MECHNOTES

CONTENTS

LIST OF EXPERIMENTS COMPLETED

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IC ENGINE
INTRODUCTION

Introduction:

Heat engine is a machine which converts heat energy supplied to it into mechanical work. The heat energy is supplied to the engine by burning a fuel.

Heat engines are classified into two main groups. They are

1. Internal combustion engines and
2. External combustion engines.

Internal combustion engines:

In internal combustion engines, the combustion (burning) of fuel takes place inside the engine cylinder. Hence they are called as internal combustion engines (I.C. engines).

Examples : Diesel engines, petrol engines, gas engines, gas turbines etc.,

External combustion engines:

In external combustion engines, the combustion of fuel takes place outside the working cylinder. Hence they are called as external combustion engines (E.C. engines).

Examples : Steam engines and steam turbines.

<u>CLASSIFICATION OF I.C. ENGINES:</u>

I.C. engines are classified according to

(i) *Cycle of operation (or) No. of strokes / cycle:*
- (a) Two-stroke cycle engines and
- (b) Four-stroke cycle engines.

(ii) *Thermodynamic cycle (or) Method of heat addition:*
- (a) Otto cycle engines (combustion at constant pressure)
- (b) Diesel cycle engines (combustion at constant pressure)
- (c) Dual combustion engines (or) semi-diesel engines.

(iii) *Type of fuel used:*
- (a) Petrol or gasoline engines, (b) Diesel engines and (c) Gas engines.

(iv) *Arrangement of cylinder (or)cylinder design:*
- (a) Vertical Engines, (b) Horizontal engines,
- (c) V-type engines, (d) In-line engines,
- (e) Opposed cylinder engines and (f) Radial engines.

(v) *Ignition method:*
  (a) Spark ignition (S.I.) engines and
  (b) Compression ignition (C.I.) engines.

(vi) *Cooling system:*
  (a) Air cooled engines and
  (b) Water cooled engines.

(vii) *Valves location:*
  (a) L-head (side valve) engines,
  (b) T-head (side valve) engines,
  (c) I-head (overhead valve) engines and
  (d) F-head (overhead inlet and side exhaust) engines.

(viii) *Fuel injection (or)Fuel supply system:*
  (a) Carburetor engines,
  (b) Air-injection engines and
  (c) Air-less or solid injection engines.

(ix) *Method of governing (or) Method of control:*
  (a) Quantity governed engines,
  (b) Quality governed engines and
  (c) Hit and miss governing engines.

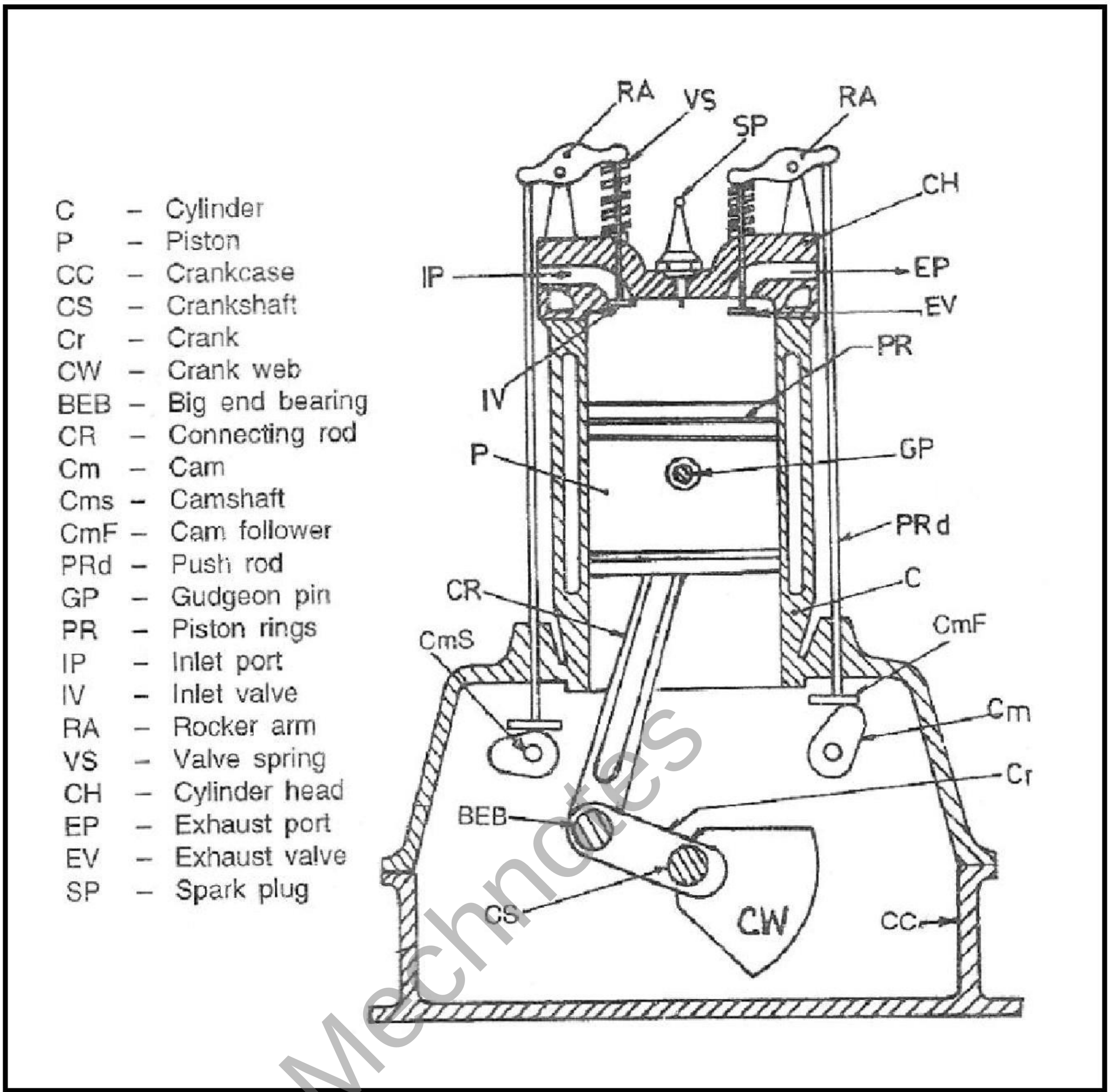
(x) *Method of application:*
  (a) Stationary engines,
  (b) Mobile engines and
  (c) Portable engines.

(xi) *Field of application:*
  (a) Stationary engines,
  (b) Mobile engines and
  (c) Portable engines.

(xii) *Speed:*
  (a) Low speed engines,
  (b) Medium speed engines and
  (c) High speed engines.

CONSTRUCTIONAL DETAILS OF AN INTERNAL COMBUSTION ENGINE:

Fig shows the constructional details of an internal combustion engine (petrol engine). The main components of a four – stoke cycle engine are cylinder, piston, connecting rod, crank, crankshaft, cylinder Head, crankcase, inlet valve, exhaust valve. Spark plug (in case of petrol engines) or injector (in case



of diesel engines), cam, camshaft, push rod, piston rings, gudgeon pin, rocker arm, big end bearing, cam follower, valve springs, inlet port etc.

Construction:

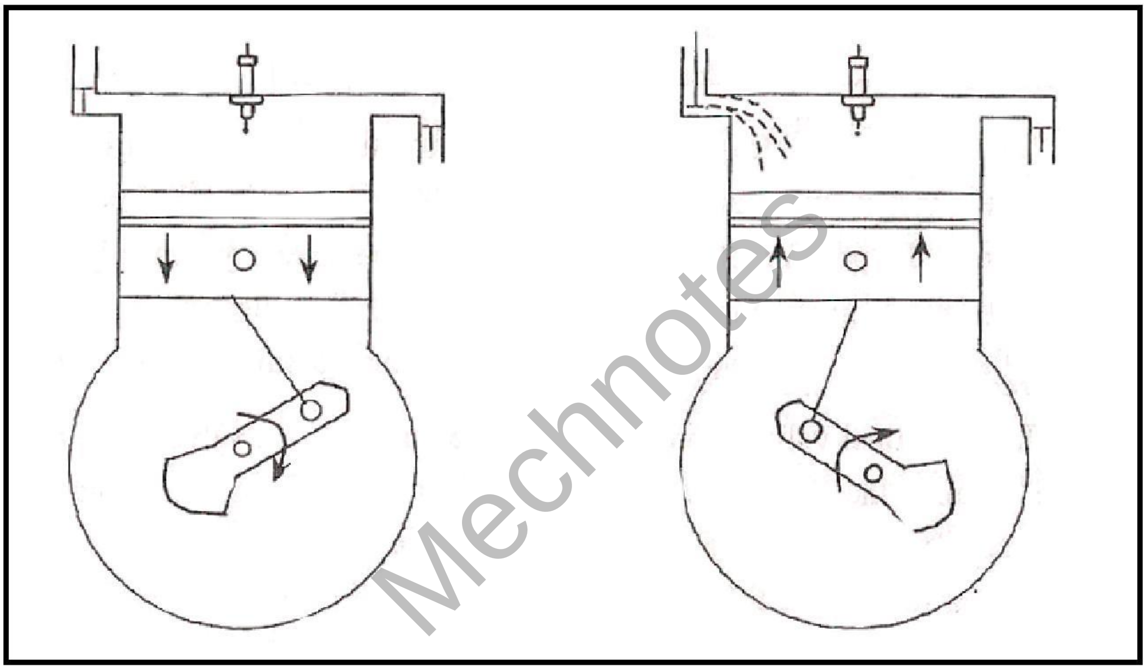
The piston reciprocates inside the cylinder. Piston rings are inserted in the circumferential grooves of the piston. The cylinder and cylinder head are bolted together. The reciprocating motion of the piston is converted into rotary motion of the crank. The small end of the connecting rod is connected to the piston by a gudgeon pin. The big end of the connecting rod is connected to the crank pin. Crank pin is a bearing surface and it is rigidly fixed to the crankshaft. The crankshaft is mounted on the main bearings. The main bearings are housed in the main bearings. The main bearings are housed in the crankcase. Camshaft is driven by the crankshaft through timing gears (not shown in figure). The camshaft actuates the inlet and exhaust valves.

The valve springs are provided to bring back the valves in the closed position. The oil sump containing lubricating oil is provided at the bottom of the crankcase. Lubricating oil is circulated to the various parts of the engine from the oil sump. A spark plug is provided in petrol engines to ignite the air-fuel mixture in the engine cylinder. An injector is provided in diesel engines to inject the fuel into the hot compressed air during power stroke.

FOUR STROKE CYCLE C.I. ENGINE (DIESEL ENGINE)

Working of four stroke cycle (diesel) C.I. engine

The working of four-stroke CI engine is similar to that of SI engine except. Here, fuel injector is placed instead of spark plug and only air is sucked into the cylinder during suction strokes. The operations are described as follows.

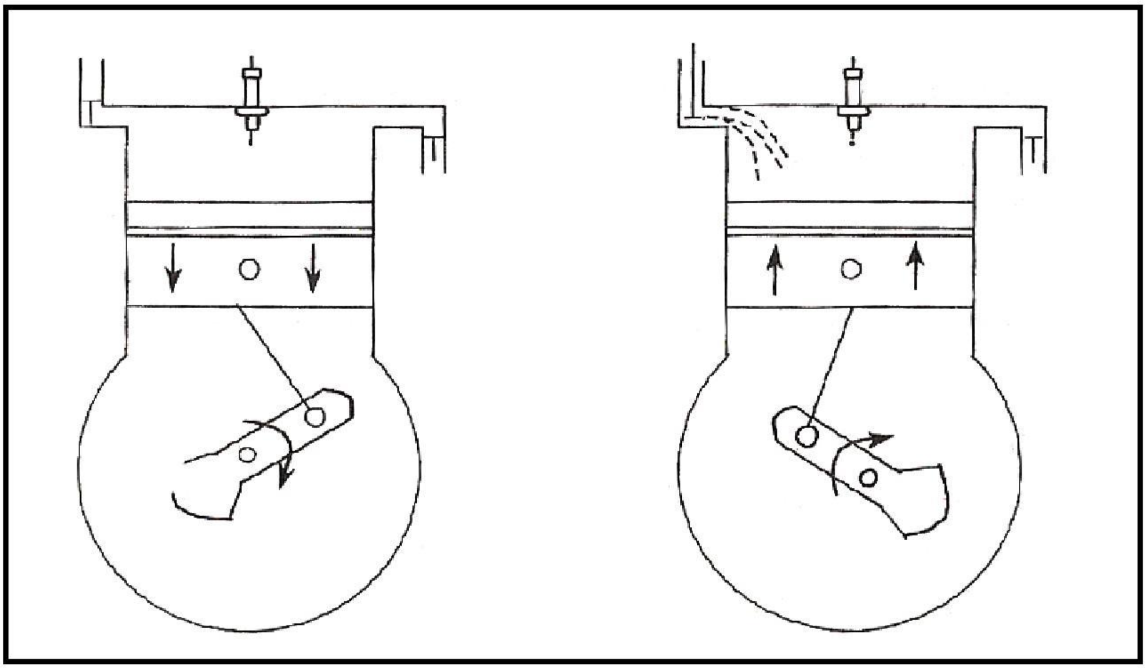


1. Suction stroke:

During the suction stroke, the piston moves from TDC to BDC. The inlet valve is in open condition where as exhaust valves is closed. When the piston moves from top to bottom, the fresh air is admitted inside the cylinder through inlet valve as shown.

2. Compression stroke:

During the compression stroke, both the inlet and exhaust valves are closed. The piston moves from BDC to TDC to compress the air. In case of CI engine, the compression ratio varies from 12 to 18. The pressure at the end of compression is about 3500 to 4000 kN/m^2. The temperature of the compressed air reaches 600 to 700Ú *C*.



3. Power stroke:

In this stroke also, both the inlet and exhaust valves are in closed position. The fuel injector opens just before the beginning of the third stroke, it injects the fuel in atomized form. Ignition of the fuel takes place automatically by means of high pressure and temperature air. The pressure and temperature further will increase due to combustion, it pushes the piston towards down. Thus, it produces power stroke.

4. Exhaust stroke:

During this stroke, inlet valve is closed and the exhaust valve opens. The piston moves from BDC to TDC. It blows out the burnt gases from the cylinder. Thus, one cycle of operation is completed and repeated again and again in the same manner.

REFRIGERATION AND COOLING TOWER

INTRODUCTION

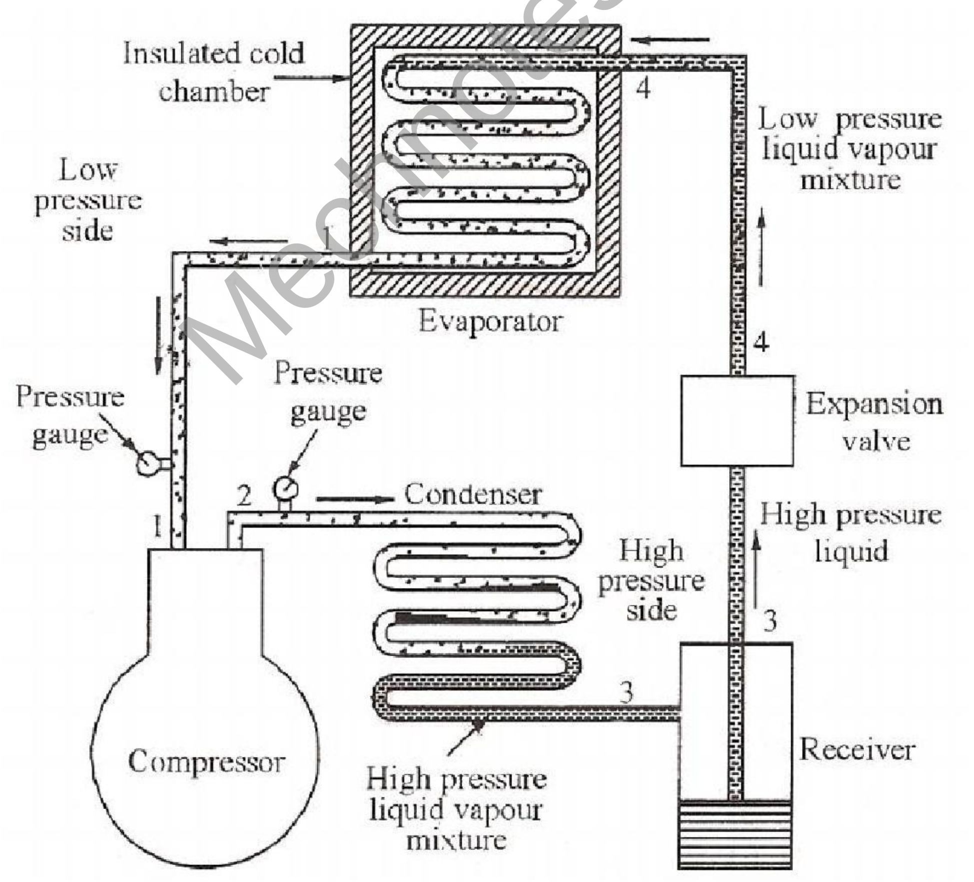
Introduction to refrigeration

'Refrigeration' aims at keeping space at a temperature lower than that of the surroundings. Many Systems are in use, which can be classified into compression systems and absorption systems. Refrigeration and air conditioning systems are dealt with in the subsequent sections.

Vapour compression refrigeration system

Vapour compression refrigeration system uses a liquefiable vapour as the refrigerant. In this system, the refrigerant used alternatively undergoes a change of phase from vapour to liquid and liquid to vapour during the cycle. In this, the isentropic expansion of Carnot cycle is replaced by a throttling process, i.e., expansion in a valve or capillary tube. A simple vapour compression refrigeration system is shown.

The latent heat of vaporizations is utilized for absorbing the heat from low temperature space and transfers it to surrounding so that the space is maintained at a temperature lower than that of surrounding.



1. **Compressor:**

The main function of compressor is to increase the increase the pressure and temperature of the Refrigerant above atmospheric. The compressor used here is of reciprocating type.

2. **Condenser:**

The condenser is used to cool the vapour and the vapour will be converted into liquid.

3. **Receiver:**

The receiver is a storage tank, which stores the liquid.

4. **Expansion valve or Throttle valve:**

The valve is used to reduce the temperature and pressure of the liquid refrigerant.

5. **Evaporator:**

Evaporator causes the cooling effect in the refrigeration space by absorbing the heat from the space. It is made up of copper coils.

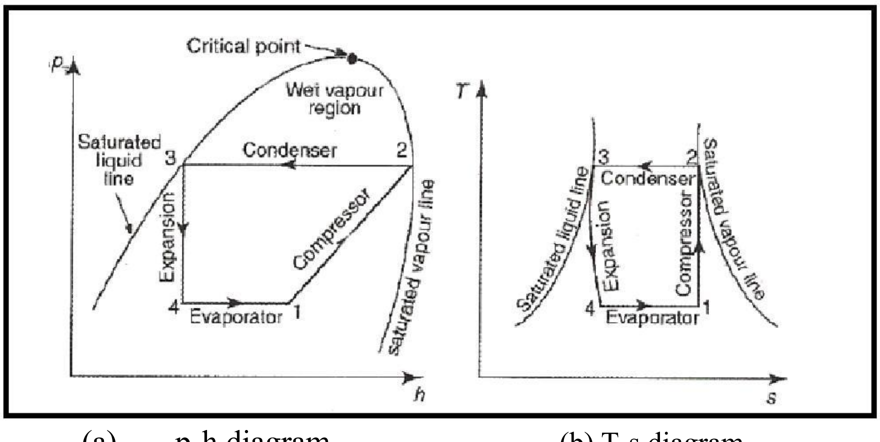
Working:

The high pressure vapour refrigerant from the condenser enters the expansion or throttle valve where it expands to the required pressure. During expansion pressure is reduced and the vapour becomes partially converted to liquid and produces cooling effect. This process is represented in p-h diagram as 3-4.

A mixture of low temperature vapour and liquid from expansion valve is then enters the evaporator and absorbs heat from the space to be refrigerated. Thus the "*Refrigerating effect*" is obtained. This process is represented in p-h diagram as 4-1. Because of this, liquid becomes vapour (state 1) and this vapour enters the compressor. There it is compressed, thus the pressure goes up. This process is represented in p-h diagram as 1-2. This high pressure vapour enters the condenser. There, it looses its latent heat and become liquid. (Process 2-3) The liquid refrigerant is stored in a receiver and supplied to the expansion valve, and the cycle continues.

P ‾h diagram*:*

The above processes are represented on a *p – h* and *T-s* chart as shown in fig.



(a) p-h diagram (b) T-s diagram

Cooling Towers

In power plants the hot water from condenser is cooled in cooling tower, so that it can be reused in condenser for condensation of steam. In a cooling tower water is made to trickle down drop by drop so that it comes in contact with the air moving in the opposite direction. As a result of this some water is evaporated and is taken away with air. In evaporation the heat is taken away from the bulk of water, which is thus cooled.

Factors affecting cooling of water in a cooling tower are:

1. Temperature of air.
2. Humidity of air.
3. Temperature of hot air.
4. Size and height of tower.
5. Velocity of air entering tower.
6. Accessibility of air to all parts of tower.
7. Degree of uniformity in descending water.
8. Arrangement of plates in tower.

Cooling towers may be classified, according to the material of which these are made, as follows:

(a) Timber,

(b) Concrete (Ferro-concrete, multideck concrete hyperbolic) and

(c) Steel duct type.

(a) Timber towers. Timber towers are rarely used due to the following disadvantages:

(i) Due to exposure to sun, wind, water, etc., timber rots easily.

(ii) Short life.

(iii) High maintenance charges.

(iv) The design generally does not facilitate proper circulation of air.

(v) Limited cooling capacity.

(b) Concrete towers. The concrete towers possess the following *advantages:*

(i) Large capacity sometimes of the order of 5 x 10^3/h.

(ii) Improved draft and air circulation.

(iii) Increased stability under air pressure.

(iv) Low maintenance.

(c) Steel duct type. Duct type cooling towers are rarely in case of modern power plants owing to their small capacity.

The cooling towers may also be *classified* as follows:

1. Natural draught cooling towers
2. Mechanical draught cooling towers:
   (i) Forced draught cooling towers
   (ii) Induced draught cooling towers.

1. Natural draught cooling tower.

In this type of tower, the hot water from the condenser is pumped to the troughs and nozzles situated near the bottom. Troughs spray the water falls in the form of droplets into a pond situated at the bottom of the tower. The air enters the cooling tower from air openings provided near the base, rises upward and takes up the heat of falling water. A concrete hyperbolic cooling tower is shown in Fig. This tower has the following

***Advantages* over mechanical towers:**

(i) Low operating and maintenance cost.

(ii) It gives more or less trouble free operation.

(iii) Considerable less ground area required.

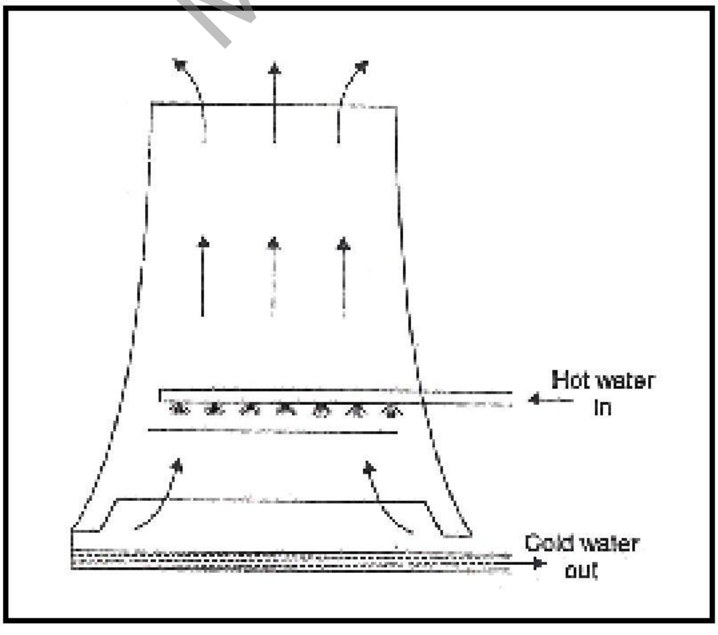
(iv) The towers may be as high as 125m and 100m in diameter at the base with the capability of withstanding winding winds of very high speed. These structures are more or less self-supported structures.

(v) The enlarged top of the tower allows water to fall out of suspension.

The main *drawbacks* of this tower are listed below :

(i) High initial cost.

(ii) Its performance varies with the seasonal changes in DBT (dry bulb temperature) and R.H. (relative humidity) of air.

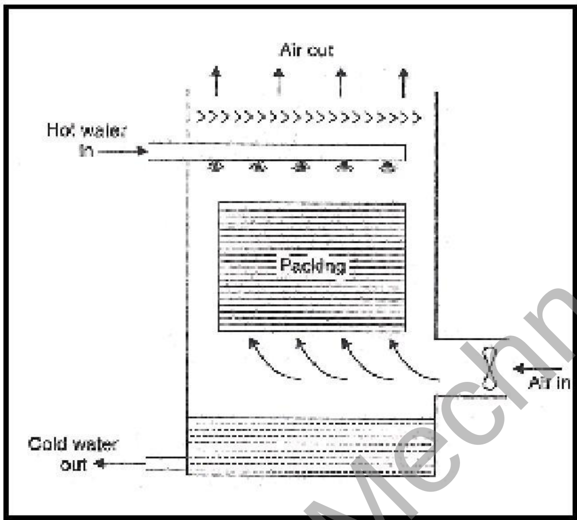


While initial cost may be higher, the saving in fan power, longer life and less maintenance always for this type of tower. It is also more favorable over mechanical draught cooling towers as central station size increases.

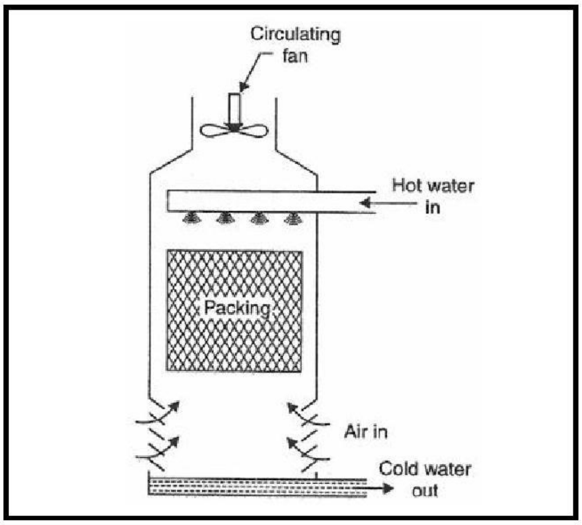
2. Mechanical draught cooling towers.

In these **towers** the draught of air for cooling the tower is produced mechanically by means of *propeller fans.* These towers are usually built in cells or units, the capacity depending upon the number of cells used.

Fig. shows a *forced draught cooling tower.* It is similar to natural draught tower as far as interior construction is concerned, but the sides of the tower are closed and form an air and water tight structure, except for fan openings at the base for the inlet of fresh air, and the outlet at the top for the exit of air and vapours. There are hoods at the base projecting from the main portion of the tower where the fans are placed for forcing the air, into the tower.



Forced draught cooling tower



Induced draught cooling tower

Fig. shows an *induced draught cooling tower.* In these towers, the fans are placed at the top of the tower and they draw the air in through louvers extending all around the tower at its base.

Comparison of forced and induced draught towers

Forced Draught cooling towers

Advantages:

1. More efficient (than induced draught).
2. No problem of fan blade erosion (as it handles dry air only).
3. More safe.
4. The vibration and noise are minimum.

Disadvantages:

1. The fan size is limited to 4 meters.
2. Power requirement high (approximately double that of induced draught system for the same capacity).
3. In the cold weather, ice is formed on nearby equipments and buildings or in the fan housing itself. The frost in the fan outlet can break the fan blades.

Induced draught cooling towers

Advantages:

1. The coldest water comes in contact with the driest air and warmest water comes in contact with the | most humid air.
2. In this tower, the recirculation is seldom a problem.
3. Lower first cost (due to the reduced pump capacity and smaller length of water pipes).
4. Less space required.
5. This tower is capable of cooling through a wide range.

Disadvantages:

1. The air velocities through the packing are unevenly distributed and it has very little movement near the walls and centre of the tower.
2. Higher H.P. motor is required to drive the fan comparatively. This is due to the fact that the static pressure loss is higher as restricted area at base tends to choke off the flow of higher velocity air.

Comparison between natural and Mechanical Draught Towers

Mechanical draught towers

Advantages:

1. These towers require a small land area and can be built at most location.
2. The fans give a good control over the air flow and thus the water temperature.
3. Less costly to install than natural draught towers.

Disadvantages:

1. Fan power requirements and maintenance costs make them more expensive to operate.
2. Local fogging and icing may occur in winter season.

PORT TIMING DIAGRAM

Expt. No. : 01 *Date :*

AIM:-

To draw the port timing diagram of a two stroke spark ignition engine.

APPARATUS REQUIRED:

1. A two stroke petrol engine
2. Measuring tape
3. Chalk

BRIEF THEORY OF THE EXPERIMENT:

The port timing diagram gives an idea about how various operations are taking place in an engine cycle. The two stroke engines have inlet and transfer ports to transfer the combustible air fuel mixture and an exhaust port to transfer exhaust gas after combustion. The sequence of events such as opening and closing of ports are controlled by the movements of piston as it moves from TDC to BDC and vice versa. As the cycle of operation is completed in two strokes, one power stroke is obtained for every crankshaft revolution. Two operations are performed for each stroke both above the piston (in the cylinder) and below the piston (crank case). When compression is going on top side of the piston, the charge enters to the crank case through inlet port. During the downward motion, power stroke takes place in the cylinder and at the same time, charge in the crank case is compressed and taken to the cylinder through the transfer port. During this period exhaust port is also opened and the fresh charge drives away the exhaust which is known scavenging. As the timing plays major role in exhaust and transfer of the charge, it is important to study the events in detail. The pictorial representation of the timing enables us to know the duration and instants of opening and closing of all the ports. Since one cycle is completed in one revolution i.e. 360 degrees of crank revolution, various positions are shown in a single circle of suitable diameter.

PROCEDURE:

1. Mark the direction of rotation of the flywheel. Always rotate only in clockwise direction when viewing in front of the flywheel.
2. Mark the Bottom Dead Center (BDC) position on the flywheel with the reference point when the piston reaches the lowermost position during rotation of the flywheel.

OBSERVATION TABLE:

Sl. No.	Description	Angle in Degrees			
		Trail -I	Trail -II	Trail -III	Average
1.	IPO before TDC				
2.	IPC after TDC				
3.	EPO before BDC				
4.	EPC after BDC				
5.	TPO before BDC				
6.	TPC after BDC				

3. Mark the Top Dead Center (TDC) position on the flywheel with the reference point when the piston reaches the top most position during the rotation of flywheel.
4. Mark the IPO, IPC, EPO, EPC, TPO, and TPC on the flywheel observing the following conditions.
5. **Inlet port open (IPO)** when the bottom edge of the piston skirt just opens the lower most part of the inlet port during its upward movement.
6. **Inlet port close (IPC)** when the bottom edge of the piston fully reaches the lower most part of the inlet port during its downward movement.
7. **Transfer port open (TPO)** when the top edge of the piston just open the top most part of the transfer port during its downward movement.
8. **Transfer port close (TPC)** when the top edge of the piston fully reaches the upper most part of the transfer port during its upward movement
9. **Exhaust port open (EPO)** when the top edge of the piston just opens the top most part of the exhaust port during its downward movement.
10. **Exhaust port close (EPC)** when the top edge of the piston fully reaches the upper most part of the exhaust port during its up ward movement
11. Measure the circumferential distance of the above events either from TDC or from BDC whichever is nearer and calculate their respective angles.
12. Draw a circle and mark the angles.

RESULT:

The given two-stroke petrol engine is studied and the Port timing diagram is drawn for the present set Of values.

VALVE TIMING DIAGRAM

Expt. No. : 02 *Date:*

AIM:-

To draw the Valve Timing Diagram of the four stroke diesel engine.

APPAATUS REQUIRED:

1. Experimental engine
2. Measuring tape
3. Chalks

BRIEF THEORY OF THE EXPERIMENT:

The valve timing diagram gives an idea about how various operations are taking place in an engine cycle. The four stroke diesel engines have inlet valve to supply air inside the cylinder during suction stroke and an exhaust valve to transfer exhaust gas after combustion to the atmosphere. The fuel is injected directly inside the cylinder with the help of a fuel injector.

The sequence of events such as opening and closing of valves which are performed by cam-follower-rocker arm mechanism in relation to the movements of the piston as it moves from TDC to BDC and vice versa. As the cycle of operation is completed in four strokes, one power stroke is obtained for every two revolution of the crankshaft. The suction, compression, power and exhaust processes are expected to complete in the respective individual strokes. Valves do not open or close exactly at the two dead centers in order to transfer the intake charge and the exhaust gas effectively. The timing is set in such a way that the inlet valve opens before TDC and closes after BDC and the exhaust valve opens before BDC and closes after TDC. Since one cycle is completed in two revolutions i.e 720 degrees of crank rotations, various events are shown by drawing spirals of suitable diameters. As the timing plays major role in transfer of the charge, which reflects on the engine performance, it is important to study these events in detail.

OBSERVATIONS:

Sl. No.	Description	Distance in mm	Angles in Degrees
1.	IVO Before TDC		
2.	IVC After BDC		
3.	EVO Before BDC		
4.	EVC After TDC		

PROCEDURE:

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

FORMULA:

$$\text{Angle} = \frac{L}{X} \times 360^0$$

Where,

L - Distance from nearest dead center in mm

X - Circumference of the Flywheel in mm

RESULT:

The given four-stroke compressed ignition engine is studied and the valve timing diagram is drawn for the present set of values.

SINGLE CYLINDER PETROL ENGINE LOAD TEST

Expt. No. : 03 Date:

Aim:

To conduct performance test on the given single cylinder petrol engine and to draw curves of BP Vs total fuel consumption and BP Vs Brake thermal efficiency

Apparatus Required:

1. Single cylinder petrol engine
2. Tachometer
3. Stop clock
4. Electric bulb with switch arrangement.

Specifications:

Single cylinder, Four stroke, vertical Air cooled High Speed petrol Engine.

Make	HONDA GK 200
Bore	67 mm
Stroke	58 mm
R.P.M.	3600
B.H.P.	3.1 HP (Single cylinder at 3600 rpm 2.8 kw)
Capacity	197 cc
Fuel Oil	Petrol start Kerosene run
Sp. Gr	0.74
Calorific value	12000 k/cal/kg
Compression Ratio	4. 5 : 1

Formulae used:

1. BHP [Brake HP]

$$BHP = \frac{V \times A \times \quad \times 1.341}{1000}$$

Where,	V	-	Voltmeter Reading
	A	-	Ammeter Reading
		-	Efficiency of the alternator

Observation & Tabulation:

Brake drum Radius R = ________________ m

Rope thickness t = ________________ m

Sl. No.	Load	Voltmeter Reading	Ammeter Reading
Unit		volts	Amp
1.			
2.			
3.			
4.			
5.			

2. Total Fuel consumption (TFC)

$$TFC = \frac{10\ cc \times Sg \times 5600}{t}\ gm/h$$

Where, Sg - specific gravity of petrol (gm/cc)

t - time in seconds for 10 cc petrol consumption

3. Fuel HP (FHP)

$$FHP = \frac{TFC \times Cv \quad \times JK}{3600 \times 1000}, np$$

Where Cv - calorific value of petrol in k cal/klg

JK - mechanical Heat equivalent 4.2 kJ/kcal

4. Specific Fuel consumption (S.F.C)

$$SFC = \frac{TFC}{BHP}$$

5. Heat Input

H.I.= T.F.C x Cal. value

Cal. value of petrol = 12000 k cal/kg

6. Indicated HP (IHP)

IHP = BHP + Negative Hp

7. Brake thermal Efficiency

$$BTE = \frac{BHP}{FHP} \times 100\%$$

8. Indicated thermal efficiency

$$ITE = \frac{IHP}{FHP} \times 100\ \%$$

9. Mechanical Efficiency

$$Mech = \frac{BHP}{IHP} \times 100\%$$

10. Work Output

$$\text{Work output} = \frac{BHP \times 4500}{427}\ k\ cal/min$$

Procedure:

The engine is started and run at constant speed at no load. Time in seconds for 10cc for petrol consumption is noted.

Then the engine is loaded to 25%, 50%, 15 % and full load and the corresponding time, value voltmeters and ammeter readings are noted and tabulated.

1. Check fuel level.
2. Check Lubricating oil level.
3. Open the three way cock, so that the fuel flows to the engine.
4. Start the engine.
5. Adjust the speed by screwing in or out of the governor nut.
6. Load the engine by adding the required bulb loads by operating the switches.
7. Notes the reading of the followings voltmeter, ammeter, speed and time taken for 10cc of fuel consumption.

Calculation:

Graph :

1. TFC Vs BHP
2. Br.TH Vs BHP
3. mech. Vs BHP
4. IHP Vs BHP
5. SFC Vs BHP

Result Tabulation :

Sl. No	Load	TFC	FHP	BHP	IHP	Mech	ITE	BTE

Thermal	S.F.C.	Heat Input	Heat Output

Result:

Thus the performance test on petrol engine was calculated and performance curves are drawn.

PERFORMANCE AND HEAT BALANCE TEST ON KIRLOSKAR ENGINE 5 HP, DIESEL SINGLE CYLINDER

Date:

Aim :

To conduct performance and heat balance test on a kirloskar engine and to draw the performance curves.

Apparatus Required :

1. Measuring tape
2. Tachometer
3. Thermometer
4. Stop watch
5. Four stroke, single cylinder Diesel engine setup.

Specifications :

Make	Kirloskar
BHP	5 HP
Bore	80 mm
Fuel	High Speed Diesel
Stroke	110 mm
Speed	1500 rpm
Type	Single cylinder 4 stroke
Loading	Rope Brake
Lubrication	Forced
Cooling	Water

Formulae used :

1. Brake Power $= \frac{2 \quad NW\,Re}{60000}$ Kw

N - Speed, rpm

W - Weight, N

Re - Equivalent Radius

$Re = r_1 + r_2$

Where, r_1 - Radius of wheel

r_2 - Radius of Rope

Observation and Tabulation :

1. Circumference of wheel = ________________ cm
2. Circumference of Rope = ________________ cm
3. Diameter of orifice (d) = ________________ cm
4. Length of stroke L = ________________ cm

Sl. No.	Load			Speed	Time for 10 cc of fuel consumption
	W_1	W_2	$W = W_1 - W_2$		
	kg	kg	N	rpm	sec
1.					
2.					
3.					
4.					
5.					

2. Total Fuel consumption (T.F.C)

$$T.F.C = \frac{25}{\text{x sp. gravity of fuel}}$$

x 3600 t x 1000

t - time, sec

3. Specific Fuel consumption (S.F.C.)

$$S.F.C. = \frac{T.F.C}{B.P.}$$

4. Frictional Power

F.P. from grap between T.F.C & B.P.

5. Indicated power (I.P.)

I.P. = BP + FP

6. Mechanical efficiency (mech)

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

7. Indicated thermal efficiency (ITE)

$$ITE = \frac{I.P. \times 3600 \times 100}{T.F.C. \times Cv}$$

Cv = calonfic value of Diesel, 43350 KJ/KgK.

8. Brake thermal efficiency (BTE)

$$BTE = \frac{B.P. \times 3600 \times 100}{TFC \times Cv}$$

9. Brake mean effective pressure

$$BMEP = \frac{B.P. \times 0.6}{LA\,\frac{N}{2}\,.\,n}$$

L	-	Length of Rop, m
A	-	$/4\, d^2$ (Area of Ro Pe), m^2
N	-	Speed, rpm
n	-	1

10. Indicated mean Effective pressure

$$IMEP = \frac{I.P. \times 0.6}{LA\,\frac{N}{2}\,.\,n}$$

Sl. No.	Tiem taken for 21 t of water collection	Cooling water temperature		
		Inlet	Outlet	
Unit	sec	^0C	^0C	
1.				
2.				
3.				
4.				
5.				

Heat Balance Test :

1. Heat Input to engine = T.F.C x cv

2. Heat equivalent to useful work = BP x 3600

   Percentage of equivalent of useful work

   $$= \frac{\text{Heat equivalent of useful work}}{\text{Heat Input}} \times 100$$

3. Heat carried away by cooling water

   = m / t x cp x t x 3600

4. Heat carried away by exhaust gases

   Volumetric efficiency = $\frac{\text{Actual volume of air}}{\text{Volume of engine cylinder}}$ Va = $\sqrt{2g \text{ Ha}}$ cd = 0.6

   Ha = hw w / a

   $V_{ad} = A_0 V_a \times c_d$

   Ma = V Pa

   Mg = Ma + TFC

   Cpg = 1.1286 K7/Kg K

   Heat carried away by extraust gases = Mg x Cpg x x

5. Unaccounted losses = Heat Input - [Heat Output] ---> useful Heat + Heat by water + Heat by gases

Procedure :

1. The fuel valve and cooling water is opened and the engine is started and adjusted to 1500 rpm.
2. The maximum load applied is already calculated and 30% of the maximum load is applied on the engine.
3. The time taken for 25cc of the fuel consumed is measured using stopwatch.
4. The time taken for 2 lts of water of collection is meased using stop watch.
5. The inlet and outlet temp of both the exhust gas and water is noted using a thermometer.
6. The same set of readings are noted for an increase in load of the engine.
7. The procedure is repeated by increasing the Load.
8. The readings are tabulated and the graphs drawn for the calculated values.
9. The graph is drawn between brake power and total Fuel consumption. From this graph, the frictional power is calculated using willier's line method.

Graph :

1. Brake power vs TFC
2. Brake Powre vs SFC
3. Brake Powre vs mech
4. Brake Powre vs BTE %
5. Brake Powre vs ITE %

Result Tabulation :

Sl. No	Load	B.P	TFC	SFC	mech	IP	BTE	ITE	BMEP	IMEP
unit	N	kw	kg/hr	kw/kwhr	%	kw	%	%	bar	bar

Result :

1. Thus the performance test on kirloskar engine was calculated and performance curves are drawn.
2. Thus the heat balance test on kirloskar engine is calculated and the curves are drawn.

Expt. No. : 5

PERFORMANCE TEST ON MULTI CYLINDER PETROL ENGINE

Date :

Aim :

To conduct performance test on given 4 stroke multi cylinder petrol engine water cooled and draw the performance curves and also prepare the heat balance sheet on hour baris.

Apparatuss require :

1. Four stroke multi cylinder water cooled petrol engine test rig
2. Stop watch
3. Tachometer
4. Thermometers
5. Read weighs.

Specifications :

Engine :

Type	:	Multi cylinder, water cooled, four stroke hand cranking
Rated Power (P)	:	10 HP
Rated Speed (N)	:	1500 rpm
Bore Dia (D)	:	80 mm
Stroke (L)	:	110 mm
Orifice dia (do)	:	30 mm
Loading device	:	7.5 kw 1500 rmp, AC Generator with resistance bank load
Load indication	:	Ammeter and voltmeter
Fuel measuring device	:	Burette with 3-way cock
Water flow meausring device	:	Measuring jar of 1 liter capacity
Temperature Measurement	:	Jacket Water, Calorimeter water, and exhaent temperatures are measured using Iron/Constantine thermocouple sensons with multiunit digital temperature indicator.

Fuel :

Calorific value of Deisel (Cv)	=	42000 KJ/Kg
Specific cravity of diesel	=	0.867

Observation and Tabulation :

1. Rated power = ____________________ kw
2. Atm. Temp. = ____________________ ^oC
3. Rated speed = ____________________ rpm

Sl. No.	Spead	Ammeter reading	Volt Meter Reading	Time taken for 10 cc for fuel consumption			Manometer Reading			Er te I
				t_1	t_2	t_{av}	h_1	h_2	$h_1 - h_2$	Tv
Unit	rpm	amp	volts	sec	sec	sec	m of water			^{0}
1.										
2.										
3.										
4.										
5.										

Description of Testrig :

The petrol engine is a multi cylinder, four-stroke water-cooled, couled with AC generator. The consumption rate of air is measured with the help of air tank fitted with an orifice. The air tank is connected with the engine inlet mainfold through a flexible pipe. The exhaust gas temperature is measured with the help of a thermocouple place inside the exhant pipe. Also a thermo couple is provided in the calorimeter to measure calorimeter water temperature. A ‘U’ tube manometer is provided for measuring the pressure drop across the orifice. The fuel consumption of the engine is measured with a graduated burette, fitted on the fuel line.

Formulae Used :

1. Brake Power (BP) $= \dfrac{2\ NT}{60 \times 1000}$ KW

   T = Torque in N - m = RW

   N = Engine Speed in rpm

   R = Torque arm length in m

   W = Applied Load in N

2. Mass of fuel consumption (mf) $= \dfrac{10}{t_{avg}} \times \dfrac{S.G.}{1000} \times 3600$ kg/hr

   Where,

   t_{avg} = time taken for 10cc of fuel consumption in seconds

   S.G. = Specific gravity of diesel

3. Frictional power (F.P) :

   Friction power is find out by using willan’s line method BP vs mf

4. Indicated power (IP) = BP + FP kw

5. Specific Fuel consumption (SFC) $= \dfrac{mf}{BP}$ kg/kw - hr

6. Mechanical efficiency (h_m) $= \dfrac{BP}{IP} \times 100$ %

7. Brake thermal efficiency (h_{Bth}) $= \dfrac{BP}{mf \times cv} \times 100$ %

8. Indicated Thermal efficiency (h_{Ith}) $= \dfrac{IP}{m_f \times c_v} \times 100$ %

9. Volumetric efficiency (η_{vol}) $= \frac{V_{act}}{V_{the}} \times 100\%$

Where,

$V_{act} = c_d \, A_0 \sqrt{2gHa}$

$A_O = \frac{\pi d_o^2}{4} \; m^2$

do = Diameter of orifice in m

C_d = co-efficient of discharge of orifice = 0.62

g = Gravitational acceleration = 9.8 m/s^2

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

ρ_w = 1000 Kg/m^3

H_w = manometric head of water in M

$\rho_a = \frac{P_a}{R\,T_a}$

Where,

P_a = Atmospheric Pressure = 1.013 x 10^5 N/m^2

T_q = Ambient temperature in K

R = Gas constant = 287 J/kg K

$V_{th} = \left(\frac{\pi}{4} D^2\right) \times L \times n \; m^3/s$

Where,

D = Diameter of bore in m

L = Length of stroke in m

n = number of working stroke per seconds

$= \frac{N}{2 \times 60}$ for Four Stroke

N = Rate speed of the engine in rpm

Heat Balance Test :

1. Mass of fuel consumption (mf) $\frac{10}{t_{avg}} \times \frac{S.G.}{1000} \times 3600$ kg/hr

   Where,

   t_{avg} = time taken for 10 cc of fuel consumption in seconds

   S.G. = Specific gravity of diesel

2. Heat supplied to Engine (Qs) = mf x cv in KJ/hr

3. Useful Heat (Heat absorbed in BP) (Qu) = $\frac{2\ NT}{60 \times 1000}$ KJ/hr

   Where,

   T = WR

   W = Applied Load in N

   R = Length of Torque Arm in m

   N = Engine speed in rpm % of useful heat

   % of useful Heat Qu = $\frac{Qu}{Qs} \times 100$ %

4. Heat carried away by the engine (Qw) = m_w CP_w (Two - Twi) KJ/hr cooling water

   m_w = mass flow rate of engine cooling water in kg/hr

   = $\frac{3600}{t_w}$ kg/hr

   Cp_w = Specific heat of water = 4.18 KJ/Kg K

   Two = Outlet temperature of cooling water in K

   Twi = Inlet temperature of cooling water in K

   % of heat carried away by the engine cooling water Qw = $\frac{Qw}{Qs} \times 100$ %

5. Heat carried away by the exhaust gases (Q_g) = mg CP_g (T_g - T_a) KJ/hr

   Where,

   mg = mass flow rate of exhast gasses in Kg/hr

   = mf + ma

   ma = mass flow rate of air in kg/hr

$$= \frac{d^2}{4} \quad _{air} \quad cd \ \overline{2g\ Ha} \ \times 3600 \quad kg/hr$$

Where,

$$_{air} \quad = \quad \text{Density of air} = \frac{P_a}{RT_a}$$

Where,

P_a = Atmospheric pressure = 1.013 x 105 N/m^2

T_a = Ambient Temeprature in K

R = Gass Constant = 287 J/Kg K

d = Diameter of orifice in m

c_d = co-efficient of discharge of orifice

H_a = Manometric Head of air = $\frac{\text{Density of water}}{\text{Density of air}}$ x Hw

cp_g = 1.005 KJ/kg K

T_g = exhaust gas Temperature in K.

% of Heat carried away by the exhaust gasses Qg = $\frac{Q_g}{Q_s}$ x 100%

7. Unaccounted heat losses (Q_{un}) = Q_s - (A_u + Q_w + Q_g)

% of unaccounted losses Q_{un} = $\frac{Q_{un}}{Q_s}$ x 100%

Precautions :

The engine should not be start or stop under loaded Condition.

The lubricating oil level should be ensured before starting the engine

The engine cooling water supply should be ensured before starting the engine.

Procedure :

1. Fill the fuel tank with diesel.
2. Open the 3 way cock, the knob facing to your left. In this position the fuel flows from the tank to the engine filling the burette, To remove air block in the hose, remove the hose from the engine and hold it vertically up. Now connect the hose back to the engine and open the air bleed screw to allow the fuel to freely through the screw. Tighten the screw put the decompression lever up.
3. Crank the engine to hear the fuel injection creek sould and put the decompression lever down and the engine starts. Care to be taken to remove the handle immediately on starting of the engine.
4. The voltmeter indicates the voltage output from the engine.

5. Switch on the resistance bank load. Select a suitable load by looking at the ammeter reading.
6. Note the voltmeter and Ammeter reading.
7. Note the time for the fuel consumption from the burette by putting the 3 way cock knob facing down for 10 cc.
8. Note the manometer reading.
9. Note the temepratures from T1 to T6.
10. Note the time for 1 litre water flow through the engine jacket.
11. Note the time for 1 litre water flow through the calorimeter.
12. Repeat the procedure for other loads.
13. It is preferred to take reading in the ascending order of loads.

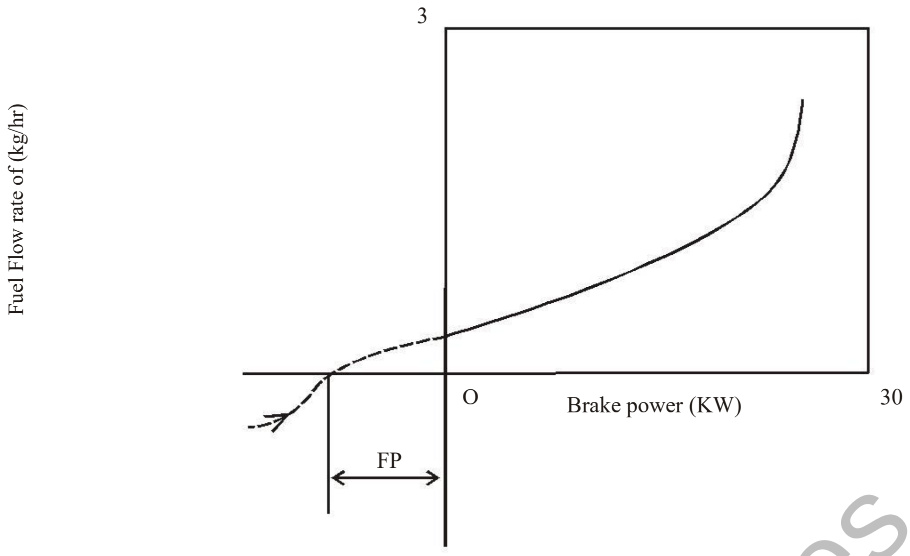
T1	-	Jacket water inlet
T2	-	Jacket water outlet
T3	-	Exhaust gas temperature from the engine
T4	-	Exhaust gas outlet temperature from the calorimeter.
T5	-	Calorimeter water inlet temperature.
T6	-	Calorimeter water outlet temperature.

Calculation :

Model Graph :

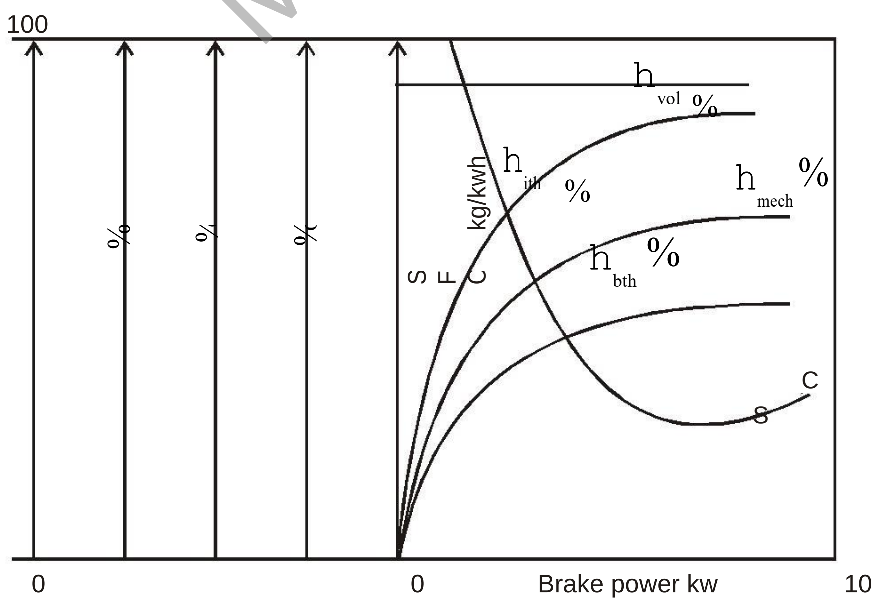
1. Determination of FP using Willan's line method :

A graph between fuel consumption (y - axis) and brake power (x-axis) at constant speed in tube drawn and it is extrapolated on the negative axis of brake power. The intercept of the negative axis is taken as the frictional power of the engine at that speed.



2. Performance Characteristics of the engine :

The engine performance is to be shown in the graphical which will be constructed from the data obtained during the actual test run. In the graph, SFC, Mechanical efficiency, Volumetric efficiency, Brake thermal efficiency and Indicated thermal efficiency (y-axis) are to be plotted against brake power (x-axis) of the engine.



Result Tabulation :

1. Frictional power FP = ______________________ kw (from the graph BP vs mf)
2. Rated speed N = ______________________ rpm

Sl. No	Load	BP	mass of fuel consumption mf (TFC)	SFC	IP	h_{mean}	h_{ith}	h_{bth}	h_{vol}
Unit	%	Kw	kg/hr	kg/hr	Kw	%	%	%	%
1	0								
2	25								
3	50								
4	75								
5	100								

Heat balance sheet on hour basis :

supplied	KJ/hr	%	utilized / wasted	kJ/hr	%
Qs heat supplied to the engine		100			
			Q_u - Heat absorbed in BP (useful heat)		
			Q_W - Heat carried away by cooling water		
			Q_g - Heat carried away by exhaut gases		
			Q_{un} - Heat unaccounted Losses		
Total		100			100

Result :

The performance test and heat balance test for the given engine has been conducted. The result are tabulated in the result table and the following raphs were drawn.

BP vs SFC,BP vs h_{mech}, BP vs h_{Bth}, BP vs h_{Ith}, BP vs h_{vol}

Expt. No. : 6

PERFORMANCE TEST ON TWIN CYLINDER DIESEL ENGINE

Date :

Aim :

To conduct performance test on given 4 stroke twin cylinder diesel engine water cooled and draw the performance curves and also prepare the heat balance sheet on hour baris.

Apparatuss require :

1. Four stroke twin cylinder water cooled diesel engine test rig
2. Stop watch
3. Tachometer
4. Thermometers
5. Read weighs.

Specifications :

Engine :

Type	:	twin cylinder, water cooled, four stroke hand cranking
Rated Power (P)	:	10 HP
Rated Speed (N)	:	1500 rpm
Bore Dia (D)	:	80 mm
Stroke (L)	:	110 mm
Orifice dia (do)	:	30 mm
Loading device	:	7.5 kw 1500 rmp, AC Generator with resistance bank load
Load indication	:	Ammeter and voltmeter
Fuel measuring device	:	Burette with 3-way cock
Water flow meausring device	:	Measuring jar of 1 liter capacity
Temperature Measurement	:	Jacket Water, Calorimeter water, and exhaent temperatures are measured using Iron/Constantine thermocouple sensons with multiunit digital temperature indicator.

Fuel :

Calorific value of Deisel (Cv)	=	42000 KJ/Kg
Specific cravity of diesel	=	0.867

Observation and Tabulation :

1. Rated power = ______________________ kw
2. Atm. Temp. = ______________________ °C
3. Rated speed = ______________________ rpm

Sl. No.	Spead	Ammeter reading	Volt Meter Reading	Time taken for 10 cc for fuel consumption			Manometer Reading			Er t I
				t_1	t_2	t_{av}	h_1	h_2	$h_1 - h_2$	T
Unit	rpm	amp	volts	sec	sec	sec	m of water			(
1.										
2.										
3.										
4.										
5.										

Description of Testrig :

The diesel engine is a twin cylinder, four-stroke water-cooled, couled with AC generator. The consumption rate of air is measured with the help of air tank fitted with an orifice. The air tank is connected with the engine inlet mainfold through a flexible pipe. The exhaust gas temperature is measured with the help of a thermocouple place inside the exhant pipe. Also a thermo couple is provided in the calorimeter to measure calorimeter water temperature. A 'U' tube manometer is provided for measuring the pressure drop across the orifice. The fuel consumption of the engine is measured with a graduated burette, fitted on the fuel line.

Formulae Used :

1. Brake Power (BP) $= \dfrac{2\ NT}{60 \times 1000}$ KW

T = Torque in N - m = RW

N = Engine Speed in rpm

R = Torque arm length in m

W = Applied Load in N

2. Mass of fuel consumption (mf) $= \dfrac{10}{t_{avg}} \times \dfrac{S.G.}{1000} \times 3600$ kg/hr

Where,

t_{avg} = time taken for 10cc of fuel consumption in seconds

S.G. = Specific gravity of diesel

3. Frictional power (F.P) :

Friction power is find out by using willan's line method BP vs mf

4. Indicated power (IP) = BP + FP kw

5. Specific Fuel consumption (SFC) $= \dfrac{mf}{BP}$ kg/kw - hr

6. Mechanical efficiency (h_m) $= \dfrac{BP}{IP} \times 100\ \%$

7. Brake thermal efficiency (h_{Bth}) $= \dfrac{BP}{mf \times cv} \times 100\ \%$

8. Indicated Thermal efficiency (h_{Ith}) $= \dfrac{IP}{} \times 100\ \%$

m_f x c_v

9. Volumetric efficiency (h_{vol}) = $\frac{V_{act}}{V_{the}}$ x 100%

Where,

Vact = c_d A_0 $\sqrt{2gHa}$

A_O = $\frac{do^2 \quad m^2}{4}$

do = Diameter of orifice in m

C_d = co-efficient of discharge of orifice = 0.62

g = Gravitational acceleration = 9.8 m/s^2

H_a = $\frac{w}{a}$ x Hw

w = 1000 Kg/m^3

Hw = manometric head of water in M

a = $\frac{Pa}{R\,Ta}$

Where,

P_a = Atmospheric Pressure = 1.013 x 10^5 N/m^2

T_q = Ambient temperature in K

R = Gas constant = 287 J/kg K

V_{th}= $\left(\frac{x\ D^2}{4}\right)$ x L x n m^3/s

Where,

D = Diameter of bore in m

L = Length of stroke in m

n = number of working stroke per seconds

= $\frac{N}{2 \times 60}$ for Four Stroke

N = Rate speed of the engine in rpm

Heat Balance Test :

1. Mass of fuel consumption (mf) $\frac{10}{t_{avg}} \times \frac{S.G.}{1000} \times 3600$ kg/hr

   Where,

   t_{avg} = time taken for 10 cc of fuel consumption in seconds
   S.G. = Specific gravity of diesel

2. Heat supplied to Engine (Qs) = mf x cv in KJ/hr

3. Useful Heat (Heat absorbed in BP) (Qu) = $\frac{2 \ NT}{60 \times 1000}$ KJ/hr

   Where,

   T = WR

   W = Applied Load in N

   R = Length of Torque Arm in m

   N = Engine speed in rpm % of useful heat

   % of useful Heat Qu = $\frac{Qu}{Qs} \times 100\%$

4. Heat carried away by the engine (Qw) = m_w CP_w (Two - Twi) KJ/hr cooling water

   m_w = mass flow rate of engine cooling water in kg/hr
   = $\frac{3600}{t_w}$ kg/hr

   Cp_w = Specific heat of water = 4.18 KJ/Kg K
   Two = Outlet temperature of cooling water in K
   Twi = Inlet temperature of cooling water in K

   % of heat carried away by the engine cooling water Qw = $\frac{Qw}{Qs} \times 100\%$

5. Heat carried away by the exhaust gases (Q_g) = mg CP_g (T_g - T_a) KJ/hr Where,

   mg = mass flow rate of exhast gasses in Kg/hr

   = mf + ma

   ma = mass flow rate of air in kg/hr

$$= \frac{d^2}{4} \quad {}_{air} \quad cd \sqrt{2g\,Ha} \times 3600 \quad kg/hr$$

Where,

$_{air}$ = Density of air = $\frac{P_a}{RT_a}$

Where,

P_a = Atmospheric pressure = 1.013 x 105 N/m^2

T_a = Ambient Temeprature in K

R = Gass Constant = 287 J/Kg K

d = Diameter of orifice in m

c_d = co-efficient of discharge of orifice

H_a = Manometric Head of air = $\frac{\text{Density of water}}{\text{Density of air}}$ x Hw

cp_g = 1.005 KJ/kg K

T_g = exhaust gas Temperature in K.

% of Heat carried away by the exhaust gasses Qg = $\frac{Q_g}{Q_s}$ x 100%

7. Unaccounted heat losses (Q_{un}) = Q_s - (A_u + Q_w + Q_g)

% of unaccounted losses Q_{un} = $\frac{Q_{un}}{Qs}$ x 100%

Precautions :

The engine should not be start or stop under loaded Condition.

The lubricating oil level should be ensured before starting the engine

The engine cooling water supply should be ensured before starting the engine.

Procedure :

1. Fill the fuel tank with diesel.
2. Open the 3 way cock, the knob facing to your left. In this position the fuel flows from the tank to the engine filling the burette, To remove air block in the hose, remove the hose from the engine and hold it vertically up. Now connect the hose back to the engine and open the air bleed screw to allow the fuel to freely through the screw. Tighten the screw put the decompression lever up.
3. Crank the engine to hear the fuel injection creek sould and put the decompression lever down and the engine starts. Care to be taken to remove the handle immediately on starting of the engine.
4. The voltmeter indicates the voltage output from the engine.

5. Switch on the resistance bank load. Select a suitable load by looking at the ammeter reading.
6. Note the voltmeter and Ammeter reading.
7. Note the time for the fuel consumption from the burette by putting the 3 way cock knob facing down for 10 cc.
8. Note the manometer reading.
9. Note the temepratures from T1 to T6.
10. Note the time for 1 litre water flow through the engine jacket.
11. Note the time for 1 litre water flow through the calorimeter.
12. Repeat the procedure for other loads.
13. It is preferred to take reading in the ascending order of loads.

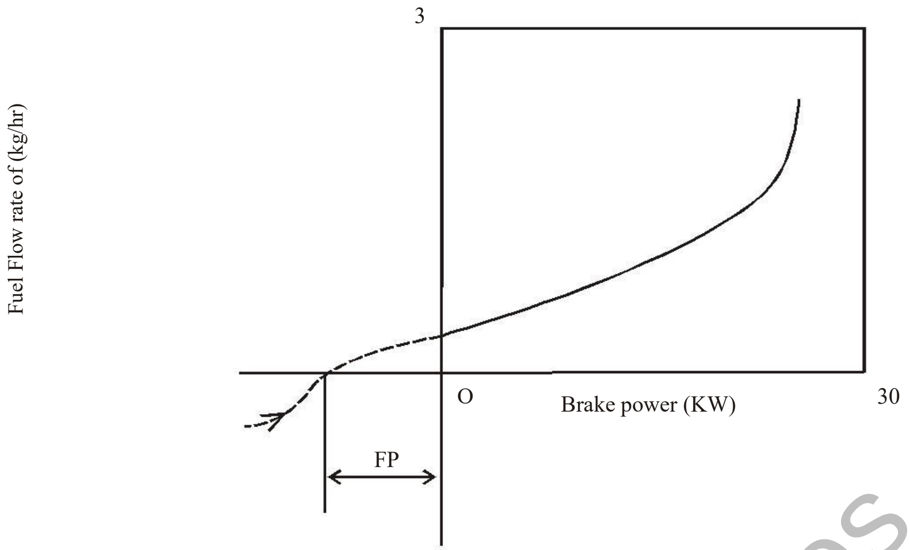
T1	-	Jacket water inlet
T2	-	Jacket water outlet
T3	-	Exhaust gas temperature from the engine
T4	-	Exhaust gas outlet temperature from the calorimeter.
T5	-	Calorimeter water inlet temperature.
T6	-	Calorimeter water outlet temperature.

Calculation :

Model Graph :

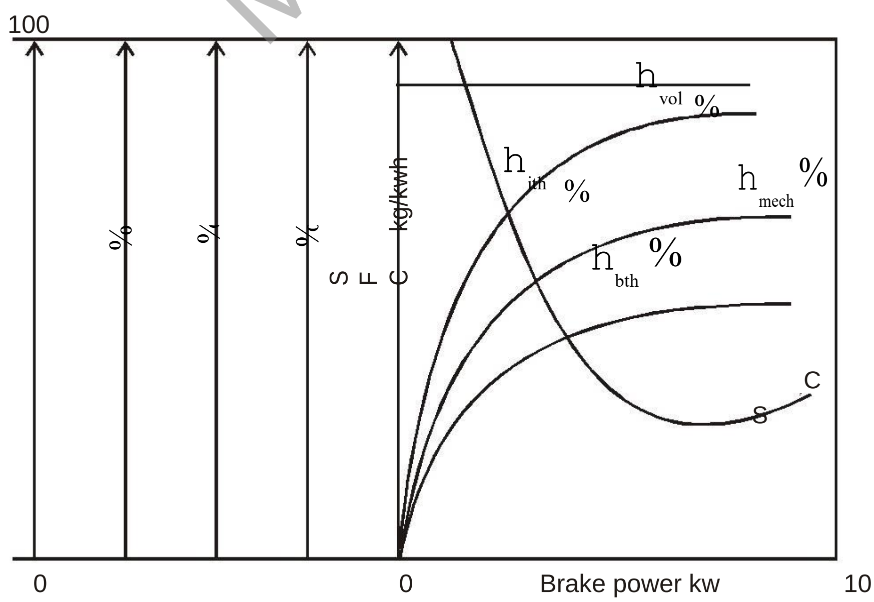
1. Determination of FP using Willan's line method :

A graph between fuel consumption (y - axis) and brake power (x-axis) at constant speed in tube drawn and it is extrapolated on the negative axis of brake power. The intercept of the negative axis is taken as the frictional power of the engine at that speed.



2. Performance Characteristics of the engine :

The engine performance is to be shown in the graphical which will be constructed from the data obtained during the actual test run. In the graph, SFC, Mechanical efficiency, Volumetric efficiency, Brake thermal efficiency and Indicated thermal efficiency (y-axis) are to be plotted against brake power (x-axis) of the engine.



Result Tabulation :

1. Frictional power FP = ____________________ kw (from the graph BP vs mf)
2. Rated speed N = ____________________ rpm

Sl. No	Load	BP	mass of fuel consumption mf (TFC)	SFC	IP	h_{mean}	h_{ith}	h_{bth}	h_{vol}
Unit	%	Kw	kg/hr	kg/hr	Kw	%	%	%	%
1	0								
2	25								
3	50								
4	75								
5	100								

Heat balance sheet on hour basis :

supplied	KJ/hr	%	utilized / wasted	kJ/hr	%
Qs heat supplied to the engine		100			
			Q_u - Heat absorbed in BP (useful heat)		
			Q_w - Heat carried away by cooling water		
			Q_g - Heat carried away by exhaut gases		
			Q_{un} - Heat unaccounted Losses		
Total		100			100

Result :

The performance test and heat balance test for the given engine has been conducted. The result are tabulated in the result table and the following raphs were drawn.

BP vs SFC,BP vs h_{mech}, BP vs h_{Bth}, BP vs h_{Ith}, BP vs h_{vol}

Expt. No. : 7

PERFORMANCE TEST ON REFRIGERATION TEST RIG

Date :

Aim :

To conduct performance test on refrigeration test rig and deermine it co-efficient of performance.

Apparatuss require :

1. Refrigeration test rig
2. Thermometer
3. Stop watch

Precautions :

1. Don't alter the compressor cut in and cut out pressures.
2. The solenoid thermostat is adjusted to cut out at 15^0C and cut in at 10^0C of chilled water, don't alter this setting.

Specifications :

Compressor	:	1/3 HP sealed reciprocating compressor.
Condenser	:	Forced air-cooled condenser.
Evaporator	:	SS vessel with copper coil wound and soldered around.
		Diameter of this vessel = 295 mm
Energy meter constant	:	750 rev/kwh
Expansion devices	:	Capillary tube and automatic expansion valve.
Valves	:	Diaphragm operated hand shut off valves and an electrically operated solenoid valve.

Formulae Used :

1. Mass of water in the evaporator vessel.

m = density of water x volume of water

= x/4 x D^2 x h kg/sec

Where,

- density of water

D - Diameter of vessel

h - height of water in vessel

Observation and Tabulation :

Evaporator vellel diameter, D = ________________ m

Energy meter constant E = ________________ rev/kwh

Sl. No.	Initial Temp. of water	Final Temp. of Water	Duration of Exp. dT	Temperature ^0C				Pressure (Psi)			
Unit	T_i	T_f		T_1	T_2	T_3	T_4	P_1	P_2	P_3	P_4
1.											
2.											
3.											
4.											
5.											

T_1 - Delivery Temperature

T_2 - Condensor outlet temperature

T_3 - Temp. after throttling

T_4 - Suction temperature

P_1 - Delivery Pressure

P_2 - Condensor outlet Pressure

P_3 - pressure after throttling

P_4 - Suction pressure

2. Heat absorbed from evaporator water (Refrigeration effect) = $\dfrac{mc_p\,(T_i - T_f)}{dT}$ J/S

Where,

T_i - Initial temperature of water

T_f - Final temperature of water

C_p - Specific Heat of water = 4.186 KJ/Kg K

dT - Duration of Experiment in sec

3. Work done by the compressor = $\dfrac{3600}{E} \times \dfrac{10}{t}$ KW

Where,

E - Energy meter constant

t - time taken for 10 revolution of the energy meter disc

4. Co-efficient of performance of the refrigeration $(C.OP)_{actual}$

$$C.O.P._{actual} = \frac{\text{Refrigeration effect}}{\text{Work done}}$$

5. Calculate Theoretical value of co-efficient of performance :

$$C.O.P\ (\text{theoretical}) = \frac{h_1 - h_4}{h_4 - h_3}$$

Where,

h_1 ---> enthalpy of water at pressure P_1

$h_2 = h_3$ ---> enthalpy of water at pressure P_2

$h_4 = h_g$ ---> enthalpy of water at pressure P_4

Conversion of PSi to bar

$$1\ \text{bar} = \frac{\text{Psi}}{14.5} + 1.03$$

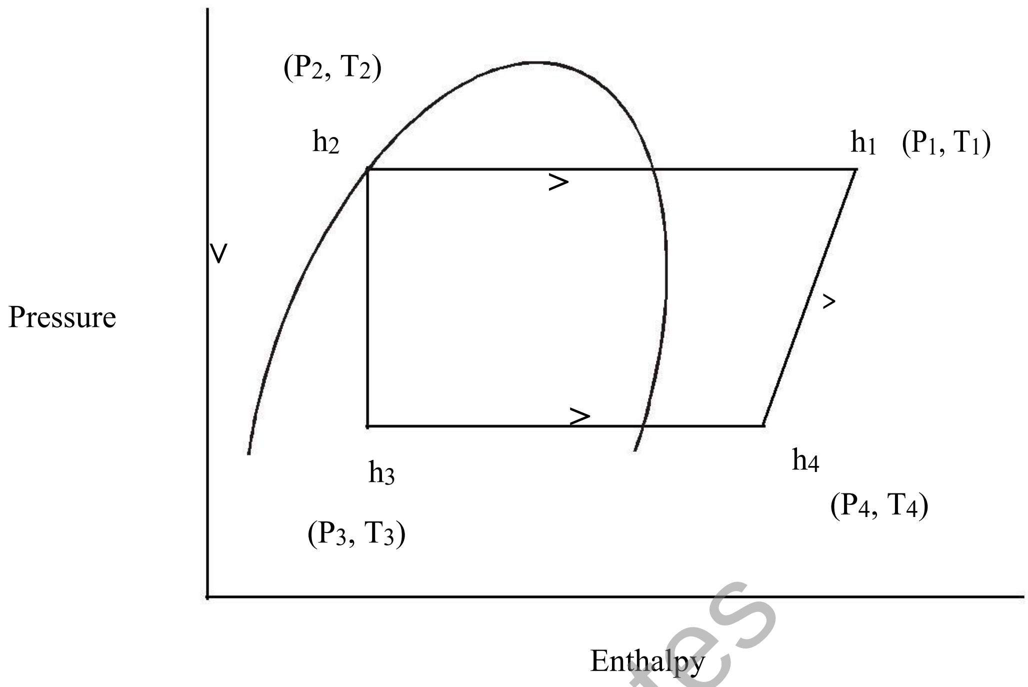
Procedure :

1. Check for any loose connection in the electrical circuit.
2. For expansion through capillary, open hand shut off valve V_1, V_2 and V_3. Close all other valves.
3. Put on the main switch, condenser fan, and Temperature indicater.
4. Fill water in the evaporator vessel to 3/4th level. Note the level of water using a measuring scale. (h).

5. Note the initial temperature of water T_5.
6. Note the starting time, and switch on the compressor.
7. Allow the unit to stabilize.
8. Note the time for 10 revolution of compressor energy meter reading.
9. When the temperature T_3 and T_4 are almost equal note the following.
10. Note the closing time, and temperature of water T_5.
11. Note pressure gauge reading P_1, P_2, P_3, and P_4 at different state points.
12. Note temperatures at different state points T_1, T_2, T_3 and T_4 using the selector switch provided on the temperatue indicater.
13. The experiment may be repeated for a different water level. Please note for repeating the experiment the water needs to be changed.
14. Fo throttling through the automatic expansion valve, open hand shut off valve V_1 and close all other valves. Put on the solenoid switch.
15. Repeat the above procedure and note down the readings.

Calculation :

Model graph :



Result :

The performance test was conducted refrigeration test rig and the result are

1. The coefficient of performance of the refrigeration system ___________________ .
2. Theoretical value of co-efficient of performance ___________________ .

Expt. No. : 8

PERFORMANCE TEST ON AIR CONDITIONING TEST RIG

Date :

Aim :

To determine the carnot cop, theortical cop and actual cop of the air conditioning system working on vapour compression cycle and show the cycle on p-n and T-s diagrams.

Requistes :

Experimental setup, theromoeters (range 10 - 110^{0}C) 2 nos and range (0.300^{0}C) 2 nos and anemometer.

Description :

The air to be conditioned in supplied by blower through a duct. The inlet condition of air is measured by dry bulb and wet bulb thermometers. Different methods of air conditioning possible with this system are cooling and denumdification. of These cooling and denumdification is widely used in tropical climate. For this a converntional vapour compression cycle with R22 as refrigerant is used.

The system consists of evaporator coil, reciprocating compressor air cooled condenser and expansion devices. The cooling section consists of evaporator coil placed inside the air duct over which the air is passed and thereby the air gets cooled and denumdified. The evaporator is finned coil type to ennance the neat transer on air side. The refrigerant picks up neat in the evaporator and gets vapourized which increases enthalpy and volume.

The compressor sucks the refrigerant from the evaporator and compressor it to a high pressure and tempareture. The power supplied to the compressor is calculated from the voltmeter and ammeter readings. The not compressed refrigerant is condensed in the condenser and the condensate flow to one of the expan-sion devices. The condenser is of a finned coil type colled by air from a fan. A bypass line. which has a sight glass and rotatmeter to measure the flow rate of refrigerant is provided. Two expansion devices namely capil-lary tube and thermostatic expansion valve are provided and the refrigermant can flow through any core of the expansion devices by operating valuves.

Procedure :

1. Check the input voltage and operate the system if it is withing 200 V and 250 V.
2. Insert the thermometers in the thermo wells provided to read tempareture T_1, T_2 and T_3, T_4
3. Provided sufficient water in the bottles of wet bulb tempareture so as to keep with wicks always wet.
4. Switch on the air blower and fully open th damper supplying maximum air to through the duct.
5. To throttle the refrigerant through the cpillary tube open the values S_2, S_3 and close the valves S_1, S_4 and S_5.

Sl.No.	PARAMETERS	CAPILLARY	THERMOSTATIC
1.	Dry bulb tempareture of inlet air (^{0}C)		
2.	Wet bulb tempareture of inlet air (^{0}C)		
3.	Dry bulb tempareture of outlet air (^{0}C)		
4.	Wet bulb temperature of outlet air (^{0}C)		
5.	pressure of refrigerant at compressor inlet (P1)		
6.	Pressure of refrigerant at compressor outlet (P2)		
7.	Pressure of refrigerant before throttling (P3)		
8.	Pressure of refrigerant after throttling (P4)		
9.	Tempareture of refrigerant at compressor inlet T1 (^{0}C)		
10.	Tempareture of refrigerant at compressor inlet T1 (^{0}C)		
11.	Tempareture of refrigerant before throttling T3 (^{0}C)		
12.	Tempareture of refrigerant after throthling T4 (^{0}C)		
13.	Velocity of air duct V (m/s)		
14.	Compressor voltage (volts)		
15.	Compressor current (I)		
16.	Energy meter reading Initial Final		

6. Switch on the condenser fan and turn the thermostal switch clockwise fully. The voltmeter and ammeter shows the voltage and current for the compressor.
7. After getting steady state condition of outlet air tempareture. Observe the following readings.
   i) Dry bulb temperature DBT_2 and wet bulb temperature WBI_2 of air at outlet of coling section.
   ii) Dry bulb tempartur DBT_1 and wet bulb tempareture WBT_1 of air at inlet of cooling section.
   iii) Velocity of air ‘v’ in the duct using anemometer.
   iv) pressure of refrigerant at compressor inlet P1.
   v) pressure of refrigerant before throttling P_2.
   vi) Pressure of refrigerant before throttling P_3.
   vii) Pressure of refrigerant after throttling P_4.
   viii) Tempareture of the refrigerant at compressor inlet T_1
   ix) Tempreture of the refrigerant at compressor outlet T_2
   x) Tempareture of the refrigerant before throtting ‘T_3’
   xi) Tempareture of the refrigerant after throttling ‘T_4’
   xii) voltmeter reading adn ammeter readings.
8. To stop air conditioning test rig switch of the compressor, condensor fan and centrifugal blower.

Formulae :

1. Carnot cop :

$$\text{Cop carnot} = \frac{TC}{TH - TC}$$

Where, TH is saturation tempareture of the refrigerant corresponding to ‘P2’ (k)

2. Theortical Cop :

$$\text{Cop theo} = \frac{h1 - h4}{h2 - h1}$$

Where, h1 - enthalpy of refrigerant at inlet of the compressor

h2 - enthalpy of refrigerant at outlet of the compressor

h4 - enthalpy of refrigerant at evaporation inlet.

3. Actual cop :

$$\text{Cop actual} = \frac{P \times 4 \times v\,(ha_1 - ha_2)}{VI \cos f}$$

Where, P	-	density of air at outlet of air conditioning duct (kg/m^3)
A	-	area of cross section (m^2)
na_2	-	enthalpy of air duct at outlet of cooling section
na_1	-	enthalpy of air duct at inlet of cooling section.
c	-	compressor voltage (v)
I	-	Compressor currect (I)
cosf	-	Power tactor of compressor motor.

Result :

For the given air conditioning test rig, the coefficient of performance on different valves are determined.

Expt. No. : 9

PERFORMANCE TEST ON COOLING TOWER

Date :

Aim :

To conduct performance test on cooling tower and determine Humdification efficiency and Energy efficiency.

Apparatuss required :

1. Cooling tower set up
2. Thermometer
3. Stop watch

Description :

The experimental cooling tower consisting of a duet with acrylic front and aluminium fills. Hot water derived from a heater unit is sprayed on top of the duct and collected at the bottom in an SS vessel. Air from a blower unit flows in counter current direction to the water. Air inlet and outlet conditions are measured using wet and dry bulb thermometer provided. Water inlet and outlet temperatures are measured using a digital temperature indicater with thermocouple sensors fitted at respective locations. Air flow rate is measured using orifice meter with U tube manometer.

The flow rates could be altered using control valves. A mist eliminator is provided at the outlet air section.

Formulae Used :

1. Overall Efficiency of the tower $= \dfrac{T_1 - T_2}{T_1 - WBT_{inlet}}$

Where,

T_1 - Inlet water temperature (^{0}C)

T_2 - Outlet Water temperature (^{0}C)

WBT_{inlet} - Wet Bulb Temperature inlet Reading

2. Humdification efficiency $= \dfrac{W_3 - W_2}{W_3 - W_1}$

From Psychomatic chart

Where,

W_1 - Specific Humidity of air at inlet condition

W_2 - Specific Humidity of air at outlet condition

W_3 - The maximum possible limit to which air can be humidified upto saturation condition corresponding to spray water temp. of 548^0C

Observation and Tabulation :

Sl. No.	Inlet water Temp	Outlet water Temp	Intermittent Temperature		Inlet condition of air		Outlet condition of air		Ti for litr wat
	T_1	T_2	T_3	T_4	WBT	DBT	WBT	DBT	t
Unit	^0C	^0C	^0C	^0C	^0C	^0C	^0C	^0C	se
1.									
2.									
3.									
4.									
5.									

3. The characteristics of the tower $= \frac{T_{1\ 2}\text{-}T}{2h}$

Where, $h = h_i + h_0$

Where, h_i - $(h_1 - h_2)$ inlet

h_0 - $(h_1 - h_2)$ outlet

$h_1 - h_2$ = enthalpy of saturated air - enthalpy of air

4. Mass Flow rate of air, $m_a = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \times a$

$_w = 1000\ kg/m^3$ $\qquad _a = 1.16\ kg/m^3$

$g = 9.81\ m/s^2$ $\qquad CPW = 4.178\ KJ/Kg\ K$

$h = \frac{w}{a}(h_1 - h_2)$

$a_1 = /4\ d_1^2$

$a_2 = /4\ d_2^2$

5. Ratio of mass flow rate of water to air $= \frac{mw}{ma}$

6. Energy transferred = m_a dho KJ/sec

Where dho - Rate of rise in enthalpy

7. Energy input = m_w CPw dt. KJ/sec

8. Energy efficiency $= \frac{\text{Energy Transferred}}{\text{Energy Input}} \times 100\ \%$

Procedure :

Connect the water and power supply to the equipment. Adjust the flow rate of water and air.

Switch on the heater and adjust the powre input to the heater allow the unit to stabilize. Note the manometer reading. Note the water flow rate using stopwatch.

Note the inlet and outlet temperature of water, and the condition of air at inlet and outlet by noting the readings on the wet & dry bulb thermometers.

Repeat the experiment for various flow rates & power input.

Calculation :

Result :

The performance Test was conducted on the cooling tower and the results are

1. Humdification efficiency = ________________________________
2. Energy efficiency = ________________________________