LABORATORY MANUAL

18MEL67 HEAT TRANSFER LAB

2019-2020

DEPARTMENT OF MECHANICAL ENGINEERING
ATRIA INSTITUTE OF TECHNOLOGY
Adjacent to Bangalore Baptist Hospital
Hebbal, Bengaluru-560024

Department of Mechanical Engineering

Vision

To be a center of excellence in Mechanical Engineering education and interdisciplinary research to confrontreal world societal problems with professional ethics.

Mission

1. To push the frontiers of pedagogy amongst the students and develop new paradigms in research.

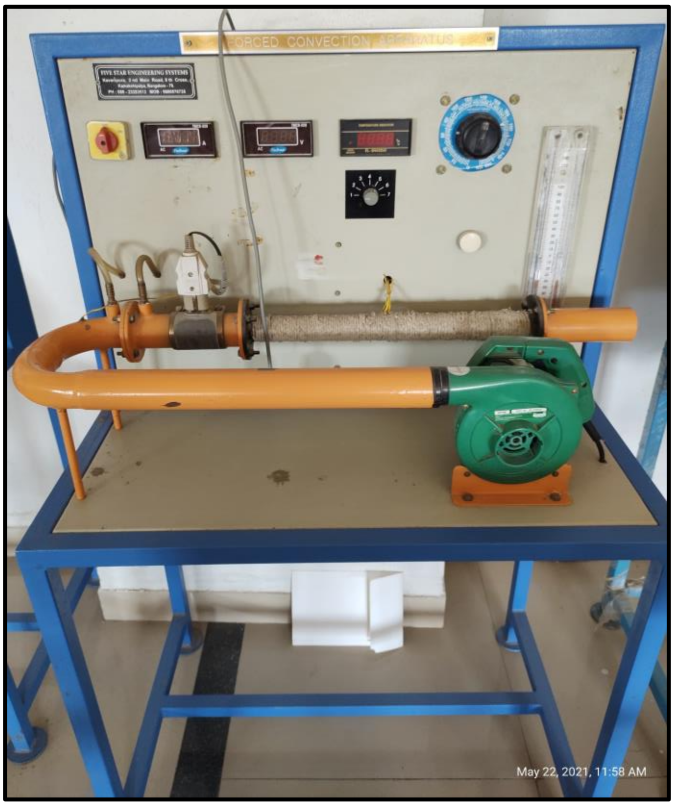
2. To develop products, processes, and technologies for the benefit of society in collaboration withindustry and commerce.

3. To mould the young minds and build a comprehensive personality by nurturing strong professionalswith human ethics through interaction with faculty, alumni, and experts from academia/industry.

HEAT TRANSFER

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy (heat) between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve heat transfer. While these mechanisms have distinct characteristics, they often occur simultaneously in the same system.

FORCED CONVECTION



Forced convection is a mechanism, or type of transport, in which fluid motion is generated by an external source (like a pump, fan, suction device, etc.). Alongside natural convection, thermal radiation, and thermal conduction it is one of the methods of heat transfer and allows significant amounts of heat energy to be transported very efficiently. This mechanism is found very commonly in everyday life, including central heating, air conditioning, steam turbines and in many other machines. Forced convection is often encountered by engineers designing or analyzing heat exchangers, pipe flow, and flow over a plate at a different temperature than the stream.

PREFACE

Heat and mass transfer is a basic science that deals with the rate of transfer of thermal energy. It has a broad application area ranging from biological systems to common household appliances, residential and commercial buildings, industrial processes, electronic devices, and food processing. Students are assumed to have an adequate background in calculus and physics. The completion of first courses in thermodynamics, fluid mechanics, and differential equations prior to taking heat transfer is desirable. However, relevant concepts from these topics are introduced and reviewed as needed. The Heat and mass transfer lab contributes to educate the undergraduate students of 6^{th} semester B.E, VTU Belagavi in the field of Mechanical Engineering.

The objectives are to cover the basic principles of heat transfer. To present a wealth of real-world engineering examples to give students a feel for how heat transfer is applied in engineering practice. To develop an intuitive understanding of heat transfer by emphasizing the physics and physical arguments. It is our hope that this book, through its careful explanations of concepts and its use of numerous practical examples and figures, helps the students develop the necessary skills to bridge the gap between knowledge and the confidence for proper application of that knowledge. In engineering practice, an understanding of the mechanisms of heat transfer is becoming increasingly important since heat transfer plays a crucial role in the design of vehicles, power plants, refrigerators, electronic devices, buildings, and bridges, among other things.

I acknowledge Dr.Ram, head of the department for his valuable guidance and suggestions as per revised Blooms Taxonomy in preparing the lab manual.

Mrs. Geetha Chavan

Lab In-charge

HEAT TRANSFER LABORATORY

Syllabus

Subject Code: 17MEL67	**IA Marks: 20**
Hours/Week: 03	**Exam Hours: 03**
Total Hours: 42	**Exam Marks: 80**

PART - A

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.
3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection on a Vertical tube.
5. Determination of Heat Transfer Coefficient in a Forced Convention Flow Through a Pipe.
6. Determination of Emissivity of a Surface.

PART – B

1. Determination of Steffan Boltzman Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
3. Experiments on Boiling of Liquid and Condensation of Vapour.
4. Performance Test on a Vapour Compression Refrigeration.
5. Performance Test on a Vapour Compression Air – Conditioner.
6. Performance test on air conditioner test rig.

Scheme for Examination:

One Question from Part A	-	**25 Marks (10 Write up+15)**
One Question from Part B	-	**40 Marks (15 Write up +25)**
Viva-Voce	-	**15 Marks**

Total		**80 Marks**

HEAT TRANSFER LABORATORY

VTU SYLLABUS

CONTENTS

PART-A

EXPERIMENT No: 1

THERMAL CONDUCTIVITY OF METAL ROD APPARATUS

AIM: To determine the thermal conductivity of the given metal rod.

APPARATUS: Experimental set up with Voltmeter, Ammeter, Heater, Seven Cr.-Al. Thermo couples: Five on test section, one each for Water inlet and water outlet and two extra thermocouples in the shell, Digital temperature indicator Dimmer stat. Selector switch, Stopwatch, Measuring jar etc.

THEORY:

It is important to know the values of Thermal conductivity of different materials as they are Useful in many industrial and domestic applications. Here metal rod is heated from one end and Heat is transferred axially to the circulating water through the other end of the rod middle portion of the rod is surrounded by a shell filled with asbestors powder. The value OF thermal conductivity of the metal of the can be easily computed by using the basic conduction equation.

PROCEDURE:

1. Proper electrical connections with ear thing are ensured.
2. Initially dimmer stat knob is kept zero.
3. The main switch is switched on and auto transformer knob is adjusted to get the required energy input.
4; Water is allowed to the chamber and required steady flow is regulated.
5. after attaining steady state condition of heat transfer, the temperatures from **T1 to T5** on metal rod are noted.
6. Inlet temperature T8 and outlet temperature T7 of circulating water are noted.
7. Circulating water flow rate is measured by using measuring jar and stop watch.

DATA:

1. Diameter of test section of the metal rod, D = 40 mm =____________________m
2. Length of test section of the metal rod, L=200 mm =_______________________m
3. Number of Themocouples on Testing metal are 5 at a distance of 50 mm.

OBSERVATION:

1. Voltmeter reading =____________________V
2. Ammeter reading =_____________________A
3. Temperatures on the metal rod;
4. Inlet temperature of Circulating water, T_{wi}=T8=___________________(°c)
5. Outlet temperature of circulating water, Two=T7=_________________(°c)
6. Volume of water collected in 60 seconds,

V_w=____________________ml

Distance, (mm)	0	50	100	150	200
Temperature (°c)	T1=	T2=	T3=	T4=	T5=

CALCULATIONS:

1. From graph, $\frac{Dt}{Dx}$ =______________________°c/m
2. Mass flow rate of the circulating water, mw

   m_w= (Vw X 10-6xPw)/60

   =_________________kg/s
3. Axial heat transfer along the metal rod Q

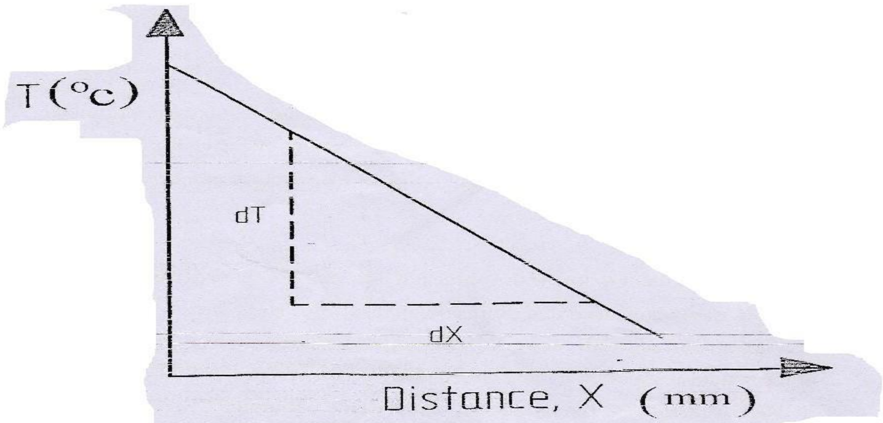
   Heat carried away by circulating water, Q= mw x Cpw x (T7-T8)

   =_______________________W
4. Thermal conductivity of given metal rod, K

   Heat transfer along axis of the metal rod, $Q = KX\frac{\pi.D2}{4} X \frac{(dt)}{(dx)}$

$$K = \frac{Q}{KX\frac{\pi.D2}{4} X \frac{(dt)}{(dx)}}$$

III. GRAPH :



Graph: Temperature Vs. Distance of the given Metal rod.

RESULTS:

Thermal conductivity of the given metal rod "k" is____________________W/m k

EXPERIMENT No: 2

HEAT TRANSFER THROUGH PLANE COMPOSITE WALL

AIM: To calculate

i. The overall heat transfer co-efficient of the given composite wall by using equation, U_o

ii. To determine the experimental overall heat transfer co-efficient, U_e

iii. To draw the graph of temperature profile across the width of the composite plane wall.

APPARATUS: Experimental set-up with a composite wall of Mild Steel plate, Asbestos plate, Copper plate, Voltmeter, Ammeter, Heater, Ten Cr-Al. Thermocouples : 8 on test section, one each for water inlet and outlet temperatures, Digital temperature indicators, Dimmer Stat, Selector switch, Stopwatch, Measuring jar etc.,

THEORY: Entire set-up is housed in stand cum panel made of Mild Steel structures with powder coating. It compromises test section and instrumentation / controls. All cylindrical discs and water chamber are held tightly between two pressure plates. One side of the heater is insulated with asbestos. Surroundings of composite wall is insulated in radial direction. When M.S disc is heated, heat transfer takes place axially. Each disc resists for the heat transfer. Surface near the heater is maximum temperature and last surface from the heater has minimum temperature. Overall Heat Transfer Co-Efficient is "The ratio of the difference between maximum and minimum temperatures to the total thermal resistance of the composite wall made up of three discs. "

PROCEDURE:

1. Proper electrical connections with earthing are ensured.
2. Initially dimmer stat knob is kept at zero.
3. The main switch is switched ON and auto transfer knob is adjusted to get the required energy input.
4. Water flow rate is adjusted and required steady flow is circulated to the chamber to absorb the transferred heat.
5. Water flow rate is measured by measuring jar and stop watch.
6. After attaining the steady state condition of heat transfer, the temperatures from T_1 to T_8 are noted.
7. Voltmeter and Ammeter readings are also noted.
8. Inlet temperatures T_9 and outlet temperature T_{10} of the circulating water are noted.

DATA :

1. Diameters of the discs, D = 150mm = 0.15m.
2. Thickness of the discs, $L_1 = L_2 = L_3$ = 6mm = 0.006m.
3. Thermal conductivity of Asbestos, K_{asb} = 0.11 W/mK.
4. Thermal conductivity of M.S., $K_{m.s.}$ = 53.6 W/mK.
5. Thermal conductivity of Copper, K_{cu} = 386 W/mK.

OBSERVATION :

1. Voltmeter reading, V =________V.
2. Ammeter reading, A =_________A.
3. Temperature at the surfaces of composite wall :

Disc Surface	**1st Surface**		**2nd Surface**		**3rd Surface**		**4th Surface**	
Temperature℃	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8

4. Volume of water collected in 60 seconds, V_w =______ml.
5. Inlet temperature of the circulating water, $T_{wi} = T_9$ =______℃
6. Outlet temperature of the circulating water, $T_{wo} = T_{10}$ =______℃

CALCULATIONS :

1).overall heat transfer co-efficient of the given composite wall by using the equation U_o

U_o =

2). The Experimental Overall heat transfer co-efficient, U_e :

1. Area of cross-section of the composite wall A = (Π.D²/4) =_______m^2
2. Temperature of the 1st . surface, $T_1 = (T_1+T_2) / 2$ =_______℃
3. Temperature of the 2nd . surface, $T_2 = (T_3+T_4) / 2$ =_______℃
4. Temperature of the 3rd . surface, $T_3 = (T_5+T_6) / 2$ =________℃
5. Temperature of the 4th . surface, $T_4 = (T_7+T_8) / 2$ =________℃
6. Mass flow rate of the circulating water ,M_w

$$M_w = (V_w \times 10^{-6} \times \rho_w) / 60 = \_\_\_\_\_\_\_\_\_ kg/s$$

7. Heat flow through plane composite wall, Q_w

$$Q_w = M_w \times C_{pw} \times (T_{wi} - T_{wo})$$
=____________________W

8. Overall heat transfer co-efficient, U_e

GRAPH : Draw the graph temperature profile across the width of the composite plane wall.

RESULTS :

i. The overall heat transfer co-efficient of the given composite wall by using the equation U_o =_____________.
ii. The experimental overall heat transfer co-efficient, U_e =___________.

Experiment Number: 3

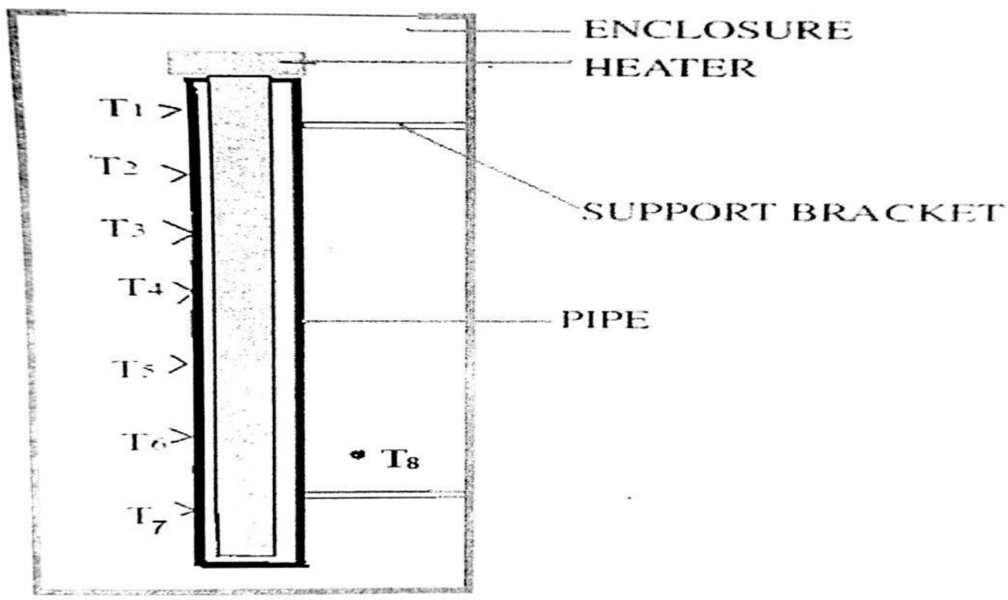
HEAT TRANSFER BY NATURAL CONVECTION

AIM : to determine 1) the heat transfer coefficient by using Empirical relations and

2) Actual heat transfer coefficient

APPARATUS

Test section of copper pipe enclosed in m.s sheet with top side open. Electrical heater, eight thermo couples of Cr-Al with temperature indicator and toggle switch, panel with mains switch, auto transformer, voltmeter, ammeter etc.



TEMPERATURES :

T_1 to T_7 : Surface Temperatures of the S.S pipe

T_8 : Ambient Temperature

Figure : SCHEMATIC SKETCH FOR NATURAL CONVECTION

DATA:

1. Diameter of the copper pipe, D=40mm =__________m
2. Length of the pipe, L=500mm =_________m

OBSERVATIONS:

1. Voltmeter reading, **V=__________v**

2. Ammeter reading, I =_________A

3. Surface temperatures:

T1 (ºC)	T2 (ºC)	T3 (ºC)	T4 (ºC)	T5 (ºC)	T6 (ºC)	T7 (ºC)

4. Ambient temperature, ta=T8=-------- oC

CALCULATIONS:

A) 1)Heat Transfer coefficient by using, $t_s = \frac{T1+T2+T3+T4+T5+T6+T7}{7}$

= .... = ... oC

2. Temperature difference, δt= ts-ta =______________=_---_____oC
3. Mean temperature, $tm = \frac{ts + ta}{2}$ = ----------------- = ------ oC
4. Coefficient of volumetric expansion, β

$B = \frac{1}{Tm+273.15}$ = ---------------- =_________/K

5. properties of Air from table at tm =________oC
    a) kinematic viscosity , ν =___________m2/s
    b) prandl number , Pr =_______
    c) Thermal conductivity of air , k air =_________W/mk
6. Grashoff number , Gr

$Gr = \frac{g .L3.\beta.(\delta t)}{g2}$ = _____________

7. Gr.Pr =________=--------
8. Nusselt number , Nu

Nu= a.{ Gr.Pr.}n   where a and n are constants

Values of a=0.59 and n= 0.25 if $_{10}4 \leq Gr.Pr \leq {}_{10}9$

And a = 0.13 and n= 0.33 if $_{10}9 \leq Gr.Pr \leq {}_{10}12$

Nu = a.{ Gr.Pr.}n = _________

9. $h_{ER.} = \frac{Nu.K_{air}}{L}$ = ___________

$h_{ER.}$ =_________w/m^2.k

B.) Actual heat transfer coefficient , h_{act} :

1. Surface area of test section, As = π.D.L
2. Rate of heat transfer, Q = V.I

   = ------------- =___________m2

3. Heat transfer coefficient, $h_{act} = \frac{Q}{A_s . \delta t}$

   = ...

   =__________W/m^{2o}C

Experiment Number: 4

HEAT TRANSFER BY FORCED CONVECTION

AIM: To determine the heat transfer coefficient in forced convection 1)The heat transfer coefficient by using empirical relation 2)actual heat transfer coefficient.

APPARATUS:

Standard Forced Convection set up, test copper tube, blower, u-tube, orifice meter, voltmeter, ammeter, temperature, selector toggle switch etc.

THEORY

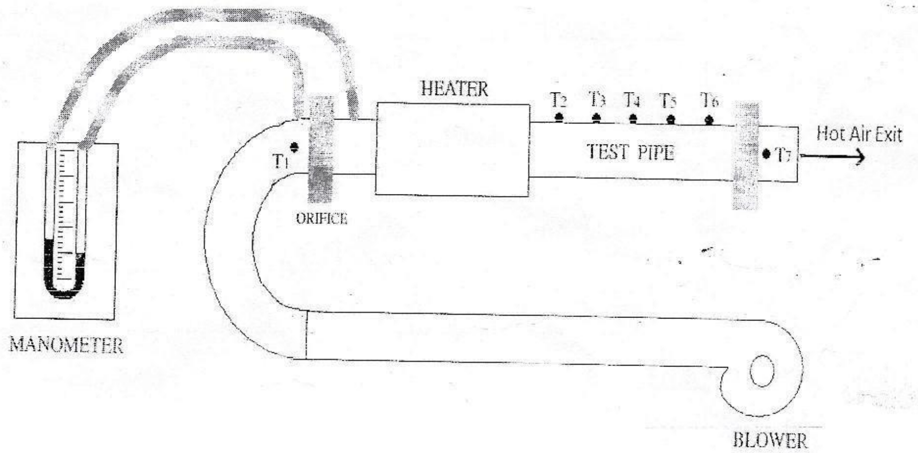
Convection is a process of energy transport by the combined action of heat conduction,energy storage and mixing motion. When the mixing motion is induced by some externalagency such as pump or a blower the process is called forced convection. The intensity ofthe mixing motion is generally high in forced convection and consequently the heattransfer coefficients are higher than free convection. By using the dimensional analysis,the experimental results obtained in forced convection heat transfer can be correlated byequation of the formRate of heat transfer through convection is given by:Q = hA (Ts-Tav) Where „h" is the average convective heat transfer coefficient, A"the area of heat transfer,Ts is the heated surface temperature and Transfer is the average fluid temperature.The apparatus consists of a blower unit fitted with the test pipeFour thermo couples are embedded on thetest sectionand two thermo couples are placed in the air stream at the entrance and exit of thetestsection to measure the air inlet and outlet temperatures. Test pipe is connected tothedelivery side of the blower along with the orifice to measure flow of air through the pipe.Input to heater is given through Dimmerstat and measured by voltmeter andammeter.Airflow is measured with the help of orifice meter and the manometer fitted on the board.

PROCEDURE:

(1) Proper electrical connection with earthing is ensured.
(2)Initially dimmer stat knob is kept zero
(3) The main switch is switched on and auto transformer knob is adjusted to get the required Energy input.
(4) The blower is switched on
(5) Note down a) Voltmeter reading „V" volts.
b) Ammeter reading „A" amps and manometer readings for all temperature.
(6) The toggle switch is kept to side 1 with temperature T1 to T5n are noted.
(7) By rotating the knob of selector switch all temperature are noted.

Experiment Number: 4

HEAT TRANSFER BY FORCED CONVECTION



TEMPERATURES:

T_2 to T_6 : Pipe Surface Temperatures ,

T_1: Air inlet Temperature

T_7: Air outlet Temperature

Figure : **SCHEMATIC SKETCH FOR FORCED CONVECTION**

DATA:

1. Diameter of copper Pipe, D = 46 mm =________________m
2. Length of copper^ pipe, i = 400 mm =___________________m

3. Diameter of Orifice , do = 20 mm =______________________m
4. Coefficient of discharge for Orifice, Cd = 0'62
5. Density of mercury, PHe= 13,600 kg. / m3

OBSERVATION;
1. Voltmeter Reading =__________________v
2. Ammeter Reading =_____________A
3. Surface Temperatures of the Pipe :

T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)

4. Temperature of air with manometer reading;

Temperatures		Manometer readings of mercury			
Air at inlet T1 (°C)	Air at outet T7 (°C)	H1, (mm)	H2, (mm)	H=(h1-h2)/1000 (m)	

CALCULATIONS:

1. Average SurfaceTemperature, $Ts=\frac{T2+T3+T4+T5+T6}{5}$

=_______________(°C)

2. Average temperature of air $Ta= \frac{T1 + T7}{2}$

=___________________(°C)

3. Mean air film temperature, $Tm= \frac{ts+ta}{2}$

=____________________(°C)

4. Properties of air at Tm=_______(°C) (from Tables):
   a) Thermal conductivity, Ka=_____________w/m°C
   b) Kinematic viscosityt va=_________________m2/s
   c) Prandtl number, Pr=______________________
   d) Density of air. Pa=______________________kg/m3
   e) Specific heat of air,Cpa=___________________J/kg k

5. Volume flow rate of air , Va

$$Va = Cd \times \frac{\pi . d^2 o}{4}$$

=________________________m3/s

6. Velocity of air, $V = \frac{Va}{\Pi . D^2/4}$

=______________________________m/s

7.Renolds number, $Re = \frac{V.D}{Va}$

=____________________

8. Nusselt number, Nu

Nu = 0.023x Re.^.8 x Pr.^n,

Where, n =0.4 for heating of fluid

n = 0.3 for cooling of fluid

Nu=_________________________

9. Heat Transfer Coefficient , her

$$Her = \frac{Nu.Ka}{D}$$

=_________________W/m^2°C

1.Surface area of the copper pipe, As= π.D.L=_________________________m^2

2.Mass flow rate of air at T1, ma= Va x pa=_______________________kg/s

3.Rate of heat transfer, Q=ma x Cpa x (T7-T1)

=________________________________W

4. Heat transfer coefficient, $hact = \frac{Q}{As.(ts-ta)}$

=_________________________W/m2°C

RESULTS:

1) Heat transfer coefficient by using Empirical relations, h_{ER} =_______W/m^{2o}C
2) Actual heat transfer coefficient h_{act} =__________W/m^{2o}C

EXPERIMENT NUMBER 5:

HEAT TRANSFER FROM A PIN-FIN

AIM: To determine the effectiveness and efficiency of a pin-fin under forced convection condition and also a estimate the temperature at the fin base,T_0 using Fourier's equation

APPARATUS:

Test section of brass fin with heater ,blower with rectangular duct,orifice meter with U tube manometer ,Six Cr-Al thermo couples,voltmeter,ammeter,temperature selector toggle switch etc.

THEORY: The heat transfer from a heated surface to the ambient surroundings is given by the relation,q=hxAxΔT where h is the convective heat transfer coeffiecient,ΔT is the temperature difference and A is the area of heat transfer To increase the heat transfer rate,h may be increased or surface area,A may be increased.In some cases it is not possible to increase the value of heat transfer coeffiecient,h and the temperature difference ΔT and hence the only alternative is to increase the surface area,A.The surface area is increased by attaching extra material in the form of rod on the surface where we have to icrease the heat transfer rate."this extra material attached is called the extended surface or Fin."

The fins may be attached on a plane surface,then they are called plane surface fins.if the fins are attached on the cylindrical surface,they are called circumferential fins.The cross section of the fin may be circular,rectangular,triangular or parabolic.

Effectiveness,of the fin,E isdefined as the ratio of the heat transfer rate with the fin in place,to the heat transfer that would occur if the fin was not there from the area of the base where fin was originally fixed.effectiveness,E should be>=2.

Efficiency of a fin,η is defined as the ratio of the actual heat transferred by finto the maximum heat tranferable by fin if the entire fin area were at the base temperature,T0 at all points.

PROCEDURE:

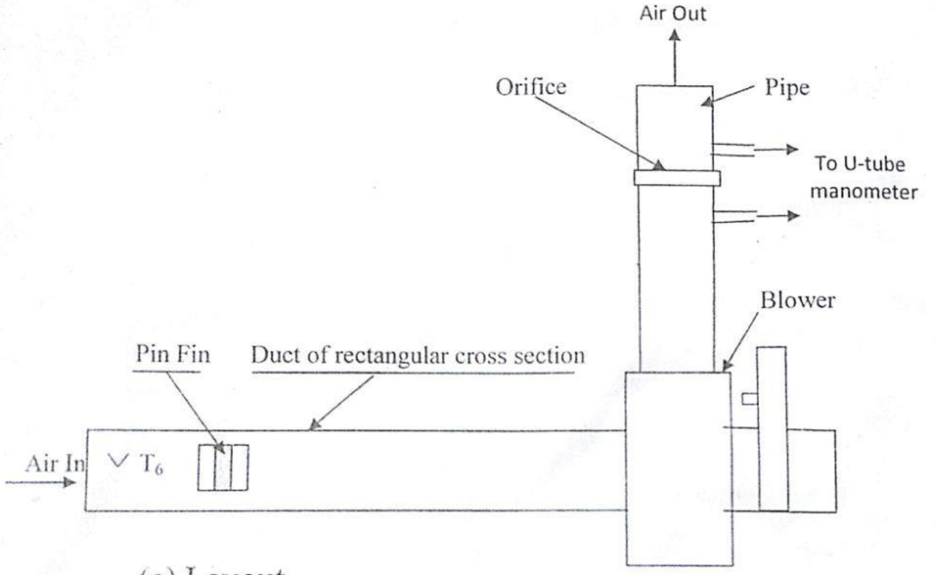
1.Proper electrical connections with ear thing are ensured
2.Initially dimmer stat knob is kept at zero
3. The main switch is switched on and auto transformer knob is adjusted to get the required energy input.
4. Voltmeter and ammeter readings are noted down
5.Blower is switched on and the flow of air is maintained
6. After steady state condition the toggle switch is operated and
7.Manometer readings in mm of mercury and also noted

DATA

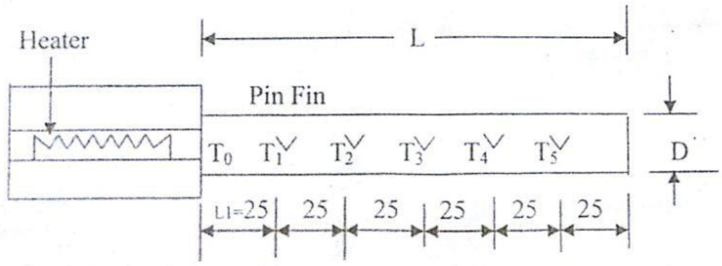
1.Length of the fin L=150mm= ---------- m

2. Diameter of the fin, D=12mm= --------m
3. Thermal conductivity of the fin material (brass),k=110w/m-k
4. Diameter of orifice ,d0=20mm= ----------m
5. Coefficent of discharge of the orifice , Cd=0.62
6. Density of mercury,ρHg=13600kg/m^3
7. Width of the air duct,w=150mm= --------- m
8. Height of the air duct,B=100mm= ----------- m

HEAT TRANSFER
FROM
A PIN FIN



(a) Layout



(b) Test Section

Figure: SCHEMATIC SKETCH OF THE EXPERIMENTAL SETUP
FOR
PIN – FIN APPARAATUS

OBSERVATIONS

1. Voltmeter reading, V= ----------- V
2. Ammeter reading ,I= -------------A
3. Surface Temperature of the fin :

T1(°C)	T2(°C)	T3((°C)	T4(°C)	T5(°C)

4. Ambient temperature , T_∞=T = --------------- C

5. Manometer Readings:

Manometer Reading		
H_1 (mm)	H_2 (mm)	$H = (H_1 \sim H_2)/1000(m)$

CALCULATIONS:

1. Average SurfaceTemperature, $TS = \frac{T1+T2+T3+T4+T5}{5}$ = ... C
2. Mean air film temperature, $T_m = \frac{T_s + T\infty}{2}$ = C
3. Properties of air at mean temperature T_m=----------- C(from tables)
   a) Thermal conductivity , a=------------W/m C
   b) inematic viscosity,ϑ=-------------- m^2/s
   c) Prandtl number,Pr=-----------
   d) Density of air , ρ_a=----------- kg/m^3
4. Volume flow rate of air , V_a

$$V_a = c_d * ((\pi * d_o^2)/4) * \sqrt{(2 * g * \rho * x * h)/\rho_a}$$

Where ρ=>ρ_{hg}

5. Velocity of air ,

V =V_a/(W*B)=

. enolds number , e =V .D/v=--------------

7. Nusset number ,Nu

$Nu = C \times Re^n \times Pr^{1/3}$

Note:For Re=4 to 40 C=0.911 and n=0.385
Re>40 to 4000, C=0.683 and n=0.466
Re>4000 to 40000, C=0.293 and n=0.618

Nu=...

8. Heat transfer Coefficient, $h = (N_U . K_a / D)$
9. Perimeter of the fin $p = \pi$ x D= -------- m
10. Cross sectional area of the fin ,A= ---------------- m^2

11. $m = \sqrt{\frac{hxP}{kxA}}$

12. Effectiveness of the fin , $\varepsilon = \frac{\sqrt{h.P.K.A}}{hxA}.\tanh(m.L)$

13. Efficiency of the fin , $\eta = \frac{\tanh(m.L)}{m.L}$

14. Rate of heat transfer ,Q=V X I =------------- W

15. Temperature at the Fin base $T_0 = \frac{QxL1}{KxA} + T1$ where L1is the distance Between the Thermocouple indicating T_0 and T_1

T_0=.................................... ℃

EXPERIMENT-6

EMISSIVITY OF SURFACE

AIM :- To determine the emissivity of a metallic body

APPARATUS :- Test section of a circular brass plate identical brass plates ,two Heating coils , two dimmer stat , thermocouple , ammeter and voltmeter etc .

THEORY :-

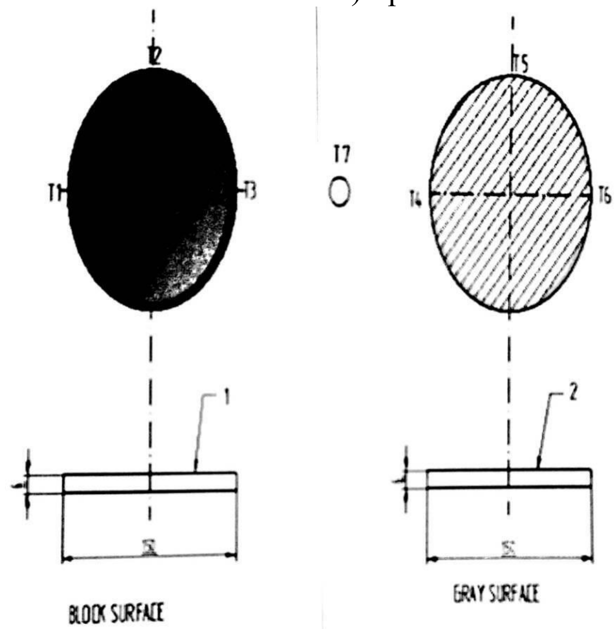
The emissivity of a surface is the ratio of the emissive power of its surface to the emissive power of the surface at the same temperatures .It is a measure of how it radiates in comparison with a black surface at the same temperatures .The emissivity of the surface is a function of its nature and characteristics .A typical experimental setup is shown . It essential consist of two identical circular brass plates provided with heating coil at the bottom surface.

PROCEDURE :-

1) Proper electrical connections with earthing are ensured
2) Initially dimmer stat is kept at zero.
3) The main switch is switched on and auto transformer knob are adjusted slowly to required power input.
4) The voltmeter and ammeter readings of both the black and grey body are noted.
5) The system is allowed to stabilize to attain the steady state.
6) Corresponding temperatures from T1 to T4 is noted down.

DATA :-

1) Specimen Material = Brass. 2) Specimen Size = Φ 150 mm ; mm



t hickness

OBSERVATION

- Power Supply reading of black body :-
  Voltmeter reading Vb =____V
  Ammeter reading Ib =______A
- Surface Temperature of black body :-

T1 = ˚C	T2 = ˚C	T3 = ˚C

- Power Supply of grey body :-
  Voltmeter reading Vg =_______**V**
  Ammeter reading Ig =_______**A**

Surface temperature of grey body :-

T4= ˚C	T5= ˚C	T = ˚C

Ambient temperature T_7=______˚**C**

CALCULATIONS :-

Average surface temperature of black body :-

Tb = (T1+T2+T3)/3

Tb=______˚**C**

Average surface temperature of grey body :-

Tg = (T4+T5+T6)/3

Tg =______˚**C**

Ambient Temperature :-

Ta = T7+273.15

Ta =____˚C

Power input to black body :-

Pb = Vd * Ib

Pb =

Pb =_____ **W**

Power input to grey body :-

Pb/Pg = σ * Tb * Ab * (Tb^4 – Ta^4) / σ * Tg * Ag * (Tg^4 – Ta^4)

Ɛg = Pg / Pb { Tb^4 – Ta^4 / Tg^4 – Ta^4 }

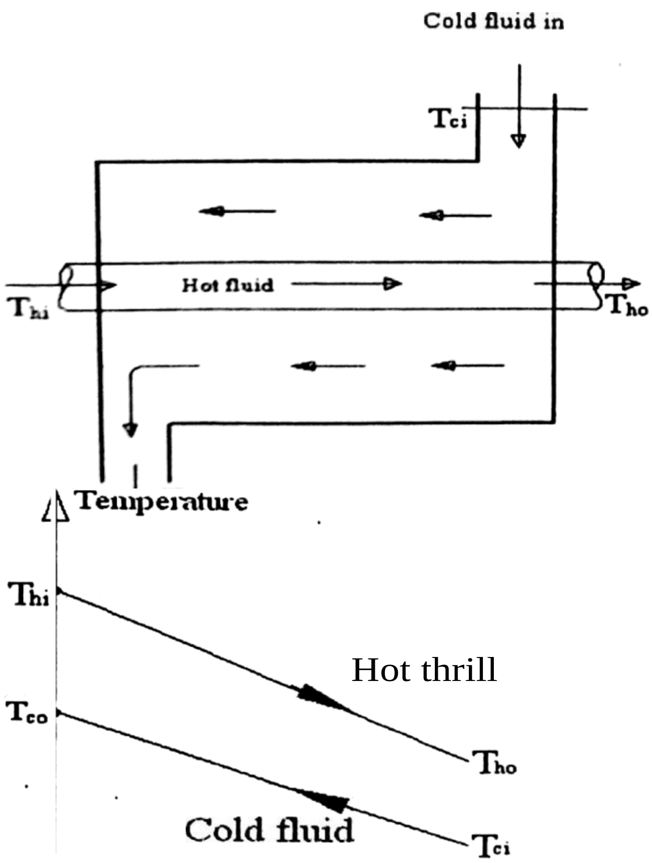
Ɛg =_____˚C

RESULT :

Emissivity of the metallic body is found to be__________.

EXPERIMENT NUMBER :7

COUNTER FLOW HEAT EXCHANGER



______________________________________Length

"Figure:SchematicLayoutandTemperature Pathlength diagram for Counterflow Heat Exchange

DATA.

Outer diameter of inner copper like, D = I 2.5 mm = m

LengthofHeatExchanger, L=1500mm =___________________m .

Energy meter constant, EMC = 3200 pulse / kWh.

OBSERVATIONS :

1) volume of Hot water collected in time t_h =

2)Volume of Cold water collected in time t_c =

3)Cold water inlet temperature, Tci = T1 =

4)Cold water outlet temperature, Tco = T2 =

5)Hot water inlet temperature, Thi =T3 =

6)Hot water outlet temperature, Tho = T4 =

III CALCULATIONS :

1. **L.M.T.D.** = $$\frac{(T_{h.i} - T_{c.o}) - (T_{h.o} - T_{c.i})}{Ln\left(\frac{T_{h.i} - T_{c.o}}{T_{h.o} - T_{c.i}}\right)}$$

______________ ^{0}C

2. **Overall Heat Transfer Co-efficient ,U**

i).Massflowrate of Hotwater in = ---------- x 10^{-6} x ρ_w / τ_1

ii). Rate of heat transfer, Q = m_h x C_{pw} x ($T_{h.i}$ - $T_{h.o}$)

=______________________

= ______________________ **W**

COUNTER FLOW HEAT EXCHANGER

AIM : To determine:
i) log Mean Temperature Difference (L.M.T.D.),
ii) Overall Heat Transfer co-efficient, U and
iii) Effectiveness, C in Parallel flow Heat Exchanger.

APPARATUS:

Experimental Set up with Geyser : 3 kW, 5 Valves , Thermocouples : S No. K type. Digital Temperature Indicator, Temperature Selector switch of 5 channel otary type‘ Measuring Jar , Stop watch etc.

THEORY:

Heat exchangers are basically used either to heat or cool one fluid with another fluid, one being cold and another hot. It depends upon application, whether the fluid of interest is to be cooled or heated. We find many examples of heat exchangers in our daily life , namely Radiator in automobiles, Gas geyser, Boilers, Refrigerators etc. –

They are classified according to Separation of fluids , Direction of flow of fluids, Construction of Heat exchangers such as Double pipe Heat exchanger, Shell and Tube type Heat exchanger, Shell and Coil type heat exchanger etc.

Experimental Set up is of Double Pipe Heat exchanger, which can work as either Parallel or counterflow type by closing and opening the valves provided for this purpose. Here hot water flows inside copper

pipe and cold water flows in annular space between inner pipe and outer G.I. pipe. A geyser supplies continuous hot water which can be regulated through control valve. Cold water supply from external source can also be regulated.

PROCEDURE:

1. Cold water and Hot water connections are properly set in Parallel flow type by keeping cold water valves V1 and V3 in open position and V2 and V4 in closed position.
2. First water is allowed through geyser and heating is done by using
Electrical power supply.
3. Hot water flow rate from outlet of geyser is controlled by operating the valve V5.
4. cold water flow rate is controlled by operating the valve V1.
5. Alter attaining Steady State Steady Flow conditions, flow rates of both Hot water and cold water are measured by using measuring jar and stop watch.
6. inlet temperature TCI (=T) and outlet temperature Tc0 (=T) of Cold water are noted from Digital temperature indicator.
7. Simultaneously Inlet temperature T_{hi} (=T) and outlet temperature T_{ho} (=T) Hot water are noted

Effectiveness of the Heat Exchange :

i). Mass flow rate of Cold water mC =------------ 10'6 x Pw / 1'2

ii) Heat capacity of cold water, CC =mC X cp =_ _ _ _ _ _

iii) Heat capacity of hot water, Ch = mc X cpw =_ _ _ _ _

C mm is minimum of CC and Ch Cmin :

$$\text{Effectiveness } E = \frac{M_C C_{PC}(T_{CO} - T_{Ci})}{m_h C_h (T_{hi} - T_{Ci})}$$

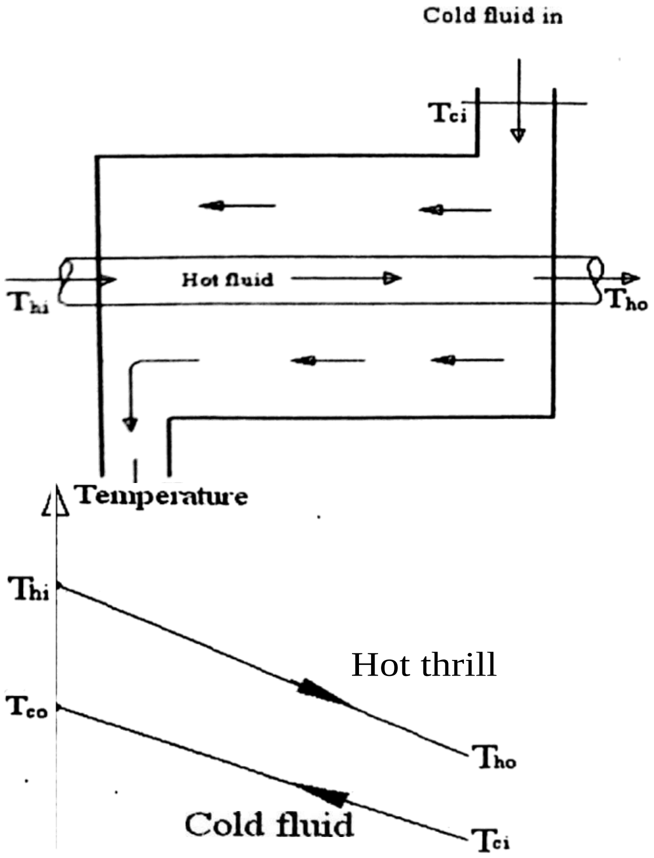
=________________

RESULTS :

1. L.M.D.T =________________________
2. Overall Heat Transfer Coefficient =_________________
3. Effectiveness of heat exchanger =___________________

EXPERIMENT NUMBER: 8

COUNTER FLOW HEAT EXCHANGER



_____________________________________Length ‘‘

Figure: Schematic Layout and Temperature Path length diagram for Counterflow Heat Exchanger

DATA.

1)Outer diameter of inner copper like, D = I 2.5 mm =________________m

2)Length of Heat Exchanger, L=1500mm =____________________m .

3)Energy meter constant, EMC = 3200 pu l se / kWh.

OBSERVATIONS :

1)volume of Hot water collected in time r, -

2)Volume of Cold water collected in time rd

3)Cold water inlet temperature, Tci = T1 =
4)Cold water outlet temperature, Tco = T2 =
5)Hot water inlet temperature, Thi =T3 =
6)Hot water outlet temperature, Tho = T4 =

III CALCULATIONS **:**

1. L.M.T.D. $= \dfrac{(T_{h.i} - T_{c.o}) - (T_{h.o} - T_{c.i})}{Ln\left(\dfrac{T_{h.i} - T_{c.o}}{T_{h.o} - T_{c.i}}\right)}$

=____________________________

2. Overall Heat Transfer Co-efficient ,U

i). Mass flow rate of Hot water in = ---------- $x\ 10^{-6} \times \rho_w / \tau_1$

ii). Rate of heat transfer, Q = $\dot{m}_h \times C_{pw} \times (T_{h.i} - T_{h.o})$

=_________________________

=_________________________W

COUNTER FLOW HEAT EXCHANGER

AIM : To determine:
i) log Mean Temperature Difference (L.M.T.D.),
ii) Overall Heat Translfer co-eflficient, U and
iii) Effectiveness, C in Parallel flow Heat Exchanger.

APPARATUS :
Experimental Set up with Geyser : 3 kW, 5 Valves , Thermocouples : S No. K type. Digital Temperature Indicator, Temperature Selector switch
of 5 channel otary type' Measuring Jar , Stop watch etc.

THEORY :
Heat exchangers are basically used either to heat or cool one fluid with another fluid, one being cold and another hot. It depends upon application, whether the fluid of interest is to be cooled or heated. We find many examples of heat exchangers in our daily life , namely Radiator in automobiles, Gas geyser, Boilers, Refrigerators etc. –

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Experimental Set up is of Double Pipe Heat exchanger, which can work as either Parallel or counterflow type by closing and opening the valves provided for this purpose. Here hot water flows inside copper pipe and cold water flows in annular space between inner pipe and outer G.l. pipe. A geyser supplies continuous hot water which can be regulated through control valve. Cold water supply from external source can also be regulated.

PROCEDURE :

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7. Simultaneously Inlet temperature Thi (=T) and outlet temperature Tho (=T) Hot water are noted

Effectiveness of the Heat Exchange :

i). Mass flow rate of Cold water mC =------------10'6 x Pw / 1'2
ii) Heat capacity of cold water, CC =mC X cp =_ _ _ _ _ _
iii) Heat capacity of hot water, Ch = mc X cpw =_ _ _ _ _

C mm is minimum of CC and Ch Cmin :

$$\text{Effectiveness } E = \frac{M_C C_{PC}(T_{CO} - T_{Ci})}{m_h C_h (T_{hi} - T_{Ci})}$$

=________________

RESULTS :

4. L.M.D.T =________________________
5. Overall Heat Transfer Coefficient =_________________
6. Effectiveness of heat exchanger =___________________

Experiment No.:9
VAPOUR COMPRESSION REFRIGERATOR

AIM : To determine i) Theoretical Coefficient Of Performance and ii) Actual Coefficient of Performance.

APPARATUS : Experimental setup of Vapour Compression Refrigerator system with Fan, Energy meter, Digital Temperature indicator with selector switch, Two Pressure gauges, Stop watch etc

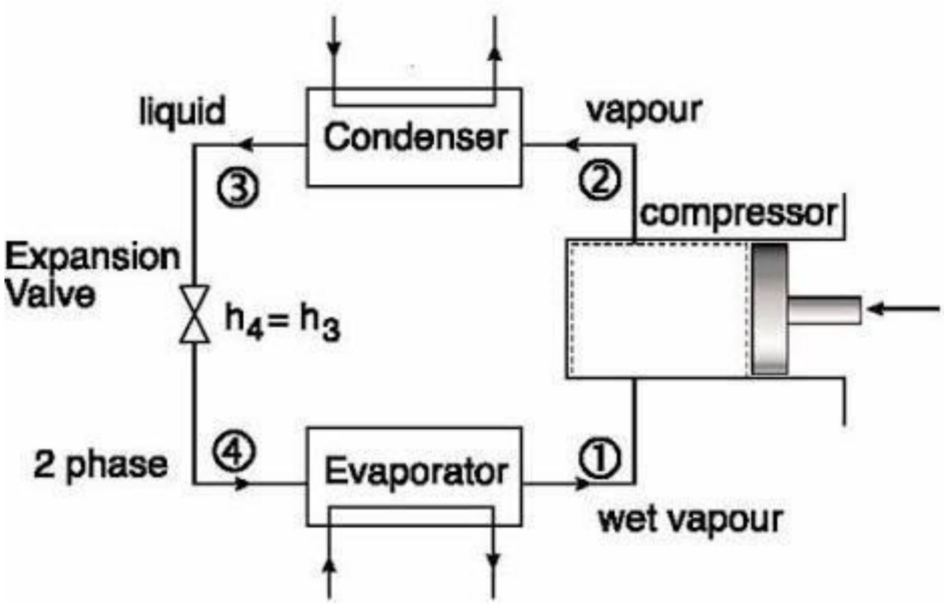
THEORY : Refrigeration is the cooling of a system below the temperature of its surroundings. A Refrigerator is a device which operating in a cycle and maintains a body at a temperature of the surroundings. One of the types of refrigerators is vapour compression refrigerator which consists of Evaporator, Compressor, Condenser and Expansion device. cycle consists of 1)adiabatic compression of the refrigerant by the compressor ii) constant pressure process

Of heat rejection at the condenser, iii) throttling of the refrigerant from higher pressure to lower pressure & iv)constant pressure process of refrigeration at the evaporator.

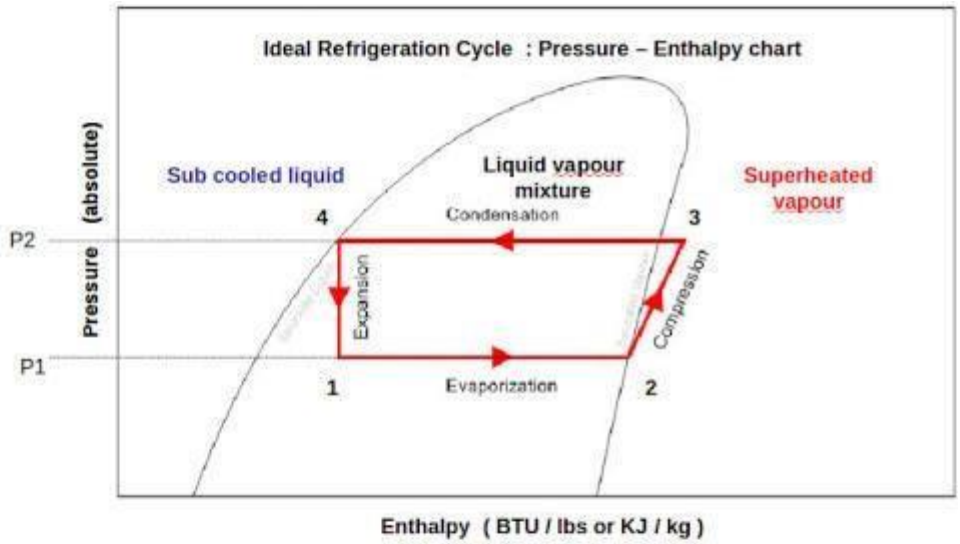
Experiment set up consists of Evaporator of cooling coil type which is surrounded by know quality of water. this water is cooled in the evaporator. Hermetically sealed compressor of 1/3 hp is used to compress the refrigerant which R-134a (Tetrafluro ethane, $CH_2 FCF_3$). The compressed high pressure refrigerant is condensed to liquid by air cooled condenser. A fan is used to force the air across the condenser. Throttling of the refrigerant can be done by expansion device which is capillary tube / refrigerant. Two pressure gauge are provided to note suction & delivery pressure. HP/LP cutout is provided to limit both the high & low pressures.

Assumptions in conducting this experiment are : i) state of the refrigerant at the exit of the condenser is saturated liquid & ii) pressure drop at the condenser & evaporator are neglected.

Schematic Diagram of the V.C. Refrigerator :



P-h Diagram for the V.C. Refrigeration cycle :



DATA :

1. Atmospheric pressure P_a=1 bar
2. Mass of the water taken in evaporator tank, m=50kg
3. Energy meter constant, K=3,200 counts / kwh
4. Efficiency of the compressor- motor unit, η=70%

OBSERVATION:

1) Suction pressure gauge reading P_{g1}= ______ kgf/cm² =______bar

2) Delivery pressure gauge reading P_{g2}=______kgf/cm²

3) Time taken for change in temperature Δ T_5 of water from T_5= ______ ℃ to_______℃ ,

t_1=______sec.

4) Time taken for n=_______counts of energy meter, t_2=_____sec.

5) Temperature of the refrigerant at the exit of the evaporator, T_1=_______℃

6) Temperature of the Refrigerant at the exit of the compressor, T_2=____________°C

CALCULATIONS :

I. Theorotical coefficient of performance, (C.O.P.)$_{th}$

1) Absolute Suction pressure, $p_1 = p_{g1}+p_a$ =_______=________bar.

2. Absolute Delivery pressure = $p_{g2}+p_a$ =_________=________bar.

From Refrigerator Tables of Ra-134a.

3. specific enthalpy of the refrigerant at the exit of the evaporator at pressure p_1, h_1

$h_1=h_{g2}=C_g$ x (T_1-T_2) where T_s is saturation temperature at the pressure p_1

h_1____________________________=____________kJ/kg.

4) Specific enthalpy of the refrigerant at the exit of the compressor at pressure p_2, h_2

$h_2=h_{g1}+C_g$ x (T_2-T_s) where T_s is saturation temperature at pressure p_2

h_2=____________________________=___________kJ/kg.

5) Specific enthalpy of the refrigerant at the exit of the condenser at pressure p_2

$h_3=h_f$ at pressure p_2=______________kJ/kg.

4. Specific enthalpy of the refrigerant at the entrance of the evaporator at the pressure p_1, h

   $H_4=h_3$=________________kJ/kg.
5. Theoretical Coefficient of Performance, $(C.O.P.)_{th}$=
   (Refrigeration..effect/Compression..work) $=(h_1-h_4)/(h_2-h_1)$

II. ***Actual Coefficient of performance,*** **$(C.O.P)_{act}$**

1. Change in temperature of the water in evaporator in time, t_1,
ΔT_5=___________=_______________

2. Actual Refrigeration effect, $(R.E.)_{act}=m x C_{pw} x (\Delta T_5/t_1)$
=_________________=________________W=___________=kW.

3. Power consumed by the compressor, ***P***=$(3600/K)x(n/t_2)x\eta$
=____________________=_________W__________kW.

4. Actual Coefficient of Performance, $(C.O.P.)_{act}=((R.E.)_{act}/p$ =______________=____________

PROCEDURE:

1. Proper electrical connections with earthing ensured.
2. The main switch is switched on and the Refrigerator is started.
3. The working of Refrigeration is observed till already state condition is reached.
4. Readings of Suction and Delivery pressure gauges are noted.
5. Time taken for decrease in temperature T_5 of known quantity of water is noted.
6. Temperature of the refrigerant at the exit of evaporator T_1 and also at the exit of the compressor for n=say 20 counts of energy meter is also noted.

Results:

1. Theoretical Coefficient of Performance, $(C.O.P.)_{th}$=______
2. Actual Coefficient of Performance (C.O.P.)=___________

EXPERIMENT NO.:9

PERFORMANCE TEST ON A V.C. AIR CONDITIONER

AIM: To determine i) the psychrometric properties of atmospheric air and ii) to estimate the C.O.P of the refrigeration system in air-conditioner.

THEORY: The science of air conditioning deals with maintaining a desirable internal air conditions irrespective of external atmospheric conditions. The factors involved in any air conditioning installation are:

- Temperature
- Humidity
- Air movement and circulation
- Air filtering, cleaning and purificationThe simultaneous control of these factors within the required limits is essential for human comfort or for any industrial application of the air conditioning system. In any air conditioning system, temperature and humidity are controlled by thermodynamic processes. Depending on the session, the air conditioning processes. Involve cooling, heating, humidification and dehumidification of air. Other aspects such as air movements, circulations, purification, etc. are obtained by installing suitable fans, blowers, ducting and filters.This equipment is designed to demonstrate different air conditioning processes such as cooling, heating, humidification, etc. required for different season of the year.

IMPORTANT DEFINITIONS:

1. **Dry Air:**Mechanical mixture of oxygen, nitrogen, carbon dioxide, etc.
2. **Moist Air:**Mixture of dry air and water vapour.
3. **Saturated Air:**Is such a mixture of dry air and water vapour when the air has diffused the maximum amount of water vapour into it.
4. **Degree of Saturation:**Is the ratio of actual mass of water vapour in a unit mass of dry air to the mass of water vapour in the same mass of Dry air when it is saturated at the same temperature and Pressure.
5. **Humidity:**Is the mass of water vapour present in 1 Kg of dry air expressed in gm per Kg of dry air

6. **Absolute humidity:**Is the mass of water vapour present in 1 m^3 of dry air, gm per cubic meter of dry air
7. **Relative Humidity:**Is the ratio of actual mass of water vapour in volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure.
8. **Dry bulb temperature:**Is the temperature of air recorded by a thermometer when it is not affected by the moisture present in the air.
9. **Wet Bulb Temperature:**Is the temperature of the air recorded by a thermometer when its bulb is surrounded by a wet cloth exposed to the Air
10. **Psychrometer:**Is an instrument containing dry bulb thermometer and wet bulb thermometer. The difference in the readings of these two thermometers gives the relative humidity of the air surrounding the Psychrometer.

DESCRIPTION OF THE APPARATUS:

It consists of a cooling coil which is a part of the vapour compression refrigeration system working on Freon – 22. In the upstream and downstream of the cooling coil, heaters are provided to heat air either at the upstream or the downstream of the cooling coil. A steam generator is provided to increase humidity of air. The system is provided to increase humidity of air. The system is provided with fans, air duct and valve system to circulate air over the cooling coil and heater and to operate the system in both closed and open cycle. The system is instrumented with thermometers, digital humidity indicators, pressure indictors and wind velocity indicators to determine the state of air – moisture mixture during the operation of the air conditioning system.

Following are the important components:

Cooling coil of the vapour compression refrigeration system consisting of Compressor, condenser, throttle / capillary tube, pressure and temperature Indicators with selector switch and power meter. The system works on Freon-22

1. Air Heaters - 2 set (3 Nos. of 500 W each)
2. Steam generator which consists of immersion type heating coil
3. Suction fan (2 Nos)
4. Valve system to change the system to perform in both closed and open
5. Duct system with a window (close / open)

6. Wind Anemometer to measure air velocity in the duct
7. Wet Bulb & Dry Bulb Temperatures (2 Nos) placed before and after evaporator / cooling coil.
8. Temperature indicator with selector switch to measure air temperature upstream of coolingcoil and downstream of post heater.
9. Energy meters (2 Nos) for compressor and downstream of compressor
10. Pressure gauges – at both upstream and downstream of compressor
11. Pressure switches to limit pressures upstream and downstream of compressor
12. Thermostat to limit negative temperatures in the cooling coil

WORKING PRINCIPLE:

Definition of some pschrometric processes:

- Sensible cooling*:* Is a process where air is cooled without changing specific humidity
- Sensible heating*:* Is a process where air is heated without changing specific humidity
- Humidification: Is a process where moisture is added to the air without changing the dry bulb temperature
- De-humidification*:* Is a process where moisture is removed from the air without changing the dry bulb temperature

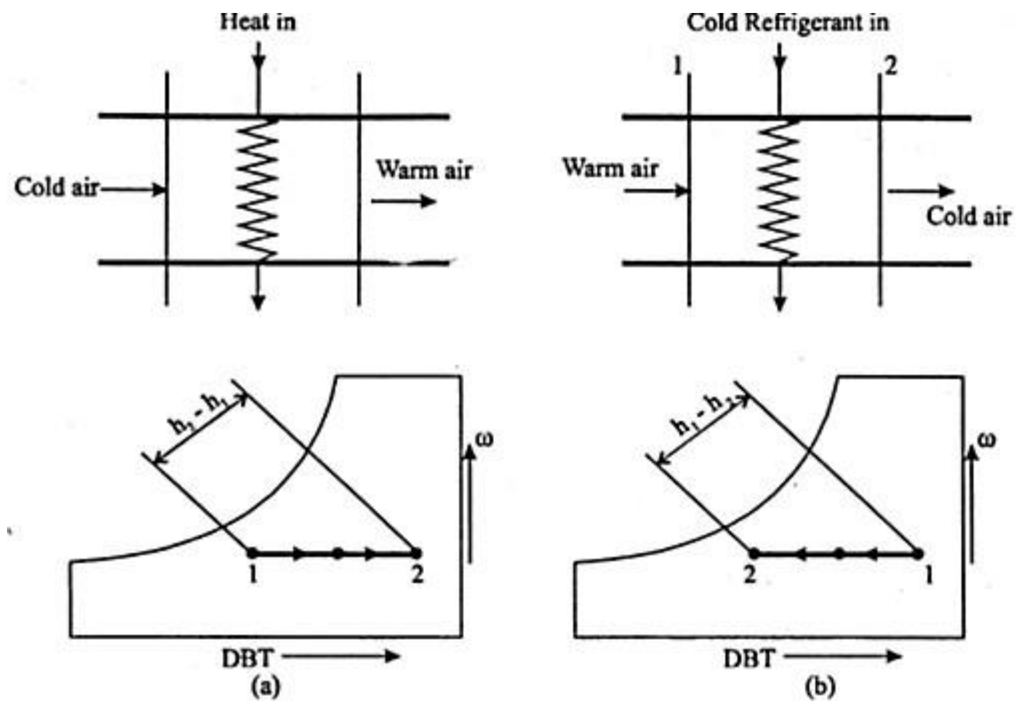


Fig: Sensible heating & Sensible cooling:

Fig.(1)Shows the schematic of the psychometric process and its representation in the psychometric chart. The heat rejected by air (per Kg of air) during cooling can be obtained from the psychometric chart by the enthalpy (Δh) difference between the air inlet and outlet

Heat rejected = (h_1-h_2) KJ/Kg

It may be noted that the specific humidity remains constant ($\omega_i=\omega_o$), the dry bulb temperature reduces from T_1 to T_2 and the relative humidity increases from $\phi_i$to ϕ_o

*Cooling and humidification:*Fig (2) shows the pschrometric process and its representation in the pschrometric chart. In this process, steam (or moisture) is added to the airstream before cooling by the cooling coil.In this process, the dry bulb temperature decreases from T_1 to T_2,specific humidity increases from ω_i to ω_o, and the relative humidity increases from ϕ_i to ϕ_o.The net amount of heat rejected (per Kg) by air during this process is given by

Heat rejected = (h_1-h_2) KJ/Kg

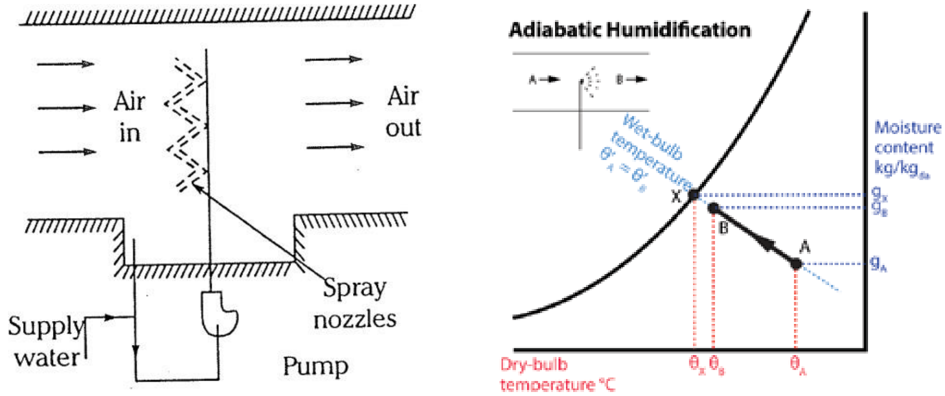


Fig: 2Cooling and humidification system

*Simulation of winter air heating process:*In this process, cold air from the cooling coil is again heated to the required temperature by the post heater as shown in fig (3). This simulates the air heating process encountered during winter.

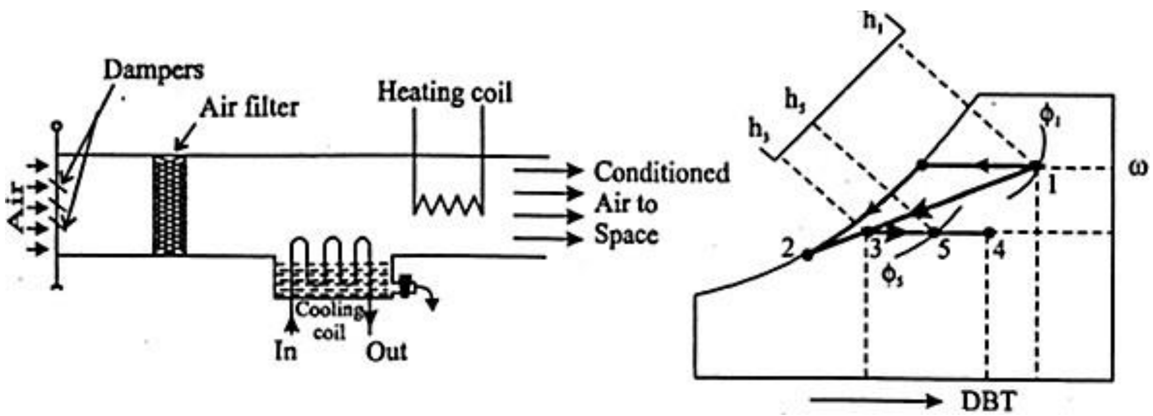


Fig: 3 winter air conditioning system

Specifications:

Evaporator cooling coil type, hermetically sealed compressor, air cooled condenser, expansion device, capillary tube/ thermostatic type, refrigerant: R-22(Monochlorodifluoro methane, $CHCIF_2$).

PROCEDURE:

1. proper electrical connections with ear thing are ensured

2. The main switch is switched on and the air conditioner is started.

3. The working of air conditioner is observed till steady state condition is reached.

4. Velocity of air at the inlet of duct is noted from anemometer.

5. Readings of D.B.T. and W.B.T. of the incoming air are noted from the psychrometer.

6. Readings of D.B.T. of the conditioned air are also noted from another psychrometer.

DATA:

1. Size of the air duct = L*B = 28cm*28cm

2. Energy meter constant K = 3200 counts/kwh

3. Efficiency of the compressor motor unit, η=70%

OBSERVATION:

1. D.B.T of incoming air, t_{di} =___________^{0}C

2. W.B.T of incoming air, t_{wi} =___________^{0}C

3. D.B.T of conditioned air, t_{do} =___________^{0}C

4. Velocity of air at the air duct outlet, V =___________m/s

5. Time taken for 50 counts of energy meter =___________s

CALCULATIONS:

1. Mass flow rate of air, m = (L*B*V) / V_1 =___________kg/s

2. Heat removed from the incoming air, R.E = m *C_p *(t_{di} -t_{do})

3. Power consumed by the compressor, P = 3600/K * n/ τ_2 * η

4. Coefficient of performance, C.O.P = R.E / P = ___________

5. From psychrometric chart,

The psychrometric properties of atmospheric air are tabulated as follows:

SL NO.	PROPERTIES	ATMOSPHERIC AIR, 1
1	Relative humidity	Φ_1 = ------------------ %
2	Specific humidity	ω_1 =------------------kg w.v / kg.d.a
3	Specific enthalpy	h_1 = ------------------ kj/kg
4	Specific volume	V_1 = ------------------m^3/kg
5	Dew point temperature	$(DPT)_1$ ----------------^{0}C

RESULT:

1. C.O.P of the refrigeration system in air conditioner is ______________

2. Psychrometric properties of atmospheric air are as shown in calculations.

EXPERIMENT NO.:10

PERFORMANCE TEST ON AIR CONDITIONER TEST RIG.

AIM: To determine:

i) Capacity of the cooling coil in ton refrigeration and

ii) Rate of removal of water vapor in kg.per.hour

APPARATUS: Air conditioning test rig with two psychrometers, anemometer etc.

THEORY: The science of air conditioning deals with maintaining a desirable internal air conditions irrespective of external atmospheric conditions. The factors involved in any air conditioning installation are:

- Temperature
- Humidity
- Air movement and circulation
- Air filtering, cleaning and purificationThe simultaneous control of these factors within the required limits is essential for human comfort or for any industrial application of the air conditioning system. In any air conditioning system, temperature and humidity are controlled by thermodynamic processes. Depending on the session, the air conditioning processes. Involve cooling, heating, humidification and dehumidification of air. Other aspects such as air movements, circulations, purification, etc. are obtained by installing suitable fans, blowers, ducting and filters.This equipment is designed to demonstrate different air conditioning processes such as cooling, heating, humidification, etc. required for different season of the year.

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15. **Humidity:** Is the mass of water vapour present in 1 Kg of dry air expressed in gm per Kg of dry air

16. **Absolute humidity:**Is the mass of water vapour present in 1 m^3 of dry air, gm per cubic meter of dry air

17. **Relative Humidity:**Is the ratio of actual mass of water vapour in volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure.

18. **Dry bulb temperature:**Is the temperature of air recorded by a thermometer when it is not affected by the moisture present in the air.

19. **Wet Bulb Temperature:**Is the temperature of the air recorded by a thermometer when its bulb is surrounded by a wet cloth exposed to the Air

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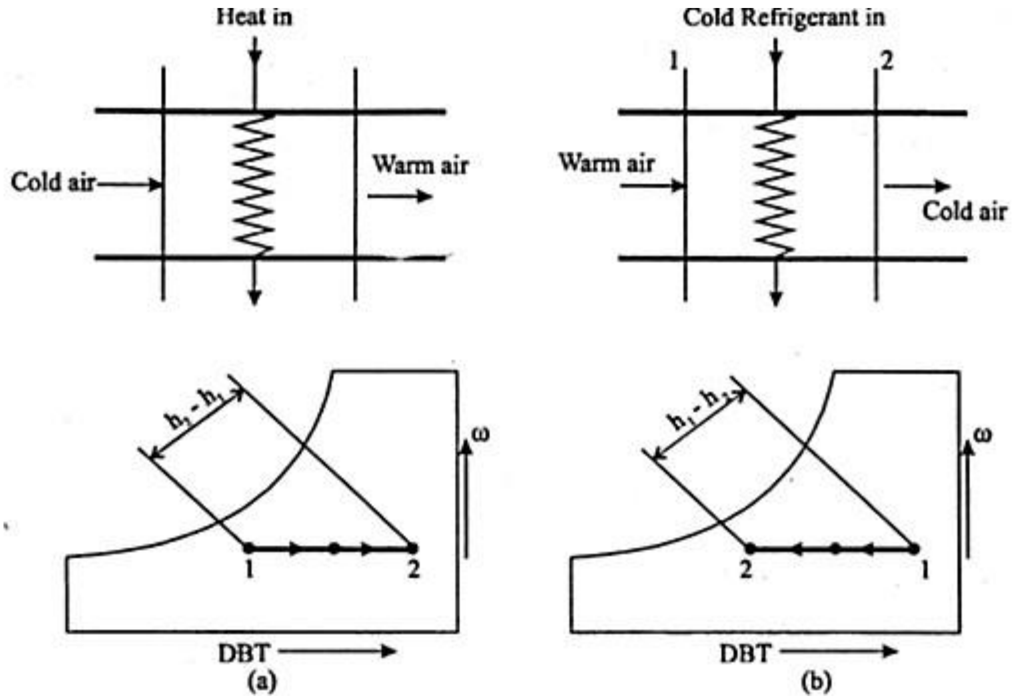

Fig: Sensible heating & Sensible cooling:

Fig. (1)Shows the schematic of the psychometric process and its representation in the psychometric chart. The heat rejected by air (per Kg of air) during cooling can be obtained from the psychometric chart by the enthalpy (Δh) difference between the air inlet and outlet

Heat rejected = (h_1-h_2) KJ/Kg

It may be noted that the specific humidity remains constant ($\omega_i=\omega_o$), the dry bulb temperature reduces from T_1 to T_2 and the relative humidity increases from $\phi_i$to ϕ_o

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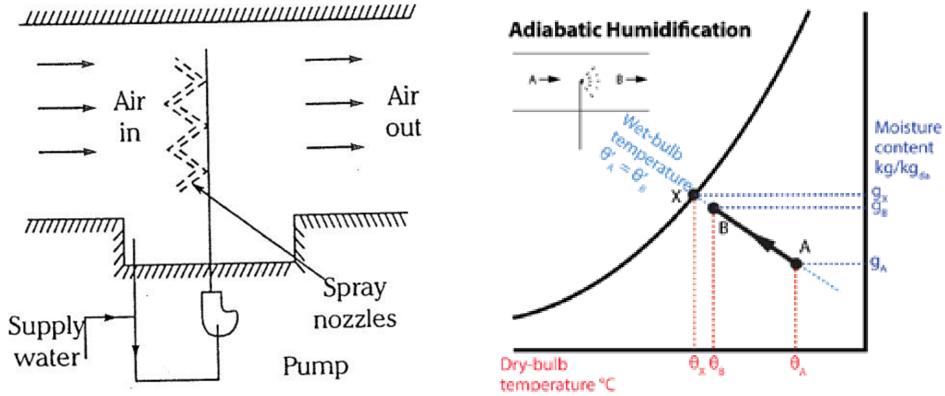

Fig: 2Cooling and humidification system

*Simulation of winter air heating process:*In this process, cold air from the cooling coil is again heated to the required temperature by the post heater as shown in fig (3). This simulates the air heating process encountered during winter.

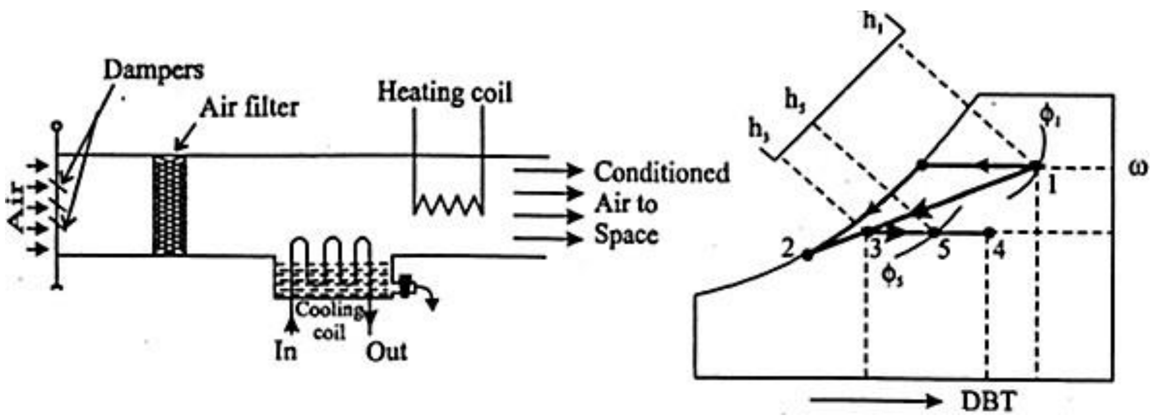

Fig: 3 winter air conditioning system

Specifications:

Evaporator cooling coil type, hermetically sealed compressor, air cooled condenser, expansion device, capillary tube/ thermostatic type, refrigerant: R-22(Monochlorodifluoro methane, $CHClF_2$).

PROCEDURE:

1. Proper electrical connections with ear thing are ensured
2. The main switch is switched on and the air conditioner is started.
3. The working of air conditioner is observed till steady state condition is reached.

4. Velocity of air at the inlet of duct is noted from anemometer.

5. Readings of D.B.T. and W.B.T. of the incoming air are noted from the psychrometer.

6. Readings of D.B.T. of the conditioned air are also noted from another psychrometer.

DATA:

1. Size of the air duct = L*B = 28cm*28cm

2. Energy meter constant K = 3200 counts/kwh

3. Efficiency of the compressor motor unit, η=70%

OBSERVATION:

1. D.B.T of incoming air, t_{di} =___________ ^{0}C

2. W.B.T of incoming air, t_{wi} =___________ ^{0}C

3. D.B.T of conditioned air, t_{do} =___________ ^{0}C

4. W.B.T of conditioned air, t_{wo} =___________ ^{0}C

5. Velocity of air at the air duct outlet, V =___________m/s

CALCULATIONS:

I. From psychrometric chart, the following psychrometric properties of atmospheric air and conditioned air are noted and tabulated as follows:

SL NO.	PROPERTIES	ATMOSPHERIC AIR, 1	CONDITIONED AIR, 2
1	Relative humidity	Φ_1 = ------------------%	Φ_2 = ------------------%
2	Specific humidity	ω_1 =--------------- kg w.v / kg.d.a	ω_2 = -------- kg w.v / kg.d.a
3	Specific enthalpy	h_1 = ------------------kj/kg	h_2 = ------------------kj/kg
4	Specific volume	v_1 = ------------------m^3/kg	v_2 = ----------------- m^3/kg

II. <u>Capacity of the cooling coil in ton refrigeration:</u>

1. Mass flow rate of air, m = A*V / v_1 =_____________=___________kg/s

2. Capacity of the cooling coil = m (h1-h2) *60 / 211 =_______=______T.R

III. Rate of removal of water vapour in kg.per.hour = m*(ω_1- ω_2) * 60* 60

= ___________

=___________kg/h

RESULT:

1. Capacity of the cooling coil in ton refrigeration_____________T.R

2. Rate of removal of water vapor in kg.per.hour______________kg/h

3. Psychrometric properties of atmospheric air are as shown in calculations.

HEAT AND MASS TRANSFER VIVA QUESTIONS

1. Define Heat transfer?
2. What are the modes of heat transfer?
3. Define the conduction, convection and radiation heat transfer modes
4. What are the applications of heat transfer?
5. Differentiate between heat transfer and thermodynamics?
6. List down the three types of boundary conditions.
7. What is heat conduction?
8. What is thermal conductivity?
9. Define Fourier Law of Conduction.
10. Which mode of heat transfer is most efficient?
11. State the following laws
    i.Fourier's law of heating ii. Newton's law of cooling iii. Stefan Boltzmann law
12. Mention the thermal conductivity of following materials
    i. Diamond ii. Gold ii. Copper iii. Aluminum iv. Brick v. Mica vi. Bakelite
13. What is the effect of temperature on thermal conductivity of solids, liquids and gasses?
14. When overall heat transfer coefficient will be used?
15. What is the effect of temperature on thermal conductivity of non-metallic amorphous solids
16. Due to which reason most metals are good conductors of heat?
17. Compare Fourier's law of conduction with Ohm's law of electricity
18. What is steady state and unsteady state hear transfers? Give examples
19. Define composite wall and overall heat coefficient
20. Define thermal contact resistance
21. Define critical thickness of insulation. What is its significance?
22. Define Thermal Conductivity of material. State which material has highest and lowest Thermal conductivity?
23. What is effect of temperature on thermal conductivity of gases?
24. What is effect of temperature on thermal conductivity of metals?
25. What is temperature gradient?
26. Define heat flux.
27. Define thermal Diffusivity.

28. Give examples for initial'&; boundary conditions.
29. Write the units for heat transfer coefficient, overall heat transfer coefficient, thermal conductivity and thermal diffusivity.
30. What is the purpose of a dimmerstat?
31. In case of liquids and gases, the heat transfer takes place according to

    (a) Conduction (b) Convection (c) Radiation (d) None of these
32. Which of the following has maximum value of thermal conductivity?

    (a) Aluminum (b) Steel (c) Brass (d) Copper
33. What is the driving force to transfer following

    i. Heat transfer ii. Mass transfer iii. Fluid transfer iv. Electrical energy transfer
34. What is convection?
35. Classify convection.
36. What is forced convection & natural convection? Give examples
37. Explain difference between forced convection and natural convection?
38. On which properties does convection heat transfer strongly depend?
39. Define convection heat transfer coefficient with dimensions.
40. Explain how the heat gets transferred in case of conduction, convection and radiation.
41. Explain the differences between heat transfer co-efficient and overall heat transfer co-efficient.
42. Define Steady state and Transient state of heat transfer. What are its applications?
43. Define Newton's Law of Cooling.
44. Is the heat transfer rate more in Forced convection or Natural Convection, Justify?
45. Define Convective heat transfer co-efficient
46. List the assumptions made for composite walls.
47. Give examples for free convection.
48. Define Steffan's Boltzmann law of radiation
49. What is steady-state condition?
50. What is emissivity?
51. What is gray and black body?
52. What is Stephan Boltzmann law & its constant value?
53. Define concept of Black body.

54. What is the effect on internal energy of an object during radiation?

55. State the properties of a black body.

56. Write the units for emissive power and Stefan Boltzmann constant.

57. What is the range of values for the emissivity of a surface ?

58. What is a gray surface?

59. Explain the mechanism of radiation heat transfer

60. Define absorptivity, reflectivity and Transmittivity

61. Define black body, grey body, white body and diathermanous body

2. State Stefan Boltzmann law, irchhoff's law, Lambert cosine law, Wien's displacement Law, Planks law

63. Define emissive power

64. What is the value of Stefan Boltzmann Constant?

65. Define intensity of radiation

66. What do you mean by greenhouse effect?

67. What is radiation shield? What is its effect on heat transfer?

68. Define fins or extended surfaces.

69. State the applications of fins.

70. Define fin. Mention its function

71. List out the types of fins

72. What are three conditions of fin?

73. What is the purpose of a Fin?

74. What are Fin's and how are they classified?

75. Give an example for fins in engineering application.

76. Explain the Boundary Layer Concept in heat transfer mechanism

77. Define Effectiveness and Efficiency of fin.

78. Define Effectiveness of heat exchanger.

79. What is Orifice - meter?

80. What is the function of blower?

81. What is the range of 'h' for Natural convection in gases & liquids?

82. What is Nusselt Number?

83. Define Biot number.

84. Define Lumped parameter method.

85. Define Biot and Fourier numbers
86. What is the significance of Biot and Fourier Number?
87. Define Grashoff, Nusselt and Prandtl numbers
88. What is the significance of Grashoff, Nusselt, eynold's and Prandtl numbers in convection heat transfer.
89. What is transient heat conduction? What do you mean by characteristic length? Get the characteristic length of rectangular slab, cylinder and sphere
90. Define local heat transfer coefficient and average heat transfer coefficient
91. What do you mean by drag coefficient?
92. What are the parameters affecting on forced convection heat transfer?
93. Explain the significance of thermal diffusivity.
94. What is a boundary layer?
95. What is the application of fins?
96. Explain the method of heat transfer in extend surface?
97. What type of fin possess highest heat dissipation rate according to cross section & Arrangement?
98. Name the material used for insulation purpose & as heating element?
99. Heat Transfer takes place according to which law of thermodynamics?
100. Give examples of use of fins in various engineering applications.
101. What are the various conditions in Fins?
102. In which applications Orifice, Venturimeter and simple U- tube manometer are used.
103. Write the expansion of LMTD.
104. Out of parallel flow, counter flow and cross flow heat exchangers, which is more effective.
105. Explain counter flow?
106. Explain parallel flow?
107. What is heat exchanger?
108. Define and classify heat exchangers
109. Name the various types of heat exchangers.
110. Why Logarithmic Temperature difference are considered in calculation of heat exchanger.
111. Differentiate between AMTD and LMTD?

112. Explain NTU in heat exchangers.

113. In heat exchangers, is heat transfer more in Parallel flow or counter flow heat exchanger, Justify?

114. When NTU method is particularly useful in design of heat exchangers?

115. What is heat exchanger?

116. Explain LMTD?

117. For evaporators & condensers ,LMTD for parallel & counter flow is

118. What is the value of LMTD if heat capacity of both fluids is same?

119. Define number of transfer units.

120. What is meant Fouling factor?

121. What is difference between condenser and heat exchanger?

122. Define COP.

123. Define 1 ton of refrigeration.

124. Name the refrigerants used in VCR and Air Conditioning.

125. List few refrigerants and list the properties of refrigerants.

126. Differentiate between Capillary and Throttling Mechanism is VCR.

127. Draw T-S diagram for Vapour Compression Refrigeration.

128. Define Dry Bulb Temperature, Wet Bulb Temperature, Humidity and Specific Humidity.

129. Define Sensible cooling, Sensible heating and adiabatic heating.

130. Define Specific heat and Latent heat of Ice.

131. What is Relative direction of motion of fluids?

132. Dropwise condensation usually occurs on which surfaces?

133. Define Film wise condensation.

134. Define Drop wise condensation.

135. What is meant by condensation?

136. Define Stanton number and Raleigh Numbers

137. Define thermal boundary layer and hydro dynamic boundary layers

138. What do you mean by leading edge and trailing edge?

139. Define heat exchanger

140. What are the applications of heat exchanger?

141. Classify heat exchangers

142.What do you mean by compact heat exchanger?

143.What is fouling and fouling factor?

144.Define effectiveness of heat exchanger

145.Define capacity rate and capacity ratio

146. Why effectiveness of counter flow heat exchanger is more than that of parallel flow heat exchanger

147. What is NTU? What are its significances?

148.List out the types of condensation

149. Define film condensation and drop wise condensation

150. What are the surface conditions required for drop wise condensation?

151.Define boiling

152.List out the applications of boiling

153.List out the different forms of boiling

154.Define pool boiling

155.Define sub cooled boiling

156.Define Nucleate boiling

157.Define film boiling

158.What are the regimes of pool boiling

159.What is excess temperature

160.Define refrigeration

161.List out the applications of refrigeration

162.Define COP, relative COP

163.What are the properties of a good refrigerant

164.Classify refrigeration systems

165. List out various types of refrigerants

166. What are the advantages of vapour compression refrigeration

167. Define wet compression, dry compression, super heating and sub cooling

168.Draw vapour compression refrigeration on P-H chart

169.What is the chemical name of R-12, R22 and R-134a

170.What is air conditioning

171.What are the applications of air conditioning

172.Define psychrometry.

173. Define DBT, WBT, WBD, SH, AH, RH, Specific weight, DPT, Saturation ratio, adiabatic temperature, enthalpy of saturated air
174. Show following processes on psychometric chart , Sensible heating, sensible cooling, cooling with dehumidification, humidification, heating with humidification
175. Classify air conditioning systems
176. What do you mean by comfortable air conditioning
177. Write the Dr. Carrier's equation