NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE
(NAAC Accredited)
(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

THERMAL ENGINEERING LABORATORY

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- Established in: 2002
- Course offered : B.Tech in Mechanical Engineering
- Approved by AICTE New Delhi and Accredited by NAAC

- Affiliated to the University of Dr. A P J Abdul Kalam Technological University.

DEPARTMENT VISION

Producing internationally competitive Mechanical Engineers with social responsibility & sustainable employability through viable strategies as well as competent exposure oriented quality education.

DEPARTMENT MISSION

1. Imparting high impact education by providing conductive teaching learning environment.
2. Fostering effective modes of continuous learning process with moral & ethical values.
3. Enhancing leadership qualities with social commitment, professional attitude, unity, team spirit & communication skill.
4. Introducing the present scenario in research & development through collaborative efforts blended with industry & institution.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1: Graduates shall have strong practical & technical exposures in the field of Mechanical Engineering & will contribute to the society through innovation & enterprise.

PEO2: Graduates will have the demonstrated ability to analyze, formulate & solve design engineering / thermal engineering / materials & manufacturing / design issues & real life problems.

PEO3: Graduates will be capable of pursuing Mechanical Engineering profession with good communication skills, leadership qualities, team spirit & communication skills.

PEO4: Graduates will sustain an appetite for continuous learning by pursuing higher education & research in the allied areas of technology.

PROGRAM OUTCOMES (POS)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and

modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: Students will be able to apply principles of engineering, basic sciences & analytics including multi variant calculus & higher order partial differential equations..

PSO2: Students will be able to perform modeling, analyzing, designing & simulating physical systems, components & processes.

PSO3: Students will be able to work professionally on mechanical systems, thermal systems & production systems.

COURSE OUTCOMES

CO1	Summarize the diesel and petrol engine systems and parts
CO2	Carryout performance test on SI engines and CI engines with various types of loading systems
CO3	Carryout test on IC engines to determine the friction power.
CO4	Carryout test on CI engines to determine Air fuel ratio, volumetric efficiency and heat balance.
CO5	Carryout test on CI engines to determine the optimum speed and cooling water temperature.
CO6	Carryout performance test on air compressor and blower

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	-	-	-	-	3	-	-	3	3	-	3	3	-	**3**
CO2	3	-	-	-	3	3	-	-	3	3	-	3	3	3	**3**
CO3	3	-	-	2	3	-	-	-	3	3	-	3	3	-	**3**
CO4	3	-	-	2	3	3	-	-	3	3	-	3	3	3	**3**
CO5	3	-	-	2	3	-	-	-	3	3	-	3	3	3	**3**
CO6	3	-	-	2	3	-	-	-	3	3	-	3	3	3	**3**
	3.00	-	-	2.00	3.00	3.00	-	-	3.00	3.00	-	3.00	3.00	3.00	3.00

Note: H-Highly correlated=3, M-Medium correlated=2, L-Less correlated=1

SYLLABUS

Course No.	Course Name	L-T-P-Credits	Year of Introduction
ME232	**THERMAL ENGINEERING LABORATORY**	**0-0-3-1**	**2016**

Prerequisite : Should have registered for ME204 Thermal Engineering

Course Objectives:

1. To study the various types IC engines and their parts
2. To conduct the performance test on IC engines, compressors and blowers
3. To familiarize equipment used for measuring viscosity, flash and fire point and Calorific value of petroleum products

Syllabus

List of experiments:

Study of I.C engines :-

a) Diesel engines - all systems and parts

b) Petrol engines - all systems and parts

Experiments

1. Determination of flash and fire points of petroleum products -flash and fire point apparatus
2. Determination of viscosity of lubricating oil- viscometer
3. Determination of calorific value of solid and liquid fuels- calorimeter
4. Determination of calorific value of and gaseous fuels - calorimeter
5. Performance test on petrol engines with various types of loading systems
6. Performance test on Diesel engines with various types of loading systems
7. Heat Balance test on petrol/Diesel engines
8. Cooling curve of IC engines
9. Valve timing diagram of IC engines
10. Economic speed test on IC engines
11. Retardation test on IC engines
12. Determination volumetric efficiency and Air-fuel ratio of IC engines
13. Morse test on petrol engine
14. Performance test on reciprocating compressor
15. Performance test on rotary compressor/blower
16. Draw velocity profile in a pipe flow using Prandtl -Pitot tube
17. Analysis of automobile exhaust gas and flue gas using exhaust gas analyser

Note: 12 experiments are mandatory

Expected outcome: At the end of the course the students will be able to

1. Determine the efficiency and plot the characteristic curves of different types of Internal Combustion engines, compressors and blowers
2. Conduct experiments for the determination of viscosity, calorific value etc of petroleum products

DETERMINATION OF FLASH AND FIRE POINT

OBJECTIVE:

To find the flash and fire point of the given oil by Cleveland's open cup apparatus.

PRINCIPLE:

This apparatus consists of a cylindrical cup of standard size, it is held in place with the metallic holder which is placed on the wire gauge and is heated by means of electric heater bounded inside mechanical holder. The filling mark has been scribed on the inner side of the cup and the sample of oil is filled up to the mark.

The test cup is filled to a specific level to the sample , the temperature of the sample is increased by a fairly rapid speed rak on the flash point is increased fairly rapidly at first and then at a flow content rak on the flash point is appeared. At specified intervals a small test flame is introduced across the cup. The leanest temperature at which application of the test, flame causes the surface of the liquid to ignite momentually is taken as the flash point. The test is again done to determine the fire point. Until the application of the test flame causes the oil to ignite and burn for at least 5 seconds.

MATERIALS AND METHODS:

Open cup apparatus, thermometer (0-250^{0}c), sample of oil and splinter stick.

PREPARATION OF APPARATUS:

Support the apparatus on a level steady table in a draught free room or compartment. Shield the top of the tester strong tight by any, suitable means to permit ready detection of flash point.

Wash the test cup with an appropriate solvent to remove any oil or traces of gum or residues from a test done before. If any deposits of carbon are present they may be removed with steel. Flush the cup with cold water and for a few minutes place it over an open flame or a hot plate to remove the last residue up to a temperature at least 56^0 c before the expected flash point before using.

Support the thermometer in a vertical position with the bottom of the bulb '6mm' from bottom of the cup and locate a point half way between the centre and the side of the cup. A diameter perpendicular to the time of sweep of the test flame and on the side opposite of the test flame burner arm.

The immersion line engraved on the thermometer is about 2mm below the level of the rim of cup when the thermometer is properly positioned.

The methods of experiments are follows:

1. Fill the cleaned cup with the given sample of oil upto standard filling mark of the cup.

2. Insert the thermometer in the holder on the top of the edge of the cup. Make sure that the bulb of the thermometer is immersed in the oil and should not touch metallic part.
3. Apply heat initially by means of an electric heater, so that the rate of temperature rise of the sample is 14^0 to 16^0 per minute. When the sample temperature is approximately 56^0 below the anticipated flash point, decreases the heat supply so that the rate of temperature rises for the last 28^0 before flash point is 5^0 to 6^0 per minute.
4. Starting at least 28^0 below the flash point, apply the test flame when temperature read on thermometer reaches each successive 2^0 mark. Pass the test flame across the centre of the cup at right angles of the diameter which passes through the thermometer.
5. When the oil gives out vapour starts to introduce spline (the flame should not touch with the oil) and watch for flash with flickering sound. The time consumed in passing the test flame across the cup shall be about one second.
6. Blow out the burned vapour before introducing next glowing splines. This insures that always fresh vapour alone is left over the surface oil and test is carried out accurately.
7. Record the flash point, the temperature read on the thermometer when flash appears with peak flickering sound at any point on the surface of the oil but do not confuse the true flash with bluish pale that sometimes surround test flame.
8. To determine fire point, continue heating so that sample temperature increases at rate of 5^0 to 6^0 ignites per minute. Continue the application of test oil ignites and then continues to burn for at least 5 seconds. Record the temperature at this point as fire point of oil.
9. Repeat test twice or thrice with fresh sample of sample oil until results are equal.
10. The observations are tabulated.

OBSERVATION

SL NO.	**TEMPERATURE**	**RESULT**
1	45	**No flash**
2	50	**No flash**
3	55	
4	57	
5	60	
6	64	

RESULT AND DISCUSSION:

1. The flash point of given sample of oil =
2. The fire point of given sample of oil =

CONCLUSION:

The flash and fire point experiment was conducted as per the procedure.

VIVA QUESTIONS

1. What is flash point?
2. Explain fire point.
3. What is the significance of flash and fire point determination experiment?
4. How the flash and fire point differs for petrol and diesel fuels?

DETERMINATION OF VISCOSITY USING REDWOOD VISCOMETER

OBJECTIVE

To determine absolute and kinematic viscosities of given lubricating oil at various temperatures starting from room temperature.

PRINCIPLE

1. Viscosity: It is a measure of resistant to relative translation motion of adjacent layers of fluid. Its unit is centipoise or poise.
2. Specific viscosity: It is the ratio of viscosity of fluid to that of 20 degree since water has viscosity of 1 cp at 20 degree.
3. Kinematic viscosity: It is the ratio of viscosity of fluid to that of density of fluid.

For liquids, viscosity decreases with increase in temperature while for gases it increases with increase in temperature. Various forces are a result of intermolecular cohesion and momentum transfer.

For $t<100$, $\nu = (0.226t-(195/t))$

For $t>100$, $\nu = (0.22t-(135/t))$

THEORY

Redwood viscometer consists of heavily silver plated coil with a distilled bottom placed in bright chrome plated water bath which is mounted on a stand with a levelling screw. The maximum oil level is marked on oil cup, both of the liquid is stirred manually by cylindrical section surrounding oil cup provided with three vanes having upper and lower position turned in opposite direction. Oil flow is controlled by a ball valve on a staff both heavily silver plated.

APPARATUS

Redwood viscometer, lubricating oil

PROCEDURE

1. The prepared sample of oil is poured into oil cup.
2. The temperature of both is adjusted until the sampling cup is maintained at constant required temperature by continuous stirring.
3. When sample temperature reaches desired value, the ball valve is lifted and time for 50cc of oil to collect in measuring flask is noted.
4. The procedure is repeated for various temperatures and the results are tabulated.

OBSERVATION

Sl.No	Oil Temperature	Water Temperature	Time for 5ml rise of oil (s)	Kinematic viscosity(stokes)	Absolute Viscosity(Ns/m^2)

1					
2					
3					

CALCULATION

Kinematic Viscosity, ν = ((0.226t – (195/t)) stokes for 34 < t < 100.

ν = ((0.22t – (135/t)) stokes for t < 100.

Where, t = redwood seconds and t = temperature.

Average Kinematic Viscosity = ____ stokes

Absolute viscosity = Kinematic viscosity x Density

Average absolute viscosity = ____ Ns/m^2

RESULT AND DISCUSSION

The experiment was done as per the procedure. The required calculations were done and the following graphs were plotted.

1. Absolute viscosity v/s temperature.
2. Kinematic viscosity v/s temperature.
   The average kinematic viscosity is calculated as ……. Stokes.

CONCLUSION

Viscosity is helpful in determining degree of flow of a particular fluid at a particular time and temperature.

VIVA QUESTIONS

1. What is viscosity?
2. How viscosity of a fluid varies with temperature?
3. Differentiate between absolute viscosity and kinematic viscosity?

PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR

AIM

The experiment is conducted at various pressures to determine the

i. Volumetric efficiency.
ii. Isothermal efficiency.

APPARATUS

i. Air compressor test rig
ii. Tachometer
iii. stopwatch

PROCEDURE

1. Check the lubricating oil level in the compressor.
2. Start the compressor by switching on the motor.
3. The slow increase of the pressure inside the air reservoir in observed.
4. Maintain the required pressure by slowly operating the discharge valve (open/close). (Note there may be slight variations in the pressure readings since it is a dynamic process and the reservoir will be filled continuously till the cut-off.)
5. Now note down the following readings in the respective units
   i. Speed of the compressor.
   ii. Manometer readings.
   iii. Delivery pressure.
   iv. Temperatures.
   v. 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/cm²	Time for 'n' revolutions of energy meter, 'T' sec	Manometer meter reading in 'm'		
				h1	h2	Hw
1						
2						
3						
4						
5						

CALCULATIONS

A)Pressure head across orifice, 'h' in meters of water.

h=h1-h2

h1,h2 =manometer reading in m of water.

B)Equivalent height of air column, H

H=h*(ρw/ ρair) m of air,

Where ρw=density of water =1000kg/m^3

ρair =1.225

C) Actual intake volume of air in to the compressor at ambient conditions, Va

Va = cd*a*√2gH in m^3/sec

Cd = coefficient of discharge of orifice (0.64)

a= area of the orifice = (Π D^2)/4 in m^2

d= diameter of the orifice in m

D) Actual intake volume of air in to the compressor at NTP conditions,V1

V1=Va *(T1/Ta) in m^3

T1 = 273k,Ta = (273+t)k

E) Theoretical volume swept by piston at NTP

Vth = (Π D^2 L N)/4*60

D= bore dia of the cylinder in m

L = Stroke length in m

N = shaft speed in rpm

F) VOLUMETRIC EFFICIENCY, ηvol

ηvol =(V1/Vth)*100 in %

G) Compression ratio, r

= (Pgauge + Patm)/ Patm

I) Work input to the compressor shaft. Win

Win =[(n*3600)* ηm* ηb]/(t*k) watts

n =number of revolutions of energy meter disc

ηm =motor efficiency

ηb = belt efficiency

K = energy meter constant, 240rev/KWhr

J) Isothermal Efficiency, ηiso

ηiso =(Wiso/Win)*100

K) Adiabatic work done ,Wadia in Watts

Wadia = (n/n-1) *Pa Va[r^(n-1/n)-1]

n = isothermal expansion index =1.3 for air

r, compression ratio =V1/V2

L) Adiabatic efficiency, ηadia

ηadia = (Wadia/Win)*100

OBSERVATIONS

Sl No	Head of air h_a, m	Actual Volume of air compressed Q_a m^3/s	Theoretical Volume of air compressed Q_{th}, m^3/s	Isothermal work done kW	Iso Thermal Efficiency I_{iso}, %	Volumetric Efficiency, η_{vol}, %
1						
2						
3						

GRAPHS TO BE PLOTTED

1. Delivery Pressure vs. η_{vol}
2. Delivery Pressure vs. η_{iso}

RESULT & INFERENCE

Performance test on air compressor is conducted and the isothermal and volumetric efficiencies are found out.

η_{vol} =

η_{iso}=

VIVA QUESTIONS

1. What are compressors? Why compressors are used?
2. Explain types of compressors.
3. What are 2-stage compressors?
4. Name some applications of compressors
5. How to find the efficiency of a compressor?

MORSE TEST ON TWIN CYLINDER FOUR-STROKE DIESEL ENGINE.

AIM:
To study and conduct Morse test on the 2- cylinder four stroke diesel engine.

APPARATUS:
i. Two cylinder four stroke diesel engine
ii. Stopwatch

PRINCIPLE
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.
Morse Test is used to find a close estimate of Indicated Power (IP) of a Multi cylinder Engine. In this test, the engine is coupled to a suitable dynamometer and the brake power is determined by running the engine at the required speed. The fuel flow in first cylinder is now cut off by closing the fuel injector of the first cylinder in the diesel engine.
As a result of cutting out the first cylinder, the engine speed will drop. Load on the engine is now removed so that the original speed is attained. The brake power under this load is determined and recorded (BP1). The first cylinder operation is restricted normal and the second cylinder is fuel injector is cut-out. The engine speed will again vary. By adjusting the load on the engine, speed brought to original speed and the new BP is recorded (BP2).

PROCEDURE:
Start set up and run the engine at no load for some time for warming up the engine.
Gradually increase the load on the engine by loading it.
Increase the engine throttle to any desired position and simultaneously load the engine to obtain desired speed for which frictional power is to be calculated.
Wait for few minutes till steady state is achieved, note engine speed and load.
Cut off the fuel flow in the first cylinder. The engine speed will decrease, at this state decrease the load and bring the engine speed to the original state.
Wait for steady state and tabulate the readings.
Repeat the procedure for the second cylinder and tabulate the readings.

OBSERVATIONS

SlNo	Number of power cylinders	Voltage	Current	Speed
1	All cyl			
2	Ist cyl cutoff			
3	2nd cyl cutoff			

CALCULATIONS:

1. Mass of fuel consumed, m_f

m_f = 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 = mf x Calorific Value of Fuel kW

Where,

Calorific Value of Petrol= 43120 kJ/kg

3. Output or Brake Power, BP

BP = kW

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

4. Specific Fuel Consumption, SFC

SFC = mf x 3600 kg/kW – hr

Brake Thermal Efficiency, η_{bth}%

η_{bth}% = 3600 x 100

13. Mechanical Efficiency, η_{mech}%

η_{mech}% = BP

IP is calculated using the Morse test facility

14. Calculation of head of air, Ha

Ha = h_w L_{water}

Lair

Where,

L_{water} = 1000 Kg/m

L_{air} = 1.2 Kg/m @ R.T.P

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

15. Volumetric efficiency, A_{vol}%

I_{vol} % = Qa

where,

Qa = Actual volume of air taken = Cd a N (2gHa)

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (Q(0.025)/4)

Ha = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

Q_{th} = (Q/4) x D x L x N

60 x 2

Where,

D = Bore diameter of the engine = 0.084m

L = Length of the Stroke = 0.082m

N is speed of the engine in rpm.

Frictional Power, FP= IP-BP.

Brake Power, BP

$BP = \frac{VIcos\phi}{\eta alt\ x\ 1000}$ kW

V= voltmeter reading.

I = ammeter reading.

$cos\phi = 1$

N = Speed of the engine, rpm

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

1. Indicated Power , BP

IP = IP1 + IP2 kW

Where,

Indicated power of 1^{st} cylinder, IP1 = BP – BP1.

$BP_1 = (V_1 I_1 \cos\phi) / (\eta_{otto}\ x\ 1000)$ kW

IP2 = BP – BP2.

Mechanical Efficiency, η_{mech}= (BP/IP) x100 %

RESULT & INFERENCE

Morse test is conducted on the given engine and the indicated power, brake power and frictional power were found out.

VIVA QUESTIONS

1. What is meant by brake power of engine?
2. Explain difference between brake power and indicated power.
3. How to find out the frictional power of an engine cylinder?
4. What are valves? Explain its working.

HEAT BALANCE TEST ON TWIN CYLINDER FOUR-STROKE DIESEL ENGINE

AIM:

To perform a heat balance test on the given single cylinder four stroke C.I engine and to prepare the heat balance sheet at various loads.

APPARATUS REQUIRED:

1. C.I. Engine coupled with a dynamometer.
2. Air tank with air flow meter
3. Burette for fuel flow measurement
4. Rotameter for water flow measurement
5. Stop watch.
6. Thermometers.

PRINCIPLE

From the law of conservation of energy, the total energy entering the engine in various ways in a given time must be equal to the energy leaving the engine during the same time, neglecting other form energy such as the enthalpy of air and fuel. The energy input to the engine is essentially the heat released in the engine cylinder by the combustion of the fuel. The heat input is partly converted into useful work output, partly carried away by exhaust gases, partly carried away by cooling water circulated and the direct radiation to the surroundings. In a heat balance test all these values are calculated and converted to percentage with respect to the input and are presented in a chart at various loads.

PROCEDURE

1. Start the engine at no load and allow idling for some time till the engine warm up.
2. At no load condition, note down the readings as per the observation table.
3. Note down the time taken for 5cc of fuel consumption using stopwatch and fuel measuring burette.
4. After taking the readings open the fuel line to fill burette and supply fuel to run the engine from the fuel tank again.
5. Now load the engine gradually to the desired value.
6. Allow the engine to run at this load for some time in order to reach steady state condition.
7. Note down the readings as per the observation table.
8. Repeat the experiment for different loads.
9. Release the load slowly and stop the engine.

STARTING THE ENGINE:

1. Keep the decompression lever in the vertical position
2. Insert the starting handle in the shaft and rotate it
3. When the flywheel picks up speed bring the decompression lever into horizontal position and remove the handle immediately.
4. Now the engine will pick up.

STOPPING THE ENGINE:

1. Cut off the fuel supply by keeping the fuel governor lever in the other extreme position. (For Diesel Engine)

OBSERVATION

Sl No	Load (kw)	Manometer reading	T1	T2	T3	T4	Speed	Current	voltage	Water flow	

		H1	H2	H3									Time for 5cc fuel consumption
1													
2													
3													
4													
5													

CALCULATIONS

Maximum Load = $B.P_r \times \eta_{alternator}$
Brake power, B.P= $(VI\cos\phi)/(\eta_{alt} \times 1000)$
$\cos\phi=1$
V= alternator output voltage in volts
I= alternator output current in Amperes.
Total Fuel consumption, TFC=$(Vc \times \rho_{f)\,/\,10}{}^{6}t$ kg/sec.
Vc=volume of fuel consumed.
t=time taken to consume ‘Vc’ amount of fuel.
$\rho_{f=}$density of diesel fuel=830 kg/$m^{3.}$
Mass flow rate of water, $m_w=v_w\rho_w \times {}^{10\text{-}6}$ kg/sec.
V_w=water flow rate in rotameter (cc/sec)
ρ_w=density of water = 1000 kg/m^3
Input Power, IP= TFC x CV kW.
Cv = calorific value of fuel = 44000 KJ/Kg
Heat carried away by cooling water = $Qw=m_wC_{pw}(T2-T1)$
Where m_w =mass flow rate of water kg/sec
Cpw – specific heat of water = 4.187 kJ/kg-K
T1 – inlet temperature of cooling water
T2 – outlet temperature of cooling water
$\rho_{air=}$ 1.17 kg/m^3
Manometric Head, Ha=$[(h1-h2)(\rho_{m-}\ \rho_{air)}]/100 \times \rho_{air}$ metres.
h1,h2=manometric readings in cms
$\rho_{m=}$density of mercury= 13600 kg/$m^{3.}$
Actual volume flow rate, Va=$CdA_o\sqrt{2gha}$ m^3/sec
Cd=coefficient of discharge=0.62
$A_o=(\pi do^2)/4$

Mass of air = $m_a=v_a \times \rho_a$ kg/sec
Mass flow rate of exhaust, $m_e=m_a$+TFC kg/sec
Heat carried away by exhaust air, $Q_e=m_eC_{pe}(T3-T4)$ kW
$m_{e=}$mass of exhaust gas
C_{pe}=specific heat capacity of exhaust=1.25
T3=temp of exhaust gas outlet
T4= ambient air temperature.

Unaccounted energy, E_u=IP-BP-Qw-Qe.
IP=input power
BP=brake power
Qw=heat carried away by water.

Qe=heat carried away by exhaust.
Percentage Energy:
% of useful energy=(BP/IP) x 100=__ % of total energy
% of energy carried away by cooling water = (Qw/IP) x 100=__ % of total energy.
% energy carried away by exhaust gas=(Qe/IP)x 100=__ % of total energy.
Energy unaccounted=(Eu/IP) x 100=__ % of total energy.

PRECAUTIONS
1. The engine should be checked for no load condition.
2. The cooling water inlet for engine should be opened.
3. The level of fuel in the fuel tank should be checked.
4. The lubrication oil level is to be checked before starting the engine.

RESULT & INFERENCE

The heat balance test is conducted in the given diesel engine to draw up the heat balance sheet at various loads.

VIVA QUESTIONS

1. How power is produced in an I.C engine?
2. How much percentage of total energy (approximately) is produced on the crankshaft?
3. How to calculate the energy lost through the exhaust?
4. What are the different types of energy losses in an I.C engine?
5. What are the different ways to minimize the energy losses in an engine?
6. How to increase the power output of an engine without compromising on fuel economy?

PERFORMANCE TEST ON SINGLE CYLINDER PETROL ENGINE

AIM

The experiment is conducted to study and understand the performance characteristics of the engine & to draw Performance curves.

APPARATUS

i. Two-stroke petrol engine test rig.
ii. Electrical Dynamometer Loading.

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.
8. Allow to attain the steady state.
9. Load the engine by switching on the Load controller switches provided.
(Each loading is incremental of 0.5kW)
10. Note the following readings for particular condition,
a. Engine Speed
b. Time taken for ____cc of petrol consumption
c. Water meter readings.
d. Manometer readings, in cms of water &
e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the 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, t sec	Time for 5 rev of Energy meter,
		'F' kW	h1	h2	h_w = (h1+h2)		

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

Sl. No.	Temperature, °C	
	T1	T2

CALCULATIONS

Mass of fuel consumed, mf

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

SG of Petrol is = 0.71

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

Heat Input, HI

HI = mf x Calorific Value of Fuel kW

Where,

Calorific Value of Petrol = 43,120 KJ/Kg

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

Output or Brake Power, BP

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

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%

Specific Fuel Consumption, SFC

SFC = (mf x 3600)/BP kg/kW – hr

Brake Thermal Efficiency, η_{bth} %

η_{bth}% = (3600 x 100)/(SFC x CV)

Calculation of head of air, Ha

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

L_{water} = 1000 Kg/m^3

L_{air} = 1.2 Kg/m^3 @ R.T.P
hw is the head in water column in 'm' of water
11. Volumetric efficiency, η_{vol}%

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

Qa = Actual volume of air taken
Qa = Cd A $\sqrt{2gHa}$

Cd = Coefficient of discharge of orifice = 0.62
a = area at the orifice, = (Q(0.015)□/4)
Ha = head in air column, m of air.
Qth = Theoretical volume of air taken

$$Q_{th} = \frac{(\Pi/4) \times D\square \times L \times Gr \times 0.5N}{60}$$

D = Bore diameter of the engine = 0.057m
L = Length of the Stroke = 0.057m
N is speed of the engine in rpm.
Graphs to be plotted:

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

RESULT & INFERENCE

The performance test on the given engine is conducted and the required graphs are drawn.

VIVA QUESTIONS

1. Explain working of an I.C engine.
2. What you mean by Brake Power of an engine?
3. What is volumetric efficiency?
4. What is brake thermal efficiency?

PERFORMANCE TEST ON DIESEL ENGINE

To perform load test on a single cylinder slow speed diesel engine, study its performance under various loadsand to plot the following graphs

1. Total Fuel Consumption (TFC) Vs Brake Power
2. specific fuel consumption (SFC) Vs Brake Power
3. Indicated power (IP) Vs Brake Power
4. Brake thermal efficiency (BTE) Vs Brake Power
5. Indicated thermal efficiency (ITE) Vs Brake Power
6. Mechanical efficiency (ME) Vs Brake Power
7. Volumetric efficiency Vs Brake Power
8. Brake mean effective pressure(BMEP) Vs Brake Power
9. Indicated mean effective pressure (IMEP) Vs Brake Power

DESCRIPTION

The water-cooled single cylinder diesel engine is coupled to a rope pulley brake arrangement to absorb the power produced. Necessary weights and spring balances are included to apply load on the brake drum. Suitable cooling water arrangement for the brake drum is provided. Separate cooling water lines fitted with temperature measuring thermocouples are provided for the engine cooling. A fuel measuring system consisting of a fuel tank mounted on a stand, burette, three way cocks and a stop watch is provided. Air intake is measured using an air tank fitted with an orifice and a water U-tube manometer.

PRINCIPLE

Engine performance is represented by typical characteristic curve with an operating engine parameter. These curves are useful in comparing the performance of an engine with another. Energy flow in engine is expressed in three distinct terms viz. indicated power, friction power and break power. The engine performance is expressed in terms of efficiency.

ENGINE SPECIFICATIONS

(i) Rated brake power = 5HP
(ii) Compression ratio = 16.5:1
(iii) Bore of cylinder = 80mm
(iv) Engine speed = 1500rpm
(v) Stroke of cylinder = 110cm
(vi) Loading type = rope brake drum
(vii) Diameter of orifice = 17mm

THEORY

1.Brake power B.P. $=\frac{2\pi NT}{60\times1000}KW$

N- speed in rpm
T-torque=ωr
ω-load in kg
r- arm length in m.

2. Total Fuel Consumption, TFC = $\frac{x \times 3600 \times \rho}{t \times 1000} kg/hr$

x-fuel consumption in cc

t-time taken for x cc fuel consumption

ρ- density of the fuel used

3. Specific fuel consumption, SFC = $\frac{TFC}{BP}$kg/KWhr

4. Indicated horse power, IP = BP + FP KW

FP – frictional power obtained from graph

5. Brake thermal efficiency, BTE = $\frac{BP \times 3600 \times 100}{TFC \times CV}$

CV- calorific value = 45000 kJ/kg for diesel

6. Indicated thermal efficiency, ITE =$\frac{IP \times 3600 \times 100}{TFC \times CV}$

7. Brake mean effective pressure, BMEP = $\frac{BP \times 60 \times 2}{LAN} N/m^2$

8. Indicated mean effective pressure, IMEP = $\frac{IP \times 60 \times 2}{LAN} N/m^2$

9. Mechanical efficiency, ME =$\frac{BP}{IP} \times 100$

10. Volumetric efficiency, VE = $\frac{Q_{act}}{Q_{th}} \times 100$

PROCEDURE

1. Check the fuel level.
2. Check Lubricating Oil Level.
3. Open the three way cock, so that the fuel flows to the engine.
4. Supply the cooling water through inlet pipe.
5. Start the engine. (at no load condition).
6. If required, adjust the speed by screwing in or out the governor nut.
7. Load the engine by adding the required dead weights upon the hanger.
8. Allow the cooling water in the brake drum and adjust it to avoid spilling.
9. Note the following reading.
    a) Engine Speed = N rpm
    b) Dead weight = W_1 kg
    c) Spring balance reading = W_2 Kg
    d) Air tank water manometer reading:

i) Left column = h_1 cm
ii) Right column = h2 cm

e) Time for 10cc. of fuel consumption = t_f sec
f) Engine cooling water flow rate = W_e kg/sec
g) Ambient temperature = T_o ºC
h) Engine cooling inlet water temperature = T_1 ºC
i) Engine cooling outlet water temperature = T_2 ºC
j) Exhaust gas temperature = T_EºC

10. Repeat the experiment for various loads.

APPARATUS REQUIRED

Engine test rig with loading system, Stop watch.

PRECAUTIONS

i) Ensure oil level is maintained in the engine up to recommended level always. Never run the engine with insufficient oil.
ii) Never run the engine with insufficient engine cooling water.

THEORY

Maximum Load,

$$\text{Brake Power, (BP)} = \frac{2 \times \pi \times N \times Wmax \times L \times g}{60 \times 1000} \text{ kW}$$

Where,

BP	= Brake Power in kW
W_{max}	=Maximum load in kg.
L	=Length of the torque arm in meter
g	= Acceleration due to gravity in m/s^2
N	= Speed of the engine in rpm.

Therefore,

$$\text{Net maximum load, } (W_{max}) = \frac{(BP \times 60 \times 1000)}{(2 \times \pi \times N \times g \times L)} \text{ kg}$$

1. BRAKE POWER (BP)

Brake horsepower (abbreviated *bhp*) is the measure of an engine's horsepower without the loss in power caused by the gearbox, generator, differential, water pump, and other auxiliary components such as alternator, power steering pump, muffled exhaust system, etc. "Brake" refers to a device which was used to load an engine and hold it at a desired RPM. During testing, the output torque and rotational speed were measured to determine the "brake horsepower". Horsepower was originally measured and calculated by using an engine dynamometer.The output delivered to the driving wheels is less than that obtainable at the engine's crankshaft.

Diameter of the Brake Drum = 0.4 m
Diameter of Rope = 0.015 m
Equivalent diameter, D = 0.415m
Length of the torque arm, L = 0.2075 m
Dead weight, W_1 = …….. Kg
Spring load, W_2 = …….. Kg
Weight of Hanger, W_o = 1 Kg
Net load, W = $(W_1 - W_2) + W_o$ kg
Torque, T = W ×L × g

Brake Power, (BP) = $\frac{2\times \pi\times N\times T}{60\times1000}$ kW

2. TOTAL FUEL CONSUMPTION (TFC)

Volume of fuel consumed, x =………. cc
Time forxcc. of fuel, t = ………sec
Density of Diesel fuel, ρ = …… kg/m^3

Total Fuel consumption = $\frac{x}{t}\times \frac{\rho}{10^6}$ kg/sec

3. SPECIFIC FUEL CONSUMPTION (SFC)

Specific Fuel consumption = $\frac{TFC}{BP}$kg/kW-sec

4.HEAT INPUT (Heat *i/p*)

Calorific value of Diesel = …………kJ/Kg

Specific Fuel consumption = TFC× CV kW

5. FRICTIONAL POWER (FP**)**< from graph >

*Willan's Line Method:*This method is also known as fuel rate extrapolationmethod. In this method a graph of fuel consumption (vertical axis) versus brake power (horizontal axis) is drawn and it is extrapolated on the negative axis of brake power.The intercept of the negative axis is taken as the friction power of the engine at that speed.

6. INDICATED POWER (IP)

Indicated horsepower (abbreviated*ihp*) is the theoretical power of a reciprocating engine if it is completely frictionless in converting the expanding gas energy (piston pressure x displacement)in the cylinders. It is calculated from the pressures developed in the cylinders, measured by a device called an *engine indicator*– henceindicated horsepower. As the piston advances throughout its stroke, the pressure against the piston generally decreases, and the indicator device usually generates a graph of pressure vs stroke within the working cylinder. From this graph the amount of work performed during the piston stroke may be calculated.

IP = (BP + FP) kW

7. BRAKE THERMAL EFFICIENCY (BTE), η_{bth}

Brake thermal efficiency (BTE), $\eta_{bth} = \frac{BP}{\text{Heat } i/p} \times 100$ %

8. INDICATED THERMAL EFFICIENCY (ITE), η_{ith}

Indicated thermal efficiency (ITE), $\eta_{ith} = \frac{IP}{\text{Heat } i/p} \times 100$ %

9. MECHANICAL EFFICIENCY (ME), η_{mech}:

Mechanical efficiency (ME), $\eta_{mech} = \frac{BP}{\text{IP}} \times 100$ %

10. VOLUMETRIC EFFICIENCY, $\eta_{vol.}$

Volumetric Efficiency $= \frac{Va}{Vt} \times 100$ %

Actual air intake, (V_a)

Difference of water column, Δh $= (h_1 - h_2)$ m of water

Equivalent air column, Ha $= \Delta h \times \frac{\rho\ water}{\rho\ air}$ m ,(Say ρ air = 1.16)

Diameter of the orifice, d = 0.018 m

Area of the orifice, a $= \frac{\pi}{4} d^2\ m^2$

Volume of air, Va $= Cd \times a \times \sqrt{2g\ Ha}$ m^3/sec

(Where Cd = 0.62)

Wt. of air intake - Wa = 1.16 × Va kg/sec

Theoretical air intake, (V_t)

Dia. of the piston, D = ……...m
Stroke length, L = ……..m
Engine Speed, N = ……rpm.

Theoretical Volume of air - Vt = $\frac{\pi}{4} D^2 \times L \times \frac{N}{2}$ m^3/sec

Wt. of theoretical air intake = 1.16 ×Vtkg/sec

11.AIR FUEL RATIO, A/F

$$\text{Air fuel ratio} = \frac{Mass\ of\ air}{Mass\ of\ fuel}$$

12. BRAKE MEAN EFFECTIVE PRESSURE (BMEP)

Dia. of the piston, D = ……… m
Stroke length, L = ……… m
Area of bore, A =………..m^2
Engine Speed, N =…… ...rpm, (N = N/2 for 4-Stroke engines.)
Number of cylinder, *n* = ……….nos.

$$BMEP = \frac{BP \times 60 \times 1000}{LAN \times n} \ \text{N/m}^2$$

13. INDICATED MEAN EFFECTIVE PRESSURE (IMEP)

$$IMEP = \frac{IP \times 60 \times 1000}{LAN \times n} \ \text{N/m}^2$$

OBSERVATION

Sl.No	Load ,W (kg)	Spring balance reading, S	W-S (kg)	Time for 10cc consumption of fuel(sec)	B.P (kW)
1					
2					
3					
4					
5					

RESULT

The performance test on single cylinder four stroke engine was conducted with mechanical loading and curves are plotted.

a. Maximum brake power, BP_{max}=
b. Frictional power, FP =
c. Maximum brake thermal efficiency, BTE_{max}=
d. Total fuel consumption, TFC =
e. Maximum specific fuel consumption, SFC_{max} =
f. Maximum brake mean effective pressure, $BMEP_{max}$ =
g. Maximum indicated mean effective pressure, $IMEP_{max}$ =
h. Maximum indicated thermal efficiency, ITE_{max}=
i. Maximum mechanical efficiency, ME_{max} =
j. Average volumetric efficiency, VE_{avg}=

INFERENCE

i. On extending BP vs TFC graph, we get frictional power
ii. Mechanical efficiency, brake thermal efficiency and brake mean effective pressure increase with increase in brake power
iii. Total fuel consumption and indicated mean effective pressure are directly proportional to brake power
iv. Specific fuel consumption is inversely proportional to brake power. Variations are observed due to parallax & instrument errors.

VIVA QUESTIONS

1. Explain the working of a diesel engine.
2. Why performance test is done on engines?
3. What you mean by BHP?
4. What is Volumetric efficiency?
5. How the efficiency of an engine can be increased?

VALVE TIMING DIAGRAM FOR FOUR STROKE DIESEL ENGINE

OBJECTIVE

To obtain a valve timing diagram for a given four stroke diesel engine (at section model)

PRINCIPLE

Angular distance of event from nearest dead centre

ϴ= 360 x **l/S degree**

Where,

I = distance of event from nearest dead centre

S=circumference of flywheel

Time taken for event

T=60 x **ϴ/N360**

Where,

ϴ= angular movement of event degree

N=rated speed of engine, rpm

Angular movement for

i. Suction stroke = IVO+180+IVC degree
ii. Compression stroke = 180-IVC degree
iii. Power stroke = 180-EVO degree
iv. Exhaust stroke = EVO-180+EVC degree
v. Fuel injection period = FIS+FIE degree
vi. Overlapping period = IVO+EVC degree

Where,

IVO = INLET VALVE OPEN, degree

IVC = INLET VALVE CLOSE, degree

EVC = EXHAUST VALVE CLOSE, degree

EVO = EXHAUST VALVE OPEN, degree

FIS = FUEL INJECTION START, degree

FIE = FUEL INJECTION END, degree

MATERIALS

Measuring tape, chalk piece

ENGINE SPECIFICATIONS

Rated brake power =3.75 kW

Rated speed=1500 rpm

Compression ratio =16.5**:**1

Bore of the cylinder=80 mm

Stroke of the cylinder=110 mm

PROCEDURE

i. Measure the circumference of the fly wheel using measuring tape
ii. Find the proper direction of the rotation of flywheel in sequence of function , compression, power and exhaust stroke
iii. Then first mark the TDC position on the flywheel by rotating the flywheel and watching. The position of the piston inside the cylinder just begins to move downward from the top most position. Similarly mark BDC position on the flywheel using identification of the piston just begins to move upward from the bottom position.
iv. Then rotated the flywheel in the correct direction and watch the push rod which is to be fitting the inlet valve. Mark the IVO position on the flywheel when the push rod of the inlet valve gets tightened.
v. Similarly continue the rotation in the same direction until the pushrod gets loosened, mark the position as IVC on the flywheel.
vi. Rotate the flywheel in the same direction and mark the FIS position on the flywheel as IVC on the flywheel when the plunger of lever of the fuel pump begins to move down.
vii. Continue the flywheel rotation in the same direction and mark the position EVO when the push rod of the exhaust valve gets tightened
viii. Similarly mark the position EVC when the push rod of the exhaust valve get loosened
ix. Measure the circumferential distance on the flywheel for all events (IVO,IVC,FIS,FIE,EVO,EVC) from the nearest dead centre using measuring tape
x. Then find out the angular distance at each event from its nearest dead centre using formula.
xi. Find out all the strokes (suction, compression, power and exhaust) movements and periods (fuel injection and overlapping) in the form angular movement.
xii. Find out the time taken for all strokes and position using the formula.
xiii. Using the angular movement, data, draw a valve timing diagram as the polar chart in the sequence of events IVO, IVC, FIE, FIS, EVO, EVI.
xiv. Then mark the name of the strokes and periods on the diagram.

OBSERVATIONS

Sl.No	**Event**	**Position of nearest dead centre**	**Distance of nearest dead centre (cm)**	**Angular distance of event from nearest dead centre (degree)**
1	IVO	Before TDC		
2	IVC	After BDC		

3	FIS	Before TDC		
4	FIE	After TDC		
5	EVO	Before BDC		
6	EVC	After TDC		

CALCULATION

Suction stroke = IVO+IVC+180 =

Compression Stroke = 180-IVC =

Power Stroke = 180-EVO =

Exhaust Stroke = 180+EVO+EVC=

Circumference of flywheel, s=124 cm = 1.24m.

Angular distance, ϴ= 360 x l/S degree.

Time taken for event, T=60 x ϴ/N360.

Distance of nearest dead centre, l=

Angular distance of event from nearest dead centre, ϴ=

For Suction stroke, angular movement for event, ϕ =

Time taken for event, T =

Fuel Injection period = FIS+FIE=

Angular Overlap = 360 x (IVO/1.24) + 360 x (EVC/1.23) =

RESULTS AND DISCUSSION

Thus the valve timing diagram of given four stroke diesel engine was plotted and marked all events on it.

Overlapping period =

Fuel injection period=

CONCLUSION

The experiment was conducted as per the procedure and the valve timing diagram was plotted.

VIVA QUESTIONS

i. How the valve timing diagram of diesel engine differs from that of petrol engine?

ii. Explain the working of diesel engine.
iii. What you meant by valve overlapping?
iv. Why exhaust valve is opened before BDC?
v. What is the significance of fuel injection period?

PERFORMANCE TEST ON AN AIR BLOWER.

AIM: To conduct the performance test on the centrifugal blower & determine the overall efficiency at various gate openings.

APPARATUS: centrifugal blower test rig with three types of interchangeable impellers,

Stop watch

THEORY: The blower is a single stage, centrifugal type in which air is sucked from the atmosphere through a spiral case & comes out at the outlet, which is in the form of a long pipe. This pipe is provided with tapings connected to water manometers to determine the suction pressure, stagnation pressure & static pressure. The pipe is also provided with an orifice connected to a mercury manometer to measure the discharge of air. Blowers are used to discharge large volumes of air at lower pressure in copula furnaces.

PROCEDURE:

1. Check the necessary electrical connection
2. Set the pitot tube to Zero position
3. Check the manometer for Zero position
4. Adjust the speed to the required range
5. Adjust the gate openings for various stages $\left(\frac{1}{2}, \frac{1}{4}, \frac{3}{4}\right)$
6. Start the blower & note down the readings (speed of the blower, manometer, Pitot tube & energy meter)
7. Repeat the experiment for different gate opening.

FORMULE:

1. Flow across Pitot tube $h_a = \frac{h \times \rho_{water}}{\rho_{air}}$ m

Where h = Flow Head in m of water

$$\rho_{water} = 1000\, kg/m^3$$

$$\rho_{air} = 1.293\, kg/m^3$$

2. Static Head $h_{sh} = \frac{h_w \times \rho_{water}}{\rho_{air}}$ m

Where $h_w =$ flow head in meter of water.

3. Velocity of Air = $v = \sqrt{2gh_a}\ m/s$

4. Actual Volume of Air Discharged $Q_a = A \times v\ m^3/s$

Where A = Area of duct in m^2

5. Input Power $IP = \frac{3600 \times n \times \eta_m}{K \times T}$ KW

Where n = No of Revolution of energy meter

K = Energy meter Constant

T = Time For n revolution of energy meter

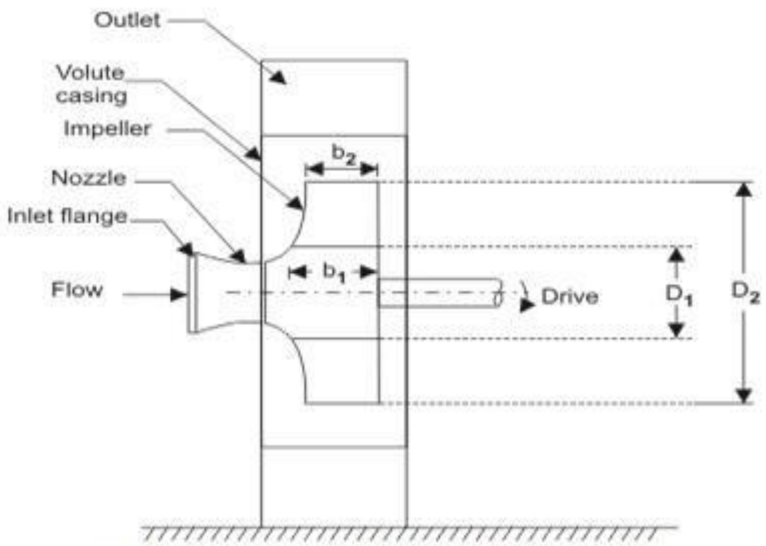
η_m =Efficiency of belt Transmission = 0.7

6. Output power $OP = \frac{\rho_a \times g \times Q_a \times h_{sh}}{1000}$ kW

7. Efficiency of the blower

$$\eta = \frac{OP}{IP} \times 100\ \%$$

DIAGRAM:



Main components of a centrifugal blower

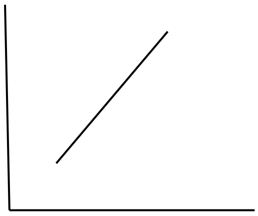
OBSERVATION:

1. Length of duct = -------- mm
2. Width of duct = ---------- mm
3. Breadth of duct = --------- mm
4. Cross sectional area of the duct = -------- m^2
5. Number of revolutions of energy meter = n = ----------

6.. Mechanical efficiency, η_m = ------------

Performance Curves/GRAPHS:

1. Discharge Vs Efficiency



TABULAR COLUMN (Centrifugal Blower)

Gate Opening Position	Manometer reading			Pitot tube reading			Time taken for n revolution in (sec)	Static head of air h_{sh} (m)	Q_a, m^3/s	IP in KW	OP in KW	η mech %
	H_1 (cm)	H_2 (cm)	Hw (m)	IR (cm)	FR (cm)	Difference (m)						

RESULT:

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

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

EQUIPMENT REQUIRED:

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

DESCRIPTION:

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

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

STARTING THE ENGINE:

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

PROCEDURE:

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

PRECAUTIONS:

1. Before stating the engine check all the systems such as cooling , lubrication and fuel system

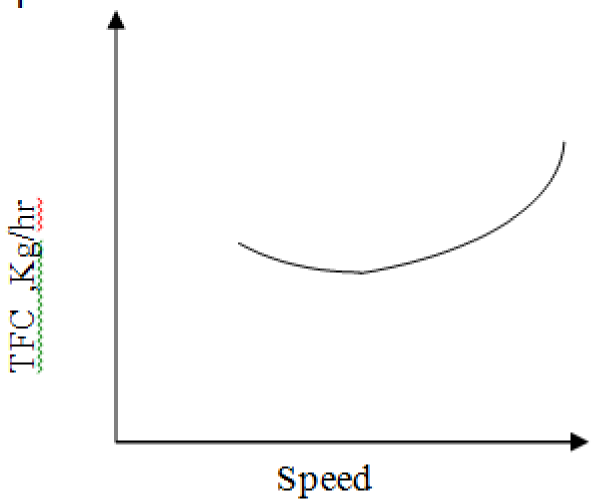
2. Ensure oil level is maintained in the engine upto recommended level always. Never run the engine with insufficient oil.

3. Never run the engine with insufficient engine cooling water and exhaust gas calorimeter cooling water.

4. For stopping the engine, load on the engine should be removed.

GRAPHS:

1. T.F.C Vs Speed



OBSERVATIONS:

Sl. No0	Load on the Dynamometer W Kg	Speed, Rpm	Time for 10 cc of fuel (sec)	T.F.C Kg/hr
1				
2				
3				
4				
5				
6				

Brake Power (BP_{max}) $= \frac{W\max \times N}{2000 \times 1.36}$ …….KW

Where,

N= rated speed …… rpm,

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

Full Load, $W_{max} = \frac{B.P \times 2000 \times 1.36}{N}$ ……. Kg

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

Load on Dynamometer, W = $\frac{B.P \times 2000 \times 1.36N}{N}$

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

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

Total Fuel consumption, TFC = mf $\times$ 60….kg / hr.

RESULTS

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

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

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

INSTRUMENTATION:

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

PROCEDURE:

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

FUEL MEASUREMENT

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

AIR INTAKE MEASUREMENT:

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

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	h_w = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

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

CALCULATIONS:

Mass of fuel consumed, mf

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

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

Heat Input, HI

HI = mf x Calorific Value of Fuel, kW

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

Output or Brake Power, BP

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

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

Specific Fuel Consumption, SFC

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

Brake Thermal Efficiency, ηbth%

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

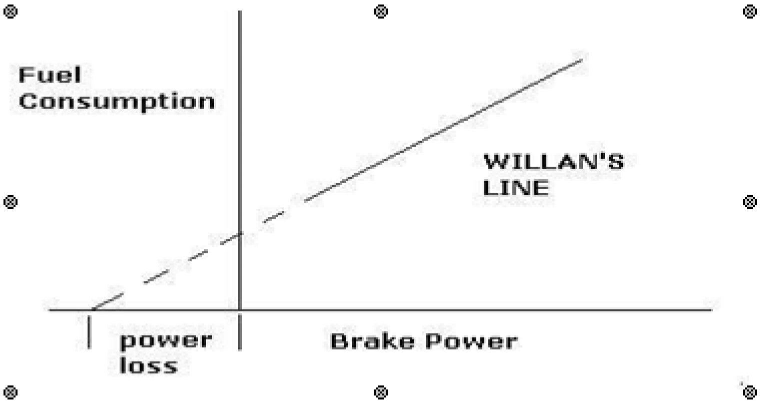
Mechanical Efficiency, ηmech%

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

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

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

IP = BP + FP



Calculation of head of air, Ha

$$Ha = \frac{hw\ \rho water}{\rho air}$$

Where,

ρwater = 1000 Kg/m

ρair = 1.2 Kg/m @ R.T.P

hw is the head in water column in „m‟ of water

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

Where,

Cd = Coefficient of discharge of orifice = 0.62 a =

area at the orifice, = (∏(0.02) /4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Qth = \frac{(\Pi/4) \times D^2 \times L \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

Air Fuel Ratio:

M_a/M_f =

PRECAUTIONS:

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6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
8. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

RESULT