 10.28:1

3^{rd} gear = 7.31:1

4^{th} gear = 5.36:1

TABULATION:

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

RESULT:

Graphs to be plotted:

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

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.

Practical:06-PERFORMANCE TEST ON SINGLE CYLINDER FOUR STROKE PETROLENGINE

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.

AIM:

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

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
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 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 therespective 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 change over switch in the generator direction.

7. Apply ¼ load (1.9 Amps).

8. Notedown 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 suchas,

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 for 10cc of fuel collected,
		'F' kW	h1	h2	h_w = (h1+h2)	t sec

ENGINE PERFORMANCE:

1. *BRAKE POWER*

$$BP = \frac{VI}{1000 \times \eta_g} \text{ kW}$$

Where, V = DC voltage in volts.

I = DC current in amps.

η_g = efficiency of generator = 85%

2. MASS OF FUEL CONSUMED.

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

Where, X = burette reading in cc

0.72 = density of petrol in 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.

$$V_a = C_d \times A \sqrt{2gH} * 3600 \text{ .... } m^3 / hr.$$

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

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:

$$V_S = \frac{\pi d^2}{4} L$$

Where, d = dia of bore = 70 mm

L = length of stroke = 66.7 mm

6. VOLUMETRIC EFFICIENCY:

$$\eta_v = \frac{V_a}{V_s} \times 100 \text{ ....} \%$$

7. BRAKE THERMAL OR OVER ALL EFFICIENCY

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

Where, CV = calorific value of petrol = 43500 kJ / kg.

BP = Brake Power in kW.

8. INDICATED THERMAL EFFICIENCY:

$$\eta_{ith} = \frac{IP \times 3600 \times 100}{m_f \times CV} \%$$

9. MECHANICAL EFFICIENCY:

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

Where, BP = Brake Power in kW.

IP = Indicated power in kW.

Practical-07:PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR

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 pressuregauge 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.

EXPERIMENTATION:

AIM:

The experiment is conducted at various pressures to

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

PROCEDURE:

1. Check the necessary electrical connections and also for thedirection 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 sinceit 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 the compressor.

Manometer readings.

Delivery pressure.

Temperatures.

Energy meter reading.

6. Repeat the experiment for different delivery pressures.

7. Once the set of readings are taken switch of the compressor.
8. 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.

9. Repeat the above two steps after every experiment.

OBSERVATIONS:

Sl. No.	Compressor Speed, N rpm	Delivery Pressure, 'P' kg/cm^2	Time for 'n' revolutionsof energy meter, 'T' sec	Manometer meter reading in 'm'		
				h1	h2	Hw
1						
2						
3						
4						
5						

CALCULATIONS:

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

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

Where,

h_w is Water column reading in m of water.
ρ_{water} is density of the water = 1000 kg/m^3

ρ_{air} is the density of the air = 1.293 kg/m^3

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

$$Qa = Cd\ a \sqrt{(2gha)} \quad m^3/s$$

Where,

ha is air head causing the flow in m of air.
Cd = co efficient of discharge of orifice = 0.62
a = Area of orifice = $(\prod d)^2 / 4$

d = diameter of orifice = 0.02m

3. Theoritical volume of air compressed Qth,Qth

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

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

$$\text{Input Power} = \frac{3600 \times n \times \eta_m}{K \times T}, \quad \text{kW}$$

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 Work done, WD

$$WD = \rho a \times Qa \ln r \ \text{kW}$$

Where,

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

Qa = Actual volume of air compressed.

r = Compression ratio

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

Where Atmospheric pressure = 101.325 kPa

NOTE: To convert delivery pressure from kg/cm[to kPa

multiply by 98.1

6. Volumetric efficiency, ηvol

$$\eta vol = Qa/Qth \times 100$$

7. Isothermal efficiency, η_{iso}

$$\eta_{iso} = \frac{\text{Isothermal work done}}{IP} \times 100$$

TABULATIONS:

Sl. No	Head of air ha, m	Act. Vol. of air compressed Qa mZ/s	Theo. Vol. of air compressed Qth, mZ/s	Isothermal work done kW	Iso Thermal Efficiency ηiso, %	Volumetric Efficiency, ηvol, %
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 directionchange the phase line of the motor to run in appropriate direction.
3. Do not forget to give electrical earth and neutral connectionscorrectly.

RESULT:

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

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

GRAPHS TO BE PLOTTED:

1. Delivery Pressure vs. ηvol
2. Delivery Pressure vs. ηiso