GOVERNMENT COLLEGE OF ENGINEERING, KEONJHAR

(GCE KEONJHAR)

DEPARTMENT OF MECHANICAL ENGINEERING

THERMODYNAMICS LAB MANUAL

IV-SEMESTER MECHANICAL

NAME: ____

REGISTRATION NUMBER: ______________________________

SUBJECT: ____

SEMESTER: ____________________ **YEAR:** ____________________

DEPARTMENT OF MECHANICAL ENGINEERING

THERMODYNAMICS LAB MANUAL

IV-SEMESTER MECHANICAL

Edited and compiled by

Debi Prasad Sahoo
Assistant Professor
Mechanical Engineering Department

Prepared by

Aurobinda Das
Lab Instructor
Thermal Engineering Lab
Mechanical Engineering Department

GYANAM ANANTAM
ज्ञानम् अनन्तम्
GOVERNMENT COLLEGE OF ENGINEERING, KEONJHAR

Mechanical Engineering Department
Academic Year- 2022-2023

CONTENT

Sl. No.	Name of Experiment	Date	Page No.	Signature and Remark
1				
2				
3				
4				
5				
6				
7				
8				

Experiment No: - **Date: - / /**

Aim of the Experiment:

Load test on 4-stroke single cylinder CI engine.

Description:

An AC Alternator is fixed to the engine is mounted on ms channel frame. Panel board is used to fix burette with 3-way cock, digital RPM indicator, voltmeter, ammeter, temperature indicator and U tube manometer. The AC alternator with resistance rheostat is used here for the application of load on the engine.

Instrumentation:

1. Manometer to measure the quality of air drawn in to the engine cylinder.
2. Burette to measure the rate of fuel consumption.
3. Digital RPM indicator to measure the speed.
4. Voltmeter and Ammeter to check the voltage and current.

Engine Specification:

Make	:	Kirloskar
BHP	:	5HP
Speed	:	1500 RPM
No of cylinder	:	ONE
Compression ratio	:	16.5:1
Bore	:	80mm
Stroke	:	110mm
Orifice diameter	:	20mm

Type of ignition : Compression Ignition

Method of loading : AC alternator with rheostat

Method of starting : Crank Start

Method of cooling : Water

AC Generator/ Loading Rheostat

Voltage	:	230V
Ampere (MAX)	:	12 amps
Speed	:	1500RPM
Efficiency of alternator	:	78%
Nichrome wire wound	:	500Watts

Procedure:

Step 1:

Connect the panel instrumentation input power line to a 230V 50Hz single phase power source.

Step 2:

Fill fuel into the fuel tank mounted on the panel frame.

Step 3:

Check the lubricating oil in the engine sump with the help of dipstick provided.

Step 4:

Open the fuel lock provided under the fuel tank and ensure that no air is trapped the fuel line connecting the fuel line and engine.

Step 5:

Decompress the engine by decompression lever provided on the top of the engine head.

Step 6:

Crank the engine slowly, with the help of cranking handle provided and ascertain proper flow of fuel into the pump and in turn through the nozzle into the engine cylinder. When maximum cranking speed is attained, pull the decompression lever down, now engine starts. Allow the engine to run and stabilize.

Step 7:

Now load the engine with the help of rheostat by switching the resistance coil ON and wait for the RPM to get stable.

Step 8:

Now note down all the parameters which are required for calculation and mentioned in the table. After noting down the parameters repeat the same by increasing load.

Step 9:

To stop the engine after the experiment is over pull the governor lever towards the engine cranking side.

Formulas:

1. Brake Horse Power (BHP) = $\frac{V \times I}{736 \times \eta_g}$ HP

2. Weight of fuel consumed (W_f) = $\frac{X_{cc} \times 0.838 \times 60 \times 60}{T_{sec} \times 1000}$ Kg/hr

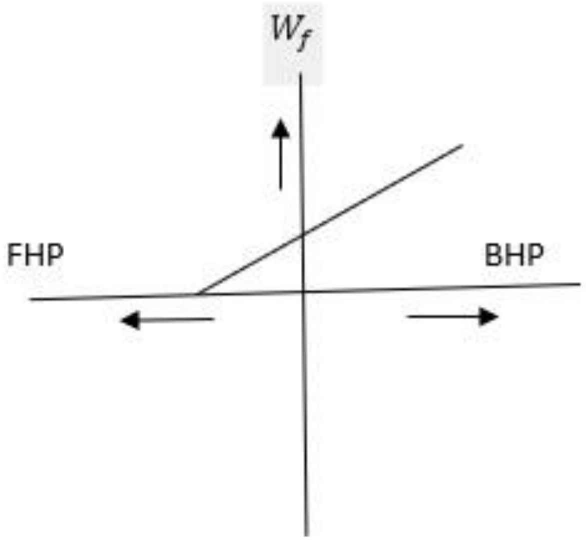
Where density of Diesel is 0.838 gm/cc

3. Specific fuel consumption (SFC) = $\frac{W_f}{BHP}$ Kg / BHP hr

4. Brake thermal efficiency (BTH) = $\frac{BHP \times 4500 \times 60 \times 100}{427 \times C_v \times W_f}$ %

   Where Calorific value of Diesel is 11000 Kcal/Kg

5. Indicated horse power (IHP) = Can be calculated by Williams Line Graph method.



   IHP = BHP + FHP

6. Mechanical Efficiency (η_{mech}) = $\frac{BHP}{IHP} \times 100$ in%

7. Actual volume of air drawn into the cylinder

   (Va) = Cd. a. $\sqrt{2gh_m \frac{\rho_w}{\rho_a}} \times 3600$ m^3/hr

8. Swept Volume (Vs) = A. L. $\frac{N}{2} \times 60\ m^3$

9. Volumetric efficiency (η_{vol}) = $\frac{Va}{Vs} \times 100$ in%

Observation Table:

Sl No.	Load	RPM	Voltage (V)	Current (A)	Manometric head in mm		Time taken for X_{cc} in Sec
					H_1	H_2	
1							
2							
3							
4							

Calculation:

Conclusion:

The load test on a 4-stroke CI engine was carried out and the mechanical efficiency found to be _____________ %.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Load test on 4-stroke single cylinder SI engine.

Description:

A rope brake dynamometer is fixed to the engine shaft is mounted on MS channel frame. A spring balance is there for load measurement. A weight hanger is there to hang the dead weights due to which the weight can be applied on the engine. Water connection is there with the load drum to resist over heating of the drum due to the friction between load drum and rope. Panel board is used to fix burette with 3-way cock, digital RPM indicator and U tube manometer.

Instrumentation:

1. Manometer to measure the quality of air drawn in to the engine cylinder.
2. Burette to measure the rate of fuel consumption.
3. Digital RPM indicator to measure the speed.
4. Rope brake dynamometer is there to apply load and measurement of torque.

Engine Specification:

Make	:	Greaves
BHP	:	2.5HP
Speed	:	3000 RPM
No of cylinder	:	ONE
Compression ratio	:	7.4:1

Bore	:	70mm
Stroke	:	66.7mm
Orifice diameter	:	20mm
Type of ignition	:	Spark Ignition
Method of loading	:	Rope Brake and dead weights
Method of starting	:	Rope Start
Method of cooling	:	Air

Rope Brake Dynamometer

Rope Diameter	:	16mm
Hanger Weight	:	1Kg
Loading Drum Diameter	:	0.2m
Rope Diameter	:	16mm

Procedure:

Step 1:

Connect the panel instrumentation input power line to a 230V 50Hz single phase power source.

Step 2:

Fill fuel into the fuel tank mounted on the panel frame.

Step 3:

Check the lubricating oil in the engine sump with the help of dipstick provided.

Step 4:

Open the fuel lock provided under the fuel tank and ensure that no air is trapped the fuel line connecting the fuel line and engine.

Step 5:

Start the engine with the help of rope and wait till the RPM of the engine reach to a constant state.

Step 6:

Allow the brake drum cooling water by operating the gate valve for a less flow.

Step 7:

Now load the engine by placing dead weights on the load hanger attached with the load drum.

Step 8:

Now note down all the parameters which are required for calculation and mentioned in the table. After note down the parameters repeat the same by increasing load.

Step 9:

To stop the engine after the experiment is press the stop button on the engine.

Formulas:

1. Brake Horse Power (BHP) = $\frac{2\pi N\ (W-S)[\frac{D+d}{2}]}{4500}$ HP = $\frac{2\pi N\ (W-S)r}{4500}$ HP

   W = Dead weights in Kg + Hanger weight in Kg

   S = Spring balance reading in Kg

   D = Diameter of brake drum in m

   d = Diameter of rope in m

   N = Speed of engine

   r = Arm length radius in m

2. Weight of fuel consumed (W_f) = $\frac{X_{cc}\times 0.720\times 60\times 60}{T_{sec}\times 1000}$ Kg/hr

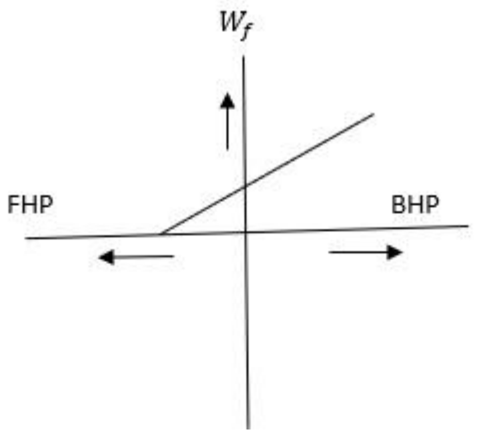
   Where density of Petrol is 0.720 gm/cc

3. Specific fuel consumption (SFC) = $\frac{W_f}{BHP}$ Kg/BHP hr

4. Brake thermal efficiency (η_{BTH}) = $\frac{BHP\times 4500\times 60\times 100}{427\times C_v\times W_f}$ %

   Where Calorific value of Diesel is 11000 Kcal/Kg

5. Indicated horse power (IHP) = Can be calculated by Williams Line Graph method.



IHP = BHP + FHP

6. Indicated thermal efficiency (η_{ITH}) = $\frac{IHP \times 4500 \times 60}{427 \times C_v \times W_f} \times 100\%$
7. Actual volume of air drawn into the cylinder

$$(V_a) = Cd.\ a.\sqrt{2gh_m \frac{\rho_w}{\rho_a}} \times 3600\ m^3/hr$$

8. Swept Volume (Vs) = A. L. $\frac{N}{2} \times 60\ m^3$
9. Volumetric efficiency (η_{vol}) = $\frac{Va}{Vs} \times 100$ in%
10. Mechanical Efficiency (η_{mech}) = $\frac{BHP}{IHP} \times 100$ in%

Observation Table:

Sl No.	Load in Kg	RPM	Spring balance in Kg	Manometric head in mm		Time taken for X_{cc} in Sec
				H1	H2	
1						
2						
3						
4						

Calculation:

Conclusion:

The load test on a 4-stroke SI engine was carried out and the mechanical efficiency found to be ______________ %.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Load test on 2-stroke single cylinder SI engine.

Description:

A rope brake dynamometer is fixed to the engine shaft is mounted on MS channel frame. A spring balance is there for load measurement. A weight hanger is there to hang the dead weights due to which the weight can be applied on the engine. Water connection is there with the load drum to resist over heating of the drum due to the friction between load drum and rope. Panel board is used to fix burette with 3-way cock, digital RPM indicator and U tube manometer.

Instrumentation:

1. Manometer to measure the quality of air drawn in to the engine cylinder.
2. Burette to measure the rate of fuel consumption.
3. Digital RPM indicator to measure the speed.
4. Rope brake dynamometer is there to apply load and measurement of torque.

Engine Specification:

Make	:	Bajaj
BHP	:	2.5HP
Speed	:	3000 RPM
No of cylinder	:	ONE
Compression ratio	:	7.4:1

Bore : 57mm

Stroke : 57mm

Orifice diameter : 20mm

Type of ignition : Spark Ignition

Method of loading : Rope Brake and dead weights

Method of starting : Kick Start

Method of cooling : Air

Rope Brake Dynamometer

Rope Diameter : 16mm

Hanger Weight : 1Kg

Loading Drum Diameter : 0.2m

Rope Diameter : 16mm

Procedure:

Step 1:

Connect the panel instrumentation input power line to a 230V 50Hz single phase power source.

Step 2:

Fill fuel and 2T into the fuel tank mounted on the panel frame.

Step 3:

Check the lubricating oil in the engine sump with the help of dipstick provided.

Step 4:

Open the fuel lock provided under the fuel tank and ensure that no air is trapped the fuel line connecting the fuel line and engine.

Step 5:

To start the engine switch ON the button on panel then start the engine with the help of kick and wait till the RPM of the engine reach to a constant state.

Step 6:

Increase the speed of the engine using the throttle screw to 3000RPM. Allow the brake drum cooling water by operating the gate valve for a less flow.

Step 7:

Now load the engine by placing dead weights on the load hanger attached with the load drum.

Step 8:

Now note down all the parameters which are required for calculation and mentioned in the table. After note down the parameters repeat the same by increasing load.

Step 9:

To stop the engine after the experiment is switch OFF the Off button on the panel.

Formulas:

1. Brake Horse Power (BHP) = $\frac{2\pi N\ (W-S)[\frac{D+d}{2}]}{4500}$ HP = $\frac{2\pi N\ (W-S)r}{4500}$ HP

W = Dead weights in Kgs + Hanger weight in Kg

S = Spring balance reading in Kg

D = Diameter of brake drum in m

d = Diameter of rope in m

N = Speed of engine

r = Arm length radius in m

2. Weight of fuel consumed (W_f) = $\frac{X_{cc} \times 0.720 \times 60 \times 60}{T_{sec} \times 1000}$ Kg/hr

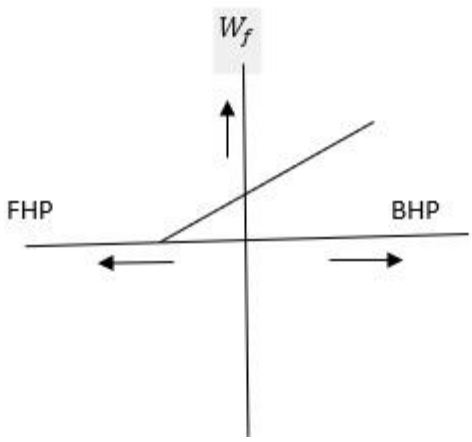
   Where density of Petrol is 0.720 gm/cc

3. Specific fuel consumption (SFC) = $\frac{W_f}{BHP}$ Kg/BHP hr

4. Brake thermal efficiency (η_{BTH}) = $\frac{BHP \times 4500 \times 60 \times 100}{427 \times C_v \times W_f}$ in %

   Where Calorific value of Diesel is 11000 Kcal/Kg

5. Indicated horse power (IHP) = Can be calculated by Williams Line Graph method.



IHP = BHP + FHP

6. Indicated thermal efficiency (η_{ITH}) = $\frac{IHP \times 4500 \times 60}{427 \times C_v \times W_f} \times 100\%$

7. Actual volume of air drawn into the cylinder (Va) = Cd. a.$\sqrt{2gh_m \frac{\rho_w}{\rho_a}} \times 3600$ m^3/hr

8. Swept Volume (Vs) = A. L. N × 60 m^3

9. Volumetric efficiency (η_{vol}) = $\frac{Va}{Vs} \times 100$ in%

10. Mechanical Efficiency (η_{mech}) = $\frac{BHP}{IHP} \times 100$ in%

Observation Table:

Sl No.	Load in Kg	RPM	Spring balance in Kg	Manometric head in mm		Time taken for X_{cc} in Sec
				H1	H2	
1						
2						
3						
4						

Calculation:

Conclusion:

The load test on a 2-stroke SI engine was carried out and the mechanical efficiency found to be ______________ %.

Teacher’s Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Morse test on multi cylinder petrol engine.

Description:

The engine and hydraulic dynamometer are mounted on mild steel channel frame. The engine is directly coupled to the hydraulic dynamometer, which loaded by water flow into the dynamometer. The load can be varied by operating gate valve provided on the inlet line of dynamometer. A breather valve is provided at the bottom of the dynamometer which is used for draining water from dynamometer after the experiment. To start the engine a battery of 12V connected with the engine. Panel board is used to fix burette with 3-way cock, digital RPM indicator, temperature indicator and U tube manometer.

Instrumentation:

1. Manometer to measure the quality of air drawn in to the engine cylinder.
2. Burette to measure the rate of fuel consumption.
3. Digital RPM indicator to measure the speed.
4. Hydraulic dynamometer is there to apply load and measurement of torque.

Engine Specification:

Make : Maruti Suzuki

BHP : 7.5 HP

Speed : RPM

No of cylinder	:	THREE
Bore	:	68.5 mm
Stroke	:	72 mm
Orifice diameter	:	20 mm
Type of ignition	:	Spark Ignition
Method of loading	:	Hydraulic Dynamometer Loading
Method of starting	:	Self Start
Method of cooling	:	Water Cooled

Procedure For Load Test:

Step 1:

Connect the water inlet of the engine jacket and hydraulic dynamometer at constant head of water.

Step 2:

Connect the battery terminals to a well charged 12 V battery with terminals as marked to the engine cable terminals.

Step 3:

Connect the instrumentation power input to 230 V, single phase power source.

Step 4:

Start the engine with the help of key by self-starting and allow it to run for some time in ideal condition.

Step 5:

Increase the speed by turning the accelerator knob until the RPM indicator reads 1500 RPM.

Step 6:

Now open the dynamometer inlet valve gradually to load the engine through hydraulic dynamometer. The load is indicated on a dial type spring balance in terms of Kg. Now engine speed decreases due to the application of load. Operate the acceleration knob simultaneously with the hydraulic dynamometer inlet gate valve and set the load to 3 kg + spring balance error if any and bring the engine speed to 1500 RPM.

Step 7:

Note down all the required parameters mentioned in the tabulation.

Step 8:

Repeat the step 6 and 7 with another load i.e 6 Kg, 9 Kg and 12 Kg

Procedure for Morse test:

Step 1:

Keep the engine on full load condition i.e 12 Kg at rated speed and allow it to run for few minutes.

Step 2:

Cut off power to one cylinder by switching OFF the cut off switch provided on the engine panel. Now the engine is running on two cylinders only. As the result the speed of the engine decreases.

Step 3:

By operating the water inlet gate valve of hydraulic dynamometer reduce the load slowly so the speed of engine comes back to its rated speed i.e.1500 RPM and note down the observations.

Step 4:

Now without altering the water inlet to the dynamometer and accelerator knob switch ON the same cutoff switch, then the speed increases.

Step 5:

Cut off the next cylinder by switching OFF of another cut off switch immediately and observe the engine speed. If the speed of the engine does not reach the rated speed increase or decrease the load as applicable and maintain the speed.

Step 6:

Follow the above step for the last cylinder also and note down the observations.

Observation Table:

Sl No.	RPM	Load in Kg	Spring Balance Error	Manometric Difference $(h_1 - h_2)$ in mm	Time For X_{cc} in Sec

Sl No.	RPM	Load in Kg	Spring Balance Error	Manometric Difference $(h_1 - h_2)$ in mm	Time For X_{cc} in Sec

T_1 = Temp of water inlet to engine =

T_3 = Temp of exhaust gas =

T_2 = Temp of water outlet to engine =

T_4 = Ambient Temp =

Formulas:

1. Brake Horse Power (BHP) = $\frac{W \times N}{2000}$ HP

   Where W = Load as per spring balance

   N = Speed of the engine in RPM

   A = BHP when three cylinders are working

   B1 = BHP when first cylinder is cutoff

   B2 = BHP when second cylinder is cutoff

   B3 = BHP when third cylinder is cutoff

2. IHP of first cylinder = A – B1

   IHP of second cylinder = A – B2

IHP of third cylinder = A – B3

3. Weight Of Fuel Consumed (W_f) = $\frac{Xcc \times 0.72 \times 3600}{T \times 1000}$ Kg/hr

   Where X_{cc} = Volume of fuel, 0.72 is fuel density of petrol.

4. Specific fuel consumption (SFC) = $\frac{W_f}{BHP}$ Kg/hr

5. Actual Volume of Air Flow In To The Cylinder

$$(V_a) = C_d \times a \times \sqrt{2gh\ \frac{\rho_w}{\rho_a}} \times 3600 \qquad m^3/hr$$

   Where C_d = 0.62

   a = Area of orifice

   h = $h_a \left(\frac{\rho_w}{\rho_a}\right)$

   ρ_a = 1.193 Kg/m^3 = Density of air

   ρ_w = 1000 Kg/m^3 = Density of water

   h_a = Head of water by manometer in m

   h = Head of air in m

6. Swept Volume Of Each Cylinder (V_s) = A × L × $\frac{N}{2}$ × 60 m^3/hr

   Where A = Area of the piston

   L = Length of the stroke

   N = Speed of the engine

7. Volumetric Efficiency (η_{vol}) = $\frac{V_a}{V_s \times 3} \times 100$ %

8. Brake Thermal Efficiency (η_{BTH}) = $\frac{BHP \times 4500 \times 60}{427 \times C_v \times W_f}$ ×100

   Where C_v = Calorific value of fuel = 10500 Kcal/Kg

9. Mechanical Efficiency (η_{mech}) = $\frac{BHP}{IHP} \times 100$

Heat Balance Sheet:

1. Heat Input = H = $W_f \times C_v$ Kcal/hr
2. Heat Equivalent to BHP = $h_1 = \frac{BHP\times4500\times60}{427}$ Kcal/hr
3. Heat Carried Away by engine jacket cooling water = $h_2 = m_w\times C_p\times(T_2-T_1)$ Kcal/hr

   m_w = Mass of water passed through engine jacket = $\frac{\text{Rate of flow}\times\text{Density of water}\times3600}{1000}$ Kg/hr

   C_p = Specific heat of water

   T_2-T_1 = Temperature difference of water
4. Heat carried away by exhaust gas =

   $h_3 = (\text{mass of fuel} + \text{mass of air}) \times \text{specific heat of gas} \times \text{temp. difference}$

   $= (m_f + m_a)\, C_{pg}\, (T_3 - T_4)$

   Where T_3 = Exhaust gas temperature

   T_4 = Ambient temperature

   m_f = Mass of fuel = weight of fuel

   m_a = Mass of air = $V_a\times \rho_a$

   C_{pg} = Specific heat of exhaust gas = 0.24 Kcal/Kg℃
5. Heat Unaccounted = H- $(h_1+h_2+h_3)$

Calculation:

Conclusion:

The Morse test was carried out and the mechanical efficiency found to be ______________ %.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Performance analysis of a reciprocating air compressor.

Description:

Two stage compressor is a reciprocating type driven by a prime mover AC motor through belt. The test rig consist of a base on which the air receiver is mounted. The electrical safety valve is provided for safety. A mechanical safety valve is also provided for additional safety. The suction pipe is connected with a calibrated orifice plate through the manometer. An electrical meter records the input to the motor. The temperature and pressure of air can measured by temperature and pressure indicators mounted on the panel. The air first compressed by the Low Pressure Cylinder and delivered to High Pressure Cylinder through an Inter Cooler and further compressed by High Pressure Cylinder and delivered to the receiver tank.

Instrumentation:

1. Manometer to measure the quality of air drawn in to the compressor cylinder.
2. Digital RPM indicator to measure the speed.
3. Temperature indicators are there to measure temperature at different points.

Specifications:

Make : Suguna

Bore LP cylinder : 70mm

Bore HP cylinder	:	50mm
Stroke	:	85mm
Motor Capacity	:	3HP
Orifice Diameter	:	16mm
Energy Meter Constant	:	60REV/KWH

T_1 = Temp of air inlet to compressor =

T_2 = Temp of air outlet LP cylinder =

T_3 = Temp of air outlet inter cooler =

T_4 = Temp of air outlet HP cylinder =

Procedure:

Step 1:

Connect the instrument panel with 3 phase electric supply.

Step 2:

The manometer may be filled with water up to the half level.

Step 3:

Close the valve of the receiver tank.

Step 4:

Start the compressor and observe that the pressure being developed slowly.

Step 5:

At the particular test pressure open the outlet valve slowly and adjust in the way that the pressure of the tank will maintain constant.

Step 6:

Note down all the parameters required for calculation mentioned in the table.

Step 7:

Repeat step 5 for another test pressure i.e 2bar, 3bar, 4bar, 5bar, etc. and note down the parameters accordingly.

Observation Table:

Sl No.	RPM (N)	Pressure at tank	Discharge pressure (HP)	Head of water (h_w) = (h_1-h_2)	Rotation of the disc (n)	Time for n rotation in sec
1						
2						
3						
4						

Formulas:

1. Head of air (h_a) = $h_w \times \frac{\rho_w}{\rho_a}$

   Where ρ_w = Density of water = 1000 Kg/m^3

ρ_a = Density of air at 30°C = 1.162 Kg/m^3

2. Actual volume of air drawn into cylinder (V_a) = C_d a $\sqrt{2gh_a}$ m^3/sec

   Where C_d = Coefficient of discharge of orifice = 0.62

   a = Area of orifice

3. Theoretical volume of air drawn into cylinder

   (V_s) = $\frac{\pi}{4} \times \left[D_1{}^2 + D_2{}^2\right] \times \frac{N}{60} \times L$ m^3/sec

   Where D_1 = Diameter of low-pressure cylinder

   D_2 = Diameter of high-pressure cylinder

   N = Speed in RPM

   L = Stroke length

4. Volumetric efficiency (η_{vol}) = $\frac{V_a}{V_s} \times 100$

5. Input power (IP) = $\frac{3600 \times n \times \eta_m \times \eta_b}{E \times T}$ KW

   Where n = Number of revolutions of disc in energy meter

   η_m = Motor efficiency = 80% (assumed)

   η_b = Belt transmission efficiency = 75% (assumed)

6. Isothermal work done (W_{iso}) = $P_a \times V_a \times \ln\left(\frac{P_d}{P_a}\right)$

   Where P_d = Compressor discharge pressure

   P_a = Atmospheric pressure

   V_a = Actual volume of air drawn in to cylinder

7. Isothermal efficiency = (η_{iso}) = $\frac{W_{iso}}{IP} \times 100$

Calculation:

Conclusion:

The performance analysis was carried out in the air compressor and isothermal efficiency found to be _____________ %.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Determination of performance characteristic of gear pump.

Description:

A gear oil pump is mounted on MS channel frame. A motor of 0.5 HP is connected to the pump shaft. Sump is there which is filled 3/4th with oil. Suction pipe is connected with suction side of the pump and the pipe is dipped in the oil. A delivery pipe is connected with the delivery side of the pump and also connected to the measuring tank. Energy meter is there to measure power input. Two pressure gauges are there, one is delivery pressure gauge another is suction/Vacuum pressure gauge to measure delivery pressure and suction pressure respectively. Gate way valve is connected to the delivery pipe for load application.

Specifications:

Size	:	3/4th BSP
Capacity	:	30LPM
RPM	:	1500
Measuring Tank	:	200 × 200 mm
Motor	:	0.5 HP
Motor RPM	:	1440
Energy Meter Constant	:	200REV/KWH

Procedure:

Step 1:

The internal dimensions of the collecting tank are measured. The energy meter constant is noted.

Step 2:

The supply tank is filled with oil to the required height say ¾ of the tank.

Step 3:

The gate valve is opened in the delivery tube fully.

Step 4:

Connect the plug with 3 phase power supply.

Step 5:

The motor is started and the following readings are noted.

a. Pressure gauge & vacuum gauge readings

b. Time for "h" m rise of oil in the tank.

c. Time for "N" revolutions in the energy meter disc

d. Take 4 or 5 sets of readings varying the delivery pressure by closing the gate valve in the delivery pipe.

Observation table:

Sl No.	Discharge Pressure (in Kg/cm^2)	Vacuum Pressure (in mm of Hg)	Time for rise of 10 cm oil in tank (in Sec) (T)	Time taken for 5 revolutions of disc (sec) (t)
1				
2				
3				
4				

Formulas:

1. Actual discharge (Q) = $\frac{\mathrm{Ah}}{\mathrm{T}}$
2. Total head (H) = Pressure head + Vacuum head

   Pressure head = Discharge pressure × 10 m of water

   Vacuum head = Vacuum pressure × 0.0136 m of water
3. Input Power (IP) = $\frac{\mathrm{N} \times 3600}{\mathrm{E} \times \mathrm{t}}$
4. Output Power (OP) = Vacuum pressure × Specific weight of water × Discharge × Head
5. Efficiency (η) = $\frac{\mathrm{Output}}{\mathrm{Input}} \times 100$

Calculation:

Conclusion:

The mechanical efficiency of gear pump found to be _____________ %.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Performance test on Air conditioning test rig (Duct type).

Apparatus required: 1. Air conditioning test rig

2. Anemometer

Description:

The test rig essentially consist of a vapour compression refrigeration system, an air conditioning chamber, heater, one fan/blower, a boiler, etc. The vapour compression refrigeration system consist of a compressor (supposed to be heart of the system), an air cooled condenser, an expansion device called capillary is provided. A rotameter is there to measure the rate of flow of refrigerant. A filter drier and evaporator also there. A fan/blower is arranged across the evaporator coil and the coil is incorporated inside a metal chamber of given cross-section to cool the flowing air. The system is provided with thermocouples to measure temperature of the refrigerant at various points with digital temperature indicator. Two pressure gauges are there which will measure the suction and discharge pressure of compressor. Two hygrometers are provided both ends of the duct to measure the air condition. A boiler is there to provide steam to increase the humidity inside the duct.

Specifications:

Refrigerant used	: R22
Multichannel temperature indicator	: (-300°C - 8000°C)
Chromel- Alumel thermocouple	: 4Nos
Energy meter constant (Compressor)	: 375 Rev/KWh

Energy meter constant (heater) : 1800 Rev/KWh

Area of air duct : 300 × 250 mm

Theory:

An air conditioning system generally works on simple vapour compression cycle which is discussed below:

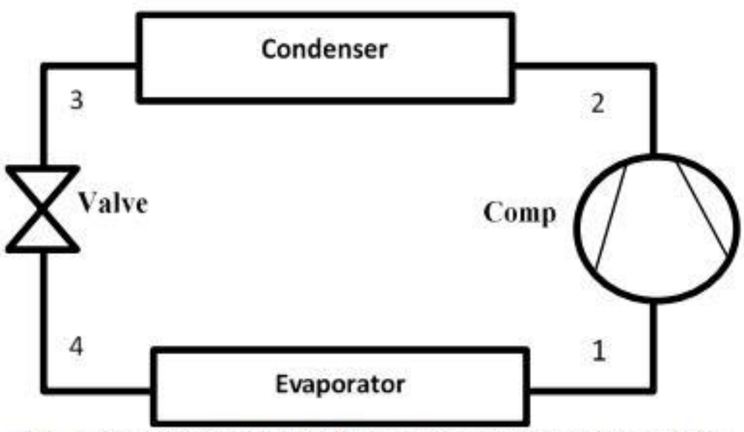


Fig. 1. Schematic diagram of vapor compression refrigeration

Process 1-2: Reversible adiabatic compression from standard vapour to a super heated condition.

Process 2-3: Reversible heat rejection at constant pressure.

Process 3-4: Irreversible isenthalpic expansion from saturated liquid to a low pressure liquid and vapour.

Process 4-1: Reversible heat addition at constant pressure.

The actual cycle differs slightly from the SVCC due to some practical consideration. The coefficient of performance of any refrigeration cycle is defined as the ratio between net refrigeration and compressor work.

$$COP = \frac{\text{Net Refrigeration}}{\text{Compressor work}}$$

Different psychrometric processes can be performed in this test rig. Normally these processes are combination of sensible heating, sensible cooling, humidification & de-humidification.

Sensible heating: - In sensible heating, the temp. of air is increased without changing its moisture content.

Sensible cooling: - In sensible cooling, the temp of air is decreased without changing its moisture content.

Humidification: – It is the process to add moisture in the air, without change in its dry bulb temp.

De-humidification: – It is the process to remove moisture from the air, without change in dry bulb temp.

The air conditioning processes in the system are represented on a psychrometric chart. The point 1 and 2 are marked on the psychrometric chart using dry and wet bulb temp. Specific enthalpy h1 and h2 are calculated from the chart.

Change in enthalpy = (h1 –h2) kJ/kg (For cooling)

= (h2 –h1) kJ/kg (For heating)

So, Energy transfer rate = ma (h1 –h2) kW or ma (h2 –h1) kW

Where ma = a × v × ρ_{air} kg/sec

a = Area of duct (0.30×0.25) m^2

v = Velocity of air in m/sec

The heat added during a psychrometric process may be split up into sensible heat and latent heat.

The ratio of the sensible heat to the total heat is known as sensible heat factor (SHF)

Mathematically SHF = $\frac{SH}{SH+LH}$

SH = sensible heat, LH = latent heat and SH+LH = Total heat

The ratio of the latent heat to the total heat is known as latent heat factor (LHF)

Mathematically LHF = $\frac{LH}{SH+LH}$

Procedure:

(For cooling & de-humidification)

1. Put the main switch on.
2. Start the exhaust fan.
3. Switch on the compressor for 15 minutes.
4. Record temperatures from temperature indicators, pressures from pressure gauges and dry and wet bulb temperature at inlet and outlet of duct. Measure the energy input to the compressor by energy meter.
5. Measure the velocity of air by the help of anemometer.

(For Heating & humidification)

1. Switch off the compressor
2. Fill the boiler about ¾th height with water.
3. Switch on the boiler till formation of steam.

4. When steam is formed, allow it to the duct for 15 minutes.

5. Record dry and wet bulb temperature at inlet and outlet of duct.

6. Measure the velocity of air by the help of anemometer.

(For Heating & de-humidification)

1. Switch off both heaters.

2. Switch on heater provided in the duct.

3. Allow sufficient time to pick up enough heat and also for stabilization.

4. Record dry and wet bulb temperature at inlet and outlet of duct.

5. Measure the velocity of air by the help of anemometer.

Observation Table:

For COP calculation	T_1	T_2	T_3	T_4	Time taken for N= 5 Rev of Disc (t) in sec

Sl No.	Process	Incoming Air		Conditioned Air		Velocity of air
		DBT	WBT	DBT	WBT	
1.						
2.						
3.						

Formulas:

To determine theoretical COP read h_1, h_2, h_3, h_4 from Psychrometric chart using P_1, P_2, T_1, T_2, T_3, T_4

Values observed from the experiment.

COP = $\frac{h_1 - h_4}{h_2 - h_1} = \frac{h_1 - h_3}{h_2 - h_1}$

Actual COP = $\frac{\text{Actual Refrigeration effect}}{\text{Workdone on compressor}}$

Actual Refrigeration effect = $m_a C_p \Delta T$

Work done on compressor = $\frac{N \times 3600}{E \times t}$

For psychrometric process:

From psychrometric chart, at DBT_1 and WBT_2

Find out Specific enthalpy h_1 = kJ/Kg

At DBT_2 and WBT_2 find out h_2 = kJ/Kg

And h_3 = kJ/Kg

SH= h3-h2= kJ/Kg

LH=h1-h3= kJ/Kg

Energy transfer rate= ma (h1 –h2) = a × v × ρ air × (h1 –h2)   kW

SHF = $\frac{SH}{SH+LH}$

LHF = $\frac{LH}{SH+LH}$

Calculation:

Conclusion:

The COP of air conditioning Test Rig found to be _____________.

Teacher's Signature

Experiment No: - **Date: - / /**

Aim of the Experiment:

Determination of COP of ice plant.

Apparatus Required: Ice plant test rig working on VCRS

Description:

The ice plant is basically consist of vapour compression refrigeration system, in which the brine water is colled by circulating it aroung the evaporator coil. The colled brine water is then circulates around water canes kept in for making ice. Four thermos couples are connected at various points of the refrigeration system and another thermocouple is there to measure the temperature of brine water and ice. A digital temperature indicator is there by which we can check the temperatures. Two pressure gauges are there which shows the suction and delivery pressure in the refrigeration system. A stirrer is there to stir the brine solution and circulate around the water canes.

Procedure:

1. Fill the evaporator coil with brine water and run the system.
2. Wait until temperature of brine solution decreases to -15 to 20 ℃.
3. Fill the ice can with water.
4. Note the temperature of water using thermocouple.
5. Place it inside the brine tank.
6. Run the stirrer to circulate brine around the ice cans.
7. Go on recording the water temperature till the desired temperature in the ice can reached.
8. Note down the final temperature of ice.

Observation Table:

Sl No.	P_1	P_2	T_1	T_2	T_3	T_4	t_1	t_2	Initial meter reading	Final meter reading	Time taken for the expt.

Formulas:

Amount of heat removed from 1 kg of water at temperature t_1 to ice at temperature t_2 =

$$m_w C_{pw} (t_1 - 0) + m_i L + m_i C_{pi} (0 - t_2)$$

Where m = mass of water = 1 Kg

t_1 = temperature of clean water

t_2 = temperature of ice

C_{pw} = specific heat of water = 4.187 Kj/kg°C

C_{pi} = specific heat of ice = 2.093 Kj/kg°C

L = latent heat of ice = 332.432 Kj/Kg

Work done on compressor = $KWh_2 - KWh_1$

$$COP = \frac{RE}{CW}$$

Theoretical COP can be calculated by using the pressure and temperature readings of the system and finding out the h_1, h_2 & h_3 from the psychrometric chart.

Then $COP_{theo} = \frac{h_1 - h_2}{h_3 - h_1}$

Capacity of the plant = $\frac{m_i \times 24}{t}$ Kg/hr

Calculation:

Conclusion:

The COP of Ice Plant found to be ______________.

Teacher's Signature