

HEAT POWER LAB

5th Sem Diploma

MECHANICAL ENGG. DEPT.

List Of Experiments :-

1. To study about ~~domestic~~ refrigeration system and construction features of domestic refrigerators.
2. Study the construction features of Water cooler.
3. Study about air conditioning and window type air conditioner.
4. Determine the COP of an A.C. system.
5. Determine the brake thermal efficiency of diesel engine.
6. Determine the mechanical efficiency of an air compressor.
7. Determine the BHP, IHP, BSFC of a multi cylinder engine by Morse test.

Expt: 01

①

AIM OF THE EXPT. :- To study vapour compression refrigeration system and domestic refrigerator.

APPARATUS REQUIRED :-

Domestic Refrigerator

THEORY :-

A vapour compression refrigeration system & now a days used for all purpose of refrigeration. It uses a refrigerant sealed in air tight and leak proof mechanism. The refrigerant is circulated through the system and undergoes a number of changes in its state while passing through various parts of the machine. The refrigerant ($R-13$) absorbs heat from one place and releases it to other place.

Vapour compression Refrigeration System
Mechanism of Domestic Refrigerator :-

The domestic refrigerator consists of 5 essential parts :-

1. COMPRESSOR :

The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to high pressure and temperature. Thus high press. and temp. vapour refrigerant is discharged into the condenser through the delivery or discharge valve.

2. CONDENSER :-

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The condenser or cooler consists of coils of pipes in which the high press. and temp. vapour refrigerant is cooled and condensed. The refrigerant, while passing through the condenser, gives up its latent heat to the surrounding medium which is normally air or water.

3. RECEIVER :-

The condensed liquid refrigerant from the condenser is stored in a vessel known as receiver from where it is supplied to the evaporator through the expansion valve.

4. EXPANSION VALVE :-

It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and temp. to pass at a controlled rate after reducing its press. and temp. Some of liquid refrigerant evaporates as it passes through the expansion valve, but the greater portion is vaporised in the evaporator at the low pressure and temperature.

5. EVAPORATOR :-

An evaporator consists of coils of pipe in which the liquid-vapour refrigerant at low press. & temp. is evaporated and changed into vapour refrigerant at low pressure and temperature.

In evaporating, the liquid vapour refrigerant absorbs the latent heat of vaporization from the medium (air, water or brine) which is to be cooled.

DOMESTIC REFRIGERATOR.

Domestic refrigerator is used for preserving food and thereby reducing waste. The primary function of the refrigerator is to provide food storage space maintained at low temperature for the preservation of food. Its essential secondary function is the formation of ice cubes for domestic consumption. A storage temp. of 0°C to 4°C (273K to 277K) is satisfactory for the preservation of most of the fresh foods. The freezers are generally provided at the top portion of the refrigerator space. In some refrigerators, freezers are provided at bottom.

(4)

The refrigerators may be single door, top freezer, double door bottom freezer, double door side by side door freezer, and side by side door freezer. The double door refrigerators are very commonly used now-a-day. These refrigerators are divided into compartments, one for fresh food or general items and other for the storage of frozen food.

The refrigerant used one generally R-12 or R-22. The compressor is mounted at the bottom of the refrigerator frame. The power of the compressor can vary according to size of the refrigerator (i.e. 75 W, 92 W, 125 W, 180 W, 370 W etc.). The condenser is put at the back about 40-60 mm away from the cabinet. The condenser may be either chalk type or tube and wire type. The capillary tube (expansion valve) is kept in contact with the evaporator inlet pipe. A drier is connected between the receiver and the evaporator to eliminate traces of moisture if any. The evaporator coil is wrapped around the freezer in a suitable manner to give efficient heat transfer. The cooling of lower space is accomplished by free convection. The thermostatic sensing element is provided to the evaporator coil which can control temperature in the freezer upto -15°C in steps or continuously depending upon the type of controlling switch employed.

The refrigerator body is provided with good quality insulation in order to prevent heat transfer into the system. Usually 60 to 100 mm thick glass fibre fill fiber or glass wool as thermocole is used since the conductivity of the insulating materials are quite low.

The refrigerators are fitted with the following controls :-

- a) Starting relay
- b) Overload Protector
- c) Thermostat.

CONCLUSION

From the above experiment we successfully studied about the construction features of domestic refrigerator.

Expt - 02

(1)

AIM OF THE EXPT :-

To Study about water cooler.

APPARATUS REQUIRED :-

Water Cooler

THEORY :-

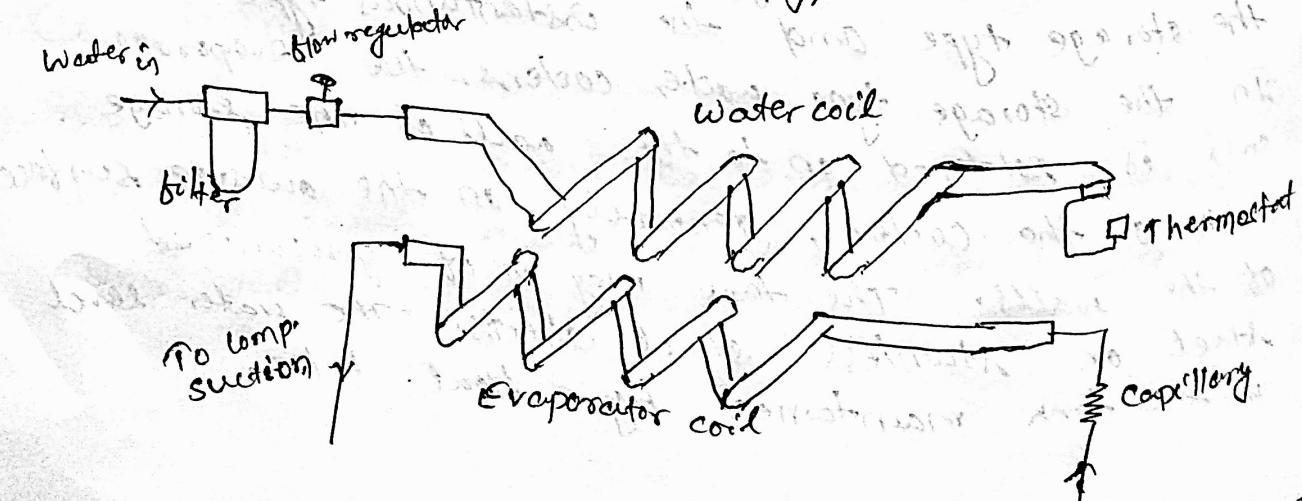
The purpose of water cooler is to make water available at a constant temperature irrespective of ambient temperature. They are meant to produce cold water at about 7°C . to 15°C (280K to 286K) for quenching the thirst of the people working in hot environment. The warm or normal water can serve the physical requirement of our system for the proper functioning of the body organs but it does not quench the thirst especially in hot summers. The temperature of cold water is controlled with the help of thermostatic switch set within 7°C . to 13°C range.

There are two types of water coolers i.e. the storage type and the instantaneous type. In the storage type water coolers, the evaporator coil is soldered on to the walls of the storage tank of the cooler, generally on the outside surface of the walls. The tank may be of galvanized steel or stainless steel sheets. The water level in the tank maintained by a float valve.

In this type of water cooler, the machine will have to run for a long time to bring down the temperature of the mass of water in the storage tank. Once the temperature touches the set point of the thermostatic, the machine cycle is stopped. When the water is drawn from the cooler and an equal amount of fresh water is allowed in the tank, the temperature will rise up slowly and the machine starts again. As such there is always a reservoir of cold water all the time.

In case of instantaneous type water coolers, the evaporator consists of two separate ~~cold~~ cylindrically wound coils made of copper or steel tube. In the figure, the cooling coil and water coil are shown separately, otherwise, the coils are entwined and bonded together by soldering. The evaporating refrigerant is one of the coils and the water to be cooled is in the other coil. The water is cooled by the refrigerant in evaporator by conduction. These water coolers are further classified as -

- bullet type
- pressure type and
- set & contained remote type.



(a) Bottle type :-

This type of water cooler employs a bottle or reservoir for storing water to be cooled. No city main inlet connection is required as it is normally used to cool water supplied in 25 litre glass bottles, which are placed on top of the unit.

(b) Pressure type :-

In this type of water cooler water is supplied under pressure. The city main water enters the cooler through the inlet connection at the rear of the cooler. It then passes through a pre-cooler. The pre-cooler is cooled by the waste water of the cooler. As the waste water ^{temp.} is low, it is made use of cooling the supply water by passing through a pipe coil wrapped around the drainage line (a counter-flow heat exchanger). This arrangement helps in reducing the cooling load for the cooler.

The amount of cooling depends upon the quantity of waste water and the length of the pipe coil comprising of pre-cooler.

The pre-cooled water then enters the storage chamber and passes its heat to the refrigerant. The outlet water pipe is connected at the bottom of the storage tank, which is fitted with a self closing valve or bubbler.

(c) Self Contained Remote type :-

This type of cooler employs a mechanical refrigeration system. The water cooled from the remote cooler is supplied to desired drinking place away from the system. This type of arrangement does no require extra space near the place of work and is quite useful.

(4)

- The fauced or push type water taps are generally provided for drawing cold water in both the types in order to minimize the wastage of refrigerated water.

- The thermostatic controls the operation of the refrigeration compressor to maintain the water temperature within the set limits. In case of instantaneous cooler, the感温 bulb is kept immersed in water in the tank or clamped to the wall of the storage tank on the outside, at a lower level, much below the lower most evaporator refrigerant tube, soldered on the tank.

- In the case of instantaneous type cooler, it is very important that the flow rate of water is adjusted to match its capacity. If the rate of flow is higher, the cooler will not be able to bring down the temperature of water to the set level. It may be noted that with a very high flow rate, the refrigeration system will work at very high evaporator temperature (so at a higher suction pressure) which may adversely affect the compressor motor of the cooling unit.

CONCLUSION:-

From the above experiment we briefly studied about the water coolers.

AIM OF THE EXPT. -

To study about air conditioner.
and window type ac.

Apparatus REQUIRED -

Air conditioning unit.

THEORY -

Air conditioning is broadly used for conditioning of air i.e. supplying and maintaining desirable internal atmospheric conditions for human comfort, irrespective of external condition.

Factors Affecting Air Conditioning

The four main important factors for comfort air conditioning are :-

1. Temperature of air -

Control of temperature means the maintenance of any desired temperature within an enclosed space even though the outside air is above or below the desired room temperature. This is accomplished either by the addition or removal of heat from the enclosed spaces as and when demanded. Human being may feels comfort when the air is at 21°C with 56% relative humidity.

2. Humidity of air -

It means the decreasing or increasing of moisture contents of air during summer or winter respectively in order to produce comfortable and healthy conditions. It can increase the efficiency of workers also. In summer the relative humidity should not be less than 60% whereas for winter it should not be more than 40%.

3. Priority of air -

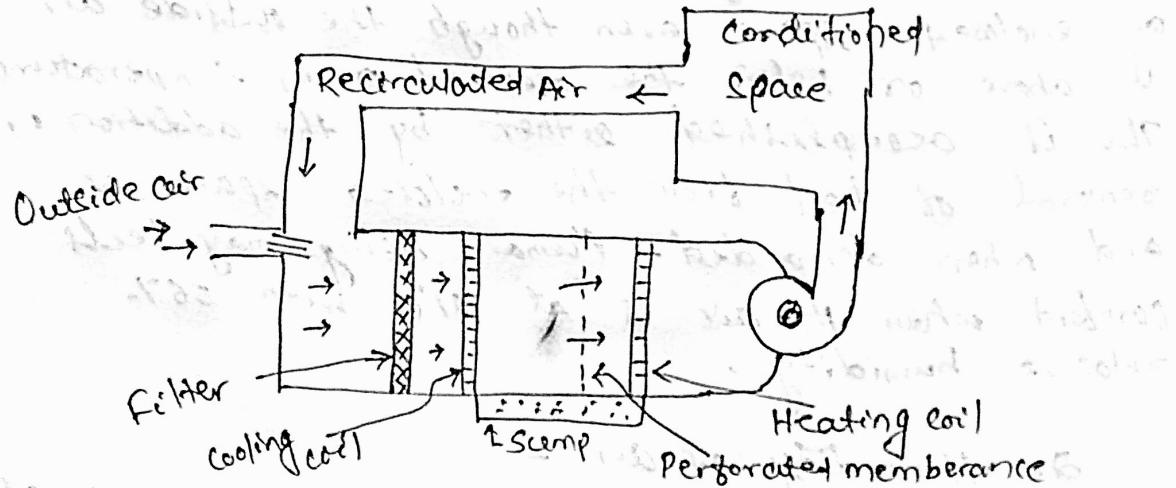
To avoid breathing contaminated air outside & it is thus obvious that proper filtration, cleaning and purification of air is essential to keep it free from dust and other impurities.

4. Motion of air -

The motion or circulation of air should be controlled, in order to keep constant temperature throughout the conditioned space.

SUMMER AIR CONDITIONING SYSTEM -

It is the most important type of air conditioning, in which the air is cooled and generally dehumidified.



The outside air flows through the damper and mixes up with recirculated air (which is obtained from the conditioned space). The mixed air passes through the filter to remove

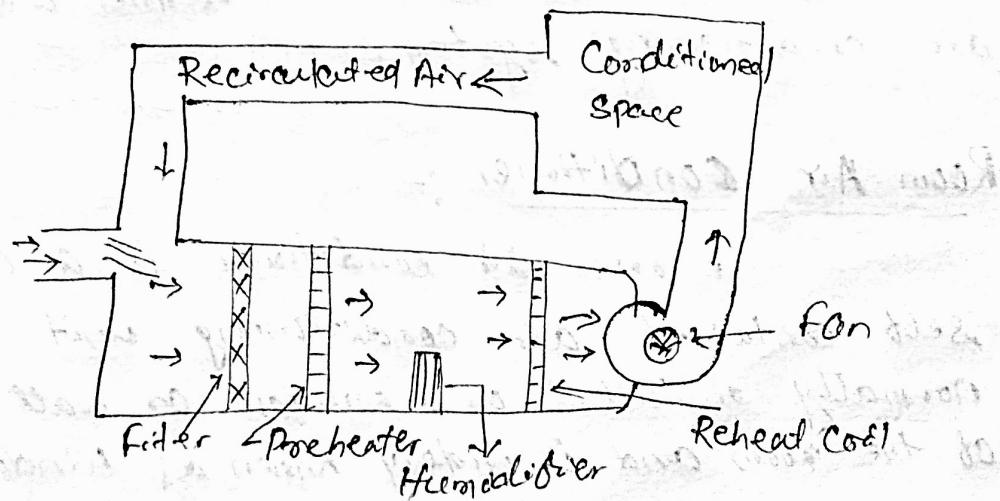
(3)

dirt, dust and other impurities. The air now passes through a cooling coil. The coil has a temperature much below the required dry bulb temp. of the air in the conditioned space. The cooled air passes through a perforated membrane and loses its moisture in the condensed form which is collected in a sump. Then the air is passed through a heating coil which heats up the air slightly. Thus it done to bring the air to the designed dry bulb temp. and relative humidity.

Now the conditioned space it air is supplied to the conditioned space by a fan. From the conditioned space a part of the air is exhausted to the atmosphere by the exhaust fans. The remaining part of the used air (known as recirculated air) is again conditioned. The outside air is sucked and made to mix with the recirculated air in order to make up for the loss of conditioned (or used) air through exhaust fans or ventilation from the the conditioned space.

WINTER AIR CONDITIONING SYSTEM :-

In winter air conditioning, the air is heated, which is generally accompanied by humidification.



(4)

The outside air flows through a damper and mixes up with the recirculated air. The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a preheat coil in order to prevent the possible freezing of water and to control the evaporation of water in the humidifier. After that the air is made to pass through a reheat coil to bring the air to the designed dry bulb temperature. Now the conditioned air is supplied to the space to be conditioned by a fan. From the conditioned space, a part of used air is exhausted to the atmosphere by the exhaust fans or ventilators. The remaining part of the used air is again conditioned. The outside is sucked and made to mix with recirculated air, in order to make up for the loss of conditioned (or used) air through exhaust fans from the conditioned space.

The Year-Round Air conditioning system should have equipment for both the summer and winter air conditioning system.

Room Air Conditioner :-

A room air conditioner is a compact, self contained air conditioning unit which is normally installed on a window or wall opening of the room and is widely known as window type AC.

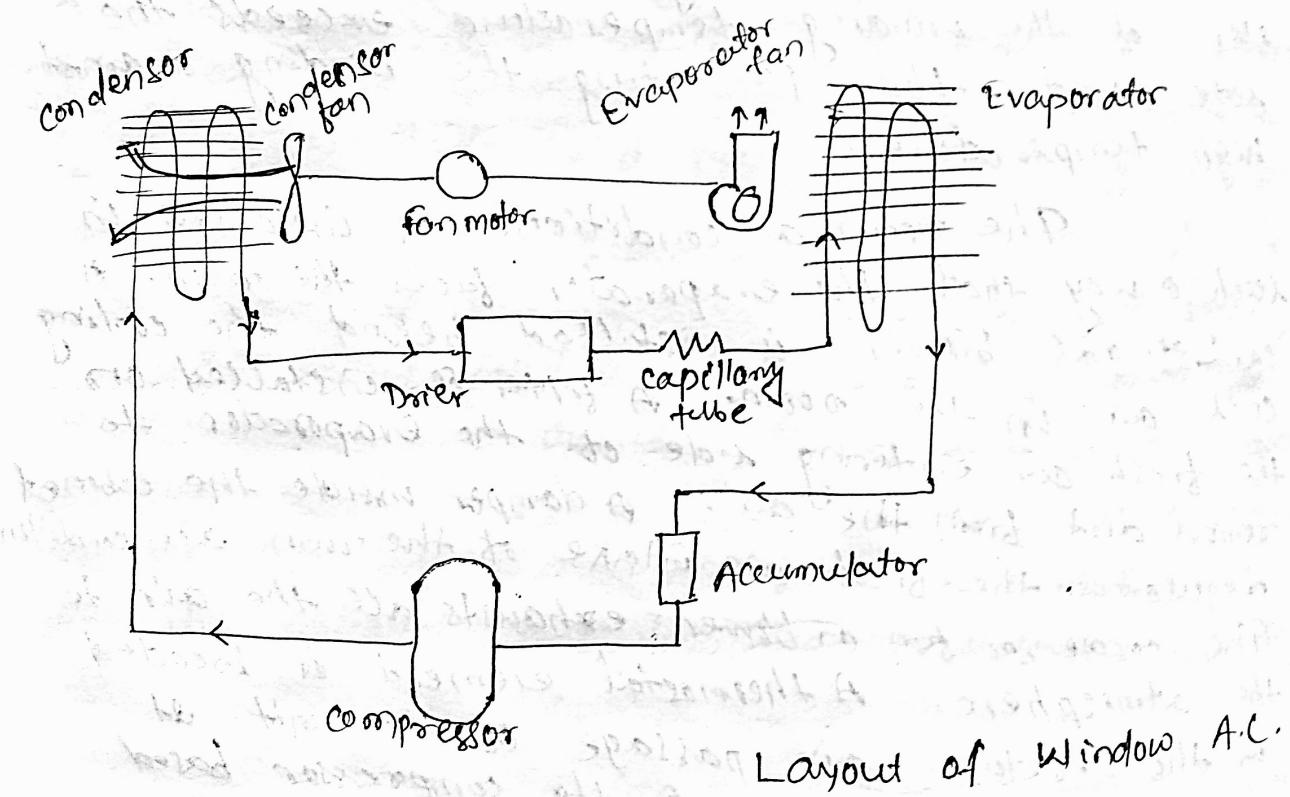
A complete unit of air conditioner consists of the refrigeration system, the control system (thermostat and selector switch), electrical protection system, air circulation system, ventilation and exhaust system.

The refrigeration system consists of a hermetic type compressor, forced air-cooled finned condenser coil, finned cooling coil, capillary tube as the throttling device and a refrigerant drier. The refrigerant used is R-12 or R-22. In hermetic compressors, a winding thermostat is embedded in the compressor motor windings. It puts off the compressor if the winding temperature exceeds the safe limit, thus protecting the winding against high temperature.

The room air conditioner is installed in such a way that the evaporator faces the room. A centrifugal blower is installed behind the cooling coil air in the room. A filter is installed on the fresh air entering side of the evaporator to remove dirt from the air. A damper inside the cabinet regulates the fresh air intake of the room air-conditioning. The condenser fan or blower exhausts all the air to the atmosphere. A thermostatic element is located in the return air passage of the unit. It controls the operation of the compressor based on the return air temp. which indicates the room temperature. When the required temperature is obtained, the compressor is stopped.

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A selector switch often known as master control, controls the compressor motor, condenser fan motor, and evaporator fan motor. When the control switch is in ventilate position, only evaporator blower motor operates and outside fresh air is supplied in the room which is not cool as the compressor is not working. In the 'cool' position all the motors i.e., compressor, compressor condenser evaporator motor are in working state and cool air is supplied to the room.



Conclusion:

From the above experiment we briefly studied about window A.C.

Air conditioning system and

Expt. No: 04

AIM OF THE EXPT :-

To determine the COP of simple vapour compression air conditioning system.

APPARATUS REQUIRED :-

Air Conditioning test rig.

THEORY

The vapour compression air conditioning system is now a days used for all purpose of air conditioning. It uses refrigerant sealed in air tight and leak proof mechanism through the system and the refrigerated is circulated through the system and undergoes a number of changes in its state. While passing through various parts of the system, the refrigerant absorbs heat from one place to another.

Construction :-

A simple vapour compression air conditioning system consists of a compressor, condenser, receiver, expansion valve and evaporator. The compressor consists of an arrangement in which an electric motor is provided. The condenser is made in a coil shaped receipt refrigerant A storage tank in which the liquid vapour refrigerant at a pressure is get evaporated. The refrigerant used is R-22.

Working Procedure :-

The low pressure vapour is dry sterile drawn from the evaporator during the suction stroke of the compressor. During compression, the pressure and temperature is increased. When the high pressure refrigerant vapours enter into the condenser, heat flows from condenser to cooling medium, thus allowing the vaporized refrigerant to return the liquid state.

After condensation, the liquid refrigerant is stored in the liquid receiver. Then it is passed through the expansion valve, where the pressure is reduced sufficiently to allow the vaporization of the liquid at a low temp. The low pressure refrigerant vapor after expansion enters the evaporator where heat is absorbed by it and the cycle is completed.

Observation :

Temperature °C	Enthalpy		Entropy	
	h_f	h_g	s_f	s_g
T_1				In g/cm²
T_2				= 1000
T_3				g/cm² = 1000
T_4				g/cm² = 1000

where T_1 = temp. of Compressor inlet

T_2 = temp. of Compressor outlet

T_3 = Condenser outlet temp.

T_4 = Evaporator inlet temp.

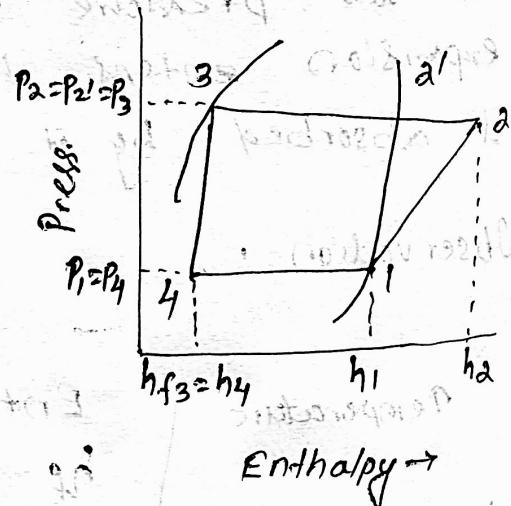
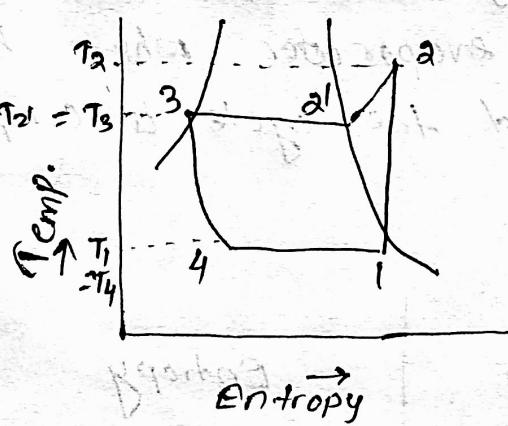
P_1 = Inlet pressure of compressor

P_2 = Outlet pressure of compressor

Enthalpy is determined by the corresponding values of temp. & pressure in the psychometric chart. (P-h chart)

Now the G.O.P. = $\frac{h_1 - h_{f3}}{h_2 - h_1}$.

As the cycle is completed with superheated vapour after compression the T-s and P-h diagram will be as -



enthalpy at

$$\text{Point } 1 - h_1 = h_g$$

$$4 - h_4 = h_{f3}$$

enthalpy at point 2 h_2

$$h_2 = h_{2'} + C_p \times \text{Degree of superheat}$$
$$= h_{2'} + C_p (T_2 - T_{2'})$$

$$C.O.P = \frac{h_1 - h_{f3}}{h_2 - h_1} : \frac{\text{refrigeration effect}}{\text{work done}}$$

The C.O.P of the air conditioner is found to be ____.

Expt No: 05

AIM OF THE EXPT :-

To determine the brake thermal efficiency of the diesel engine.

APPARATUS REQUIRED :-

Diesel engine test Rig

Engine Specification :-

Make :

BHP : 17

Speed : 1500

No. of cylinder : two

Compression Ratio : 16.5 : 1

Bore : 95 mm

Stroke : 110 mm

Orifice Dia : 25 mm

Type of ignition : compression ignition

Method of starting : Crank shaft

Method of cooling : Water

THEORY :-

Brake Thermal Efficiency :

Brake thermal efficiency & the ratio of energy in the brake power (BP) to the input fuel energy in appropriate units.

The diesel engine test rig consists of following arrangements to conduct the experiments.

1. Fuel Measuring arrangement :-

This arrangement of a fuel tank of suitable capacity mounted on a stand. The fuel goes to the engine through a 50 ml burette. The burette facilitates the measurement of fuel consumption for a definite period of time, with the help of stop watch.

2. Measuring the Heat :-

Suitable pipe fittings is provided for circulating the cooling water into the engine. The rate of flow of water circulation is measured with the help of measuring cylinder and stopwatch. The temperature of inlet and outlet water can be measured with the help of thermometer.

3. Air intake measurement :-

It consists of an orifice, a diaphragm based manifold and a U-tube manometer. With the help of orifice and manometer the volume of the air sucked can be calculated.

4. Load Arrangement :-

Load is measured with the help of hydraulic brake dynamometer.

PROCEDURE :-

1. Fill oil in the oil sump of engine. It should be in between the marks provided on the oil dipstick. If oil level is reduced, add clean oil to the crankcase by opening the cover of valve provided, at the top of the engine.
2. Fill the diesel in diesel tank.
3. Fill the manometer upto half of the height of manometer with water.
4. Fill the burette with diesel by opening the valve provided at the lower side of burette.
5. Supply the diesel to the engine by opening the valves provided in the supply line.
6. Open cold water supply to the engine for cooling the engine jacket and open the water supply for hydraulic brake dynamometer.
7. Then start the engine.
8. Run the engine for 10 minutes so that it can be stabilize. Then load on engine with the help of hand wheel and other additional weight.

9. Now note down the reading of spring balance and other additional weight.
10. Measure the RPM of dynamometer shaft.
11. Close the diesel supply valve and open the valve of burette. Note down the time to consume 100 ml of diesel with the help of stop watch.
12. Close the burette valve and open the diesel supply valve
13. Note down the reading of manometer to calculate the air intake by the engine
14. Measure the flow rate of water with the help of water meter and stop-watch.
15. Repeat the experiment for different load and different speeds.
16. Reduce the load on engine and press the lever provided on the right hand side of the engine to stop the engine.

STANDARD DATA

D = Dia. of bore of engine

= 95 mm

L = stroke of engine

= 110 mm

d_o = Dia. of orifice

= 25 mm

a_o = area of orifice

$\approx 4.906 \times 10^{-4} \text{ m}^2$

C_d = Co-efficient of discharge = 0.64

ρ_a = Density of air at 0° C. = 1.293 kg/m³

ρ_w = Density of water = 1000 kg/m³

T_1 = temp. of water at inlet of the engine

T_2 = temp. of water at outlet of the engine

C_p = Specific Heat of water = 4.18 kJ/kg°C

C_v = calorific value of diesel = 42630 kJ/kg

Specific gravity of diesel = 0.78 gm/cc

A_p = Area of pipe = $5.27 \times 10^{-4} \text{ m}^2$

FORMULAE :

$$\bullet \quad BHP = \frac{W \times N}{1000} \quad HP$$

W = net weight lifted by the dynamometer

• Fuel Consumption

$$W_f = \frac{x}{t} \times \frac{\text{Sp. gravity of fuel}}{1000} \times 3600 \quad \text{kg/hr}$$

x = volume of diesel consumed (ml)

t = time taken for x (sec.)

• Specific fuel consumption :-

$$\frac{\text{Fuel consumption}}{\text{BHP}} \quad \text{kg/BHP hr}$$

- Heat in fuel supplied (H_f)

$$H_f = m_f \times C_v / 60 \text{ KJ/min}$$

m_f = mass of fuel supplied kg/min

- Brake thermal Efficiency (η_{bth})

$$\eta_{bth} = \frac{\text{Heat equivalent to BHP}}{\text{Heat supplied by fuel, } H_f}$$

- Heat equivalent to BHP (H_{bp})

$$H_{bp} = \frac{\text{BHP} \times 746 \times 60}{1000} \text{ KJ/min}$$

- Heat carried away by engine jacket cooling water

$$H_{cw} = m_{cw} \times C_p (T_a - T_i) \text{ KJ/min}$$

m_{cw} = mass of cooling water supplied kg/min
= Water in LPM $\times \frac{1}{1000} \times 1000$ kg/min

- Air Consumption (Q_a)

Quantity of air sucked through orifice (Q_a)

$$Q_a = \frac{C_d A_0 \sqrt{2g H}}{1 - (A_0/A_p)^2} \text{ m}^3/\text{sec}$$

$$H = h \left\{ \left(\frac{P_m}{P_a} - 1 \right) \right\}^2$$

H = total pressure head m

h = Manometer difference m

• Swept Volume (V_s)

$$V_s = \frac{\pi}{4} D^2 \times L \times (\text{cycles/sec}) \times \text{No. of cylinders}$$

$$= \frac{\pi}{4} D^2 L \times \frac{1500}{2 \times 60} \times 2 \quad \text{m}^3/\text{s}$$

• Volumetric efficiency ($\eta_{vol.}$)

$$\eta_{vol.} = \frac{\text{Vol. of air actually sucked during suction stroke}}{\text{Swept Volume}} \times 100$$

OBSERVATION TABLE

BHP	Spring balance reading w_1 in kg				
	Weight added w_2 kg				
RPM					
fuel consumption	Vol. of diesel consumed x ml				
	time taken for x, t sec				
Heat carried by cooling water water through engine jacket	Water inlet temp. in engine jacket, T_1 °C				
	Water outlet temp. T_2 °C				
	Water flow rate in LPM				
	Manometer pressure diff., h cm				

CONCLUSION :-

The brake thermal efficiency of the diesel engine is found to be _____.

AIM OF THE EXPT. :-

To determine the mechanical efficiency of an air compressor.

APPARATUS REQUIRED :-

Air compressor test rig.
Tachometer
Stop watch.

THEORY :-

An air compressor is the machine which compresses the air and to raise its pressure. The air compressor sucks air from atmosphere, compresses it and then delivers the same under a high pressure to a storage vessel. It is called a positive displacement compressor because air is first sucked in a chamber and the compression is achieved by decreasing area of the chamber.

- It consists of -
1. Cylinder
 2. Piston
 3. Inlet valve
 4. Outlet valve
 5. Pressure gauge
 6. Pressure vessel

(2)

WORKING PRINCIPLE :-

When the piston moves downward the pressure inside the cylinder falls below the atmospheric pressure. Due to this pressure difference the inlet valve gets opened and the air is sucked into the cylinder at inlet pressure till the piston completes the outward stroke. Now when the piston moves upward the pressure inside the cylinder goes on increasing till it reaches the discharge pressure. At this stage the discharge valve opens and air is delivered to the container. At the end of the delivery stroke a small quantity of air, at high pressure is left in the clearance space, as the piston starts its suction stroke, the air contained in the clearance space expands till pressure.

At this stage the inlet valve gets opened as a result of which fresh air is sucked into the cylinder and the cycle is repeated.

TYPES OF RECIPROCATING AIR COMPRESSOR :-

1. Single Acting
2. Double Acting
3. Single stage air compressor
4. Double stage air compressor

1. Single Acting :-

In single acting reciprocating air compressor only single side of the piston is used for the compression of the air and other side is connected to the crankcase and not used for compression.

2. Double Acting :-

In this type of compressor, both the sides of the piston is used for the compression of the air. When suction takes place at one side then compression is taking place at other side. Both suction and compression takes place on each stroke of the piston.

3. Single Stage :-

In single stage reciprocating air compressor the compression of the air takes place in a single cylinder. In the first stroke, it sucks the air from the atmosphere and in the second stroke it compresses it and deliver it to the storage tank.

(4)

4. Double Stage :-

In this type of compressor, the compression of the air takes place in two stages i.e. the air is first compressed to some extent in one cylinder and then it is transferred to the second cylinder for further compression. Finally the compressed air is stored in a tank.

SPECIFICATION :-

Make

Diameter of low pressure piston : $70 \text{ mm} = 0.07 \text{ m}$
 " high pressure : $57 \text{ mm} = 0.057 \text{ m}$

Stroke

Operating Pressure : 2 kg/cm^2

Speed

: 1440 RPM

Diameter of orifice

: $11 \text{ mm} = 0.011 \text{ m}$

Power

: 2 HP

PROCEDURE :-

1. Open the discharge valve of the compressor and draw off air completely and close the valve.

(5)

2. Start the compressor, by starting the compressor motor & observe the pressure developing slowly.
3. At the particular test pressure, the outlet valve is opened slowly and adjusted so that the pressure in the tank maintained constant.
4. At the particular test pressure, note the following reading
 - (i) Manometer
 - (ii) Speed of the compressor
 - (iii) Pressure
 - (iv) Time taken for 10 rev. of energy meter
5. Adjust the discharge valve so that pressure changes again.
6. Repeat the above procedure for different pressures.
7. Switch off the power supply and stop the compressor.

S.No.	Pressure (kgf/cm ²)	Energy meter reading for 'n' number of revolutions	Diff. in manometer reading h_w , cm	Speed N rpm	Actual Volume V_a m ³ /sec	Theoretical Volume V_t m ³ /sec	Volumetric efficiency $\eta_{vol.}$
1	2	200	0.0	100	0.0	0.0	0.0
2	4	400	0.0	100	0.0	0.0	0.0
3	6	600	0.0	100	0.0	0.0	0.0
4	8	800	0.0	100	0.0	0.0	0.0
5	10	1000	0.0	100	0.0	0.0	0.0
6	12	1200	0.0	100	0.0	0.0	0.0
7	14	1400	0.0	100	0.0	0.0	0.0
8	16	1600	0.0	100	0.0	0.0	0.0
9	18	1800	0.0	100	0.0	0.0	0.0
10	20	2000	0.0	100	0.0	0.0	0.0
11	22	2200	0.0	100	0.0	0.0	0.0
12	24	2400	0.0	100	0.0	0.0	0.0
13	26	2600	0.0	100	0.0	0.0	0.0
14	28	2800	0.0	100	0.0	0.0	0.0
15	30	3000	0.0	100	0.0	0.0	0.0
16	32	3200	0.0	100	0.0	0.0	0.0
17	34	3400	0.0	100	0.0	0.0	0.0
18	36	3600	0.0	100	0.0	0.0	0.0
19	38	3800	0.0	100	0.0	0.0	0.0
20	40	4000	0.0	100	0.0	0.0	0.0
21	42	4200	0.0	100	0.0	0.0	0.0
22	44	4400	0.0	100	0.0	0.0	0.0
23	46	4600	0.0	100	0.0	0.0	0.0
24	48	4800	0.0	100	0.0	0.0	0.0
25	50	5000	0.0	100	0.0	0.0	0.0
26	52	5200	0.0	100	0.0	0.0	0.0
27	54	5400	0.0	100	0.0	0.0	0.0
28	56	5600	0.0	100	0.0	0.0	0.0
29	58	5800	0.0	100	0.0	0.0	0.0
30	60	6000	0.0	100	0.0	0.0	0.0
31	62	6200	0.0	100	0.0	0.0	0.0
32	64	6400	0.0	100	0.0	0.0	0.0
33	66	6600	0.0	100	0.0	0.0	0.0
34	68	6800	0.0	100	0.0	0.0	0.0
35	70	7000	0.0	100	0.0	0.0	0.0
36	72	7200	0.0	100	0.0	0.0	0.0
37	74	7400	0.0	100	0.0	0.0	0.0
38	76	7600	0.0	100	0.0	0.0	0.0
39	78	7800	0.0	100	0.0	0.0	0.0
40	80	8000	0.0	100	0.0	0.0	0.0
41	82	8200	0.0	100	0.0	0.0	0.0
42	84	8400	0.0	100	0.0	0.0	0.0
43	86	8600	0.0	100	0.0	0.0	0.0
44	88	8800	0.0	100	0.0	0.0	0.0
45	90	9000	0.0	100	0.0	0.0	0.0
46	92	9200	0.0	100	0.0	0.0	0.0
47	94	9400	0.0	100	0.0	0.0	0.0
48	96	9600	0.0	100	0.0	0.0	0.0
49	98	9800	0.0	100	0.0	0.0	0.0
50	100	10000	0.0	100	0.0	0.0	0.0

S.No.	Gauge pressure (kgf/cm ²)	Motor input power P _e KN	Output power P _o KW	Compressor input	Compressor output	Isothermal efficiency

CALCULATIONS:-

1. Actual Air intake:

Manometer reading $h_1 = \text{cm of water}$
 " $h_2 = \text{cm of water}$

Difference in water level $\frac{h_1 - h_2}{100} \text{ m of water}$

Equivalent air column, $h_a = \frac{h_w \times \rho_{air}}{\rho_{water}} = \frac{h_w \times 1000}{1.16} \text{ m of air}$

Volumetric Efficiency = $\frac{V_{actual}}{V_{theoretical}}$

" Actual volume of air compressed V_{act}
 $V_{act} = Cd \times A \times V_{2g} h_w \text{ m}^3/\text{sec}$

$Cd = \text{Coefficient of discharge} = 0.64$

$A = \text{Area of orifice}$

Theoretical volume of air

$$V_{th} = \frac{\pi}{4} \frac{D^2 L N}{60} \text{ m}^3/\text{s}$$

$D = \text{Dia. of piston}$

$L = \text{Stroke length}$

$N = \text{Speed}$

$$\text{Isothermal Efficiency} (\eta_{is}) = \frac{V_{ac}}{V_{th}} \times 100$$

- Torque $T = F \times R$
- F = force in Spring balance
 R = Radius of swing lever

- Isothermal HP = $\frac{Q_{NTP}}{75} \times \text{fa} \times r$
- fa = atm. pressure
 r = compression ratio = $\frac{\text{Gauge Pr.} + \text{Atm. Pr.}}{\text{Atm. Pr.}}$

- Head rejected in inter cooler

$$H = M_d \times C_p \times (T_2 - T_3) \quad \text{units}$$

$$C_p = 1 \times 10^3 \text{ J/kg/K}$$

CONCLUSION :-

The efficiency of the air compressor is found to be medium.

AIM OF THE EXPT. :-

To determine the BHP, IHP of multi cylinder petrol engine by morse test.

APPARATUS REQUIRED

Multi cylinder Petrol engine test rig.

THEORY

The morse test is used to find out the indicated power of a multi cylinder reciprocating engine. The engine is run at a particular speed and the torque is measured by cutting out the firing of each cylinder in turn and noting the fall in brake power each time while maintaining the set engine speed by reducing load.

PROCEDURE :-

Load the engine to maximum load (24kg) at rated speed (1500RPM). Allow it to run for few minutes. Cut off the first cylinder by opening the knife switch. Now the engine is running in 3 cylinders only. As a result the speed of the engine decreased by turning the E.C. drive knob in anticlockwise direction to reduce the load slowly, so as the speed of

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the engine comes back to its rated speed (1500 rpm). Re-record the load on the engine. Now without altering the load and the accelerator knob, switch on the knife of 1st cylinder to its original position and wait till all the four cylinders working and cut off the second cylinder and observe the engine speed. If the speed of the engine does not reach the rated speed, increase or decrease the load according to requirement. Record the load after attaining the rated speed. ~~Follow~~ Follow the similar procedure for the rest of the cylinders.

Calculate the BHP when all the four cylinders are working. Similarly calculate the BHP of four cylinder when each of the cylinders is disconnected. By this method indicated horsepower of the engine can be calculated.

BHP, when four cylinders are working = BP
BHP of 3 cylinders when 1st cylinder is cut off = BP₁
BHP of " 2nd " " " = BP₂
BHP of " 3rd " " " = BP₃
BHP of " 4th " " " = BP₄

IHP of 1st cylinder = IP₁ = BP - BP₁

, 2nd cylinder = IP₂ = BP - BP₂

, 3rd cylinder = IP₃ = BP - BP₃

, 4th cylinder = IP₄ = BP - BP₄

Total IHP of the engine IP = (IP₁ + IP₂ + IP₃ + IP₄)

FORMULAS.

1. Brake Power (BP)

$$BP = \frac{\alpha \pi NT}{4500} \times 0.75 \text{ KW}$$

N = Speed of the engine in RPM

T = torque = $W \times R_e$

W = Load in kg

Radius Arm length in mts

2. Weight of fuel consumed (W_f) in Kg/hr

$$W_f = \frac{X_{cc} \times \text{Sp. gravity of fuel} \times 60 \times 60}{T \text{ sec} \times 1000}$$

X_{cc} = Vol. of fuel consumed in T sec.

Sp. gravity of petrol = 0.78 gm/cc

3. Sp. fuel consumption (SFC) kg/kW hr.

$$SFC = \frac{W_f}{BP}$$

4. Brake thermal efficiency (η_{bth})

$$\eta_{bth} = \frac{BP \times 3600}{CV \times W_f} \times 100 \text{ in \%}$$

CV of petrol = 42802 kJ/kg

5. Indicated thermal efficiency (η_{ith})

$$= \frac{IP \times 3600}{CV \times W_f} \times 100 \text{ in \%}$$

6. Mechanical Efficiency (η_{mech})

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

7. Actual volume (V_a) of air drawn into the cylinder at RTP in m³/hr & calculated by

$$V_a = Cd A_o \sqrt{\rho g h_w \frac{f_w}{P_a}} \times 3600 \text{ m}^3/\text{hr}$$

$$Cd = 0.62$$

A_o = area of orifice

h_w = manometric head in m of water

f_w = density of water = 1000 kg/m³

P_a = air = 1.293 kg/m³

8. Swept volume (V_s) in m^3/hr

$$V_s = \frac{\pi A L N}{2} \times 60 \times 3600$$

\rightarrow A = area of cylinder

L = stroke length

N = speed of engine

9. Volumetric Efficiency (η_{vol})

$$\eta_{vol} = \frac{V_a}{V_s} \times 100 \text{ in \%}$$

CONCLUSION:-

The BHP is found to be _____

The IHP is found to be _____

The SFC is found to be _____