THERMAL ENGINEERING LAB

Branch & Year :III Year B.Tech. M.E. - I Semestar

LIST OF EXPERIMENTS

1. I.C. Engines Valve / Port Timing Diagrams

2. I.C. Engines Performance Test(4 -S Diesel Engines)

3. I.C. Engines Performance Test on 2-S, Petrol

4. Evaluation of Engine friction by conducting morse on 4-S Multi cylinder Petrol Engine

5. Evaluation of Engine friction by conducting motoring/ retardation and motoring test on 4- S diesel engine

6. I.C. Engines Heat Balance.

7. Determination of A/F Ratio and Volumetric Efficiency on IC Engines.

8. Determination of Economical speed test for fixed load on 4-S Engine.

9. Determine optimum cooling water temperature on IC Engine

10. Dis-assembly / Assembly of Engines.

11. Performance test on Reciprocating Air-Compressor unit.

12. Study of Boilers.

SAFETY REGULATIONS

Users of Thermal Engineering Lab must comply with the following safety instructions.

1. Wear always pants and safety shoes when you operate any engine. Sandals are not allowed at all.

2. There should be no over-crowding.

3. Make sure that you stay away from hot exhaust lines and moving parts of engines

4. Before operating any machine, you must be aware of the following
   a. Location of fire extinguishers and the outside exits.
   b. How the engine operates. Read instruction or manual before operating it.
   c. How to turn off the engine in case of damages.

5. When you hear or see a danger alarm from the engine that you using, stop the engine immediately.

6. Make sure that there is no fuel or oil spill on the floor.

7. Consult the instructor for safety precautions to be followed.

8. Do not run inside the lab and concentrate on the present task.

9. When moving heavy equipments or gas cylinders, use carts

10 Always use the right tools for the given task.

11. Handle the tools and equipments with extreme care and return the tools to their proper places (Tool Cabinets).

12 For cleaning tools or equipments, use only the proper cleaner. Never use fuels such as gasoline or diesel for cleaning.

13. Handle fuels with extreme caution.
   a. Use the designated area for this purpose.
   b. Use the proper containers (safety cans) to carry fuels.
   c. Make sure there is no electric spark present.
   d. Do not leave fuels in open containers.

14. Make sure that all gas cylinders are chained and well supported.

15. Before operating engine, make sure that there is no fuel or gas leakage

Experiment No. 1
VALVE TIMING DIAGRAM

Objective: To conduct valve timing test on a four stroke single cylinder diesel engine to find out the suction, compression, expansion, exhaust and valve overlap periods, to draw the port timing diagram, and explain the reasons of deviation from the theoretical timings.

Specifications:

Brake power of the engine = 3.5kW
Rated speed = 1500rpm

Theory:

Though theoretically the valves are supposed to open and close only at dead centers, there is a large deviation in actual practice. The deviation is because o f the following two factors:

Mechanical factors:
The poppet valves of the reciprocating engines are opened and closed by cam mechanism. The clearance between the cam and the poppet and valve must be slowly taken up and valve slowly lifted at first if noise and wear is to be avoided. For the same reason, the valve cannot be closed abruptly else it will become bounced on its seat. Thus the valve opening and closing periods are spread over a considerable number of crank shaft degrees. As a result the opening of the valve must commence ahead of the time at which it is fully opened (i.e. before dead centre). The same reasoning applied for closing time and the valve must close after dead centers.

Dynamic factors:
Besides mechanical factors of opening and closing the valves the actual valve timing is set, taking into consideration the dynamic effects of gas flow.

Intake valve timing:
Intake valve timing has a bearing on the actual quantity of air sucked during the suction stroke i.e. it affects the volumetric efficiency. For a variable speed engine, the chosen intake valve setting is a compromise between the best setting for low and high speeds. There is a limit to the high speed for advantage of ram effect. At very high speeds, the effects of fluid friction may be more than offset, the advantage of ram effect and the charge for cylinder per cycle falls off.

Exhaust valve timing:
The exhaust valve is set to open before BDC. If the exhaust valve does not start to open until BDC, the pressures in the cylinder would be above atmospheric pressure, the overall effect of opening the valve prior to the time, the piston reaches BDC , result in overall gain in output. The closing time of the exhaust valve offsets the volumetric efficiency. The period when both the intake and exhaust valves are open, at the same time, is called valve overlap this overlap should not be excessive, it allows the burned gases to be sucked into the intake manifold or the fresh charge to escape through exhaust valve.

Procedure:

1. The circumference of the wheel is measured with the help of scale and thread.
2. By turning the fly wheel, various events are marked on the fly wheel they are:
   Top dead centre (TDC)
   Inlet valve opening (IVO)
   Inlet valve closing (IVC)
   Exhaust valve opening (EVO)
   Exhaust valve closing (EVC)
   Bottom dead centre (BDC)

TDC: The fly wheel is slowly rotated and the point where the piston reaches the top most position in the cylinder is marked on the flywheel as top dead centre.

IVO: The fly wheel is slowly rotated with the help of handle. The piston moves in the cylinder. There are push rods which operate with the help of a cam. These rods aid in opening and closing of valves through spring loaded mechanisms. The inlet valve opens before TDC position when the push rod tightens. This is marked as IVO.

BDC: The fly wheel is further rotated. BDC is taken as the point when the piston reaches bottom most point in the cylinder.

IVC: The fly wheel is further rotated. The push rod then passes through the phase in which it loosens from tight position. The point is marked as IVC.

EVO: The exhaust valve opening and closing are determined in the same way as that of inlet valve.

Precautions:

1. The valve opening is to be taken as the point where it begins to open.
2. The valve closure is taken as the point where valve closes completely.
3. The flywheel is to be rotated in proper direction.

Result:

The following are found out Valve timing diagram is drawn and the direction of flywheel rotation is shown.

Suction period = $180^0 + \theta_1 + \theta_2$
Compression period = $180^0 - \theta_2$
Expansion period = $180^0 - \theta_3$
Exhaust period = $180^0 + \theta_3 + \theta_4$
Valve overlap = $\theta_1 + \theta_4$

Discussion on the result obtained:

Observations: Circumference of the fly wheel = ……in cm = l cm

Sl. No.	Event	Distance from the nearest Dead centre in cm.	Angular distance in degrees
1	Inlet valve opening Before BDC	l_1	θ_1=
2	Inlet valve closing After BDC	l_2	θ_2=
3	Exhaust valve opening Before BDC	l_3	θ_3=
4	Exhaust valve closing After TDC	l_4	θ_4=
5	Valve overlap		$\theta_1+\theta_4$=

Model Calculations:

Circumference $=360^0$
i.e. $l = 360^o$
Therefore, $\theta_1 = (360 * l_1 / l)^0$

Suction period $= 180^0 + \theta_1 + \theta_2$
Compression period $= 180^0 - \theta_2$
Expansion period $= 180^0 - \theta_3$
Exhaust period $= 180^0 + \theta_3 + \theta_4$
Valve overlap $= \theta_1 + \theta_4$

Viva Questions

1. Explain the principle of working of a 4-stroke S.I engine with a neat sketch?

2. What is valve overlap?

3. How many degrees the crank shaft rotate during one cycle in a 2-stroke engine?

4. How many degrees the crank shaft rotate during one cycle in a 4-stroke engine

Experiment No. 2

PORT TIMING DIAGRAM

Objective : To conduct the port timing diagram test on a cut section model of a single cylinder two strike petrol engine to find out the suction, compression , expansion and exhaust periods, and to draw the port timing diagram.

Instrumentation:

Engine cut section model, thread, chock piece and steel rule.

Specifications:
Engine type = SI engine
Cycle of operation = 2 stroke
Model = cut section model

Theory: ignition and expansion takes place in the usual way. During the expansion stroke, the air in the crank case is coIn a two stroke engine, the cycle is completed in two strokes i.e. one revolution of crank shaft as against two revolutions of a four stroke cycle. The difference between two stroke and four stroke engine is, in the method of filling cylinder with fresh charge and removing the burnt gases from the cylinder. In a four stroke engine, these operations are performed by the engine piston during suction and exhaust strokes respectively.

In a two stroke engine, suction is accomplished by air compression in crank. The induction of compressed air removes the products of combustion, through exhaust port. Therefore, no piston strokes are required for these two operations. Only two piston strokes are required to complete the cycle, one for compression of fresh charge and the other for power stroke. The air or charge is sucked through spring loaded inlet valves when the pressure in the crank cases reduces due to upward motion of the piston during compression stroke. After the compression pressed. Near the end of the expansion stroke piston uncovers the exhaust ports and the cylinder pressure drops to atmospheric values as the combustion products leave the cylinder.

Further motion of the piston uncovers the transfer port, permitting the slightly compressed air or mixture in the crank case to enter the engine cylinder. The top of the piston usually has a projection to deflect the fresh air to sweep up to the top of the cylinder, before flowing to the exhaust ports. This serves the double purpose of scavenging the upper part of the cylinder of combustion products and preventing the fresh charge from flowing directly to the exhaust ports. The same objective can be achieved without piston deflector by proper sloping of the transfer port. During the upward motion of the piston from BDC, the transfer and exhaust ports close, compression of charge begins and cycle is repeated (Draw figures)

Procedure:

The cycle of operation proceeds as suction, compression, power and exhaust strokes takes place in series.

(1) Initially the circumference of the flywheel is measured. A pointer is attached above the flywheel such that it coincides with B.D.C marked on the flywheel at the starting of the engine .This pointer is used for marking specific points. The duration of each stroke theoretically is 90^0, but since the actual span varies, the port timings are to be individually measured.
(2) The flywheel is rotated .The instant at which inlet port starts to open is determined and corresponding point is marked on flywheel . This when converted to degrees gives IPO.
(3) The position when the piston completely closes the inlet port is marked as IPC.
(4) The points EPO and EPC corresponding to exhaust port opening and exhaust port closing are marked similar to that of IPO and IPC.
(5) The position when the transfer port opens and closes is marked as TPO and TPC

Precautions:

(1) The ports opening are to be taken as the point when it just begins to open.
(2) The ports closure is taken as the point where the port closes completely.
(3) The flywheel is to be rotated in proper direction.

Result:

The following are found out and port timing diagram is drawn and flywheel rotation is shown.

Suction period = $\theta_4+\theta_5$ =
Compression period =180- θ_6 =
Expansion period =180 - θ_3 =
Exhaust period = $\theta_3 + \theta_6$ =

Discussion on the result:

Observations: circumference of the fly wheel = ……cm = l cm

Sl. No.	**Event**	**Distance from the nearest dead centre in cm.**	**Angular distance in degrees**
1	Inlet port opening before TDC	l_1	θ_1=
2	Inlet port closing after TDC	l_2	θ_2=
3	Exhaust port opening before BDC	l_3	θ_3=

4	Transfer port opening Before BDC	l_4	θ_4 =
5	Transfer port closing after BDC	l_5	θ_5 =
6	Exhaust port closing after BDC	l_6	θ_6=
7	Spark timing	l_7	θ_7=

Model Calculations:

Circumference = = l cm = 360^0
i.e. l = 360°
Therefore, $\theta_1 = (360 * l_1 / l)^0$

Suction period = $\theta_4+\theta_5$ =
Compression period =180- θ_6 =
Expansion period =180 - θ_3 =
Exhaust period = $\theta_3 + \theta_6$ =

Viva Questions

1. Through which port the charge from crank case enters into the combustion chamber?

2. Draw the port timing diagram for a petrol engine?

3. Why 2-stroke engines are more pollutants?

4. Why 2-stroke engines less efficient?

5. In a spark ignition engine, the spark is issued at the instant of …….

a) Contact breaker points closed b) Contact breaker points opened

c) No need of breaker point opening/closing

6. A …….in the primary circuit of the ignition system, prevents the arcing across the contact breaker points. a) HT coil b) Cam c) Switch d) condenser

Experiment No. 3

PERFORMANCE TEST ON FOUR-STROKE TWIN CYLINDER DIESEL ENGINE

AIM: To conduct a performance test on the 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. Digital RPM indicator to measure the speed of the engine.
2. Digital temperature indicator to measure various temperatures.
3. Differential manometer to measure quantity of air sucked into cylinder.
4. Burette with manifold to measure the rate of fuel consumed during test.
5. Digital Voltmeter 0-500 V with selector switch.
6. Digital Ammeter 0-20 A with selector switch.

ENGINE SPECIFICATIONS:

MAKE	:	KIRLOSKAR
BHP	:	10 HP
SPEED	:	1500 RPM
NO. OF CYLINDER	:	TWO
COMPRESSION RATIO	:	17.5 : 1
BORE	:	87.5 mm
STROKE	:	110 mm
ORIFICE DIAMETER	:	20 mm
TYPE OF IGNITION	:	COMPRESSION IGNITION
METHOD OF STARTING	:	CRANK START
METHOD OF COOLING	:	WATER COOLED
METHOD OF LOADING	:	AC GENERATOR

TO DETERMINE THE FOLLOWING:

Brake Power	:	BP
Specific fuel consumption	:	Sfc
Actual volume	:	V_s
Brake thermal efficiency	:	η_{bth}
Swept volume	:	v_s
Volumetric efficiency	:	η_v

LOADING SYSTEM:

The engine Test Rig is directly coupled to an AC Generator 3 Phase, 7.5kW, 50 Hz. Which in turn is loading by resistance load bank. The load can be varied in steps of ¼, ½, ¾, and full load by operating the rotary switches provided in the Load bank panel.

Between voltage each phase & Neutral BP = $\sqrt{3}$ VI cos Φ

Where, v = Voltage across two phase
I = Current in each phase
Φ = Power factor = 0.8

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)

LUBRICATION:

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

THERMOCOUPLE DETAILS:

T1 = INLET WATER TEMPERATURE OF ENGINE JACKET & CALORIMETER.

T2 = OUTLET WATER TEMPERATURE OF ENGINE JACKET.

T3 = TEMPERATURE OF WATER OUTLET FROM CALORIMETER.

T4 = TEMPERATURE OF EXHAUST GAS INLET TO CALORIMETER.

T5 = TEMPERAUTRE OF EXHAUST GAS OUTLET FROM CALORIMETER.

T6 = AMBIENT TEMPERATURE.

PROCEDURE:

1. Connect the panel instrumentation input power line at 230v 50hz, single-phase power source.
2. Connect the inlet and outlet water connection to the engine and calorimeter.
3. Fill fuel into the fuel tank mounted on the panel frame.
4. Check the lubricating oil in the engine sump with the help of dipstick provided.
5. Open the fuel cock provided under the Burette and ensures no air trapped in the fuel line connecting fuel tank and engine.
6. De-compress the engine by decompression lever provided on the top of the engine head. (Lift the lever for decompression)
7. Crank the engine slowly with the help of handle provided and ascertains proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. Increase cranking rate and pull the compression lever down, now the engine start. Allow then engine to run and stabilize at approximately 1500 RPM. (The engine is a constant speed engine, fitted with centrifugal governor).
8. Now load the engine by operating the rotary switches on the resistance load bank, in steps of ¼, ½, ¾ & full load.
9. Note down the required parameters, indicated on the panel instruments on each load step.

    a. Speed of the engine from digital RPM indicator.
    b. Voltage & current from voltmeter & ammeter respectively,
    c. Fuel consumption from burette.
    d. Quantity of airflow from manometer.
    e. Different temperatures from Temperature indicator.

10. Turn off the fuel knob provided on the panel after the test.

RESULT : The Performance Test was conducted on four stroke twin cylinder diesel engine.

PERFORMANCE TEST:

1. BRAKE POWER:

$$BP = \sqrt{3}\ VI \cos \Phi$$

Where, v = Voltage across two phase
I = Current in each phase
Φ = Power factor = 0.8

2. MASS OF FUEL CONSUMED

$$M f c = \frac{X \times 0.82 \times 3600}{1000 \times T} \quad \text{Kg/hr}$$

Where, X = burette reading in cc
0.82 = density of diesel in gram/cc
T = Time taken in seconds.

3. SPECIFIC FUEL CONSUMPTION.

$$Sfc = \frac{Mfc}{BP} \quad \text{Kg/ KW hr}$$

4. ACTUAL VOLUME OFAIR SUCKED IN TO THE CYLINDER.

$$Va = Cd \times A \sqrt{2gH} * 3600 \ldots\ldots\ldots\ldots m^3 / hr.$$

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

A = area of orifice = $\Pi d^2 / 4$
h = manometer reading in mm
ρw = density of water = 1000 kg/m^3
ρa = density of air = 1.193 kg/m^3
Cd = co – efficient of discharge = 0.62

5. SWEPT VOLUME

$$V_S = \frac{\pi d^2}{4} L \ (N/2)\ 60\ (2)$$

Where, d = dia of bore = 87.5 mm
L = length of stroke = 110 mm
N = Speed of the engine in RPM.

6. VOLUMETRIC EFFICIENCY

$$\eta_v = \frac{V_A}{V_S} \times 100 \quad \ldots\ldots\ldots\ldots\%$$

7. BRAKE THERMAL OR OVER ALL EFFICIENCY

$$\eta_{bth} = \frac{BP \times 3600 \times 100}{mfc \times cv} \quad \ldots\ldots\ldots\ldots\%$$

Where, CV = calorific value of diesel = 42,500 KJ/kg.
BP = Brake Power in KW

TABULAR COLUMN:

SL. NO.	RPM	Current (I)			Time taken for 10 cc of fuel in sec	Manometer difference in mm	Voltage (V)		
		R	Y	B			RY	YB	BR

PERFORMANCE

BP In kW	Mfc In kg/hr	Sfc IN kg/BP hr	η_{bth}	η_v IN %

10.Actual volume of air sucked in the cylinder is given by

11.In a four stroke cycle S.I.engine the camshaft runs at_____

12.The following is an S.I. engine_____ [ ]
a) Diesel engine b) petrol engine
c) Gas engine d) none of the above

13.The following is C.I. engine [ ]
a) Diesel engine b) petrol engine
c) Gas engine d) none of the above

14.In a four stroke cycle petrol engine , during suction stroke [ ]
a) Only air is sucked in b) only petrol is sucked in
c) Mixture of petrol and air is sucked in d) none of the above

15. In a four stroke cycle diesel engine , during suction stroke _____ [ ]
a) Only air is sucked in b) only fuel is sucked in
b) Mixture of fuel and air is sucked in d) None of the above

16.Flywheel in I.C.Engines is made of

17.Firing order of 3-cylinder engine is

18.the thermal efficiency of petrol engine as compared to diesel engine is__

19. Carburetor is used in _____engines.

20. Fuel injector is used in _____engines.

Experiment No. 4
I.C. ENGINES PERFORMANCE TEST ON 2-S, PETROL ENGINE

Introduction:-

A Machine which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a heat engine. They are classified as external and internal combustion engine. In an external combustion engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to develop the power. An internal combustion engine is one where 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, speede, fuel,cooling, method of ignition,mounting of engine cylinder and applicatyion.

Description of apparatus:-

The test rig is built for loading mentioned below:

a)Electrical Dynamometer loading(AC)

1. The equipment consists of a brand new bajaj makes 5port model petrol engine is coupled ta a AC alternated for loading purposes. Coupling is done by an extension shafty in a aepharate bearing house and extension shaft in a separate bearing house and is belt driven. The dynamometer is provided with load controller suitenes for varying the load.

2.The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachement for varying the spark timing.

3.Engino speed at various conditions is determined by a digital RPM indicates.

4.Load on the engine is measured by means of electrical energy meter.

5.A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively

6.The testing arrangement is mounted on an aestetically designed self sustained study frame made of MS channels with anti vibration mounts.

7.The test rig comes with a separate conter names made of NOVAPAN board which houses all indicators, accessories and necessary instrumentations.

Experimentation:

Aim: The experiment is conducted to

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

Procedure:

1. Give the necessary electrical connection 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 dyanometer
5. Open the three way wok so that fuel flows to the engine.
6. Set the accelerated to the minimum condition
7. Start the engine by cranking
8. Allow to attaing the steady state
9. Load the engine by switching on the load controller switched provided.
10. Note the following readings for particular condition,
    a)engine speed
    b)Time taken for oc of p consumption
    c)water meter readings
    d)manometer readings in cms of water and
    e)temperatures at different locations.
11. Repeat the experiment
12. After the completion relese the load and then switch of the engine by pressing the ignition cut off switch and than turn off the panel

Calculations:

1.Mass of fuel consumed, mf

Mf= Xcc X specific gravity of fuel / 1000 X t kg/sec

Where,
Sg of petor is = 0.71
Xcc is the volume of the fuel consumed = 10 ml
T is tijme taken in second

2. Heat input, mi

Mi=mfXcalorific value of fuel Kw
Where ,
Calorific value of petrol = 43,120 kj/kg.

3. Output power, bp
4. Bp=n x 3600 / kxtxnm kw

Where,
n= no of revolutions of energy meter
k= energy meter constant
= 750 rws/ kw-hr

T= time for 5 revolutions of energy meter in seconds
Nm= efficiency of bel;t transmission
= 80%

5. Specific fuel consumption, sfc
   sfc=mfX3600/BP kg/kw-hr
6. Calculation of head of air, Ha
   Ha=hw. Water/air

   Where,
   Water=1000 kg/m3
   Air=1.2 kg/ m3 @ RTP
7. Volumetric efficiency,
   Vol%= qa/qtn X 100

   Where cd= 0.62
   a= piX(0.015)2/4

   qtn=(pi/4)Xd2XLXGrX0.5v/60

   where,
   d=0.057
   l=0.057m
   n= speed of engine in rpm
   Gr= gear ratio
   1st gear = 14.47:1
   2nd gear=10.28:1
   3rd gear=5.36:1

   Precautions:
   1.Do not run the engine if supply voltage is less than 180v
   2.Do not run the engine without the supply of water
   3.supply water free from dust to prevent blockage in rotometer, engine head and colorimeter.
   4.Always set the acceleratyed knows to the minimum condition and start the engine.
   5. Do not forget to give electrical earth netural connections currectly.

   Result:
   1. Volumetric efficiency
      Nvol= 42.79%

Experiment No. 5

Evaluation of Engine friction by conducting Morse on 4-S Multi cylinder Petrol Engine

AIM: To determine Frictional power of four stroke three cylinder petrol engine.

INSTRUMENTATION:

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

ENGINE SPECIFICATION:

ENGINE	:	MARUTHI 800 ENGINE
BHP	:	10 H.P
RPM	:	1500 RPM
FUEL	:	PETROL
No OF CYLINDERS	:	THREE
BORE	:	70 mm
STROKE LENGTH	:	66 mm
STARTING	:	SELF START
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF IGNITION	:	SPARK IGNITION

DESCRIPTION:

The MARUTI 800 engine is a four stroke three cylinder, water – cooled, spark ignition type petrol engine. It is coupled to a loading system which is in this case is a HYDRAULIC DYNAMOMETER.

FUEL MEASUREMENT:

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

AIR INTAKE MEASUREMENT:

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

LUBRICATION:-

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

TEMPERATURE MEASUREMENT:

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

ROTAMETER :

A rotameter is provided at the inlet of engine jacket to measure the quantity of water allowed into the engine jacket. Valves are provided to regulate the flow rate of water flowing and that can be directly read on the rotameter in cc/sec.

LOADING SYSTEM:

The engine shaft is directly coupled to the hydraulic dynamometer and is loaded by varying the quantity of water allowed into the dynamometer at constant pressure head. By operating the gate valve provided on the inlet line of the dynamometer, we can vary the load. The outlet will be connected to a valve to be adjusted depending upon the load conditions.

PROCEDURE :

1. Run the engine at 1500 RPM & load it to 10 H.P. Morse test can be conducted by disconnecting the power of the individual cylinder one by one with the use of knife switches provided on the panel.
2. Cut off one cylinder, then the engine speed will drop. Bring back the speed of the engine to 1500 RPM by reducing the load and measuring the power developed.
3. Repeat the above procedure by cutting off cylinders 2 & 3. (At a time only one cylinder should be cut off)
4. Calculate the BP with 3 cylinders, which is 10 H.P. at 1500 RPM.

Calculate BP at 1500 RPM with one cylinder cut off (with remaining two cylinders on). The difference will give IP of one cylinder i.e., cut off cylinder. Similarly, calculate the IP of the remaining two cylinders. Then the total IP of the engine can be calculated by adding the IP of the individual cylinder.

5. To find out FP of the engine, deduct total BP from total IP.

RESULT : Indicated power and Frictional power of the given engine is determined.

TEST:

Running Cylinder nos.	**Cut – off cylinder no.**	**Load in kg**	**RPM**	**BP of running cylinder**	**IP of cut – off cylinder**

$$BP = \frac{W \times N}{C} = \ldots\ldots\ldots\ldots\ KW.$$

Where, W = Spring balance reading in kg.
N = Speed of the engine in RPM.
C = constant = 2000

$IP_1 = BP_{(total)} - BP_{2\,\&\,3}$
$IP_2 = BP_{(total)} - BP_{1\,\&\,2}$
$IP_3 = BP_{(total)} - BP_{1\,\&\,3}$

$IP_{(total)} = IP_1 + IP_2 + IP_3$

Therefore,

Frictional Power, $FP = IP_{(total)} - BP_{(total)}$

OBSERVATIONS &CALCULATIONS:

S.No.	Running cylinder no.	Cut off cylinder no.	Load in kg	RPM	BP of Running Cylinder	IP of cut off cylinder
1	3	0	8	1680	6.6	9.8695
2	2	1	4.1	1680	3.3825	3.1275
3	2	2	4.4	1680	3.63	2.97
4	2	3	3.9	1680	3.2175	3.382

$IP_{total} = IP_1 + IP_2 + IP_3$

$= 3.1275 + 2.97 + 3.382$

$= 9.8695$ kW

$FP = IP_{total} - BP_{total}$

$= 9.8695 - 6.6$

$= 3.2695$ kW

Viva Questions

1. Can Morse test be conducted on a single cylinder engine?
2. What is the purpose of conducting the Morse test?
3. What are the precautions to be taken during conducting Morse test?
4. Define mechanical efficiency.
5. Define Indicated Power.
6. Define Brake Power.
7. Define brake thermal efficiency.
8. Define indicated thermal efficiency
9. How frictional power is determined in multi cylinder engines.
10. What is the function of carburetor?

Experiment No. 6
MOTORING TEST

OBJECTIVE: To measure the FP of the given Four stroke single cylinder petrol engine by MOTORING TEST.

INSTRUMENTATION:

Digital RPM indicator to measure the speed of the engine.

Digital temperature indicator to measure various temperatures.

Differential manometer to measure quantity of air sucked into cylinder.

Burette with manifold to measure the rate of fuel consumed during test.

ENGINE SPECIFICATION:

ENGINE	:	YAMAHA
BHP	:	3 HP
RPM	:	3000 RPM
FUEL	:	PETROL
No OF CYLINDERS	:	SINGLE
BORE	:	70 mm
STROKE LENGTH	:	66.7 mm
STARTING	:	ROPE & PULLEY STARTING
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	AIR COOLED
METHOD OF IGNITION	:	SPARK IGNITION
ORIFICE DIA.	:	20 mm
COMPRESSION RATIO	:	4.67
SPARK PLUG	:	MICO W 160Z2

CARBURATOR	:	YAMAHA 1320
GOVERNOR SYSTEM	:	MECHANICAL GOVERNOR
TYPE	:	SELF EXCITED, DC SHUNT GENERATOR
POWER	:	1.5 KW
SPEED	:	3000 RPM
RATED VOLTAGE	:	220 v DC

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

RESISTANCE LAMP BANK SPECIFICATION:

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

DESCRIPTION:

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

FUEL MEASUREMENT:

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

AIR INTAKE MEASUREMENT:

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

LUBRICATION:

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

TEMPERATURE MEASUREMENT:

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

LOADING SYSTEM:

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

PROCEDURE:

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

RESULT:

FRICTIONAL POWER OF THE ENGINE:

$FP_{(ENGINE)} = FP_{(TOTAL)} - FP_{(MOTAR)}$

Where, $FP_{(MOTAR)}$ = No load generator losses.

$FP_{(TOTAL)}$ = Total frictional power.

$$= \frac{V \times I}{1000 \times \eta} \quad \ldots\ldots\ldots\ldots\ldots \text{ kW.}$$

There fore, FP = …….. …KW

S.NO	SPEED	VOLTAGE	CURRENT	FRICTIONAL POWER

SAMPLE OBSERVATIONS &CALCULATIONS:

S.No	Voltage (V)	Current (I)	Frictional Power
1	156	3.5	0.64
2	183	4	0.86
3	220	4.5	1.16
4	234	4.75	1.3
	266	5.06	1.58

Experiment No. 7
Retardation test on 4- S diesel engine

OBJECTIVE:

Determination of frictional power of an engine by retardation through additional flywheel method.

DESCRIPTION

The mechanical brake drum is fixed to the engine flywheel and the engine mounted on the M.S. channel chasi and further mounted on antivibromounts. A separate panel board is used to fix burette with 3 way cock, digital temperature indicator & rpm indicator, temperature selector switch, "U" tube manometer.

SPECIFICATION:

ENGINE	:	FOUR STROKE SINGLE CYLINDER
BHP	:	5 HP
SPEED	:	1500 rpm
FUEL	:	DIESEL
No OF CYLINDERS	:	SINGLE
BORE DIA	:	80 mm
STROKE LENGTH	:	110 mm
STARTING	:	CRANKI NG
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF IGNITION	:	COMPRESSION IGNITION

INSTRUMENTATION :

1. Digital speed indicator to measure the speed of the engine.
2. Digital temperature indicator to measure various temperatures.
3. Differential manometer to measure quantity of air sucked into cylinder.
4. Burette with manifold to measure the rate of fuel consumed.

LOADING SYSTEM :

The brake drum is directly coupled to the engine flywheel and a rope brake is wounded around the drum, Top end of the rope is connected to a spring balance and bottom end of the rope is connected to a weight platform. The load to the engine can be varied by adding slotted weights

provided on to the platform. (Please see that the weight platform is above the base, while the engine is loaded; to do so, use the hand wheel provided on the loading frame).

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)

FUEL MEASUREMENT:

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel gauge (Burette).

LUBRICATION:

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

PROCEDURE:

1. Start the engine and allow it to stebilize rated speed. (1500 rpm).
2. Remove the brake load by removing the dead weight of the dead weight and rope to keep the speed at 1500 rpm.
3. Cut off the fuel supply completely by pressing the rack of the fuel pump to stop position.
4. Note down the time taken in second (t1) for the speed to come down from 1500 to 1400 rpm.
5. Now declutch the additional flywheel even while the engine running. Repeat the steps 2 to 4 and note down the time (t2) for the engine to come down from 1500 to 1400 rpm.

In both cases, the engine speed comes down only due to frictional power of the engine. From these, we can observe that the time t1 is greater than t2 because of inertia of the additional flywheel.

<u>The frictional power of the engine can be calculated by using following formula</u>:

1. Mass moment of inertia of additional flywheel.

I_f ……. kg – m/sec^2

$$= \frac{\quad}{g}$$

But, $I_f = W \times r^2$ ……. Kg. m^2

Where, W = weight of the additional flywheel in kg = 40 kg.
r = radius of the additional flywheel in meter.

2. Angular deceleration.

a. with additional flywheel, $Ad_1 = \dfrac{2\,\Pi\,(N1 - N2)}{60\ t_1}$ rad/sec^2

b. without additional flywheel, $Ad_2 = \dfrac{2\Pi\,(N1 - N2)}{60\ t_2}$ rad/sec^2

where, N1 = Initial speed of the engine (1500 rpm)
N2 = Final speed of the engine (1400 rpm)
t1 = Time taken for the speed to come down from 1500 to 1400 RPM with flywheel.
t2 = Time taken for the speed to come down from 1500 to 1400 RPM without flywheel.

There fore,

Frictional torque = mass moment of inertia x angular deceleration

i.e. $T_f = I_f \times Ad_1$

To find frictional power,

$$FP = \frac{2\,\Pi\,NT_f}{60}$$

where, N = average speed $= \dfrac{N1 + N2}{2}$

T_f = Frictional torque.

TABULAR COLUMN (For retardation test):

S. No.	Load (Kg)	t1 (sec)	t2 (sec)	Angular deceleration (rad/sec^2)		Speed range (rpm)	Frictional Torque (kg.m)	Frictional Power
				With flywheel	Without flywheel			

SAMPLE OBSERVATIONS &CALCULATIONS:

S.No.	Load in kg	T_1(sec)	T_2(sec)	Angular deceleration (rad/sec^2)		Speed range (rpm)	Frictional Torque (kg.m)
				With flywheel	Without flywheel		
1	5	10	9	15.7	17.45	1500	12.81
2	7	11	8	14.279	19.63	1500	11.679
3	8	13	6	12.08	26.179	1500	9.88

Experiment No. 8
I.C. ENGINES HEAT BALANCE

AIM : To prepare heat balance sheet on 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. Digital RPM indicator to measure the speed of the engine.
2. Digital temperature indicator to measure various temperatures.
3. Differential manometer to measure quantity of air sucked into cylinder.
4. Burette with manifold to measure the rate of fuel consumed during test.
5. Digital Voltmeter 0-500 V with selector switch.
6. Digital Ammeter 0-20 A with selector switch.

ENGINE SPECIFICATION:

MAKE	:	KIRLOSKAR
BHP	:	10 HP
SPEED	:	1500 RPM
NO. OF CYLINDER	:	TWO
COMPRESSION RATIO	:	17.5 : 1
BORE	:	87.5 mm
STROKE	:	110 mm
ORIFICE DIAMETER	:	20 mm
TYPE OF IGNITION	:	COMPRESSION IGNITION
METHOD OF STARTING	:	CRANK START
METHOD OF COOLING	:	WATER COOLED
METHOD OF LOADING	:	AC GENERATOR

LOADING SYSTEM:

The engine Test Rig is directly coupled to an AC Generator 3 Phase, 7.5 Kw, 50 Hz. Which inturn is loading by resistance load bank. The load can be varied in steps of ¼, ½, ¾, and full load by operating the rotary switches provided in the Load bank panel.

Between voltage each phase & Neutral BP = $\sqrt{3}$ VI cos Φ

Where, v = Voltage across two phase
I = Current in each phase
Φ = Power factor = 0.8

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)

LUBRICATION:

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

THERMOCOUPLE DETAILS:

T1 = INLET WATER TEMPERATURE OF ENGINE JACKET & CALORIMETER.

T2 = OUTLET WATER TEMPERATURE OF ENGINE JACKET.

T3 = TEMPERATURE OF WATER OUTLET FROM CALORIMETER.

T4 = TEMPERATURE OF EXHAUST GAS INLET TO CALORIMETER.

T5 = TEMPERAUTRE OF EXHAUST GAS OUTLET FROM CALORIMETER.

T6 = AMBIENT TEMPERATURE.

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PROCEDURE:

1. Connect the panel instrumentation input power line at 230v 50hz, single phase power source.
2. Connect the inlet and outlet water connection to the engine and calorimeter.
3. Fill fuel into the fuel tank mounted on the panel frame.
4. Check the lubricating oil in the engine sump with the help of dip stick provided.

5. Open the fuel cock provided under the Burette and ensures no air trapped in the fuel line connecting fuel tank and engine.
6. De-compress the engine by decompression lever provided on the top of the engine head. (Lift the lever for decompression)
7. Crank the engine slowly with the help of handle provided and ascertains proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. Increase cranking rate and pull the compression lever down, now the engine start. Allow then engine to run and stabilize at approximately 1500 RPM. (The engine is a constant speed engine, fitted with centrifugal governor).
8. Now load the engine by operating the rotary switches on the resistance load bank, in steps of ¼, ½, ¾ & full load.

9. Note down the required parameters, indicated on the panel instruments on each load step.

    a) Speed of the engine from digital RPM indicator.
    b) Voltage & current from voltmeter & ammeter respectively,
    c) Fuel consumption from burette.
    d) Quantity of airflow from manometer.
    e) Different temperatures from Temperature indicator.

10. Turn off the fuel knob provided on the panel after the test.
11. Prepare heat balance sheet at any one load on the engine.

OBSERVATIONS:

Voltage = V =

Current = I =

Brake Power = BP = $\sqrt{3}$ VI cos Φ =

T_1 = Inlet water temperature of engine jacket & calorimeter.

T_2 = Outlet water temperature of engine jacket.

T_3 = Temperature of water outlet from calorimeter.

T_4 = Temperature of exhaust gas inlet to calorimeter.

T_5 = Temperature of exhaust gas outlet from calorimeter.

T_6 =Ambient temperature

MFC = mass of fuel consumed in kg/hr

$$= \frac{X \times 0.82 \times 3600}{1000 \times T} \quad \text{Kg/hr}$$

Where, X = burette reading in cc
0.82= density of diesel in gram/cc
T = Time taken in seconds.

CV = Calorific value of fuel (diesel) = 42500 kJ/Kg

ACTUAL VOLUME OF AIR SUCKED IN TO THE CYLINDER:

$$Va = Cd \times A \times \sqrt{2gH} \times 3600 \ m^3/hr$$

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

A = area of orifice = $\Pi d^2 / 4$
H = manometer reading in mm

ρ_w = density of water = 1000 kg/m^3

Cd = co – efficient of discharge = 0.62

$$Va = Cd \times A \times \sqrt{2gh} \times 3600$$

CALCULATIONS:

01. Heat Input = H = MFC x CV KJ/hr.

02. Heat equivalent to BP = H1 = BP X 3600 kJ/hr

03. Determine Frictional Power using willan's Line method i.e. Draw a graph BP vs Mfc And extend the line obtained to intersect negative X axis. The intercept on negative X axis is the Frictional Power (FP).

Heat equivalent to FP = H2 = FP X 3600 kJ/hr

04. Heat carried away by exhaust gas = H3

H3 = (Mass of fuel + Mass of Air) x (Specific heat of gas) x Temperature difference

$$= [mf + V_a \rho_a] (Cpg) (T4 - T6) \text{ kJ/kg}$$

Where T4 is are exhaust gas inlet temperature to calorimeter and T6 is ambient temperature in deg. centigrade.

ρ_a = Density of Air = 1.193 kg/m^3
m_f =mass of fuel consumed in kg/hr
m_a = Mass of air = Volume of air x Density of air =$V_a \rho_a$
Cpg = Specific heat of gas = 0.92 kJ/kg k

05. Heat carried away by calorimeter water

H4 = (mass of water passed through calorimeter) x (Specific heat of water) x temperature difference).
H4 = Mw x Cp. x (T3 – T1)

Where T1 and T3 are water inlet and outlet temperatures of the calorimeter respectively.

M_w = mass of water = calorimeter rotameter reading in cc/sec.

$$= \frac{\text{CC x Density of water in gm/cc X 3600}}{\text{Sec} \quad 100} \text{ Kg/hr}$$

Where density of water = 1 gm/c.c [i.e. 1000 kg/m^3]

06. Heat carried away engine jacket cooling water.

H5 = (mass of water passed through engine jacket) x (Specific heat of water) x temperature Difference.

H5 = mw x Cp x (T2 – T1)
Where T1 and T2 are water inlet and outlet to the engine jacket respectively.

07. Heat unaccounted

H6 = H - (H1 + H2 + H3 + H4 + H5)

SL. NO.	RPM	Current (I)			Time taken for 10 cc of fuel in sec	Voltage (V)		
		R	Y	B		RY	YB	BR

BP In kW	Mf In kg/hr

TEMPERATURES:

T0	T1	T2	T3	T4	T5	T6

Experiment No. 9
I.C.Engines A/F Ratio and Volumetric Efficiency determination

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. Digital RPM indicator to measure the speed of the engine.
2. Digital temperature indicator to measure various temperatures.
3. Differential manometer to measure quantity of air sucked into cylinder.
4. Burette with manifold to measure the rate of fuel consumed during test.
5. Digital Voltmeter 0-500 V with selector switch.
6. Digital Ammeter 0-20 A with selector switch.

ENGINE SPECIFICATIONS:

MAKE	:	KIRLOSKAR
BHP	:	10 HP
SPEED	:	1500 RPM
NO. OF CYLINDER	:	TWO
COMPRESSION RATIO	:	17.5 : 1
BORE	:	87.5 mm
STROKE	:	110 mm
ORIFICE DIAMETER	:	20 mm
TYPE OF IGNITION	:	COMPRESSION IGNITION
METHOD OF STARTING	:	CRANK START
METHOD OF COOLING	:	WATER COOLED
METHOD OF LOADING	:	AC GENERATOR

TO DETERMINE THE FOLLOWING:

Brake Power	:	BP
Specific fuel consumption	:	Sfc

Actual volume	:	V_s
Brake thermal efficiency	:	η_{bth}
Swept volume	:	V_s
Volumetric efficiency	:	η_v

LOADING SYSTEM:

The engine Test Rig is directly coupled to an AC Generator 3 Phase, 7.5kW, 50 Hz. Which in turn is loading by resistance load bank. The load can be varied in steps of ¼, ½, ¾, and full load by operating the rotary switches provided in the Load bank panel.

Between voltage each phase & Neutral BP = $\sqrt{3}$ VI cos Φ

Where, v = Voltage across two phase
I = Current in each phase
Φ = Power factor = 0.8

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)

LUBRICATION:

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

THERMOCOUPLE DETAILS:

T1 = Inlet water temperature of engine jacket & calorimeter.

T2 = Outlet water temperature of engine jacket.

T3 = Temperature of water outlet from calorimeter.

T4 = Temperature of exhaust gas inlet to calorimeter.

T5 = Temperautre of exhaust gas outlet from calorimeter.

T6 = Ambient temperature.

PROCEDURE:

1. Connect the panel instrumentation input power line at 230v 50hz, single-phase power source.
2. Connect the inlet and outlet water connection to the engine and calorimeter.
3. Fill fuel into the fuel tank mounted on the panel frame.
4. Check the lubricating oil in the engine sump with the help of dipstick provided.
5. Open the fuel cock provided under the Burette and ensures no air trapped in the fuel line connecting fuel tank and engine.
6. De-compress the engine by decompression lever provided on the top of the engine head. (Lift the lever for decompression)
7. Crank the engine slowly with the help of handle provided and ascertains proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. Increase cranking rate and pull the compression lever down, now the engine start. Allow then engine to run and stabilize at approximately 1500 RPM. (The engine is a constant speed engine, fitted with centrifugal governor).
8. Now load the engine by operating the rotary switches on the resistance load bank, in steps of ¼, ½, ¾ & full load.
9. Note down the required parameters, indicated on the panel instruments on each load step.

    a. Speed of the engine from digital RPM indicator.
    b. Voltage & current from voltmeter & ammeter respectively,
    c. Fuel consumption from burette.
    d. Quantity of airflow from manometer.
    e. Different temperatures from Temperature indicator.

10. Turn off the fuel knob provided on the panel after the test.

CALCULATIONS:

1. MASS OF FUEL CONSUMED:

$$M_{fc} = \frac{X \times 0.82 \times 3600}{1000 \times T} \quad \text{kg/ hr}$$

Where, X = burette reading in cc
0.82 = density of diesel in gram / cc
T = time taken in seconds.

2. SPECIFIC FUEL CONSUMPTION:

$$Sfc = \frac{mfc}{BP} \quad \ldots\ldots\ldots\ldots \text{ kg/kW hr}$$

3. ACTUAL VOLUME OF AIR SUCKED IN TO THE CYLINDER:

$$Va = Cd \times A \times \sqrt{2gH} \times 3600 \ m^3/hr$$

$$\text{Where, } H = \frac{h}{1001} \times \frac{\rho_w}{\rho_a} \ldots\ldots\ldots\ldots \text{ meter of water.}$$

A = area of orifice = $\Pi d^2 / 4$
H = manometer reading in mm

ρ_w = density of water = 1000 kg/m^3

Cd = co – efficient of discharge = 0.62

$$Va = Cd \times A \times \sqrt{2gh} \times 3600$$

4.Mass of air actually consumed by the cylinder :

$$M_a = V_a \ \rho_a$$

5. Air Fuel Ratio :

$$\mathbf{M_a/M_f} =$$

6. SWEPT VOLUME :

$$V_S = \frac{\pi d^2}{} \quad L \ (N/2) \ 60$$

4

Where, d = dia of bore = 80 mm

L = length of stroke = 110 mm

N = Speed of the engine in rpm

7. VOLUMETRIC EFFICIENCY :

$$\eta_v = \frac{V_A}{V_S} \times 100 \text{ ..... \%}$$

Experiment No. 10
STUDY OF LANCASHIRE BOILER

AIM: To study Lancashire boiler.

Theory: Evaporating the water at appropriate temperatures and pressures in boilers does the generation of system. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Lancashire boiler.

Observation: Lancashire boiler has two large diameter tubes called **flues**, through which the hot gases pass. The water filled in the main shell is heated from within alround the flues and also from bottom and sides of the shell, with the help of other masonry ducts constructed in the boiler as described below.

The main boiler shell is of about 1.85 to 2.75 m in diameter and about 8 m long. Two large tubes of 75 to 105 cm diameter pass from end to end through this shell. These are called **flues.** Each flue is proved with a **fire door** and a **grate** on the front end. The shell is placed in a placed in a masonry structure which forms the external flues through which, also, hot gases pass and thus the boiler shell also forms a part of the heating surface. The whole arrangement of the brickwork and placing of boiler shell and flues is as shown in fig.

SS is the boiler **shell** enclosing the main **flue tubes**. SF are the **side flues** running along the length of the shell and BF is the **bottom flue**. Side and bottom flues are the ducts, which are provided in masonry it self.

The draught in this boiler is produced by chimney. The hot gases starting from the grate travel all along the flues tubes; and thus transmits heat through the surface of the flues. On reaching at the back end of the boiler they go down through a passage, they heat water through the lower portion of the main water shell. On reaching again at front end they bifurcate to the side flues and travel in the forward direction till finally they reach in the smoke chamber from where they pass onto chimney.

During passage through the side flues also they provide heat to the water through a part of the main shell. Thus it will be seen that sufficient amount of area is provided as heating surface by the flue tubes and by a large portion of the shell

Operating the dampers L placed at the exit of the flues may regulate the flow of the gases. Suitable firebricks line the flues. The boiler is equipped with suitable firebricks line the flues. The boiler is equipped with suitable mountings and accessories.

There is a special advantage possessed by such types of boilers. The products of combustion are carried through the bottom flues only after they have passed through the main flue tubes, hence the hottest portion does not lie in the bottom of the boiler, where the sediment contained in water as impurities is likely to fall. Therefore there are less chances of unduly heating the plates at the bottom due to these sediments.

Result: The Lancashire boiler is studied.

Experiment No. 11
STUDY OF BABCOCK-WILCOX BOILER

Aim: To study Babcock-Wilcox boiler.

Theory: Evaporating the water at appropriate temperatures and pressures in boilers does the generation of steam. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Babcock-Wilcox boiler.

Observation: In thermal powerhouses, Babcock Wilcox boilers do generation of steam in large quantities.

The boiler consists essentially of three parts.

1.**A number of inclined water tubes**: They extend all over the furnace. Water circulates through them and is heated.

2. **A horizontal stream and water drum**: Here steam separate from the water which is kept circulating through the tubes and drum.

3. **Combustion chambers**: The whole of space where water tubes are laid is divided into three separate chambers, connected to each other so that hot gases pass from one to the other and give out heat in each chamber gradually. Thus the first chamber is the hottest and the last one is at the lowest temperature. All of these constituents have been shown as in fig.

The Water tubes 76.2 to 109 mm in diameter are connected with each other and with the drum by vertical passages at each end called **headers**. Tubes are inclined in such a way that they slope down towards the back. The rear header is called the **down-take header** and the front header is called the **uptake header** has been represented in the fig as DC and VH respectively.

Whole of the assembly of tubes is hung along with the drum in a room made of masonry work,lined with fire bricks. This room is divided into **three compartments A,B,and C** as shown in fig,so that first of all, the hot gases rise in A and go down inn B,again rises up in C, and then the led to the chimney through the smoke chamber C.

A **mud collector M** is attached to the rear and lowest point of the boiler into which the sediment i.e. suspended impurities of water are collected due to gravity, during its passage through the down take header.

Below the front uptake header is situated the greate of the furnace ,either automatically or manually fired depending upon the size of the boiler. The direction of hot gases is maintained upwards by the **baffles L.**

In the steam and water drum the steam is separated from the water and the remaining water travels to the back end of the drum and descends through the down take header where it is subjected to the action of fire of which the temperature goes on increasing towards the uptake header.Then it enters the drum where the separation occurs and similar process continuous further.

For the purpose of super heating the stream addition sets of **tubes of U-shape** fixed horizontally,are fitted in the chamber between the water tubes and the drum. The steam passes from the steam face of the drum downwards into the super heater entering at its upper part, and spreads towards the bottom .Finally the steam enters the **water box W,** at the bottom in a super heated condition from where it is taken out through the outlet pipes.

The boiler is fitted with the usual mountings like **main stop valve M, safety valve S, and feed valve F,** and **preesure gauge P.**

Main stop valve is used to regulate flow of steam from the boiler, to steam pipe or from one steam one steam pipe to other.

The function of safety valve is used to safe guard the boiler from the hazard of pressures higher than the design value. They automatically discharge steam from the boiler if inside pressure exceeds design-specified limit.

Feed check valve is used to control the supply of water to the boiler and to prevent the escaping of water from boiler due to high pressure inside.

Pressure gauge is an instrument, which record the inside pressure of the boiler.

When steam is raised from a cold boiler, an arrangement is provided for flooding the super heater. By this arrangement the super heater is filled with the water up to the level. Any steam is formed while the super heater is flooded is delivered to the drum ultimately when it is

raised to the working pressure. Now the waterr is drained off from the super heater through the cock provided for this purpose, and then steam is let in for super heating purposes.

Result: The Babcock – Wilcox boiler is studied.

VIVA QUESTIONS

1. The function of fusible plug in a boiler is to
   a) Control pressure b) control water level
   c) Extinguish fire d) generate steam [ ]

2. In case of locomotive boiler, the draught is produced by
   a) Chimney b) steam jet c) fan d) blower [ ]

3.Which one of the following is a modern high-pressure boiler?
   a) La Mont boiler b) Babcock & Wilcox boiler
   c) Cochran boiler d) simple vertical boiler [ ]

4. The cycle efficiency of a modern thermal power plant is approximately
   a) 29% b) 60% c) 80% d) 44% [ ]

5. The draught, which a chimney produces, is
   a) Induced draught b) natural draught c) forced draught d) none [ ]

6.The artificial draught is produced by
   a) Induced fan b) forced fan c) induced and forced fan d)all [ ]

7. For the induced draught, the fan is located
   a) Near bottom of chimney b) near bottom of furnace
   c) At the top of chimney d) anywhere permissible. [ ]

8. The efficiency of chimney is approximately
   a) 80% b) 40% c) 20% d) 0.25% [ ]

9. The pressure at the furnace is minimum in case of
   a) Forced draught b) induced draught
   c) Balanced draught d) natural draught [ ]

10. For the same draught produced, the power of induced draught fan compared to forced draught fan is
   a) less b) more c)same d) not predictable [ ]

Experiment No. 12
OPTIMUM COOLING WATER FLOW AND OPTIMUM COOLING WATER TEMPERATURE TEST ON A DIESEL ENGINE

Objective: To conduct Optimum cooling water flow and optimum cooling water temperature test on the Diesel engine at a given load.

Instrumentation:

1. Diesel Engine test rig with electrical dynamometer
2. Digital speedometer
3. Digital temperature indicator to measure different temperatures sensed by different thermocouples
4. Voltmeter & Ammeter
5. Measuring system for the fuel consumption, circulating water flow

Engine Specifications

Brake power	: 3.7 kW
Speed	: 1500 rpm
Number of cylinders	: 1
Compression ratio	: 16.5: 1
Bore	: 80 mm
Stroke	: 110 mm
Type of ignition	: compression ignition
Method of loading	: DC generator with resistive load bank
Orifice diameter	: 20 mm
Method of starting	: Crank start

Theory: Cooling is provided to avoid the bad effects of overheating as listed below:

1. The high temperature reduces the strength of the piston and piston rings and uneven expansion of cylinder and piston may cause the seizure of the piston

2. The high temperature causes the decomposition of the lubricating oil and lubrication between the cylinder wall and piston and may break down resulting in a scuffing of the piston.

3. Over heating of the valves may cause the scuff of the valve guides due to lubrication breakdown.

4. The tendency of the detonation increases with increase in temperature o;f the cylinder body

To avoid the adverse effects mentioned above, it is necessary to cool the engine. The cooling system used for IC engine generally carries 30 to 35% of the total heat generated in the cylinder due to the combustion of fuel.

It is also necessary that the temperature of the engine should be maintained above a particular temperature. This is essential for easy running and better evaporation of fuel. Over cooling of the engine is also undesirable for its safety and smooth running of the engine.

For these reasons, the engine is tested at constant speed and at various load steps. For each load step, fuel consumption rates are to be found out by varying the water flow rates.

Full load of the engine is calculated as fallows:

The engine specifications give the power out put as 3.7 kW at the rated speed of 1500rpm. Brake power equation for the engine is

POWER [BP] $= V * I / \eta_g$

Where, BP = rated brake power at full load = 3.7 kW

V = Voltage of the generator out put = 220 V

I = full load current of the generator for rated out put $= I_{max}$ Amps

η_g = generator efficiency = 80 %

Therefore, the full load is calculated as given below

$$I_{max} = BP * \eta_g / V$$

When the load on the engine is increased insteps, its speed decreases. Then the governor adjusts the fuel supply to maintain the engine speed constant. Corresponding to each load the fuel consumption, speed, and load are to be recorded. The SFC, IP, mechanical efficiency is to be calculated and plotted against BP.

Engine Description: The engine is a four-stroke, single cylinder water cooled, and vertical diesel engine.

Cooling System: **Water-cooled.**

Loading System: The engine is fitted with an electrical dynamometer (D.C. Generator with resistive load bank). The engine can be loaded in steps of 0, ¼, ½, ¾ and full load.

Fuel Measurement: The fuel tank is fitted on the panel frame and it is in turn connected to the engine through a graduated burette.

Air flow measurement: An air drum fitted on the panel frame connected with a flexible air hose to the engine facilitates air flow measurement. For this, an orifice meter is fitted to the air drum whose pressure tapings are connected to a 'U' tube manometer, which enables calculation of the quantity of air drawn into the engine cylinder.

Cooling water flow measurement: The quantity of water flowing through engine jacket and calorimeter can be measured individually with the help of two separate rotameters provided with the test rig.

Procedure: Connect water line to the engine jacket inlet

1. Connect the panel instrumentation input power line to a 220V, 50 Hz single-phase power source. All the panel meters namely rpm meter, D.C. Voltmeter, D.C. Ammeter and temperature meter indicate respective readings. Also, connect the water rheostat filled with water (added with common salt) to the D.C. Generator.
2. Fill up fuel into the fuel tank mounted on the panel frame, necessary care should be taken by pouring the fuel into the fuel tank.
3. Check the lubricating oil in the engine sump with the help of a dipstick provided.
4. Open the fuel cock provided under the fuel tank and ascertain no air is trapped in the fuel line-connecting fuel tank and engine.
5. Decompress the engine by decompression lever provided on the top of the engine head.

6. Crank the engine slowly with the help of handle provided and ascertain proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. Increase cranking rate and pull the decompression lever down, now the engine starts. Allow the engine to run and stabilize at approximately 1500 rpm. (The engine is constant speed engine fitted with centrifugal governor and the DC voltmeter reads 220V).
7. Now load the engine by rotating the hand wheel provided on top of water rheostat in anti-clockwise direction to the desired load step (either 0, ¼, ½, ¾ and full load) at which the optimum cooling water flow to be found out
8. Open the gate valves (control valve) and set to full flow rate.
9. Record the following parameters indicated on the panel instruments for different water flow rates (150, 125, 100, 75, 50 CC / S).
   i. Speed of engine from rpm indicator
   ii. Rate of fuel flow from burette (time taken for 10 cc of fuel consumption).
   iii. Voltage reading and ammeter reading(slight variation may be there).
   iv. Engine jacket outlet temperature(t_5).

To stop engine after the experiment is over, first unload the engine, and pull the governor lever towards the engine cranking side.

The optimum water flow is calculated as per the following model calculations.

<u>The following Graphs are to be drawn:-</u>

1] SFC Vs Engine jacket water flow rate

2] SFC Vs Engine jacket water outlet temperature

<u>Result:</u> The experiment is conducted and the graphs are drawn. The optimum cooling water flow rate is determined by plotting the graph between brake specific fuel consumption and water flow rates. The optimum cooling water flow will be the flow rate at which the SFC is minimum. From the experiment it has been found that the optimum water flow through the engine jacket is ……CC /s at the load of …….(0, ¼, ½, ¾ and full load).

Precautions:

1. After applying the load allow the engine to run for some time to obtain steady state conditions then take readings.
2. While taking readings do not alter flow rates
3. The engine should not be overloaded
4. Stop the engine only after unloading the engine
5. Maintain the generator out put voltage as 220 volts.

Observations:

LOAD: ……..Amps at 220 Volts (Load may be 0, ¼, ½, ¾ and full load)

S No.	Water flow rate through engine jacket (cc/s)	Time taken for consumption of 10cc of fuel in seconds (t)	t_5
1.	150		
2.	125		
3.	100		
4.	75		
5.	50		

Results Table:

Sl. No.	Mass of fuel consumed kg/hr	SFC kg/kWh	Water flow rate through the engine jacket cc/s	t_5
1.				
2.				
3.				
4.				
5.				

Model Calculations:

Calculations for the load of ……..(Preferably for the third reading)

1. Mass Of Fuel Consumed: (m_f) in kg/ s

   m_f = (x_{cc}* sp.gravity of fuel) / (t_{sec}* 1000) kg/s

   x_{cc} → volume of fuel consumed = 10 cc

   sp.gravity = 0.838 (for Diesel)

   t_{sec} → time in seconds taken for x_{cc} fuel consumption

Note: In the results table note down the (m_f) value in kg/ hr

2. Brake Power:

   BP= V * I / η_g

3. Specific Fuel Consumption: SFC in kg/kwh

SFC = mass of the fuel consumed in kg per hour / BP

= m_f / BP kg/ kWh

The following Graphs are to be drawn:-

1] SFC Vs Engine jacket water flow rate

2] SFC Vs engine jacket water outlet temperature

Questions

1. Explain the importance of conducting Optimum cooling water temperature experiment Draw the model graph and identify the point where SFC is minimum