SIR C R REDDY COLLEGE OF ENGINEERING
ELURU-534 007

MECHANICAL ENGINEERING LAB-II
MANUAL

DEPARTMENT OF MECHANICAL ENGINEERING

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MECHANICAL ENGINEERING LAB-II

LIST OF EXPERIMENTS

1.MORSE TEST

AIM:
To conduct Morse Test on 4-cylinder 4-stroke Matador diesel engine and hence to determine the FRICTIONAL POWER (FP) and MECHANICAL EFFICIECY (η_m) of the engine.

APPARATUS:

Diesel engine test rig coupled with hydraulic dynamometer, stopwatch and tachometer.

ENGINE SPECIFICATIONS:

Make: EEE, Coimbatore.
No of cylinders: 4
Output Power: 7.35 KW
Capacity: 449.25 cu.cm
Compression Ratio: 19.8:1
Bore: 73 mm
Stroke: 94 mm

DESCRIPTION:

A medium capacity 4-stroke vertical water-cooled diesel engine is selected. The engine is coupled with a hydraulic dynamometer. This consists of two half castings and a rotor assembly of rotor shaft and coupling running on ball bearings. The casing is balanced by a spring-mass damper system. The principle of operation of the unit is similar to the fluid coupling. The reaction at the casing is measured by a mechanism consisting of lever arm and spring balance

THEORY:
Morse test is conducted on multicylinder engines to determine the frictional power, indicated power and mechanical efficiency of the engine. The power available at the shaft (Brake Power) is always less than the indicated power of the engine. These two parameters are related as follows.

$$IP = BP + FP \longrightarrow (1)$$

Where, IP = Indicated power
BP = Brake power
FP = Frictional Power

In this experiment the engine is run at a constant speed of 1500 rpm. to keep the FP of the engine constant. To calculate the IP of a particular cylinder, say n^{th} cylinder, the fuel supply is cut-off to that cylinder and speed is kept constant at 1500 rpm. Then IP of that n^{th} cylinder is given by

$$(IP)_n = (BP) - (BP)_n\, off \longrightarrow (2)$$

Where BP = Brake Power of the engine with all cylinders working

$$= \frac{W \times N}{2720} \longrightarrow (3)$$

$(BP)_n$ off= Brake Power of the engine with fuel supply cut-off to n^{th} cylinder.

The hydraulic dynamometer works at an operating pressure of 1 Kg / cm^2. The maximum load on the engine is calculated as follows.

$$7.36 = \frac{W_{max} \times 1500}{2720} \longrightarrow (4)$$

PROCEDURE:

1. The fuel level and lubricating oil level are checked.
2. The engine is started and the load is adjusted to 8 Kg at an engine speed of 1500rpm.
3. The engine is allowed to run for some time at this condition. Then first cylinder is cut-off by operating the lever.
4. The engine speed is adjusted to 1500 rpm by decreasing the load on the engine. The load at which speed becomes 1500 rpm is noted. In no case the accelerator be touched while adjusting the speed.
5. The first cylinder is put on to working condition by operating the lever and the engine allowed to run for some time at this states.
6. The second cylinder is cut-off and the load at which speed is maintained at 1500 rpm is noted.
7. The above procedure is repeated for the third and fourth cylinders.

OBSERVATIONS:

S no	Cylinder status	Speed Rpm	Load Kg
1	All cylinders On	1500	8
2	First Cylinder Cut-Off	1500	
3	Second Cylinder Cut-Off	1500	
4	Third Cylinder Cut-Off	1500	
5	Fourth Cylinder Cut-Off	1500	

MODEL CALCULATIONS:

1. Brake Power (BP)

$$BP = \frac{W \times N}{2720}$$

2. Brake Power of the engine when n[th] cylinder cut-off, $(BP)_n$ off

$$(BP)_{n\text{-off}} = \frac{W_{n\text{-off}} \times N}{2720} \text{ --------------- KW}$$

3. Indicated Power of n th cylinder $(IP)_n$

$$(IP)_n = (BP) - (BP)_{n\text{-off}} \text{ ----------------- KW}$$

4. Indicated power (IP) of the engine:

$$IP = (IP)_1 + (IP)_2 + (IP)_3 + (IP)_3 \text{ ---------------- KW}$$

5. Frictional Power Of the Engine (FP):

$$FP = IP - BP \text{ ------------ KW}$$

6. Mechanical Efficiency of the engine(η_m):

$$\eta_m = \frac{BP}{IP} \times 100.$$

RESULTS:

Sno	Cylider No	IP (KW)
1	1	
2	2	
3	3	
4	4	

PRECAUTIONS:

1. Only one cylinder should be cut-off at a time
2. The engine should not be operated with a cut-off cylinder for a long time.
3. The engine should be started and stopped at no load condition.
4. The load applied on the engine should not exceed the maximum load that can be applied.

VIVA QUESTIONS

1. What is the purpose of conducting Morse test?
2. What is the firing order of 4-cylinder engine?
3. What is the firing order of 6-cylinder engine?
4. What is the necessity of the firing order?
5. Two engines are at 0.5 bsfc and 0.8 bsfc, which is best?
6. What is C.C of an engine?
7. How the maximum load calculated in electrical dynamometer?
8. What is the purpose of flywheel?

2.LOAD TEST -I

Aim: To conduct load test on single cylinder, vertical, water-cooled diesel engine and hence to determine frictional power and draw the performance characteristic curves.

Apparatus:-Single cylinder diesel engine test rig coupled with rope brake dynamometer, stop watch and tachometer.

Engine Specifications:-

Make	:	Kirloskar
No. of cylinders	:	1
Bore `	:	80 mm
Stroke	:	110 mm
Speed	:	1500 rpm
Output	:	3.68 Kw
Compression ratio	:	16.5:1
Brake drum diameter	:	0.315 m
Orifice diameter	:	20 mm
Specific gravity of H.S.D. oil	:	0.8275
Calorific value	:	45380 KJ/Kg

Description:-

The water-cooled single cylinder diesel engine is coupled with a rope brake dynamometer. Separate cooling lines are provided for the drum and the engine. Thermocouples are arranged for sensing the temperature of cooling water consisting of fuel tank mounted on stand, burette with 3- way cock arrangement is provided.

Theory:-

Load test is conducted to study the performance characteristics of the engine. The single cylinder diesel engine is run at a constant speed of 1500 rpm. The engine is loaded in steps of constant internal loads i.e. 0 Kg, 2 Kgs, 4 Kgs ---- etc. At each load fuel consumed is determined. The output of the engine is calculated as follows-

$$B.P. = \frac{\pi WDN x 9.81}{60000} ----KW$$

A graph with B.P. on X- axis and Fuel consumed per hour (FCH) on Y- axis is plotted. The line joining the all datapoints when extended back, it intercepts the –ve X-axis. The negative intercept magnitude gives the Frictional power of the engine. The line connecting the data points is known as the WILAN'S LINE.

The other performance parameters like Brake Mean Effective Pressure(B_{mep}), Indicated thermal efficiency (η_{ith}), Brake thermal efficiency (η_{bth}), Mechanical efficiency (η_{mech}), Specific Fuel Consumption(SFC) are determined and graphs are plotted.

Maximum load on the Engine (W_{max}):

$$W_{max} = \frac{3.68x60000}{\pi DN\ x\ 9.81}$$

Procedure:-

1. The fuel level in the tank is checked.
2. Lubricating oil level is checked.
3. The engine is started at no-load condition and the time taken for 10 cc fuel consumption is noted.
4. A load of 2 Kgs is applied on the engine .the spring balance reading $w_{2,}$ applied load w_1, time taken for 10 cc of fuel consumption is noted down.
5. The above procedure is repeated at different loads like 4 Kgs, 6Kgs, ---- 15 kgs.
6. Frictional Power is obtained from the WILAN'S LINE graph.
7. The other parameters like SFC, B_{mep}, IP, η_{ith}, η_{bth}, η_{mech}, are calculated.
8. Graphs are plotted as given below.

   (i) BP Vs FCH

   (ii) BP Vs SFC

   BP VsB_{mep}

   (iii) BP Vsη_{mech}

   BP Vsη_{bth}

   BP Vsη_{ith}

S. No.	Dynamometer Reading (Kg)			Speed (rpm)	Time for 10 cc of fuel consumption (sec)
	W_1	W_2	$W = W_1 - W_2$		

Model Calculations:-

1. B.P. = $\frac{\pi WDNx9.81}{60000} ----KW$
2. Fuel consumed per Hour (FCH)

   FCH = $\frac{10}{t} x \frac{3600x0.8275}{1000} ---- \frac{Kg}{hr}$
3. SFC = $\frac{FCH}{BP} ------ \frac{Kg}{Kw - hr}$
4. Indicated Power (IP)

   IP = BP + FP
5. Mechanical Efficiency (η_{mech})

   $\eta_{mech} = \frac{BP}{IP}$
6. $B_{mep} = \frac{60000xBP}{LA\left(\frac{N}{2}\right)x10^5 xn} ----- bar$

Where ,

BP is in Kw.

N Is in rpm.

N= no of cylinders = 1

7. $\eta_{ith} = \frac{IPx3600}{FCHxC.V} x100 ----- \%$
8. $\eta_{bth} = \frac{BPx3600}{FCHxC.V} x100 ----- \%$

where

i) IP and BP are in kilo watts.

ii) CV= calorific value of the fuel in $\frac{KJ}{Kg}$

Results Table

Speed, N= 1500 rpm.

S.No.	BP (Kw)	FCH (Kg/hr)	FP (Kw)	IP (Kw)	SFC (Kg/Kw-hr)	B_{mep} (bar)	η_{mech} %	η_{bth} %	η_{ith} %

Precautions:-

1. The engine should be started and stopped at No Load condition.
2. Cooling water supply and must be ensured throughout the experiment.
3. The readings should be noted without parallax error.

VIVA QUESTIONS

1. What are the parameters calculated in load test?
2. Define indicated thermal efficiency?
3. Define brake thermal efficiency?
4. Petrol engine works on which cycle?
5. Diesel engine works on which cycle?
6. Explain working of two stroke engine with help of cut model?
7. Why the deflector is provided on the piston crown in the two stroke engine?
8. What is the air standard efficiency of otto cycle?
9. Explain working of four stroke engine with help of cut model?
10. What is the air standard efficiency of diesel cycle?
11. Define compression ratio of an I.C Engine?
12. What are the ranges of compression ratios in petrol engine and diesel engine?
13. Which number used to indicate the quality of petrol?
14. Which number used to indicate the quality of diesel?
15. What is relative efficiency?
16. What is the method followed for finding the frictional power in load test 1 and load test2?
17. What is engine operating temperature and why the engine has to run at operating temperature?
18. What is the purpose of dynamometer and what are the different dynamometers used in this lab?
19. Define indicated power and brake power?
20. Why we consider N/2 in calculation of indicated power for four-stroke engine?
21. Why we consider N in calculation of brake power for four stroke engine?

3.LOAD TEST- II

Aim: - To conduct load test on twin cylinder diesel engine and draw the performance characteristic curves.

Apparatus: - Twin cylinder diesel engine test rig coupled with electrical dynamometer, stopwatch and tachometer.

Engine Specifications:-

Make	:	Kirloskar
No. of cylinders	:	2
Bore `	:	80 mm
Stroke	:	110 mm
Speed	:	1500 rpm
Output	:	7.36 Kw
Compression ratio	:	16:1
Brake drum diameter	:	0.315 m
Orifice diameter	:	20 mm
Specific gravity of H.S.D. oil	:	0.8275
Calorific value	:	45380 KJ/Kg

Description:-

The diesel engine is coupled to an alternator through flexible coupling. The alternator acts as the loading device for the engine. A rheostat is provided for loading the alternator. Separate cooling water line is fitted with temperature measuring thermocouples to the engine. A burette with three-way cock arrangement is fitted for the measurement of fuel consumption.

Theory:-

Load test is conducted to study the performance characteristics of the engine. The twin cylinder diesel engine is run at 1500 rpm. As the speed of the engine is kept constant, the

Frictional Power of the engine also remains constant. The engine is loaded in steps of increasing loads like 0, 0.5 Kw, 1Kw etc. the maximum current that can flow is calculated as given below.

$$B.P. = \frac{A\ V}{1000\ x\ \eta_{generator}} ----KW$$

$$7.36 = \frac{A_{max}\ V}{1000\ x\ 0.8}$$

A graph with B.P. on X- axis and Fuel consumed per hour (FCH) on Y- axis is plotted. The line joining the all data points when extended back, it intercepts the –ve X-axis. The negative intercept magnitude gives the Frictional power of the engine. The line connecting the data points is known as the WILAN'S LINE.

The other performance parameters like Indicated Power (IP), Brake Mean Effective Pressure(B_{mep}), Indicated thermal efficiency (η_{ith}), Brake thermal efficiency (η_{bth}), Mechanical efficiency (η_{mech}), Specific Fuel Consumption(SFC) are determined and graphs are plotted.

Maximum Current Calculation (A_{max})

$$A_{max} = \frac{7.36x1000x0.8}{V}$$

Procedure:-

9. The fuel level in the tank is checked.
10. Lubricating oil level is checked.
11. The load on the rheostat is removed. Cooling water supply is ensured to the engine.
12. The engine is started and allowed to run for some time.
13. At no- load condition the time taken for 10 cc of fuel consumption is noted.
14. The rheostat load is increased to the next step. The current increases. At this condition the time taken for 10 cc of fuel consumption is noted.
15. The above procedure is repeated at different loads applied on the engine.
16. Frictional Power is obtained from the WILAN'S LINE graph.
17. The other parameters like SFC, B_{mep}, IP, η_{ith}, η_{bth}, η_{mech}, are calculated.
18. Graphs are plotted as given below.
    - (i) BP Vs FCH
    - (ii) BP Vs SFC

BP VsB_{mep}

(iii) BP Vsη_{mech}

BP Vsη_{bth}

BP Vsη_{ith}

Observations:-

S. No.	Dynamometer Reading		Time for 10 cc of fuel consumption (Sec)
	Voltage (V)	Current (A)	

Model Calculations:-

9. B.P. = $\dfrac{A\ V}{1000\ x\ \eta_{generator}} ----KW$

10. Fuel consumed per Hour (FCH)

FCH = $\dfrac{10}{t} x \dfrac{3600x0.8275}{1000} ----\dfrac{Kg}{hr}$

11. SFC = $\dfrac{FCH}{BP} ------\dfrac{Kg}{Kw-hr}$

12. Indicated Power (IP)

IP = BP + FP ------ Kw

13. Mechanical Efficiency (η_{mech})

$\eta_{mech} = \dfrac{BP}{IP}$

14. $B_{mep} = \dfrac{60000xBP}{LA\left(\dfrac{N}{2}\right)x10^{5}xn} ----- bar$

Where,

BP is in Kw.

N Is in rpm.

N= no of cylinders = 2

15. $\eta_{ith} = \dfrac{IPx3600}{FCHxC.V} x100 - - - - - \%$

16. $\eta_{bth} = \dfrac{BPx3600}{FCHxC.V} x100 - - - - - \%$

where

i) IP and BP are in kilowatts.

ii) CV= calorific value of the fuel in $\dfrac{KJ}{Kg}$

Results Table

Speed, N= 1500 rpm.

S.No.	BP (Kw)	FCH (Kg/hr)	FP (Kw)	IP (Kw)	SFC (Kg/Kw-hr)	B_{mep} (bar)	η_{mech} %	η_{bth} %	η_{ith} %

Precautions:-

4. The engine should be started and stopped at No Load condition.
5. Cooling water supply and must be ensured throughout the experiment.
6. The readings should be noted without parallax error.
7. The rheostat switches should never be put on all at a time as it over loads the engine.
8. Care should be taken not to touch the uninsulated parts of the rheostat switches.

VIVA QUESTIONS

1. What are the parameters calculated in load test?
2. Define indicated thermal efficiency?
3. Define brake thermal efficiency?
4. Petrol engine works on which cycle?
5. Diesel engine works on which cycle?
6. Explain working of two stroke engine with help of cut model?
7. Why the deflector is provided on the piston crown in the two stroke engine?
8. What is the air standard efficiency of otto cycle?
9. Explain working of four stroke engine with help of cut model?
10. What is the air standard efficiency of diesel cycle?
11. Define compression ratio of an I.C Engine?
12. What are the ranges of compression ratios in petrol engine and diesel engine?
13. Which number used to indicate the quality of petrol?
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15. What is relative efficiency?
16. What is the method followed for finding the frictional power in load test 1 and load test2?
17. What is engine operating temperature and why the engine has to run at operating temperature?
18. What is the purpose of dynamometer and what are the different dynamometers used in this lab?
19. Define indicated power and brake power?
20. Why we consider N/2 in calculation of indicated power for four-stroke engine?
21. Why we consider N in calculation of brake power for four stroke engine?

4.HEAT BALANCE SHEET

AIM:

To conduct a test on single cylinder slow speed diesel engine and to draw the heat balance sheet

APPARATUS:

Single cylinder slow speed diesel engine coupled with rope brake dynamometer, stop watch tachometer, measuring jar.

ENGINE SPECIFICATION:

Make	: Anil
Number of cylinders	: one
Speed	: 650 rpm
Output	: 4.416 kw
Bore	: 114.3 mm
Stroke	: 139.7 mm
Calorific value of the fuel	: 45380 KJ/Kg
Specific gravity of the fuel	: 0.8275

THEORY :

Internal combustion engines utilize the principle of burning the fuel inside the cylinder (internal combustion). The energy released inside the cylinder goes to various forms only a part of it is available at the shaft. The various forms are energy carried away by the cooling water jacket round the cylinder, energy carried away by the exhaust gases and unaccounted losses like due to friction, radiation etc.

A single cylinder diesel engine is chosen for the experiment which runs at a constant speed. The experiment may be carried out at $3/4^{th}$ of maximum load or 1/2 the maximum load.

The engine output is calculated as follows

$$B.P = \frac{\Pi W D N}{60000} \times 9.81 \quad kw$$

The measurement of cooling water flow rate may be done with the measuring jar and a stopwatch. The cooling water flow rate should be adjusted in such a way that the outlet cooling water temperature is maintained in between 45 to 50 degrees.After achieving this state only the readings should be noted.The mass flow rate of air intake may be measured from the orifice water manometer arrangement.

The sum of the mass flow rate of fuel and mass flow rate of intake air gives the mass flow rate of exhaust gases.

Let

E = Total energy supply rate to the engine in Kj/min

Ee = Energy carried away by the exhaust gases inKj/min

Ec = Energy carried away by the cooling water in kj/min

Eo = Engine output rate kj/min

Eua = Unaccounted energy losses due to friction kj/min

Then

$$E = E_e + E_c + E_o + E_{ua}$$

As E , E_e , E_c , E_o can be calculated

E_{ua}may be obtained as follows

Eua = E – {Ee+ Eo +Ec}------------------kj/min

PROCEDURE:

1.Fuel oil level and lubricating oil level are checked.

2.Engine is started at noload condition and cooling water supply is ensured.

3.The engine is loaded with 13kg weights at the dynamometer i.e half load.

4.At this load the engine is run for atleast 5 minutes. cooling water flow rate is adjusted, in such a way that the cooling water temperature Tco lies in the range 45 to 50 degrees.

5.The time taken for 10 cc of fuel consumption, spring balance reading, water manometer reading, cooling water flow rate are noted.

6. The above procedure is repeated at 18 kg dead weight load and the readings are noted down.

S. No	Dynamo meter readings		Speed rpm	Time for 10 CC of fuel consumption T1	Exhaust gas temp Te ($_0$C)	Ambient temp Ta ($_0$C)	Cooling water temperature		Water manometer deflection on H (cm)	Time for ½ litre water collection t2 (sec)
	Dead weight w1 kg	Spring balance W2 kg					Tci ($_0$C)	Tco ($_0$C)		

MODEL CALCULATIONS:

1. Maximum load on the engine

$$\text{Wmax} = \frac{60000 \times BP}{\pi DN \times 9.81} = \frac{60000 \times 4.416}{\pi DN \times 9.81} \text{kg}$$

2. Fuel consumption per minute (m_f)

$$m_f = \frac{10}{t1} \times \frac{60 \times 0.8275}{1000} \text{kg/min}$$

3. Mass flow rate of air (m_a)

$$m_a = \rho_a \times C_d \times (\Pi/4)\, d^2 \times \sqrt{2\, g\, H_a}$$

where $C_d = 0.62$

d = orifice diameter

$$H_a = H_w \times (\rho_w / \rho_a)$$

4. Heat carried away by exhaust gases

$E_e = (m_a + m_f)\, C_{pg}(T_e - T_a)$ ------ Kj / min

Where C_{pg}= 1.0046 Kj / Kg-^{0}C.

5. Heat carried away by cooling water:

$E_c = m_c C_{pg}(T_{co} - T_{ci})$

Where m_c = $(500/ t_2) \times (60 / 1000)$ -----Kg / min

C_{pw} = 4.2 kj/ kg-k

6. Engine out put rate:

$$E_o = \frac{\Pi W D N}{1000} \times 9.81 \quad kj / min$$

7. Energy input rate:

   $E = m_f \times$ Calorific Value
   Where Calorific Value = 45380 kj/ kg

8. unaccounted losses

Eua= E – (Ee + Ec + Eo) ---------- kj/min

RESULTS:

1.Energy distribution table

S.No	Parameter	Energy Kg/min
1	Input energy (E) Output energy (Eo) Energy to cooling water (Ec) Energy to exhaust gases (Ee) Unaccounted losses (Eva)	

2.Percentage energy distribution

S.No	Parameter	% Energy
1	Engine output	$\frac{Eo}{E} \times 100$
2	Energy to cooling water	$\frac{Ec}{E} \times 100$
3	Energy to exhaust gases	$\frac{Ee}{E} \times 100$
4	Energy to unaccounted losses	$\frac{Eua}{E} \times 100$
	Total energy	100%

PRECAUTIONS:

1. engine should be started and stopped at no load condition
2. cooling water must be ensured throughout the experiment
3. The engine should be run for sufficient time so that equilibrium conditions will be attained.
4. The manometer readings should be noted without parallax error.

VIVA QUESTIONS

1. How the heat is distributed in an I.C engine?
2. What are the different sources of heat loss in un accounted heat loss?
3. How the load is varied in electrical dynamometer?
4. Explain the working principle of an I.C engine?
5. Explain classification of I.C engines.
6. Differentiate two-stroke engine and Four-stroke engine?
7. Thermal efficiency for which engine i.e. two-stroke engine or four-stroke engine is more? Why?
8. Mechanical efficiency for which engine i.e. two-stroke engine or four-stroke engine is more? Why?
9. Why the deflector is provided on two-stroke engine piston?
10. Explain the working principle of two-stroke engine?
11. Explain the working principle of four-stroke engine?
12. In which engine i.e. two stroke engine or four-stroke engine larger flywheel is required? Why?

5.STATIC PRESSURE DISTRIBUTION ROUND AN AEROFOIL

AIM: To draw the static pressure distribution for the given aerofoil and cylinder.

APPARATUS:

1. Wind tunnel test rig
2. NACA 0018 aerofoil with pressure taps. Axial chord h = 16 cm, span = 25 cm
3. A pitot tube with a U- tube manometer
4. A multi limbed manometer for measuring the static pressure distribution.

THEORY:

Wind tunnels are generally used for testing the models of various shapes like aerofoils, cylinders, cascade of blades etc. In a wind tunnel the important part is the test section. The aim is to obtain a truly rectilinear flow across the test section. The objects to be tested are placed in the test section. The wind tunnel can be of suction type or blower type. As air enters in to the settlings chamber on account of the large cross sectional area (about 16 times that of the test section) of the settling chamber, the flow velocity is reduced. The wire gauges and honey combsstarighten the flow before it is expanded in the contraction zone.

DESCRIPTION:

The wind tunnel is of suction type with an axial flow test driven by a variable speed D.C motor. It consists of an extreme section with a bell mouth inlet containing a flow straighter, screeners and a straw honey comb. This section is followed by 6.25:1 contraction section. The test section, diffuser and the duct containing the axial flow fan from the whole unit is supported on steel frames.. The complete wind tunnel except the test section is constructed of MS iron sheets for strength and rigidity. The test sections are made of teak wood and have glass windows for visual observations of flow phenomena. The control of the DC motor is by a rectifier controlled variable speed drive.

MEASUREMENT OF STATIC PRESSURE DISTRIBUTION:

On the aerofoil, hypodermic tubes are provided at various sections along the section and pressure sides of the blade surface. They are closed at one end and along the whole length of the blade. The tubes are inside the slots on the blade surface. The open ends of these tubes project out through one of the side walls of the test section. Local static pressure on the aerofoil surfaces are transmitted to the multi-limbed manometer through hypodermic tubes.

PROCEDURE:

1. The aerofoil is fixed in the test section and bolted rigid in its position. Incidence angle is kept at 0^0 .
2. The hypodermic tubing is connected to the respective limbs at the multi-limb manometer.
3. Pitot tube is also given connection to the U-tube manometer
4. The heights of the water column on various limbs of the multi-limbed manometer are noted. The manometer deflection from the pitot tube is also noted.
5. The above procedure is repeated for different incidence angles of the aerofoil.
6. The aerofoil is replaced with the cylinder and the above procedure is repeated.
7. Graphs are plotted for static pressure co-efficient Vs chord lengths of the aerofoil and the cylinder static pressure co-efficient.

OBSERVATIONS:

Aerofoil Incidence angle α (deg)	Pitot Tube Reading q (cm)	Static pressure in mm of Water Column													
		1	2	3	4	5	6	7	8	9	10	11	12	13	atm

MODEL CALCULATIONS:

Velocity Of Air = 13 $\sqrt{q}$ m/s
Where q = Deflection Of Water Manometer in cm

Static pressure coefficient (Cp)

For the given aerofoil :
$Cp = (P - P_{ref})/ q$

where $P_{ref} = P_{atm}$

Static Pressure Coefficient for the Cylinder:

Pref = (q) – P_2

Where P_2 = Pressure at stagration Point.

RESULTS:

Angle Of Inclination α (deg)	Static Pressure Coefficient (C_p)											
	1	2	3	4	5	6	7	8	9	10	11	12

PRECAUTIONS:

1. When the power is turned on with main switch, the speed control knob or the motor should be kept at minimum
2. The motor should not be operated at low voltage (lessthan 350 volts)
3. The aerofoil or the cylinder should be tight in their positions while taking readings for a particular incident angle.
4. The hypodermic tubing should be handled with care.
5. Pressure readings are noted from the multilimbed when there are no fluctuations.

VIVA QUESTIONS

1. Why the pressure variation created on an aerofoil?
2. Define static pressure, dynamic pressure, and stagnation pressure?
3. Differentiate absolute pressure and gauge pressure?
4. Define Reynolds number; what is the use of Reynolds number?
5. Explain the pressure distribution on an aerofoil at 0^0 angle of impact?
6. What is the purpose of Pitot static tube?
7. Differentiate manometer and piezo meter?
8. Differentiate laminar flow and turbulent flow?
9. What are the forces predominant in the laminar flow?
10. What are the forces predominant in the turbulent flow?
11. Explain working of multi limbed manometer?
12. What is purpose of hypodermic tubes?

6.LIFT AND DRAG CO-EFFICIENT FOR AN AEROFOIL

AIM:

To determine the lift and drag forces for the given aerofoil and hence to obtain co-efficient of lift and coefficient of drag.

APPARATUS:

1. Wind tunnel test rig
2. NACA 0018 aerofoil of axial chord = 16 cm and Span = 25 cm
3. NACA 0018 aerofoil with a linkage mechanism and a digital component force measuring transducer to determine lift and drag forces.
4. A pitot – static tube with a U-tube water manometer

DESCRIPTION:

The wind tunnel is of suction type with an axial flow fan driven by a variable speed DC motor. It consists of an entrance section with a bell mouth inlet containing a flow straighter, screen and a straw honeycombs. A nozzle section, test section, a diffuser section and a duct containing the axial flow fan follow this section. The whole unit is supported on steel frame. The complete wind tunnel except the test section is constructed of MS sheets for strength and rigidity. The test section is made of teak wood and has plexiglass window for visual observations of flow phenomena. The control of the DC motor is by a rectifier controlled variable speed drive.

THEORY:

Wind tunnel is generally used for testing the models of various shapes like aerofoils, cylinders, cascade of blades etc. In a wind tunnel the important part is the test section. The aim is to obtain a truly rectilinear flow across the test section. The object to be tested is placed in the test section. The wind tunnel can be of suction type or blower type. The air enters in to the settling chamber on account of the large cross section area of the setting chamber. Its velocity is reduced, and the presence of wire gauges and honey comb straightens the flow before it is expanded in the contraction zone. The working or test section receives a uniform stream of air from the contraction zone.

PROCEDURE:

1. The given aerofoil is rigidly fixed in the test section to the vertical rod extending from the transducer. The angle of incidence (α) is kept at zero initially.

2. The transducers are connected to the digital display device where the lift and drag forces can be read directly.
3. The motor is started and speed is increased gradually. So that manometer deflection from the pitot tube is at least 5 cm.
4. The lift force & drag force are noted from the display device
5. The angle of incidence is altered to different angles and the readings of lift and drag forces are noted.
6. Graphs are plotted for C_L, C_D Versus Incidence angle.

OBSERVATIONS:

S.No	angle α (Incidence Deg)	Pitot tube reading q (cm)	Drag force F_D (kgf)	Lift force F_L (kgf)

MODEL CALCULATIONS:

Incidence angle (α) = 0^o

Pitot tube reading = q cm

Velocity (V) = 13 $\sqrt{q}$ m/s.

Drag co-efficient (C_D):

Drag co-efficient (C_D) = F_D / (½) ρV^2 x A

Where A = Chord x Span

Lift Coefficient (C_L):

Lift coefficient (CL) = F_L / (½)ρV^2 x A.

RESULTS:

Sno	angle of Incidence α (Deg)	Velocity Of Air V (m /sec)	Drag Coefficient (C_D)	Lift Coefficient (C_L)

PRECAUTIONS:

1. When the power is turned with main switch, the speed control knob of the motor should be kept at minimum.
2. The DC motor should not be operated at low inlet voltages
3. The aerofoil should be tight in its position while taking the readings for a particular incidence angle.

VIVA QUESTIONS

1. How the lift and drag forces are created on an aerofoil?
2. Define static pressure, dynamic pressure, and stagnation pressure?
3. Differentiate absolute pressure and gauge pressure?
4. Define Reynolds number; what is the use of Reynolds number?
5. Explain the pressure distribution on an aerofoil at 0^0 angle of impact?
6. What is the purpose of Pitot static tube?
7. Differentiate manometer and piezo meter?
8. Differentiate laminar flow and turbulent flow?
9. What are the forces predominant in the laminar flow?
10. What are the forces predominant in the turbulent flow?

7.RECIPROCATING AIR COMPRESSOR

AIM: To conduct test on reciprocating air compressor and to determine following at various delivery pressures. 1) Volumetric efficiency 2) Isothermal efficiency

APPARATUS: Air compressor test rig, Stop watch

DESCRIPTION: Air compressor test rig comprises followings.

1. Air compressor
2. Air measuring setup
3. Control panel
4. Accessories

1. **AIR COMPRESSOR:** It has discharge capacity of 435 lt/min at a working pressure of 12 kg/cm^2 running at a speed of 270 rpm. The tank capacity of compressor is 250 litres.
2. **AIR MEASURING SETUP:** It consists of an air tank orifice, manometer connecting hose and a stand

THEORY: Air compressor can be classified as two types. They are rotary and reciprocating air compressor. Further reciprocating compressors are classified as single stage and multi stage. Multistage compressors have following advantages over single stage.

1. Better volumetric efficiency
2. Working temperatures are much low, therefore lubrication is better and lesser wear and tear
3. They have better mechanical balancing, requiring small flywheel due to even torque.
4. Cylinders are lighter

USES OF COMPRESSED AIR:

In industries, it is used for construction works, driving vibrators, pneumatic drill, for blasting rocks and pneumatic brakes, as agitator in chemical processing tanks. In work shops it is used for operating forge hammer, spray painting, as drier etc.

At different delivery pressures, the intermediate pressure inter cooler temperature, tank temperature, manometer readings and the time for 5 revolutions of the disc in the energy meter are noted.

At different delivery pressures thermal efficiency and volumetric efficiencies are calculated and graphs are drawn as follows

1. Delivery pressure Vs Volumetric efficiency
2. Delivery pressure Vs Isothermal efficiency

PROCEDURE:

1. All electrical connections and direction of rotation are checked.
2. Shut off valve and drain cock is closed.
3. Water is filled in the manometer up to zero position
4. The compressor motor is stated
5. The pressure rise in the tank is observed.
6. A 1 kg/cm^2 of tank pressure, the shut off valve is adjusted to maintain the tank pressure at 1 kg./cm^2
7. At this point all the temperature readings manometer levels and time required for 5 revolutions of energy meter disc are noted.
8. The shut off valve is closed to allow the pressure rise in the tank.
9. The experiment is repeated for 2,3,4 and 5 kg./cm^2 pressure

OBSERVATIONS:

S.No	Delivery pressure (N / m^2)	Intermediate pressure (N / m^2)	Inter cooler temperature (T_2^{o}C)	Tank temperature (T_3^{o}C)	Time for 5 rev of energy meter disc (t) in sec	Manometer reading		Ambient temperature (T_a^{o}C)
						H_1 cm	H_2 cm	

CALCULATIONS:

1. Area of the orifice A_o in m^2

   $A_o = (\pi /4) d^2$ where d = 0.01525 m

2. Atmospheric pressure P_1 in N/m^2

   $P_1 = B/760 \times 1.0332 \times 10^5$

Where B = Barometric pressure = 760mm of mercury

3. Density of air a in kg/m^3

   $\rho_a = P_1 / (R\, T_a)$ kg/m^3

   where R = gas constant = 287 J/kg-k

4. $T_a = T_1 + 273$

5. Head of air in mts as read in manometer (H_a)

   $H_a = H_w \times P_w/P_a$

   Where $H_w = H_1 + H_2$

6. Air mass flow rate at RTP condition V_1 m^3/min

   $V_1 = A_o \times C_d \times 60 \times \sqrt{2gHa}$

   C_d = coefficient of discharge

7. Air mass flow rate at NTP condition V_s m3/min

   $V_s = P_1V_1/T_A \times T_s/P_s$ m^3/min

   Where $T_s = 15 + 273 = 288^o$ K

   $P_s = 1.00 \times 10^4$ kg/m^2

8. Swept volume V_{sw} in m^3/min

   $V_{sw} = (\pi/4)\, D_L^2 \times L \times N$ m^3/min

9. Isothermal power (Iso power)

Iso power = $P_1 V_1 \log_e (P_3/P_2)/1000$

10. Input power IP = $(5 \times 3600 \times 1.37) / (t \times K) \times \eta_m \times \eta_t$

   t = time in sec

   η_m = motor efficiency = 0.88

   η_t = transmission efficiency = 0.90

   K = energy meter constant

11. Isothermal efficiency (η_{iso}) = (Iso power /(IP)) x 100

12. Volumetric efficiency (η_{vol}) = (V_s / V_{sw})x 100

Where V_s = Mass flow rate at NTP condition m^3/ min

RESULTS:

At different delivery pressures of the compressor the values of volumetric efficiency, isothermal efficiency are tabulated as follows.

S.No	Delivery pressure (N / m^2)	Volumetric efficiency (η_{vol})	Isothermal efficiency (η_{iso})

PRECAUTIONS:

1. All the electrical connections are checked before starting the compressor
2. Manometer readings are taken without parallax error
3 . The shut off valve is closed properly

VIVA QUESTIONS

1. How the pressure increased in reciprocating air compressor?
2. What is purpose of manometer meter at inlet of air compressor?
3. Differentiate reciprocating air compressor and rotary air compressor?
4. How we can improve the efficiency of air compressor?
5. What is purpose of inter cooler? Where it is provided?
6. When we consider Adiabatic, Isothermal, Polytropic compression processes, in which process requires least work to compressor?
7. When we consider adiabatic, isothermal, Polytropic expansion processes, in which process more work delivered?
8. Define volumetric efficiency?
9. What are the applications of air compressor?
10. Draw the p-v diagram for isothermal air compression?
11. Why the two stage air compressor preferred for higher pressures?

8.CENTRIFUGAL AIR BLOWER

AIM: To determine the blower power and blower efficiency for the given type of impeller.

APPARATUS: Centrifugal air blower test rig, Stopwatch, impellers

DESCRIPTION:

Blower test rig comprises the following

1. Centrifugal blower with three impellers
2. Inlet duct and discharge pipes
3. Pitot tube
4. Motor and pulley system
5. Venturimeter
6. Control panel and manor meters

Blower consists of a rotating member called the “wheel” or impeller and stationery member called the ‘housing’. The housing is provided with an intake opening and with a discharge opening. The housing has involutes design. The differential pressure created by the energy transmitted to the set gas by the rotating impeller causes the flow of air.

DETAILS:

BLOWER: Casing is made from MS sheets. Main shaft is mounted between two bearings. One end if the shaft is fitted with the flange, to which impeller can be fixed. Another end of the shaft is fitted with three-step pulley.

IMPELLERS: These are made of MS sheets. The types of impellers provided with test rig are “radial” and forward curved blades. These impellers are fitted to the flange. Just by tightening of four nuts. Radial or straight impellers have straight blades.

]Inlet diameter = 260mm

Outlet diameter = 380mm

Width = 90mm

INLET DUCT AND DISCHARGE PIPES: Inlet duct is a small length MS sheet pipe provided with a horse nipple for connecting it to picot tube.

Discharge duct is 3m length and 110 mm dia MS pipe. It is divided into 3 parts with flanged ends for connecting it to venturimeter, butterfly valve, pitot tube etc.

MOTOR AND PULLEY SYSTEM: It is mounted on foot mounting bracket and parallel to blower shaft for easy changing of belt. Motor shaft is fitted with 3 groove pulley while blower shaft has 3 step pulley

MOTOR: Foot mounting, 90 frame, 2 pole 3HP, 2800 rpm, 3phase, 440 volts, 50 HZ
PULLEY SYSTEM: Motor pulley – 3 groove, 100 mm diameter, B section. Shaft and pulley – 3step, B section diameters: 75, 100, 125mm

PITOT TUBE: This tube is a chromium 90 plated bent copper pipe, that can be raised or lowered vertically inside the pipe to measure static head at different layers. A fine adjustment screw and a scale is provided with the system

VENTURIMETER: Venturimeter with flanged ends is made of MS sheets. Pressure tappings are provided at inlet and at throat.
Inlet diameter = 110 mm
Throat diameter = 56 mm

THEORY: A fan or a blower is a machine used for applying power to a gaseous fluid to increase its energy content to enable the flow of gas against various degrees of resistance. The function of a fan is to move gases through distribution system and apparatus required for conditionings the gas medium, such as systems for healing ventilation and air conditioning of buildings, drying and cooling of materials and products, for pneumatic conveying of materials for dust collection seperation and exhaust for industrial processing or mining work etc.

Blowers are the fans used to force air under pressure i.e. the resistance to gas or air flow is imposed primarily upon the discharge. Exhausters are a fan used to with draw air under suction i.e the resistance to flow is imposed primarily upon inlet. An experiment is conducted to determine the blower power and blower efficiency.

PROCEDURE:

1. All the electrical connections are checked
2. Mercury and water manometers are filled up to zero level
3. The given impeller is fixed to the flange and is tightened with the nuts.
4. The blower inlet is covered with the plate and all the 12 bolts are tightened.

5. A speed in the pulley system is selected first and the belt tension is adjusted
6. Butterfly valve is opened for 100% opening and locked in that position
7. The blower or motor is started with the help of starter
8. Time in seconds for 5 revolutions of the energy meter disc is noted. The levels of the fluids in both the manometers are noted.
9. The experiment is repeated for different speeds, different impellers and for different drift valve position i.e 75%, 50%, 25% and the above readings are noted down.

PRECAUTIONS:

1. The manometer readings are noted without parallax error
2. The impeller should be firmly fixed to the motor shaft while changing the impeller.
3. There should be no leakage of air through the casing and discharge duct

OBSERVATIONS:

Ambient Temperature = T_a ^{0}C

Diameter of venturimeter inlet (d1) = 110 mm = 0.11m

Diameter of venturimeter throat (d2) = 56 mm = 0.056m

Water density (ρ_w) = 1000 kg / m^3

Density of mercury (ρ_m) = 13600 kg/ m^3

Density of air (ρ_a) = 1.16 kg / m^3

Energy meter constant (KE = 150 rev/ KWH.

OBSERVATIONS TABLE:

S No	Impeller type	Valve Position	Mercury Manometer Reading (H_m) in cm	Water Manometer Reading (H_w) in cm	Energy Meter time for 5 rev (sec)	Ambient Temperature (^{0}C)
1 2 3 4 5		100% open 75% open 50% open 25% open 0 % open				

MODEL CALCULATIONS:

1.Static head of air in meters:

$$H_a = \frac{H_w \rho_w}{\rho_a}$$

2. Velocity head of air for mercury manometer

$$H_a^1 = \frac{H_m \rho_m}{\rho_a}$$

4. Discharge Of Air Through Duct:

$$Q_a = C_d \frac{A_1^2 \quad A_2^2}{\sqrt{(A_1^2 - A_2^2)}} \sqrt{(2 g H_a^1)}$$

Where C_d= Coefficient of discharge of the venturimeter = 0.97

$A_1 = (\Pi/4)\, d_1^2$

$A_2 = (\Pi/4)\, d_2^2$

5. Blower Power

$$BP = \frac{\rho_a\, g Q_a H_a}{1000} \text{ Kilo Watts}$$

6 Input Power to the blower

$$IP = \frac{5}{t} \times \frac{3600}{K} \times \eta_m \times \eta_t$$

Where η_m = Motor efficiency = 0.70

η_t = Transmission efficiency = 0.70

7. Blower Efficiency

$$\eta_{blower} = \frac{\text{Blower Power}}{\text{Input Power}} \times 100 = \frac{BP}{IP} \times 100$$

GRAPHS:

The following graphs are plotted for the given impellers.

1. Discharge (Q_a) Vs Blower Power (BP)
2. Discharge (Q_a) Vs Blower Efficiency (η_{blower})

VIVA QUESTIONS

1. How the pressure increased in centrifugal air blower?
2. What is purpose of venture meter?
3. Differentiate reciprocating air compressor and rotary air compressor?
4. How we can improve the efficiency of air compressor?
5. Which type of rotor has higher efficiency?
6. How the suction is created at the eye of rotor?
7. When we consider Adiabatic, Isothermal, Polytropic compression processes, in which process requires least work to compressor?
8. When we consider adiabatic, isothermal, Polytropic expansion processes, in which process more work delivered?
9. Define volumetric efficiency?
10. What is the purpose of casing?

9.GYROSCOPIC COUPLE

AIM: To determine the gyroscopic couple and to verify that the applied torque is equal the gyroscopic couple, using motorized gyroscope apparatus.

APPARATUS: Motorized gyroscope, Weights, Stop watch.
Mass of the disc = 3.84kg.
Radius of the rotor = R = 0.125m
Radius of gyration of the disc = k =0.09
Theory: Gyroscope is used for control of aero planes, guided missiles, ships etc. It basically consists of a spinning rotor, rotating around a spinning axis. The rotor is mounted in such a way that the axis of rotor can revolve around vertical axis and another horizontal axis perpendicular to it.

When torque is applied to the spinning rotor, perpendicular to the axis, the rotor axis also rotates about vertical axis. A couple generated due to spinning of the rotor, called Gyroscopic Couple, causes this.

Let ω = angular velocity of the rotor.
ω_p = precision velocity of the rotor axis.
I = moment of inertia of the disc, in Kg-m^3
Then, Gyroscopic couple = I ω ω_p
Let w = weight in Newton placed on the spinning axis
And x = Distance at which the weight is placed, m
Then, Applied Torque T= w x
Theoretically, Applied torque = Gyroscopic couple
i.e; T = w x = I ω ω_p

PROCEDURE:

1. The rotor is checked for vertical position.
2. The diameter stat is kept at zero position and the supply is put on.
3. A voltage of 70 volts is applied.
4. The speed of the rotor is adjusted by varying the voltage.
5. The rotor is allowed to rotate about 5minutes before the speed is recorded.
6. The required weight is placed on the axis of the rotor.
7. Time taken for 45degrees of rotation is noted with a stop watch.
8. The above procedure is repeated for different speeds and weights.

OBSERVATIONS:

S.no	Rotor speed, rpm	Weight applied (Newtons)	Time for 45deg precession(sec)
1			
2			
3			

Model calculations:

1. Angular speed of the rotor $\omega = 2\pi N / 60$ rad/sec.
2. Velocity of precession, $\omega_p = (\pi/4)(1/t)$ rad/sec.
3. Moment of Inertia of the disc $I = m k^2$
4. Applied torque, $T = W \times X$
5. Gyroscopic couple, $G = I \omega \omega_p$
6. % error $= ((G-T)/T) \times 100$

RESULTS TABLE

S.no	Torque applied,T (N-m)	Gyroscopic couple (G), N-m	% error

CONCLUSION:

1. The precessional motion of the spinning rotor is studied and well understood. It is observed that when the torque is applied to the spinning rotor the precessional motion takes place about vertical axis.
2. Theoretically applied torque should be equal to the gyroscopic couple measured. But there is some error due to the friction force opposing the rotor precession and some degree of error in noting the time taken for 45 deg of precession.

PRECAUTIONS:

1. The fastenings are checked for tightness before starting the equipment.
2. The rotor balance is checked and lubricated properly.
3. The base of the apparatus is checked for levelness.
4.

VIVA QUESTIONS

1. Define gyroscopic couple?
2. Give examples for gyroscopic couple applications?
3. Define plane of precession?
4. Define axis of precession?
5. How we can improve the efficiency of air compressor?
6. What purpose is of inter cooler? Where it is provided?
7. When we consider Adiabatic, Isothermal, Polytropic compression processes, in which process requires least work to compressor?
8. When we consider adiabatic, isothermal, Polytropic expansion processes, in which process more work delivered?
9. Define volumetric efficiency?

10.ECONOMICAL SPEED TEST

AIM: To determine the economical speed of a four cylinder matador diesel engine at half of the full load.

APPARATUS: Tachometer, Stopwatch, Diesel engine test rig.

ENGINE SPECIFICATIONS:

Max Horse Power = 7.35 at 1500 rpm

No of cylinders = 4

Capacity = 449.25 cm3

Compression ratio = 19.8:1

Cylinder bore = 78mm

Stroke = 94mm

THEORY: The economical speed test is conducted to obtain the optimum operating speed of the engine optimum operating speed means it is the speed at which specific fuel consumption is mini at a constant applied load test is conducted at a load of 6.6kg on the engine. The specific fuel consumption at different speeds of 1000 rpm, 1200, 2000, 1800, 1600, 1400 etc is measured. By keeping the load constant. A graph is plotted with engine speed on X-axis and specific fuel consumption on y-axis, from the graph the economical speed of the engine is determined.

PROCEDURE:

1. No load condition is ensured before statring the engine.
2. Fuel oil and lubricating oil level are checked.
3. Engine is started and cooling water supply is ensured.
4. The engine is nun at 1000 rpm by adjusting the load to 6.6 kg. Then the time taken for 10 CC of fuel consumption is noted. The adjustment of the load and speed is to be done carefully by adjustment of accelerator.
5. The above procedure is repeated at speeds of 2000, 1800, 1600, 1400, 1200, 1100 rpm.

GRAPH: A graph is drawn such that BSFC is taken on Y-axis and speed on X-axis. From the graph the economical speed of the engine is found out, where BSFC is minimum

OBSERVATIONS:

S.No	Speed N rpm	Load W kg	Time for 10 CC of fuel consumption	Brake Power (KW)	FCH (Kg/hr)	BSFC Kg/KW hr

MODEL CALCULATIONS:

1. Brake power

   BP = WN / 2720 ------- KW

2. Fuel consumed per hour:

   TFC = 10 / 4 x 3600/1000 x Sp gravity

3. Break specific fuel consumption

BSFC = FCH / BP Kg/KW- Hr

RESULTS:

Sno	Speed rpm	BSFC Kg/KW-Hr

PRECAUTIONS:

1. No load condition is ensured before starting and stoping of engine.
2. Cooling water supply should be ensured throughout the experiment
3. Adjustment of the load and speed is to done carefully by adjustment of accelerator.

VIVA QUESTIONS

1. What is the purpose of conducting Economical speed test?
2. What is the firing order of 4-cylinder engine?
3. What is the firing order of 6-cylinder engine?
4. What is the necessity of the firing order?
5. Two engines are at 0.5 bsfc and 0.8 bsfc, which is best?
6. What is C.C of an engine?
7. How the maximum load calculated in electrical dynamometer?
8. What is the purpose of flywheel?
9. What is the relation in between speed and load?
10. Why in our vehicles particular gear has particular economical speed?