Malla Reddy Engineering College (Autonomous)
Department of Mechanical Engineering

Academic Year 2018 -19 (I Semester)

Laboratory Course File Index

SubjectCode :83103
Subject Name :ADVANCED THERMAL ENGINEERING LAB
Class/Sem :I Year I Semester
Degree : M.Tech – Thermal Engineering
Staff Incharge :Mr.Shaik Hussain

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Staff In-charge Verified by HOD Principal

Department of Mechanical Engineering
(Established in 2002)

Course File

M. Tech – I SEM

Lab: **ADVANCED THERMAL ENGINEERING LAB**

Subject Code:83103

Academic Year 2018-19

Malla Reddy Engineering College
(Autonomous)

2018-19 Onwards (MR-18)	MALLA REDDY ENGINEERING COLLEGE (Autonomous)	M.Tech. (Thermal Engg.) I Semester		
Code: 83103	**ADVANCED THERMAL ENGINEERING LAB**	**L**	**T**	**P**
Credits: 1.5		**-**	**-**	**3**

Pre-requisites: Nil

Course Objectives: The objective of this course is to make students learn and understand application and performance of fuels, I.C. Engines, heat exchangers, solar systems, refrigerators and air conditioners.

List of Experiments:

1. Analysis of Dryness fraction estimation of steam.
2. Analysis of Flame propagation analysis of gaseous fuels.
3. Analysis of heat pipe apparatus
4. Analysis of Volumetric Efficiency test and air fuel ratio on single cylinder diesel engine.
5. Performance analysis of exhaust gases of I.C. Engines.
6. Heat Balance analysis on single cylinder variable compression ratio engine with different fuels.
7. Performance analysis on variable compression ratio engine with different fuels.
8. Performance analysis of solar Flat Plate Collector
9. Performance analysis of Evacuative tube concentrator
10. Determination of Solar I-V Characteristics.
11. Performance estimation of vapour compression refrigeration system.
12. Performance analysis of Air conditioning system.

Course Outcomes:

At the end of the course,students will be able to:

1. Apply and analyse the fundamental concepts thermodynamics
2. Analyze the performance of an internal combustion engine
3. Analyse effects of variation of compression ratio on the performance of engine.
4. Apply the concepts of solar energy for different practical application.
5. Apply and analyse principles of refrigeration and air conditioning system.

CO- PO Mapping (3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak						
COs	**Program Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	1		1	1
CO2	1	2	1		1	2
CO3	2	2	2	2	1	2
CO4	2	2	2	1	1	2
CO5	1	2	1		1	1

MALLA REDDY ENGINEERING COLLEGE (AUTONOMOUS) SECUNDERABAD-500100
DEPARTMENT OF MECHANICAL ENGINEERING
LAB PLAN
Academic Year 2018-2019

<table>
<tr><td>Department :</td><td colspan="3">MECHANICAL ENGINEERING</td></tr>
<tr><td>Course Title :</td><td>Advanced Thermal Engineering Lab</td><td>Course Code</td><td>83103</td></tr>
<tr><td>Compulsory / Elective :</td><td colspan="3">Compulsory</td></tr>
<tr><td>Prerequisites Knowledge</td><td colspan="3">Thermodynamics and Heat transfer</td></tr>
<tr><td>Duration :</td><td>16 Weeks</td><td>Credit Units :</td><td>1.5</td></tr>
<tr><td>Class / Laboratory Schedule :</td><td colspan="3">0/0/3 [L T P]</td></tr>
<tr><td rowspan="2">Curriculum gap :</td><td rowspan="2">Visits to Industry</td><td colspan="2">Matching POs and PSOs</td></tr>
<tr><td colspan="2">PO:
PSO:</td></tr>
<tr><td>Course Objectives:</td><td colspan="3">The objective of this course is to make students learn and understand application and performance of fuels, I.C. Engines, heat exchangers, solar systems, refrigerators and air conditioners.</td></tr>
<tr><td>Course Outcomes:</td><td colspan="3">1. Apply and analyse the fundamental concepts of Thermodynamics.
2. Analyze the performance of an internal combustion engine.
3. Analyze effects of variation of compression ratio on the performance of engine.
4. Apply the concepts of solar energy for different practical application.
5. Apply and analyze principles of refrigeration and air conditioning system.</td></tr>
<tr><td>Lab Equipment</td><td colspan="3">1. Separating & Throttling Calorimeter
2. Flame Propagation Test Rig.
3. Heat Pipe Apparatus.
4. Single cylinder four stroke water cooled CI engine.
5. Variable Compression Ratio Test Rig.
6. Exhaust gas analyzer
7. Solar Flat Plate Collector test rig.
8. Evacuative tube concentrator test rig.
9. Solar I-V characteristics
10. Air conditioning test rig.
11. Vapour compression refrigeration test rig.</td></tr>
<tr><td>Student Assessments:</td><td colspan="3">• Mid test I and II
• Final examination</td></tr>
<tr><td>Outcome Assessment</td><td colspan="3">• Assignments and examinations
• Course evaluation</td></tr>
</table>

CO- PO Mapping (3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak						
COs	**Program Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	1		1	1
CO2	1	2	1		1	2
CO3	2	2	2	2	1	2
CO4	2	2	2	1	1	2
CO5	1	2	1		1	1

Lab Class:						
				Target Hours 42		
Sl. No	**Date**	**Period Reqd.**	**Topics to be Covered**	**Equipment**	**Date of completion**	**Remarks**
1		3	Determination of Dryness fraction of Steam	Separating and Throttling calorimeter test rig		
2		3	Determination of burning velocity at laminar flow condition for different diameters of the jet.	Flame propagation Test Rig		
3		3	Determination of performance and emission parameters of CI engine	Single cylinder CI engine test rig		
4		3	Draw a heat balance sheet for VCR engine	VCR test rig		
5		3	Determination of performance parameters of VCR engine.	VCR test rig		
6		3	Estimation of Volumetric efficiency and air fuel ration of CI engine.	Single cylinder CI engine test rig		
7		3	Performance evaluation of Vapour compression refrigeration.	Vapour compression refrigeration test rig		
8		3	Performance evaluation of air conditioning unit.	Air conditioning test rig		
9		3	Performance evaluation of Heat Pipe	Heat Pipe test rig		

10		3	Performance analysis of Solar flat plate collector	Solar flat plate collector test rig		
11		3	Performance analysis of Evacuative tube concentrator	Evacuative tube concentrator test rig		
12		3	Determination of performance parameters of VCR engine.	VCR test rig		

M.TECH-THERMAL

CLASS TIME TABLE

Period	I	II	III		V	VI	VII
Day	9.30-10.30	10.30-11.30	11.30-12.30	12.30-1.15	1.15-2.15	2.15-3.15	3.15-4.15
MON	TNPPE	PH&MT	NPTEL	LUNCH	CFD	ATD&C	PH&MT
TUE	ATD&C	PH&MT	NPTEL		NPTEL	NPTEL	RM& IPR
WED	ATE LAB				TNPPE	LIBRARY	ENG-RPW
THU	AH&MT LAB				CFD	PH&MT	ATD&C
FRI	ATD&C	RM& IPR	TNPPE		SEMINAR		CFD
SAT	CFD	TNPPE	LIBRARY		ENG-RPW	SEMINAR	

INDIVIDUAL TIME TABLE

Period	I	II	III		V	VI	VII
Day	9.30-10.30	10.30-11.30	11.30-12.30	12.30-1.15	1.15-2.15	2.15-3.15	3.15-4.15
MON				LUNCH			
TUE							
WED	ATE LAB						
THU							
FRI							
SAT							

DETERMINATION OF DRYNESS FRACTION OF WET STEAM

AIM :

The objective of this experiment is to determine the dryness fraction of wet steam.

APPARATUS:

Ward steam bench

a) Steam boiler plant (unit 1).

b) Separating and throttling calorimeter (unit 3)

c) Measuring

d) Beaker

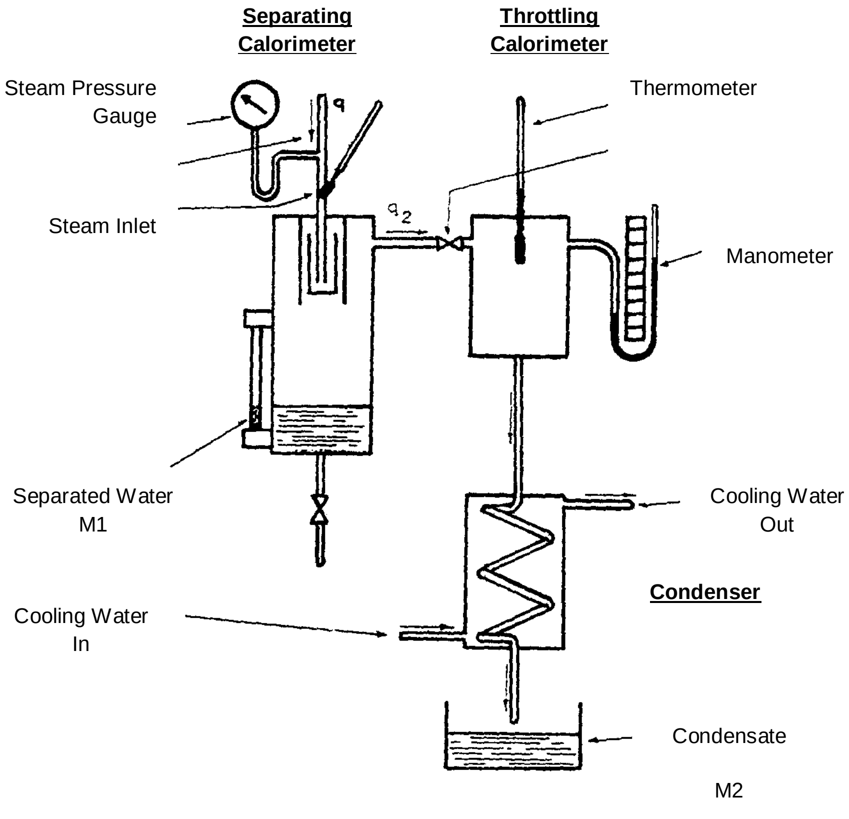


Figure1. Schematic diagram for the separating and throttling Calorimeters.

THEORY:

The separating calorimeter is a vessel used initially to separate some of the moisture from the steam, to ensure superheat conditions after throttling. The steam is made to change direction suddenly; the moisture droplets, being heavier than the vapor, drop out of suspension and are collected at the bottom of the vessel.

The throttling calorimeter is a vessel with a needle valve fitted on the inlet side. The steam is throttled through the needle valve and exhausted to the condenser. Suppose M kg of wet steam with a dryness fraction of x (state A) enters the separating calorimeter. The vapor part will have a mass of xM kg and the liquid part will have a mass of (1-x)M kg. In the separating calorimeter part of the liquid, say M_1 kg will be separated from the wet steam. Hence the dryness fraction of the wet steam will increase to x1 (state B) which will pass through the throttling process valve. After the throttling process the steam in the throttling calorimeter will be in superheated state (state C).

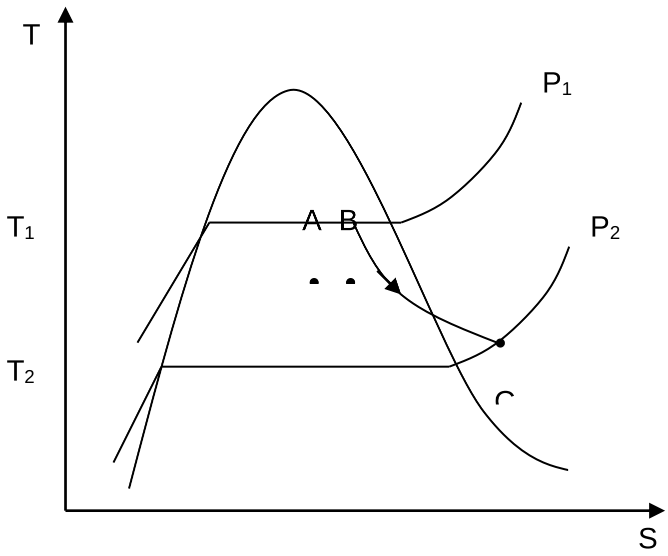


Figure2. T-S diagram of the separating and throttling calorimeter.

From the steady flow energy equation;

$$Q - W = h_C - h_B$$

Since throttling takes place over a very small distance, the heat transfer is negligible, i.e., Q = 0. Then the steady flow energy equation for the throttling process becomes,

$$h_C = h_B$$

Hence, enthalpy after throttling = enthalpy before throttling

$$h_C = h_{f1} + x_1 h_{fg1}$$

If the pressure of the steam before throttling, the pressure and temperature of the steam after throttling, are known the value of x_1 can be calculated using steam tables.

$$\text{Dryness Fraction} = \frac{\text{Mass of dry steam}}{\text{Mass of mixture}}$$

Therefore,

$$X = \frac{x_1 M_2}{M_1 + M_2}$$

Where, M_2 is the mass of condensate.

PROCEDURE:

1. Start the boiler and supply steam to the separating and throttling calorimeter unit.
2. Start the cooling water flow through the condenser.
3. Open steam valve and allow the steam to flow through the calorimeters to warm through the steam.
4. Open the throttle valve and adjust to give a pressure at exhaust of about 5cm Hg measured on the manometer.
5. Drain the separating calorimeter.
6. Start the test and take readings at 2-3 minutes intervals.
7. When a reasonable quantity of condensate is collected measure the quantity of separated water and the quantity of condensate.

TABLE OF OBSERVATIONS

Reading	**1**	**2**	**3**	**4**	**5**	**6**	**Ave.**
Steam pressure in main P_1 (bars)							
Steam pressure after throttling P_2 (bars)							
Temperature of main T_1 (^oC)							
Temperature after throttling T_2 (^oC)							
Quantity of Separated water M1 (kg)							
Quantity of condensate M_2 (Kg)							
Atmospheric pressure P_a (bars)							

RESULTS AND CALCULATIONS:

Using the average values, obtain the specific enthalpy of steam at (state C) hence calculate the dryness fraction of incoming steam. Also calculate the specific enthalpy of incoming steam.

DETERMINATION OF BURNING VELOCITY AT LAMINAR FLOW CONDITION FOR DIFFERENT DIAMETERS OF THE JET

AIM: The experiment is conducted to

a. To study and understand the flame propagation and

b. To find the Burning Velocity at laminar flow condition for different diameters of the jet using different methods.

DESCRIPTION OF THE APPARATUS

1. The equipment consists of **TOUGHNED GLASS ENCLOSURE** with safety MS cover.
2. Three jets of 3mm, 4mm & 5mm diameter are provided to study the flame velocity at different flow rates of air and fuel.
3. **ACRYLIC** Rotameters of 2lpm for AIR & FUEL respectively are provided for direct measurement and also to control the flow.
4. Standard Air Compressor which can develop pressure upto 4kg/cm2 is supplied along with the instrument.
5. Standard Lpg cylinder of 5kg is supplied along with the instrument.
6. The entire arrangement is mounted on an aesthetically designed self sustained Table top made of MS Tube and NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Check the lubricating oil level in the compress.
2. Check the fuel in the cylinder.
3. Check whether the flow valves are closed before starting
4. Fix the required jet in the position.
5. Check for no leakage by passing the only air.
6. Check for any leakage near the LPG cylinder, if so, fix it.
7. Slowly, start the LPG and set the flow below 1lpm, while doing so, light the matches and keep it near the jet so as soon as the LPG flows it burns.
8. Now, slowly start the air and set it to required flow such that the flame is formed uniformly and is in cone shape.

NOTE:Adjust the flow of both AIR and LPG as required for flame front

9. Note the Air and LPG flowrate and measure the angle using the Protractor provided.

10. Repeat the experiment for different jets and flowrates.

OBSERVATION

Sl. No.	Diameter of the jet	Flow rate, LPG		Angle Measured
		AIR	LPG	

CALCULATIONS:

1. **BURNING VELOCITY IS CALCULATED USING BELOW FORMULAE:**

Gouy first defined the burning velocity as

$$S_u = \frac{V_f}{A_F} \quad m/s$$

Where

V_f = Volume flow rate of the unburned mixture consumed

A_F = flame front surface area, m²

Where ,

$$V_f = Q_a + Q_{LPG} \quad m^3/s$$

$$Q_{LPG} = \frac{LPM\ of\ LPG}{1000 * 60} \quad m^3/s$$

$$Q_a = \frac{LPM\ of\ air}{1000 * 60} \quad m^3/s$$

Using a conventional cylindrical burner, different methods can be adopted to calculate the burning velocity.

A few of these are as follows:

<u>Burner Methods</u>

(a) Total Area Method

Assuming the cone to be right circular with base diameter equal to tube diameter (Fig. 10.4(a)) the burning velocity is given by

$$S_u = \frac{V_f}{A_F} = \frac{U_{0,m}\, A_{tube}}{A_F} \quad m/s$$

Where,

$U_{0,m}$ = Space mean velocity of approach flow in the tube, cm/s

S_u = burning velocity, cm/s

V_f = volume flow rate, cm^3/s

A_F =surface area of the cone, cm^2

A_{tube} = cross-sectional area of the tube, cm^2

$$A_F = r_{tube}^2 \sqrt{r_{tube}^2 + h^2}$$

Where h =height of the cone, cm.

(b) Total Area Method:

Cone with Convex Edges (Fig. 10.4(b)) Another good approximation for the area of the cone not having straight edges can be obtained by using the cross-sectional area of the cone as obtained by its image on a photographic plate or on any plane and calculating the area of surface as:

$$A_F = \frac{\Pi A_1\, l}{h}$$

Where

A_1 = cross-sectional area of the cone, cm^2

A_F = total surface area of the cone, cm^2

l = slant height of the cone, *cm*

h = height the cone, *cm.*

The cross-sectional area of the core can be best determinined by dividing the cone into a large number of segments or with the help of a Planimeter. Few workers prefer to take the actual diameter of the cone instead of the tube diameter and apply method (a) or (c) for calculating the flame surface area.

(c) Angle Method

If the cone is assumed to be a straight-edged right circular cone (Fig.10.4(c)), then the flame velocity can be computed by measuring the semi-cone angle between the direction of flow and the burning surface. This obviates the need for measuring or calculating the area of the flame surface, and the error due to the uncertain location of the flame reduced. The burning velocity can be given by:

$$S_u = U_0 \text{ Sin } \alpha$$

Where,

$$U_0 = \frac{2V_f\left(r_{tube}^2 - r^2\right)}{r_{tube}^4}$$

$$U_0 = \frac{U_{0,m}\left(r_{tube}^2 - r^2\right)}{r_{tube}^2}$$

Where, U_0 = local approach velocity

R =*radial distance from the tube axis to flame surface.*

PRECAUTIONS:

1. Do not run the setup if supply voltage is less than 180V
2. Do not run the equipment without proper safety measures around like a bucket of water or a fire extinguisher.
3. Frequently, at least once in three months, grease all visual moving parts.
4. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
5. It is recommended to operate the unit at low pressures only.
6. In case of any major faults, Please write to the manufacturers

   and do not attempt to repair.

DETERMINATION OF PERFORMANCE PARAMETERS OF CI ENGINE

AIM: To conduct performance test on 4-stroke, single cylinder diesel engine and to draw the performance curves.

APPARATUS: Stop watch.

Specifications: It is a 4-stroke, vertical, single cylinder, and ater cooled diesel engine coupled with rope brake dynamometer.

Engine

BHP: 5 HP

Speed: 1500rpm

Bore: 80mm

Stroke: 110mm

Compression ratio: 16.5:1

Orifice diameter: 17mm

Method of start: Crank start

Make: KIRLOSKAR

Type of ignition: compression ignition

Dynamometer

Type: Rope brake

Diameter of brake drum: 300mm

Diameter of rope: 16mm

Effective radius of brake drum: 158mm

Theory: the four stroke diesel (CI) engine operates on diesel cycle. The piston reciprocates inside the cylinder which is connected to the crankshaft by means of a connecting rod. The valves are operated by means of cams and pushrods. Water is circulated through the provision made around the cylinder called engine cooling water jackets for cooling purpose. There is a governor provided for maintaining the constant speed. The four strokes taking place mainly suction, compression, expansion (power stroke) and exhaust strokes are as explained below.

During suction stroke, the inlet valve remains opened through which fresh air is drawn into the cylinder and the exhaust valve remains closed. During the compression stroke, both inlet and exhaust valves are remain closed. During this stroke the piston compresses the sucked air to a high pressure. Fuel is injected into the cylinder at the end of this stroke in the form of fine droplets. The injected fuel ignites due to the high temperature of compressed air. During expansion stroke, the piston will be pushed backwards because of high pressure developed in the cylinder due to combustion of fuel. During exhaust stroke, the exhaust valve remains opened through which the exhaust gases are expelled while the inlet valve remains closed. The same cycle is repeated for several number of times in a minute and thus the engine runs continuously.

Generally the diesel (CI) engine is heavier than petrol (SI) engine and it has higher thermal efficiency because of high pressure developed due to greater expansion and high compression ratio.

CI engine are mainly used for heavy transport vehicles, power generation, industrial and marine applications.

Description: It is a 4-stroke, single cylinder, water cooled constant speed diesel engine which is coupled to a rope brake drum arrangement to absorb the power produced. The engine is crank started. Necessary dead weights and spring balance are included to apply load on the brake drum. Suitable cooling water arrangement for the brake drum is provided. Separate cooling water lines fitted with temperature measuring thermocouples are provided for the engine cooling. A measuring system for fuel consumption consisting of a fuel tank, burette, 3-way cock mounted on a stand and stop watch are provided. Air intake is measured using an air tank fitted with an orifice meter and a water U-tube intake is measured using an air tank fitted with an orifice meter and a water U-tube differential manometer. Also a digital temperature indicator with selector switch for temperature measurement and a digital RPM indicator for speed measurement are provided on the panel board. A governor is provided to maintain the constant speed.

PROCEDURE:

Note down the engine specifications and ambient temperature.

Calculate the full load (W) that can be applied on to the engine from the given engine specifications using the formula.

Check for fuel, lubricating oil and cooling water supply.

Start the engine by using decompression lever ensuring that no load on the engine and supply the cooling water.

Allow the engine to run for 10 minutes on no load to get stabilization.

Note down the total dead weight, spring balance reading, speed, time taken for 10 cc of fuel consumption and the manometer readings.

Repeat the above step for different loads up to full load.

Allow the engine to stabilize on every load change and then take the readings.

Stop the engine by pulling the governor lever towards the engine cranking side. Check that there is no load on the engine while stopping.

OBSERVATINS AND RESULTS:

S.No	Dead weight (w1)kg	Spring balance (w2)kg	Actual load W=w1-w2)kg	Speed (N)rpm	Manometer readings			Time taken for 10cc fuel consumption (t) sec	Fuel consumption (m_f), kg/hr	h_a, m	V_a, m_3/s
					h_1 cm	h_2 cm	hw= (h_1 ~h_2)/ 100 m				

RESULTS:

Vs m3/s	BP kw	Ma Kg/hr	IP KW	Bsfc kg/kwgh	Isfc Kg/kwh	Bmep KN/m2	Imep KN/m2	ηbth %	ηith %	ηm %	ηvol %	A/F ratio

SAMPLE CALCULATIONS

1.Fuel consumption, M_f= y/t 3 3600/1000 3ρ_f kg/h

Where t = time taken for 'y'cc (say10cc) of fuel consumption,

ρ= density of fuel = 0.825 gm/cc

2. Brake power, BP = 2Πnt

—— KW

60000

Where T = Torque = 9.81 3 W 3 R_e N-m

Actual load, W = (W_1 – Wa_2) kg

W_1 = dead weight, kg

W_2 = spring balance reading, kg

Re = effective radius of rope brake drum = 0.158 m

N = Speed, rpm

3. Actual volume flow rate of air, Vactual = $c_d a_o \sqrt{2gh_a}$

Where c_d = Co-efficient of discharge of orifice meter = 0.62

= Π

a_o = area of orifice --- d^2o m^2

4

d_o = orifice diameter, m

g = acceleration due to gravity = 9.81 m/s^2

h_a = Pressure head interims of 'in' of air =

= Density of water = 1000 kg/m^3

h_w = Difference of manometer readings = h_1~h_2 r

Density of atm, air,ρ_a= p_a/RT_a

P_a = atm, pressure = 750 mm of Hg = 1 3 10^5 N/m^2

R = gas constant of air = 287 j/kg. ^{0}k

T_a = atm, temperature, ^{0}k

mass flow rate of air, m_a = V_{actual} 3ρ_a 3 3600 kg/h

Swept volume of the engine = $\pi D^2L/4$ M^3

Theoretical volume flow rate of air, Vs=$\pi D^2L/4(N/60)$

Where D = cylinder bore = 0.08m

L = stroke = 0.11m

6. Indicate power , IP = (BP+FP) KW

Where FP = Friction power from willans line graph, KW

7. Brake specific fuel consumption, b_{sfc} = m_f/BP kg/kwh

8. Indicated specific fuel consumption. I_{sfc} = m_f/IP kg/kwh

9. Brake mean effective pressure, P_{bm} = BP 3 60000/LAN 3 1000 KN/ m^2

10. Indicate mean effective pressure, P_{im} = IP 3 60000/LAN 3 1000 KN/ m^2

11. Brake thermal efficiency, η_{bth} = BP 3 3600/ m_f 3 CV 3100%

Where CV = calorific value (lower) of the fuel (diesel) = 43200 KJ/

12. Indicated thermal efficiency, η_{ith} = IP 3 3600/ m_f 3 CV 3100%

13. Mechanical efficiency, η_m = BP/IP 3 100%

14. Volumetric efficiency, ηvol. = v_{actual} /v_s3 100 %

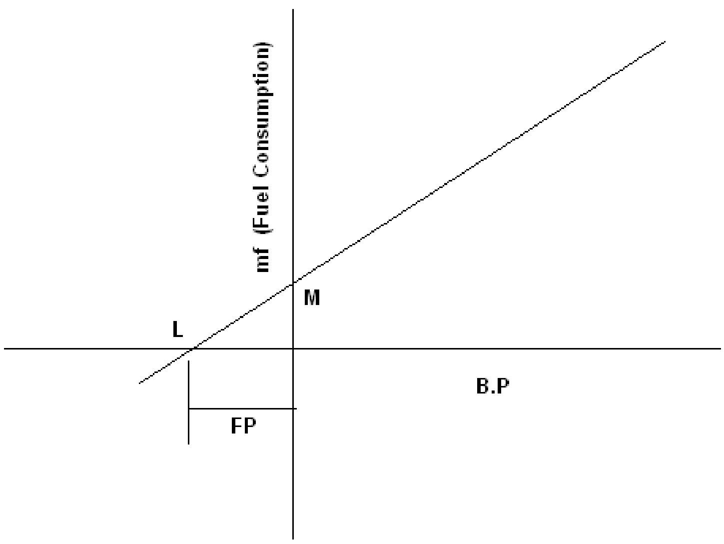
15. Air – fuel ratio, A/F = m_a/m_f.

GRAPHS:

m_f Vs BP	6. η_{bth} Vs BP
bsfc Vs BP	7. η_{ith} Vs BP
isfc Vs BP	8. η_m Vs BP
P_{bm} Vs BP	9. η_{vol} Vs BP
P_{im} Vs BP	10. A/F ratio Vs BP

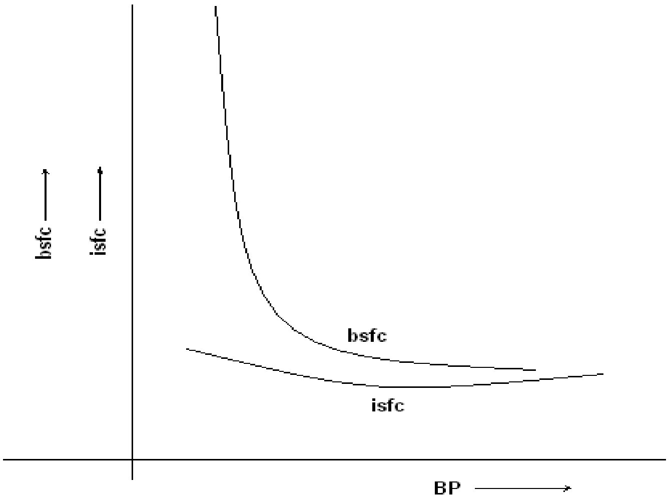
EXPECTED GRAPHS:

1. Fuel ConsumptionVs BP

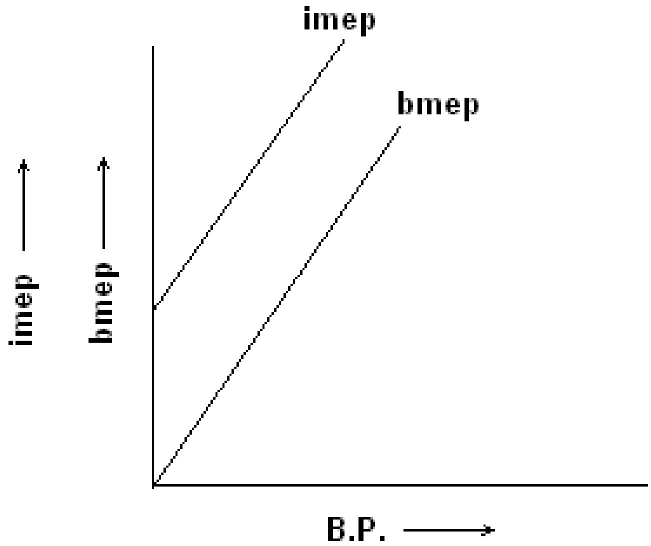


William's Line Method

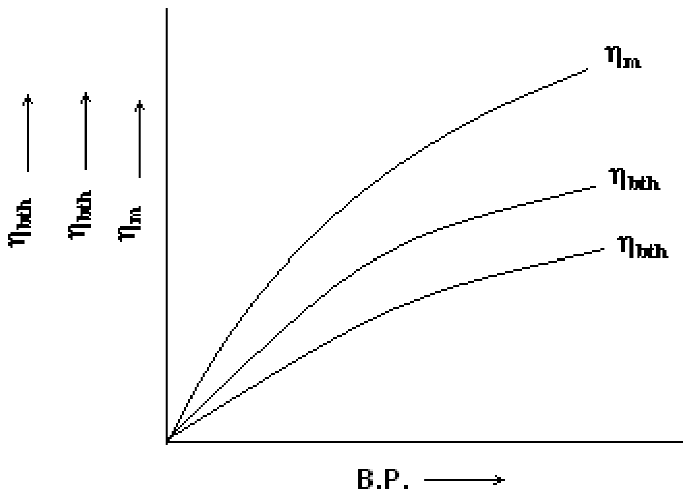
2. bsfc or isfc Vs BP



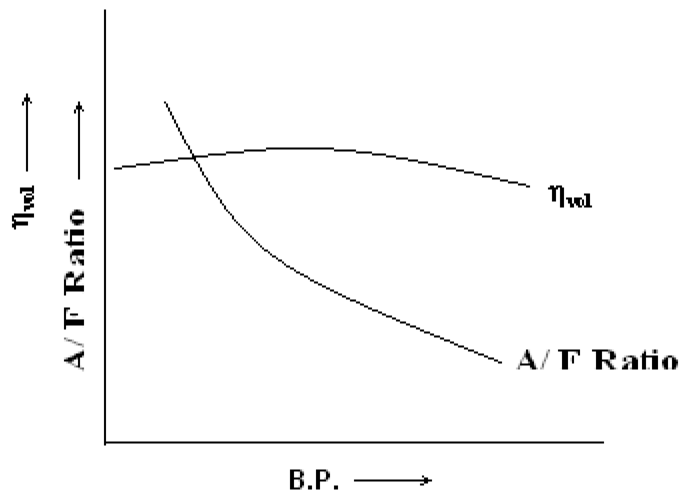
imep, bmep Vs BP



η_{bth}, η_{ith}, η_m Vs BP



5. $\eta_{vol,}$ A/F ratio Vs BP



PRECAUTIONS:

- Before starting the engine fuel supply, cooling water supply and lubricating system should be checked.
- Ensure that there is no load on the engine while stopping.
- Ensure proper cooling water supply to the brake drum.

DETERMINATION OF HEAT BALANCE SHEET, VOLUMETRIC EFFICIENCY AND AIR FUEL RATIO ESTIMATION OF A SINGLE CYLINDER DIESEL ENGINE

AIM: To conduct a Heat Balance Test on 4-stroke, single cylinder diesel engine and to draw up a heat balance sheet on an hour basis.

APPARATUS: Stop watch.

SPECIFICATIONS: It is a 4-stroke, vertical, single cylinder, and water cooled diesel engine coupled with rope brake dynamometer.

Engine:	Dynamometer
BHP: 5HP	Type: Rope brake
Speed: 1500rpm	Diameter of brake drum: 300mm
Bore: 80mm	Diameter of rope: s16mm
Stroke: 110mm	Effective radius of brake drum: 158mm
Compression ratio: 16.5:1	T_1 –Temperature of water inlet of the engine jacket
Orifice diameter: 17mm	T_2- Temperature of water outlet of the engine jacket
Method of start: Crank start	T_3- Temperature of exhaust gasses
Make: KIROLSKAR	T_4- Ambient temperature

Type of ignition: Compression ignition.

THEORY: The engine is supplied with certain quantity of heat energy in the form of fuel. Only a part of this energy is converted into useful mechanical work which is available at the engine crankshaft and the rest is wasted in engine jacket cooling water, in the exhaust gasses and in overcoming the friction. The non useful energy leaving the system should be as small as possible in order to maximize the rated power. It is the purpose of energy balance to trace the energy distribution i.e. to determine how the input energy is distributed, where the energy leaves and how much. If during a test, it is revealed that at certain loading conditions a certain form of energy loss is excessive, a careful examination of that form is needed in order to have the better performance of the engine. A statement of the heat supplied, useful energy available and the losses is called the Heat balance sheet. It can be drawn on the basis of unit time.

Heat balance sheet (on an hour basis) of an IC engine includes the following components:

i)Heat supplied to the engine in the form of fuel = Mf X CV KJ/hr

Where mf = mass of the fuel consumed = y/t X 3600/1000 X ef kg/h

t = time taken for ‘y’ cc of fuel consumption, sec

pf = density of fuel, gm/cc

CV = calofific value (lower) of fuel, KJ/Kg

ii) Heat equivalent of useful work = BP X 3600 KJ/ hr

Where BP = 2 II NT / 60 000 KW

T = 9.81 x W x Re N-m

Load, W = (w1- W2) Kg

W1 = Value of dead weight onkl the brake drum, kg

W2 = spring balance reading, kg

Re = effective brake drum radius, m

N = rated speed, rpm

iii) Heat carried away by cool9ng water = mw cpw (T2 – T1) Kj/hr

Where Mw = mass flow rate of jacket cooling water, Kg/hr

Cpw = specific heat of water, Kj/kg 0K

T1 = cooling water inlet temperature, 0K

T2 = cooling water outlet temperature, 0K

iv) Heat carried away by exhaust gasses = mg cpg (T3 – T4) KJ/hr

mg = ma + mf kg/hr

ma = mass flow rate of air, kg/hr

mf = mass flow rate of fuel, kg/hr

cpg = specific heat of exhaust gases, KJ/kg 0K

T3 = exhaust gas temperature, 0K

T4 = ambient temperature, 0K

v) Heat unaccounted = i – [ii + iii + iv) KJ/hr

The approximate percentage values of above parameters for CI(engine are given below :

Heat energy in brake power varies from 29 to 42%; heat energy carried away by cooling water varies from 20 to 35 %; heat carried away by exhaust gases varies from 25 to 45 % and unaccounted losses lies between 21 to 2 %.

The relative quantities of energy utilized, heat carried away by cooling water, heat carried away exhaust gases and heat unaccounted losses, changes as functions of load. The above calculations are made at 0, ¼ ,1/2 , ¾ of full load. The variations of above quantities are plotted as functions of load on the engine.

DESCRIPTION:

It is a 4-stroke, single cylinder, water cooled constant speed diesel engine which is coupled to a rope brake drum arrangement to absorb the power produced. The engine is crank started. Necessary dead weights and spring balance are included to apply load on the brake drum. Suitable cooling water lines fitted with temperature measuring thermocouples are provided fork the engine cooling. A measuring system for fuel consumption consisting of a fuel tank, burette, 3-way cock mounted on a stand and stop watch are provided. Air intake is measured using an air tank fitted with an orifice meter and a water U-tube differential manometer. Also a digital temperature indicator with selector switch for temperature measurement and a digital RPM indicator for speed measurement are provided on the panel board. A governor is provided to maintain the speed constant.

PROCEDURE:

1. Note down the engine specifications and ambient temperature.
2. Calculate the full load (W) that can be applied on to the engine from the given engine specifications using the formula: BP = 2 II NT /60 000 KW Where T = 9.81 X W X Re N - m
3. Check for fuel lubricating oil and cooling water supply.
4. Start the engine by using decompression lever ensuring that no load on the engine and supply the cooling water.
5. Allow the engine to run for 10 minutes on load to get stabilization.

6. Note down the time taken for 10 cc of fuel consumption, speed, manometer readings, cooling water flow rate from engine jacket Rota meter and the corresponding temperatures.
7. Repeat the above procedure and take reading at one-fourth, half, three-fourth of furl load.
8. Allow the engine to stabilize on every load change and then take the readings.
9. Stop the engine by pulling the governor lever towards the engine cranking side. Check that there is an load on the engine while stopping.

PRECAUTIONS:

1. Before starting the engine fuel supply, cooling water supply and lubricating system should be checked.
2. After starting the engine a continuous supply of cooling water and lubricating oil should be ensured.
3. Ensure that there is no load on the engine while stopping.
4. Ensure proper cooling water supply to the brake drum.

DETERMINATION OF PERFORMANCE CHARACTERISTICS OF VCR ENGINE

AIM: The experiment is conducted to

- To study and understand the performance characteristics of the engine.
- To draw Performance curves and compare with standards

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. Eddy Current Dynamometer Loading

1. The equipment consists of a Brand new **KIRLOSKAR** make AV1 model Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled.
2. The Engine is coupled to a Eddy Current Dynamometer for Loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the **Load Cell with digital load indication.**
3. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
4. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
5. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.

6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of an ACRYLIC Manometer.
7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.
8. The testing arrangement is mounted on an aesthetically designed self sustained sturdy frame made of MS channels with anti vibration mounts.
9. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flowrate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Set the compression Ratio – see Annexure I for detail
10. Switch on the Load controller and slowly load the engine by rotating the knob clockwise.
11. Note the following readings for particular condition,
    - Engine Speed
    - Time taken for ____cc of diesel consumption
    - Rotameter reading.
12. Manometer readings, in cms of water &
13. Temperatures at different locations.
14. Repeat the experiment for different loads and note down the above readings.
15. After the completion release the load and then switch of the engine.
16. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied F' N"	Manometer Reading			Time for 10cc of fuel collected, t sec
			h1	h2	hw = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

1. **Mass of fuel consumed, mf**

Xcc x Specific gravity of the fuel

1000 x t

mf = $\frac{}{}$ kg/sec

Where,
SG of Diesel is = 0.827
Xcc is the volume of fuel consumed = 10ml
t is time taken in seconds

2. **Heat Input, HI**

HI = mf x Calorific Value of Fuel kW
Where,
Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

Engine output $BP = \frac{2\Pi NT}{60000}$ kW
Where,
N is speed in rpm
T = Torque on the load indicator
T = F x r x 9.81 N-m
r = Torque arm radius = 0.15m

4. **Specific Fuel Consumption, SFC**

$SFC = \frac{mf \times 3600}{BP}$ kg/kW – hr

5. **Brake Thermal Efficiency, ηbth%**

$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$

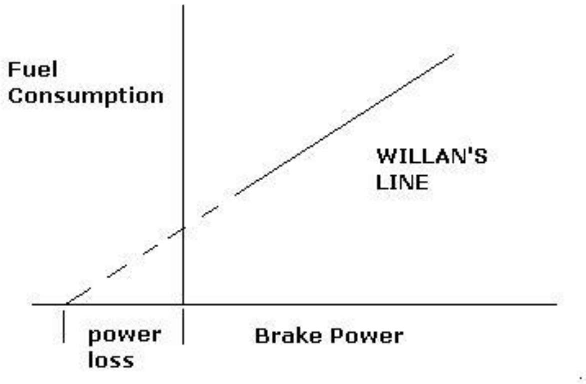
6. **Mechanical Efficiency, ηmech%**

$\eta mech\% = \frac{BP}{IP} \times 100$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

IP = BP + FP



7. **<u>Calculation of head of air, Ha</u>**

$$Ha = hw \frac{\rho water}{\rho air}$$

Where,

ρwater = 1000 Kg/m³

ρair = 1.2 Kg/m³ @ R.T.P

hw is the head in water column in 'm' of water

8. **<u>Volumetric efficiency, ηvol%</u>**

$$\eta vol\,\% = \frac{Qa}{Qth} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Where,

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.02)²/4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$\textbf{Qth} = \frac{(\Pi/4) \times D^2 \times L \times N}{60 \times 2}$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

	Input power	Output Power	SFC	Brake Thermal Efficienc	Mechanical Efficiency	Volumetric efficiency

				y		

9. **TABULATION**

Heat Balance Sheet Calculations IN SECONDS basis:

Heat Input --- A

A = mf x Calorific Value kW

Heat to BP --- B

B = Kw

Heat to cooling water --- C

$$C = m_{we} \times C_{pw} \times (T_{ei} - T_{eo}) \quad kW$$

Where

mwe = cooling water flow rate to the engine from

Rotameter

= LPM1/60 kg/sec

Cpw = Specific Heat of water = 4.18 kJ/kg

Heat to exhaust gases --- D

D = mwc x Cpw x (Tci – Tco) x [(Tgci – Ta)/ (Tgco – Tgci)] kW

Where

mwc = water flow rate in kg/sec

= LPM2/60 kg/sec

Cpw = Specific Heat of water

Ta = Engine surrounding temperature.

Tgci = Gas inlet temp to calorimeter

Tgco = Gas outlet temp from calorimeter

T_{ci} = Water Inlet temp to calorimeter

T_{co} = Water outlet temp from calorimeter

Heat Unaccounted

E = A – (B+C+D) kW

HEAT BALANCE SHEET:

Sl. No.	**Particulars**	**Heat Content kW**	**%**
1	Heat Input -- A		100
2	Heat to BP -- B		B/A =
3	Heat to Cooling Water -- C		C/A =
4	Heat to Exhaust Gases -- D		D/A =
5	Heat Unaccounted -- E		E/A =

RESULT:

Graphs to be plotted:

1) SFC v/s BP
2) η_{bth} v/s BP
3) η_{mech} v/s BP
4) η_{vol} v/s BP

4. **PRECAUTIONS:**

7. Do not run the engine if supply voltage is less than 180V
8. Do not run the engine without the supply of water.
9. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
10. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
11. Do not forget to give electrical earth and neutral connections correctly.
12. Frequently, at least once in three months, grease all visual moving parts.
13. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
14. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.
15. In case of any major faults, Please write to the manufacturers and do not attempt to repair.

DETERMINATION OF PERFORMANCE OF AN AIR CONDITIONING UNIT

AIM: To evaluate the performance of a given Air conditioning test rig.

APPARATUS: Vane type anemometer.

THEORY: The air conditioning test rig works on standard vapor compression cycle. Vapor compression refrigeration cycle is very widely used cycle of refrigeration. The domestic refrigerator, ice plants works on this cycle. It uses a variety of refrigerants such as Ammonia (NH_3), Freon's (R_{12},R_{22},R_{134a}). The vapour compression refrigeration has fundamentally four basic components as shown in Fig. 1 and four basic processes. The corresponding T-S, P-H diagrams are also indicated in Fig. 2a and 2b. Normally in the case of refrigeration P-H and T-S diagrams are extensively used for indicating various processes and hence significance of these diagrams is to be fully understood.

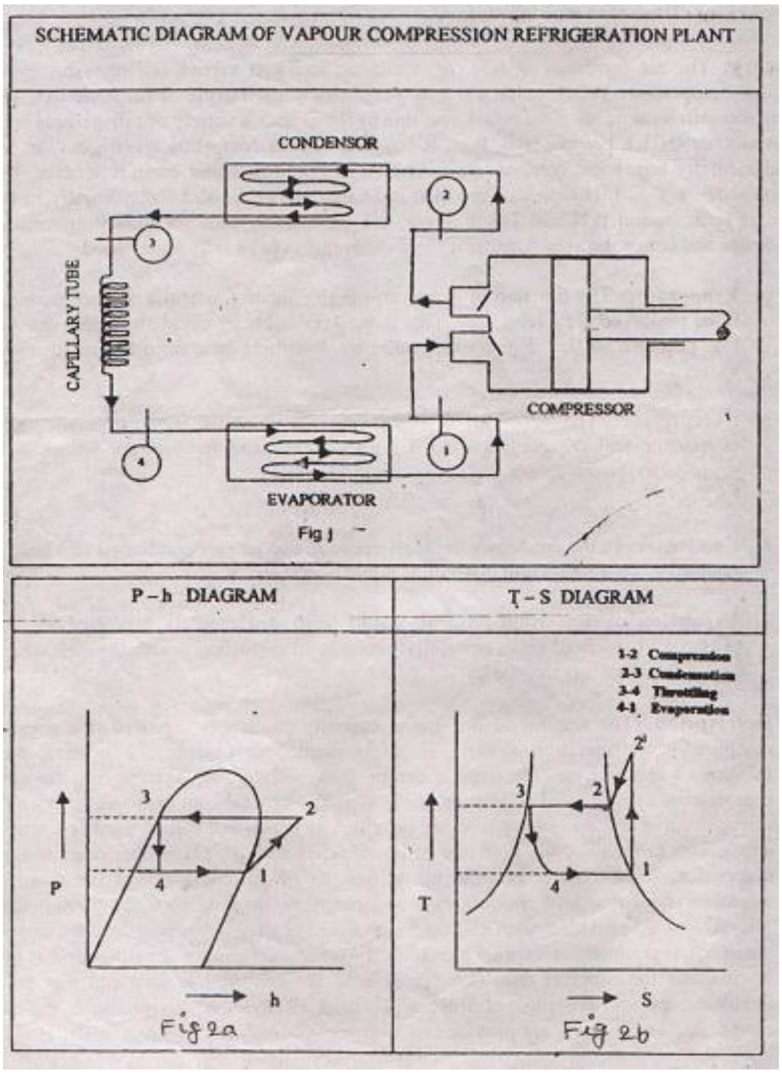
a) Evaporator: The function of evaporator is to contain foodstuffs or such material to be preserved for a long time. This is made possible by circulating refrigerant at low pressure so that it gets evaporated by absorbing heat from the refrigerated space.

b) Compressor: The function of compressor is to draw the refrigerant from evaporator and compresses it to a high pressure and temperature before it is supplied to the condenser.

c) Condenser: In the condenser the high pressure vapors are condensed and heat is rejected to cooling medium (which is atmospheric air).

d) Expansion device: High pressure liquid from condenser is expanded to low pressure. A solenoid valve or capillary tube is an expansion device through which liquid refrigerant is throttled.

DESCRIPTION: The test rig of one tone capacity essentially consists of a vapour compression refrigeration system, an air conditioning chamber, 2 heaters, one fan and blower, a boiler etc. The vapour compression refrigeration system consists of a compressor, an air cooled condenser (air is supplied by a fan), an expansion device (a solenoid valve and a capillary tube are provided of which one can be used at a time), a Rota meter to measure the flow rate of liquid refrigerant (R-22), a filter drier and an evaporator. A fan and blower is arranged across the evaporator coil and the coil-fan assembly is incorporated inside a plywood chamber (duct) to cool the flowing air. The system is provided with thermocouples and a digital temperature display to measure temperature at various locations. Two pressure gauges are fitted one at the suction and the other at the discharge side of the compressor. Dry and wet bulb thermometers are provided at inlet and outlet of the duct to; measure the air conditions. Two heaters are provided to; monitor the condition of air. A boiler is also provided to; supply steam. An energy meter is also; provided to measure the power supplied to; the compressor.



PROCEDURE:

1. Note down the initial conditions (DBT and WBT) of air at inlet and outlet of the duct and also take the initial energy meter reading of the compressor.
2. By taking all necessary precautions, switch on the main keeping the capillary valves open.
3. Run the unit for some time say 15 minutes, and take the temperatures, pressure readings, Rota meter reading, energy meter reading and the velocity of air at outlet of the duct.
4. Run the unit for another 15 minutes and take the readings.
5. Repeat the procedure with solenoid valve as expansion device and switch off the unit

SAMPLE CALCULATIONS:

Theoretical COP = $h_1 – h_4 / h_2 – h_1$

Where h_1, h_2, h_3, ($h_3 = h_4$) are the enthalpy values from p-h chart of R -22

Actual COP = Net refrigerating effect (R_n) / energy (or) Power supplied to the compressor (w)

Power supplied to the compressor (w) = (final energy meter reading – initial energy maker reading) 33600 / time in seconds.

Net refrigerating effect, Rn = m dh KW

Where m = mass flow rate of cool air = ρAV kg/s

ρ = dergity of air at outlet of the duct corresponding to DBT kg

A = cross sectional area of the duct = (0.295 3 225) m2

V = average velocity of cool air, m/s

Change in enthalpy, dh = (hi – ho) Kj/kg

Where hi & ho are the enthalpy from psychrometric chart corresponding to inlet & outlet condition of air.

Dehumidification = (w_i –w_o) gm/kg of dry air

Where wi & wo are specific humidities from psychrometric chart.

PRECAUTIONS:

1. Only one expansion device should operate at a time.
2. Care should be taken while noting down the energy meter reading.

PERFORMANCE OF AN AIR CONDITIONING TEST RIG

Initial conditions

	DBT	WBT
Inlet		
Outlet		

Energy meter reading = Kwh

S.No	Suction pressure		Discharge pressure		Temperatures, ^{0}C				
	Psi	bar	Psi	bar	T1	T2	T3	T4	T5

Rota meter reading	Inlet		Outlet		Air velocity m/s	EMR	COP	
	DBT	WBT	DBT	WBT			actual	theoretical

DETERMINATION THERMAL CONDUCTIVITY OF HEAT PIPE

AIM: To find out the thermal conductivity of copper, H.P, 1S.S.

THEORY: The heat pipe is a device of very high thermal conductance. It transfers heat by boiling a fluid at one end & condensing it at another. The evaporation & condensation processes are responsible for the nearly isothermal working of the heat pipe. The condensed liquid is transferred back to the boiling area by the capillary action through a wick structure in the heat pipe. It is the use capillary action for pumping the liquid back, which the unique characteristic of the heat pipe. The thermo siphon in many ways resembles a heat pipe, except that the return of the liquid to the evaporation is due to gravity. The effective thermal conductivity of the device is found to be a few hundred times that of solid copper of similar mass.

Apart from high thermal conductance, the heat pipe is characterized by:

1. Very high thermal conductance.
2. The ability to act as a thermal flux transformer.
3. An isothermal surface of low thermal impedance.
4. Variable thermal impedance.
5. Thermal diode & switches.

PRINCIPLE OF HEAT PIPE:

Heat from the source evaporates the working fluid & converts it into vapour. These vapours travel through the vapour core to the other end of the heat pipe source end by the surface tension forces developed in the wick. Thus the cycle continues.

The heat transfer from the source to the sink is effected mainly by the following simultaneous & independent process:

1. Heat Transfer from the source through the container wall & wick – liquid matrix to the liquid – vapour inter face.
2. Evaporation of the liquid-vapour in the core from the evaporator to the condenser.
3. Condensation of the liquid-vapour interface in the condenser.
4. Heat Transfer from the liquid-vapour interface through the wick-liquid matrix, & container wall to the sink.
5. Return flow to the condensate from the condenser to the evaporator caused by the capillary action of the wick.

It consists of a heat pipe, a stainless pipe & pipe of identical physical properties such as diameters, lengths & masses.

Heat pipe is made up of 25.5 mm outer diameter stainless steel pipe. A stainless steel wire mesh of 200 mesh size is inserted in this pipe. A stainless steel wire mesh have been used. Calculated quantity of distilled water as working fluid in introduced in the heat pipe after cleaning the pipe & mesh with hydrochloric acid, acetione & distilled water & making perfect vacuum as far as possible.

A stainless steel pipe & copper pipe (both of 25.5 mm dia) are taken for comparison. The lengths of the three members are kept approximately 350mm. with weight of 400 gm. each.

The lengths of the heating sections for the heat pipe, stainless steel pipe & copper pipe are 100 mm. The adiabatic sections for all the three measure 100 mm. While the condensing sections of 150 mm are provided at the condensing ends.

Nichrome ribbon heaters 400 W are used & are wound on the heating sections. The surface temperature along the length are measured by four calibrated copper constant thermocouple while the temperature of the water in the condense tank (sink) is measured by calibrated thermometers. A separate thermocouple is introduced in the vapour space of the heat pipe to measure the vapour temperature. Fig shows the schematic layout of the set-out provides for comparison of the heat transfer rates obtained with the three units having same physical identity.

PROCEDURE:

1. The Evaporator section was fitted into the 100 mm long heater block in the test rig, & the condenser section covered by 180mm long water jacket.
2. Tests were carried out with the heat pipe operating vertically with gravity assistance.
3. Now a known steady input of 105 W was supplied to the heating sections of three units of the demonstrator. 0.800 ltrs of water was kept in each condenser tank.The rise of temperature in these tanks as well as temparatures were noted at successive time intervals.
4. The above procedure was performed for various times intervals

SPECIFICATIONS

1. **Experimental set up**:

Heat pipe made of stainless steel

Two standard Pipes : Copper and Stainless Steel one each.

Band Heater : 400 watts

Condenser Tank : 3 nos.

2. **Control Panel:**

Temperature Indicator: 12 Channel Digital Temp Indicator with Cr/Al

Thermocouples.

Auto Transformer : 230 Volts, 2 Amp supply.

Voltmeter : 240 Volt.

Ammeter : 3 Amp

OBSERVATIONS:-

1. Internal Diameter of Heat Pipe : 31 mm
2. Outer Diameter of Heat Pipe : 38 mm
3. Length of Heat Pipe : 380 mm
4. Internal Diameter of Copper & SS Pipe : 31 mm
5. Outer Diameter of Copper & SS Pipe : 38 mm
6. Length of Copper & SS Pipe : 380 mm
7. Mesh Size : 200 mm
8. Dia. of Mesh (Wire) : 0.08 mm
9. Pore Dia of Wire : 0.0633 mm
10. Volume of Liquid in the Cooling : 800 ml

Jacket at the Condenser Section

OBSERVATION TABLE:

PIPE	TIME IN MIN	SURFACE TEMPERATURE			COOLING WATER TEMP		HEAT INPUT	
		T_1	T_2	T_3	T_4 T_C	T_H	V	I
CU								
		T_5	T_6	T_7	T_8 T_C	T_H		
HP								
		T_9	T_{10}	T_{11}	T_{12} T_C	T_H		
SS								

SAMPLE CALCULATIONS:

SS PIPE

1. Mass Flow Rate of Liquid in Cooling Jacket (M1)

= Volume X Density Kg

2. Heat Input (Q_{in}) = V X L Watts
3. Heat Output (Q_{out}): = M_1 X C_p X Δ T Watts Where Δ T = $T_{c2} - T_{c1}$
4. Effectiveness Of The Heat Pipe (H) : = Q_{out} / Q_{in}
5. Cross Sectional Area Of Pipe (A) == $(\pi/4)\ D_o^2$

= $(\pi /4)\ (0.038)^2$

= $1.134 \times 10^{-3}\ m^2$

6. Thermal Conductivity (K) = (Q X L)/ A ($T_1 - T_3$) Watt/m°k

I. COPPER PIPE

1. Mass Flow Rate of Liquid in Cooling Jacket (M1)

= Volume X Density Kg

2. Heat Input (Q_{in}) = V X L Watts
3. Heat Output (Q_{out}): = M_1 X C_p X Δ T Watts Where Δ T = $T_{c2} - T_{c1}$
4. Effectiveness Of The Heat Pipe (H) : = Q_{out} / Q_{in}
5. Cross Sectional Area Of Pipe (A) == $(\pi/4)\ D_o^2$

= $(\pi /4)\ (0.038)^2$

= $1.134 \times 10^{-3}\ m^2$

6. Thermal Conductivity (K) = (Q X L)/ A ($T_5 - T_7$) Watt/m°k

II. HEAT PIPE

1. Mass Flow Rate of Liquid in Cooling Jacket (M1)

= Volume X Density Kg

2. Heat Input (Q_{in}) = V X L Watts
3. Heat Output (Q_{out}): = M_1 X C_p X Δ T Watts Where Δ T = $T_{c2} - T_{c1}$

4. Effectiveness Of The Heat Pipe (H) : = Q_{out} / Q_{in}

5. Cross Sectional Area Of Pipe (A) == $(\pi/4)\ D_o^2$

$= (\pi /4)\ (0.038)^2$

$= 1.134 \times 10^{-3}\ m^2$

6. Thermal Conductivity (K) = (Q X L)/ A ($T_9 - T_{11}$) Watt/m^{o}k

RESULTS:

1. Thermal Conductivity of Copper Pipe :
2. Thermal Conductivity of Heat Pipe :
3. Thermal Conductivity of S.S. Pipe :

PERFORMANCE EVALUATION OF SOLAR FLAT PLATE COLLECTOR

AIM : To study the solar water heater.

THEORY:

Solar energy has the greatest potential of all the sources of renewable energy and only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted.

The solar power where sun hits the atmosphere is 10^{17} watts, whereas the solar power on earth's surface is 10^{16} watts. The total worked wide power demand of all needs of civilization is 10^{13} watts. Therefore the sun gives us the 1000 times more power than we need. The energy radiated by the sun on a bright sunny day is approximately 1 $kW/m^{2.}$

Utilization of solar energy is of great importance to india since it lies in a temperature climate of the region of the world where sun light is abundant for major part of the year.

The solar water heating systems for domestic, industrial, and commercial application s are at present available. In commercial establishment there is great potential especiall in hotels, hospitals, guest houses, tourist bunglows, canteen etc. for industrial applications solar water heating system can meet the low and medum temperature process heat requirements hot water upto 90 ^{0}C and low pressure steam upto 140 ^{0}C. These are specially useful in engineering, chemicals, textile, chemicals, pharmaceuticals.

In any collection decive, the principal usually followed is to expose a dark surface surface to solar radiation so that the radiation is absorbed. A part of the absorbed radiation is then transferred to a fluid like air or water. When no optical concentration is done, the device in which the collection is achieved is called a flat-plate collector. The flat-plate collector is the most important parts and requires little maintenance. It can be used for a variety of applications in which temperatures ranging from 40^0 C to about 100^0 C are required.

A schematic diagram is of a liquid flat – plate collector is shown in fig. It consists of an absorber plate on which the solar radiation falls after coming through one or more transparent cover (usally made of glass).

The absorbed radiation is partly transferred to s liquid flowing through tubes which are fixed to the absorber plate or are integral with it. This energy transfer is the useful gain. The remaining part of the radiation absorbed in the absorber plate is lost by conduction and re-radiation to the surrounding from the top surface, and by conduction through the back and the edges.

The transparent covers help in reducing the losses by convection and re-radiation, while thermal insulation on the back and the commonly used is water. A liquid flat-plate collector is usually held tilted in a fixed position on a supporting structure, facing south if located in the northern hemisphere.

Collector shall be tested under clear sky conditions in order to determine its efficiency on any clear day, data is recorded under steady state conditions for fixed values of 'm' (flow rate of water & inlet temperature t1. For each set of fixed values it is recommended that an equal no. of test should be conducted symmetrically before & after solar noon for e.g. between 11 am to 1 pm.

1. Fill the water in supply tank.
2. Fill the water in storage tank of solar water heter gradually.
3. Switch on the power supply to control panel.
4. Close the flow control valve fully.
5. Now slowly open the flow control valve of water & maintain flow rate of water through solar flat collector & through rotameter about 1-2 LPM.
6. Now start the water suplu to heat exchange & maintain its flow rate between 1 to 2 LPM through rotameter.
7. Note down the all temperature readings every after 10 min. interval.

OBSERVATIONS:

1. Flow rate of water through flat plate collector m = LPM
2. Mass flow rate of cooling water thr. Heat Exch. "M" = LPM
3. Inlet temperature of water to flat plate collector T_1 = ^{0}C
4. Outlet temp. of water from flat plate collector T_2 = ^{0}C
5. Hot water inlet temp. to heat exchanger T_3 = ^{0}C
6. Hot water outlet temp. from heat exchanger T_4 = ^{0}C
7. Cooling water inlet temp. from heat exchanger T_5 = ^{0}C
8. Cooling water outlet Temp. from heat exchanger T_6 = ^{0}C
9. Ambient temperature T7

SOLAR FLUX INCIDENT DATE:

Time a.m.	Flux incident on collector l_T (W/m^2)	Averager transmissivity absorptivity product $(T\alpha)^{av}$	Ambient temperature T_a (^{0}C)

OBSERVATION TABLE

Sl. No	Mass flow rate of water through flat plate collector "m" in 1pm	Mass flow rate of cooling water through heat exchanger in "M" l pm	T_1 in ^0C	T_2 In ^0C	T_3 in ^0C	T_4 in ^0C	T_5 in ^0C	T_6 in ^0C	T_7 in ^0C	Time in min.
1										
2										
3										
4										
5										

SAMPLE CALCULATION

A. The principal measurement made in each data set are the fluid flow rate (m), the fluid inlet & outlet temperature collector T 1 & T2 solr radiation incident on collector plain (l_T = 600 W/m2) the ambient temperature T7.

$$\eta_i = \frac{Qu}{A_c I_T} = \frac{mC_p(T_2 - T_1)}{A_c I}$$

Where,

M = Mass flow rate of water in kg/hr.

C_p = Specific heat of water = 1.0142 cal/g ^{0}C or 4.184 J/gm/^{0}C

T_1 = Water inlet temp. to flat plate collector

T_2 = Water outlet temp. from flat plate collector

A_c = Flat plate collector area = 1.66 m^2

I_T = Incident flux. = 600 w/m^2

b. Efficiency of flat plate collector is calculated by another method i.e., based on energy balance equation

$mc_p\Delta T = Mc_p\Delta T$

Where,

m = Mass flow rate of water through solar flate plate collector.

C_p = Specific heat of water.

ΔT = Temperature difference of water inlet to collector & outlet from collector.

M = Mass flow rate of water through heat exchanger

C_p = Specific heat of water

ΔT = Temperature difference cold water inlet to heat exchanger & outlet from heat exchanger.

So,

$$\eta_i = \frac{mC_p(T_2 - T_1)}{MC_p(T_2 - T_1)}$$

In this equation heat given by hot water of flate plate collector is heat gained by cooling water of heat exchanger is taken 100% i.e., minor losses are neglected.

PRECAUTIONS:

1. Do not keep solar flat plate collector empty.
2. Insure before heater starting storage tank is full of water.

RESULT

The efficiency of flat-plate collector:

DETERMINATION OF COP OF A VAPOUR COMPRESSION REFRIGERATION UNIT

AIM: To demonstrate the working of vapour compression refrigeration system and calculate its capacity and performance

DESCRIPTION OF THE APPARATUS

The Refrigeration system consists of:

REFRIGERANT

R-134 A is used as a medium to undergo vapour compression cycle

COMPRESSOR

Reciprocating type, capacity1/3 HP, Kirloskar make, used to compress refrigerant vapour at low pressure from the evaporator to a higher pressure at the condenser inlet

CONDENSER

Is a heat exchanger equipment to condense refrigerant vapor at higher temperature to a liquid

COOLING FAN

Provided to blow atmospheric air on the condenser to assist cooling of refrigerant in the condenser

THROTTLE VALVE

Provided to facilitate expansion of high pressure liquid refrigerant to a low pressure liquid-vapor mixture at constant enthalpy

CAPILLARY TUBE

Performs the same function as the throttle valve. It is a fixed length small bore transparent tubing installed between condenser and evaporator – used to demonstrate the working of the throttle valve. During the refrigeration experiment, either the throttle valve or the capillary tube will be used. Switching can be realized by suitable connecting / valve system.

EVAPORATOR

Is a chamber where cooling takes place because of evaporation of evaporation of liquid – vapor refrigerant at low temperature and pressure. It consists of a metallic bowl having grooves below the surface through which the refrigerant flows while evaporation

PRESSURE SENSOR

Provided to measure the refrigerant at compressor inlet and compressor outlet

DATA SCANNER

Provided to measure temperatures, Power input and pressure values of the refrigerant at different stages

PROCEDURE:

1. Switch – ON the mains and the console

2. Keep either the throttle valve or the capillary tube open Both devices have the same expansion (or throttling) effect.
   NOTE: ***While doing Capillary switch off the Solenoid Valve and when doing with Throttle Valve Switch on the Solenoid Valve and close the valves at the Capillary. This is most important task before starting the experiment***

3. Switch –ON the motor which drives the compression and the fan (which cools the condenser)

4. The refrigerant passes through the vapour compression cycle as mentioned earlier resulting in cooling in evaporator chamber or freezer

5. Wait for about 30 minutes and note the temperatures T1 to T5 and pressures P1 and P2

T1	=	Temperature at compressor inlet (°C)
T2	=	Temperature at compressor outlet (°C)
T3	=	Temperature at condenser outlet (°C)
T4	=	Temperature at evaporator inlet (°C)
T5	=	Temperature inside freezer
P1	=	Pressure upstream of the compressor, Kg/Cm²
P2	=	Pressure downstream of the compressor, Kg/Cm²
V	=	Voltage of the compressor, Volts
I	=	Current to the compressor, Amps

6. The temperature T5 in the freezer denotes the refrigeration process

7. Using the measured temperatures, pressures and power

8. input to the compressor, the co-efficient of performance and the capacity of the refrigerator can be determined using the formulae given.

9. Once experimentation is completed switch off the Compressor

DETERMINATION OF EFFECTIVENESS OF EVACUATIVE TUBE CONCENTRATOR

AIM: The experiment is conducted to demonstrate the use of Solar energy in heating the water and identify their effectiveness.

DESCRIPTION OF THE APPARATUS:

1. The apparatus consists of the following major parts
   - **Evacuative tube concentrator**.
   - **Solar Flat plate collectors**
2. An overhead tank is provided to fill the water to the system.
3. Lighting arrangement is made to create the artificial heat as a source to develop energy. A **Digital Voltmeter and Ammeter** is provided to measure the heat source.
4. Required Temperature spots are identified and connected with thermocouples and a **digital temperature indicator** with channel selector is provided to measure the same.
5. The whole arrangement is mounted on an **Aesthetically designed sturdy frame** made of **MS angle** with all the provisions for holding the tanks and accessories.

PROCEDURE:

1. Fill in the pure water to the overhead tank.
2. Open the corresponding ball valve of the overhead tank.
3. Close the Ball valve at the outlet of the solar collector in use.
4. Check the necessary electrical connection and provide 230V 1hp AC connection.
5. Place the Artificial Heat source to the required position.
6. Now provide electrical connection to the panel.
7. Switch on the mains and now turn on dimmer to set the voltage to the source.
8. After setting the dimmer, immediately start the timer.
9. Continue for about 30min and take the following readings: Voltmeter and Ammeter Reading
   Time of experiment
   Temperatures at inlet and outlet of the collector
10. Now, Repeat steps 5 to 9 by changing the settings, so as to compare.
11. Repeat the experiments for different Voltage inputs

OBSERVATIONS:

Constant Head/Speed

Sl. No	Voltmeter Reading, V volts	Ammeter Reading, I amps	Time of Conduction of experiment, 't' s

CALCULATIONS: (For given time instant)

10. **Input to the system ,IP**

IP = V x I x 0.6 kW

Where,

V = Voltmeter Reading in volts

I = Ammeter Reading in Amps

0.6 = Effective Heat passed to system leaving the losses

due to open system.

2. **Output, OP**

$$OP = m_w C_{pw} \Delta t \qquad kW$$

Where,

m_w = mass of the water in the system

= 1.75lt

C_{pw} = Specific heat of Water = 4.18kJ/kg

Δt = Temperature difference of the particular system.

3. **Effectiveness of the System**

$$\eta\% = \frac{OP \ x \ 100}{IP}$$

TABULAR COLUMN

S. No	IP, KW	OP, KW	Efficiency %η

GRAPHS

5) Time Vs. OP
6) Time Vs. Efficiency

RESULT:

The effectiveness the Sytem for the given time instant is ______

INFERENCE OF RESULT:

Note : Here the student has write the inference on the total experiment conducted viz

i) how the system reacted w.r.t time
ii) how the system effectiveness varied w.r.t time
iii) how the system responded to the varied inputs.
iv) Effects of varied input to the system

LAB INTERNAL-I QUESTION PAPER

DT:26-09-2018

Determination of Dryness fraction of Steam
Determination of burning velocity at laminar flow condition for different diameters of the jet.
Determination of performance and emission parameters of CI engine
Draw a heat balance sheet for VCR engine
Determination of performance parameters of VCR engine.
Estimation of Volumetric efficiency and air fuel ration of CI engine.

LAB INTERNAL-II QUESTION PAPER

DT:05-12-18

Performance evaluation of Vapour compression refrigeration.
Performance evaluation of air conditioning unit.
Performance evaluation of Heat Pipe
Performance analysis of Solar flat plate collector
Performance analysis of Evacuative tube concentrator
Determination of performance parameters of VCR engine.

Measuring Course Outcomes attained through University Examinations:
*Attainment Level 1: **60%** students scoring P Grade and above*
*Attainment Level 2: **70%** students scoring P Grade and above*
*Attainment Level 3: **80%** students scoring P Grade and above*

Measuring Course Outcomes attained through Serial Tests:
*Attainment Level 1: **50%** students scoring 15 and more marks out of 30*
*Attainment Level 2: **60%** students scoring 15 and more marks out of 30*
*Attainment Level 3: **70%** students scoring 15 and more marks out of 30*

Attainment of Course Outcomes: M.Tech(TE) 1-1 Sem
FACULTY NAME: Dr.Shaik Hussain

Course Outcomes	Tool	Percentage of students scoring more than the target	Attainment level	Attainment of Course Outcome
CO1	**Mid Exam I (20%)**	100	3	(0.2x3) + (0.8 x 3) = **3.0**
	End. Exam (80%)	100	3	
CO2	**Mid Exam I (20%)**	100	3	(0.2x3) + (0.8 x 3) = **3.0**
	End. Exam (80%)	100	3	
CO3	**Mid Exam I (10%)**	100	3	(0.1x3) + (0.1x3) + (0.8x3) = 3.0
	Mid Exam II (10%)	100	3	
	End Exam (80%)	100	3	
CO4	**Mid Exam II (20%)**	100	3	(0.2x3) + (0.8 x 3) = **3.0**
	End. Exam (80%)	100	3	
CO5	**Mid Exam II (20%)**	100	3	(0.2x3) + (0.8 x 3) = **3.0**
	End. Exam (80%)	100	3	

ATTAINMENT OF PROGRAMME OUTCOMES MAPPED WITH THE COURSE

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	3.0	3.0	-	3.0	-	-	-	-	-	-	-	-	-
CO2	-	-	3.0	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-
CO3	3.0	3.0	3.0	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-
CO4	3.0	3.0	3.0	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-
CO5	-	-	3.0	3.0	-	-	-	-	-	-	-	-	-	-	-

SIGNATURE OF FACULTY