SNS COLLEGE OF TECHNOLOGY,

Coimbatore-35.

(An Autonomous Institution)

DEPARTMENT OF MECHANICAL ENGINEERING

III YEAR VI SEMESTER MECHANICAL ENGINEERING

19MEB302-HEAT & MASS TRANSFER LABORATORY

Blended Course

19MEB302	**HEAT & MASS TRANSFER LABORATORY** **Blended Course**

Sl.No	List of the experiment
1.	Thermal conductivity of pipe insulation using lagged pipe apparatus
2.	Natural convection heat transfer from a vertical cylinder
3.	Forced convection inside tube
4.	Heat transfer from pin-fin (natural and forced convection modes)
5.	Determination of Stefan-Boltzmann constant
6.	Determination of effectiveness of parallel/counter flow heat exchanger.
7.	Determination of Solar radiation
8.	Experiments on air-conditioning system

P:30 PERIODS

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SPECIFICATIONS:

Inside pipe diameter (d1) = 50mm

Middle pipe diameter (d2) = 100mm

Outside pipe diameter(d3) = 150mm

Length of pipe (L) = 500mm

Voltmeter reading	Ammeter reading	Heat input (watts)	Thermocouples readings(^{0}C)								
			T1	T2	T3	T4	T5	T6	T7	T8	T9

CALCULATIONS:

THERMAL CONDUCTIVITY OF PIPE INSULATION

USING LAGGED PIPE APPARATUS

Ex.no: **Date:**

AIM:

To find the heat transfer through the insulating medium.

DISCRIPION:

The apparatus consists of 3-concentric pipe mounted in suitable stands. The inside pipe consists in the heater between in two cylinders. The insulating material with which lagged to be done is wooden duct. The thermocouples are attached to the suitable cylinder the measure the temperature. The input to the heater is varied through a dimmer stat and measure on a voltmeter, ammeter.

FORMULA USED:

Average inside pipe temperature = $(T_1+T_2+T_3)/3$

Average between pipe temperature = $(T_4+T_5+T_6)/3$

Average of outside pipe temperature = $(T_7+T_8+T_9)/3$

Heat supplied Q = $0.86 \times V \times I$

Heat through composite materials =

$$Q = 2\pi l\,(T_i - T_0) / (\ln[(r_2/r_1)/k_1) + (\ln(r_3/r_2)/k_2])$$

INSULATION MATERIAL:

Thermal conductivity (k) = 0.26 W/m-K

Thermal conductivity of Saw dust =0.069 W/m-K

Thermal conductivity of Glass wool =0.0372 W/m-K

PROCEDURE:

- State the supply of heater by varying dimmer stat.
- Adjust the input for defined value by using voltmeter and ammeter.
- Take reading of all the thermocouple when ready state is reached.
- Repeat the process and not drawn the readings.

RESULT:

The heat transfer through the insulating medium was determined

$k_{\mathbf{eff}}$ =

Q =

OBSERVATION:

Diameter of the cylinder, D =

Length of the cylinder, L =

TABULATION:

Heat input			**Surface temperature**							**Ambient Temperature**
Volts **V**	**Amps** **I**	**Watts** **Q**	**T1** **ºC**	**T2** **ºC**	**T3** **ºC**	**T4** **ºC**	**T5** **ºC**	**T6** **ºC**	**T7** **ºC**	T_{∞} **ºC**

NATURAL CONVECTION HEAT TRANSFER COEFFICIENT OF A VERTICAL CYLINDER

Ex.no: **Date:**

AIM:

To determine the surface heat transfer coefficient for a given vertical cylinder.

APPARATUS REQUIRED:

Free convection heat transfer coefficient apparatus.

THEORY:

Convection heat transfer takes place by the movement of fluid particles in free convection. Fluid motion is due to buoyancy force within the fluid. The buoyancy force is due to the presence of the fluid density gradient and body force that is proportional to density. Density variation in fluid occurs due to the presence of temperature difference between the body force and gravitational force.

FORMULA USED:

EXPERIMENT VALUE OF h

Heat input $Q = h \times A \times \Delta T$ (in W)

Surface area of the pipe $A = \pi dL$, m^2

h(experimental)=$Q/A\ (T_s - T_\infty)$

Nusselt number

$$Nu = \frac{hl}{k}$$

Prandtl number:

$$Pr = \frac{\nu}{\alpha}$$

Grashoff's number

$$Gr = \frac{g\beta\Delta TL^3}{\nu^2}$$

Where,

β = Co-efficient of volumetric expansion of fluid.(K^{-1})

T_f= Film temperature (K)

L = length of the specimen

T_w = Wall temperature (K)

T_∞ = Ambient temperature(K)

ν = Kinematic Viscosity (m^2/S)

PROCEDURE:

1. Connect the equipment to power supplies. Set the voltmeter reading to some value say 70V using the dimmer stat and maintain it as constant.
2. Allow sufficient time for observation of steady state condition.
3. After steady state reached noted down the temperature T_1-T_2 from the indication obtaining the temperature switch.
4. Note down ambient temperature.
5. Note down the distance of the thermo couple from starting to end.
6. Repeat the experiment to different heat input.

RESULT:

Thus, the surface heat transfer coefficient for a given vertical for natural convection is determined.

Heat transfer coefficient, h_{the}=

Heat transfer coefficient, h_{exp}=

SPECIFICATIONS:

Inside diameter of tube	= 40 mm
Orifice diameter	= 24.8 mm
Co-efficient of discharge of orifice	= 0.62
Test section length	= 300 mm

TABULATION:

S. NO	Voltage (V) Volts	Current (I) amps	Heat Input (Q) Watts (V×I)	Air inlet Temp T_1°C	Air Outlet Temp T_7°C	Mano Meter Reading cm		Surface temp				
						h_1	h_2	T_2 °C	T_3 °C	T_4 °C	T_5 °C	T_6 °C

CALCULATION:

HEAT TRANSFER COEFFICIENT IN FORCED CONVECTION USING INSIDE TUBE

Ex.No: **Date:**

AIM:

To determine the heat transfer coefficient in forced convection of air in a table.

APPARATUS REQUIRED:

Forced convection heat transfer coefficient apparatus.

FORMULA USED:

1. Heat input, Q = V x I, watts.
2. Heat transfer co-efficient, $h(\exp) = \frac{Q}{A\,\Delta T}\ \frac{W}{m^2K}$.

To find velocity

Discharge $Q = a \times C_d\sqrt{2gh_{air}}$, $C_d = 0.62$

$a = \frac{\pi d^2}{4}$, $h_{air} = \frac{\rho water}{\rho air} \times hw$

Reynolds number, $Re = \frac{V \times d}{v}$ Velocity (V) = $\frac{Q}{A}$ (m/s)

Properties to be evaluated at $Tm= (T_1 + T_7)/2$

Kinematic Viscosity ν = (m^2/s)

k = (W/m-K)

Pr =

3. Use Dittus – Boelter Equation $Nu = 0.023\,(Re)^{0.8}\,Pr^{0.4}$ (if $Re > 2300$)
4. h theoretical $=(Nu \times k)/d$ (W/m^2-K)
5. $Q = h \times A \times (T_s - T_m)$

PROCEDURE:

i. Start blower by keeping valves fully open.
ii. Switch on heater and adjust the heat rating to a suitable level.
iii. Allow system to initialize it to attain steady state.
iv. Record all temperature heat input and pressure drop across orifice.
v. Repeat the experiment at different heat input and air flow rate.

RESULT:

Thus the heat transfer coefficient in forced convection is found out to be

The heat transfer coefficient

h_{the} =

h_{exp} =

SPECIFICATIONS:

Length of the fin = 150 mm

Diameter of the fin = 12 mm

Thermal conductivity of fin = 110 w/m.k

Diameter of the orifice = 0.02 m

Diameter of the pipe = 3.81 cm

Width of the duct = 0.15 m

Breath of the duct = 0.1m

Coefficient of discharge of the orifice = 0.61

Density of mercury = $15.6x10^3$

TABULATION:

S.NO	VOLTS (V)	AMPS (I)	WATTS (W)	T1	T2	T3	T4	T5	T6

CALCULATION:

HEAT TRANSFER FROM PIN-FIN

Ex.no: **Date:**

AIM:

To determine the temperature distribution effectiveness and efficiency of a pin-fin.

APPARATUS REQUIRED:

Pin-fin apparatus.

FORMULA USED:

1. Velocity of orifice (V_o) =$C_d[2gh(\rho_m-\rho_a/\rho_a)]$ x $1/1-\beta^4$.

   Where,

   ρ_m - Density of a manometer fluid = 1.36x10^3 kg/m³.

   ρ_a – Density of manometer air = 1.17 kg/m³.

   β = Diameter of Orifice /Diameter of Pipe

2. Velocity of air (V_a) = Velocity of orifice (Vo) x Cross sec area of duct .

$$V_a = (V_o) \times (\pi/4) \times (d_0^2/Wb)$$

   Where,

   d_0 – Diameter of orifice = 0.2 m

   w – Width of the duct = 0.15 m

   d_p – diameter of pipe = 3.81x 10^{-2} m
   B – Breath of the duct = 0.1 m

3. Average surface temperature of finis given by,

   T_s=(T1+T2+T3+T4+T5)/5

4. Mean temperature =(T_6+T_s)/2

   T_6-Ambient Temperature ^oC

5. Reynolds number, Re = (V_a.d_f)/ν

   d_f- diameter of fin = 0.012m

6. Nusselt number Nu = C.Re^n.$Pr^{0.333}$

   C = 0.683, n = 0.46.

7. Heat transfer co-efficient h_e = Nu.k/d_f

8. Efficiency η =$\tanh(ml)/ml$

   Where P = Perimeter of the fin(m)

   Where, $m = \sqrt{\frac{hP}{kA}}$

9. Effectiveness, €=($\eta_{fin} \times A_{fin}$)/ A_b

10. $T_x = \frac{((Tb - T\infty) \cosh m(L-x))}{\cosh(mL)} + T_\infty$

11. Q = $(hPkA)^{0.5}$ (T_b-T_∞)tanh(mL)

PROCEDURE:

i. Note down the diameter and length of pin and location of thermocouple.
ii. Set the power input of the heater to a desired level through the dimersed.
iii. Switch the blower and set the air flow rate to any desired valve.
iv. Allow the system to attain stead y state.
v. At steady state record the surface temperature and ambient temperature.
vi. Note down the different in level of two limbs of manometer.
vii. Repeat the experiment for various loads.

RESULT:

Thus the heat transfer from pin-fin is studied as,

Pin-Fin efficiency =

Effectiveness =

SPECIFICATION:

T1= T2= T3= T4=

Diameter of the disc (d) = 20 mm

Thickness of disc (t) = 1.5 mm

Mass of the disc (m) = 5 gms

Sp. heat of the disc (Sp) = 380 J/kg-K

Inner dia of the hemispherical surface = 200 mm

TABULATION:

S.NO	Time ‘t’ Sec	Temperature (T) ºC

DETERMINATION OF STEFAN BOLTZMAN CONSTANT

Ex.no: **Date:**

AIM:

To determine the value of Stefan Boltzmann constant for radiation.

APPRATUS REQUIRED:

Stefan-Boltzmann apparatus.

THEORY:

Stefan Boltzmann law states that the total emissive power of a perfect black body is proportional to fourth power of absolute temperature.

$$E_b = \sigma T^4$$

FORMULA USED:

1) $Q_S = m \times C_p \times (dT/dt)$
2) Area of hemisphere(A_{hs}) = $(\pi/4)d_s^2$
3) Area of disc(A_e) = $(\pi/4)d_c^2$

$$Q_s = \frac{\sigma A_d (T_s^4 - T_w^4)}{(1/€_d) + (A_d/A_{hs})(1/€_{hs} - 1)}$$

Where $€_{hs}$ – Emissivity of hemisphere = 0.725

$€_d$ – Emissivity of disc = 0.6

MODEL CALCULATION:

Area of disc $= \frac{\pi}{4d^2}$

Area of hemisphere = π/2*(0.2)²

Heat supplied Q_s = $\frac{\sigma A_d(T_s^4 - T_w^4)}{\frac{1}{E_d}+\frac{A_d}{A_{hs}}(\frac{1}{E_{hs}}-1)}$

Average temp (T_{avg}) $= \frac{T1+T2+T3+T4+T5+T6}{6}$

PROCEDURE:

1) Fill the water in the stainless steel container with immersion heater kept on top of the panel.
2) Remove the test tube disc before starting the experiment.
3) Heat the water in the SS container to its boiling point.
4) Allow the boiling water into the container kept into the bottom containing copper hemisphere until it is full. Allow sufficient time to attain the thermal equilibrium which is indicated by the three thermocouples provided on the hemisphere.
5) Insert the test disc fixed on the Bakelite sleeve fully in and lock it. Start the stop clock simultaneously.

   Note down the temperature of the disc at an interval of 10 sec for about 5 to 10 min

RESULT:

The Stefan Boltzmann constant had determined

Stefan- Boltzmann constant =

Experimental value of Stefan- Boltzmann constant =

SPECIFICATIONS:

Length of heat exchanger =

Inner diameter of inner tube =

Outer diameter of outer tube =

Inner diameter of outer tube =

Outer diameter of inner tube =

TABULATION:

Mass flow rate of fluid kg/s		Hot water temperature °C		Cold water temperature °C		LMTD in °C ΔT_M	Heat transfer rate(Q) Kw	Overall heat transfer (U) $W/m^2 K$	Effectiveness (E)
Hot M_h	Cold M_C	Inlet T_{h1}	Outlet T_{h2}	Inlet T_{c1}	Outlet T_{c2}				

CALCULATION:

COUNTER FLOW HEAT EXCHANGER

Ex.no:

AIM:

To determine

a) Overall heat transfer coefficient
b) Effectiveness
c) LMTD of a counter flow heat exchange setup.

APPARATUS REQUIRED:

a) Counter flow heat exchange apparatus.
b) Stop clock.
c) Measuring flask.

FORMULA USED:

a) Heat exchange rate for hot fluid(Q_h)

$Q_h = C_h(T_{h1}-T_{h2})$ kW

$C_h = m_h \times C_{ph}$

m_h - Mass flow rate of hot fluid (kg/S)

b) Heat transfer rate for cold fluid(Q_c)

$Q_c = C_c\,(T_{c2}-T_{c1})$

$C_c = m_C \times C_{PC}$

m_c - Mass flow rate of cold fluid (kg/S)

c) Logarithmic Mean Temperature Difference

LMTD= $(\Delta T1 - \Delta T2) / \ln [\Delta T1/\Delta T2]$

$\Delta T_1 = T_{h1} - T_{c1}$

$\Delta T_2 = T_{h2} - T_{c2}$

d) Net heat transfer rate (Q)

$Q= (Q_h+Q_c)/2$ kW

e) Overall heat transfer coefficient (u)

U=Q/(A LMTD),W/mk

A – Surface area of heat exchange.(m^2)

f) Effectiveness (€)

$€= m_C C_{PC} (T_{c2}- T_{c1})/ (C_{min} (T_{h1}- T_{c1})$

C_{min} – Minimum of C_c and C_h

PROCEDURE:

1) Switch on the heater and wait for some time . Start the flow on the hot and cold water sides.
2) Adjust the flow rate on the water side.
3) Keep the same flow rate till steady state condition is reached.
4) Note the inlet and outlet temperature of the cold and hot fluids.
5) Repeat the experiment for different flow rates.

RESULT:

The heat transfer rate LMTD overall heat transfer coefficient and effectiveness counter flow heat exchange are

a) Heat transfer rate –
b) Overall heat transfer coefficient -
c) Effectiveness -
d) LMTD of a counter flow heat exchange setup –

SPECIFICATIONS:

Length of heat exchanger =

Inner diameter of inner tube =

Outer diameter of outer tube =

Inner diameter of outer tube =

Outer diameter of inner tube =

TABULATION:

Mass flow rate of fluid kg/s		Hot water temperature ºC		Cold water temperature ºC		LMTD in ºC ΔT_M	Heat transfer rate(Q) Kw	Overall heat transfer (U) W/m^2 K	Effectiveness (E)
Hot M_h	Cold M_C	Inlet T_{h1}	Outlet T_{h2}	Inlet T_{c1}	Outlet T_{c2}				

CALCULATION:

PARALLEL FLOW HEAT EXCHANGER

Ex.no: **Date:**

AIM:

To determine

d) Overall heat transfer coefficient
e) Effectiveness
f) LMTD of a parallel flow heat exchange setup.

APPARATUS REQUIRED:

d) Parallel flow heat exchange apparatus.
e) Stop clock.
f) Measuring flask.

FORMULA USED:

d) Heat exchange rate for hot fluid(Q_h)

$Q_h = C_h(T_{h1}-T_{h2})$ Kw

$C_h = m_h \times C_{ph}$

e) Heat transfer rate for cold fluid(Q_c)

$Q_c = C_c\,(T_{c2}-T_{c1})$

$C_c = m_C \times C_{PC}$

f) Logarithmic Mean Temperature Difference

$$LMTD = (\Delta T1 - \Delta T2)/ \ln [\Delta T1/\Delta T2]$$

$$\Delta T_1 = T_{h1} - T_{c1}$$

$$\Delta T_2 = T_{h2} - T_{c2}$$

d) Net heat transfer rate (Q)

$Q= (Q_h+Q_c)/2$ Kw

e) Overall heat transfer coefficient (u)

U=Q/A LMTD W/m- K

A – Surface area of heat exchange.

f) Effectiveness (€)

$€= m_c\ C_{PC}\ (T_{c2}- T_{c1})/(C_{min}(T_{h1}- T_{c1})$

C_{min} – Minimum of C_c and C_h

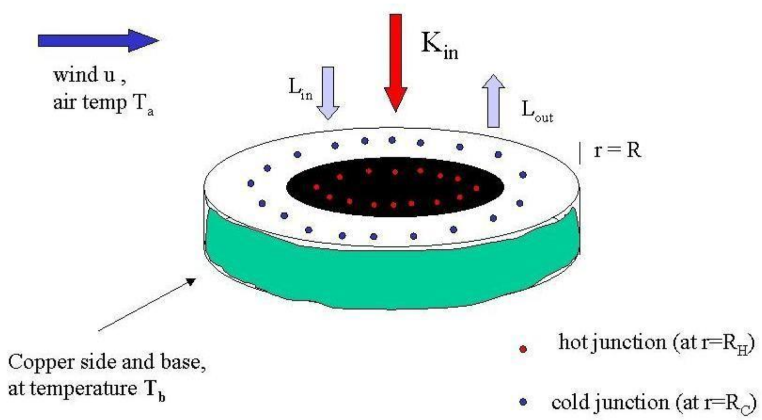
PROCEDURE:

1) Switch on the heater and wait for some time. Start the flow on the hot and cold water sides.
2) Adjust the flow rate on the water side.
3) Keep the same flow rate till steady state condition is reached.
4) Note the inlet and outlet temperature of the cold and hot fluids.
5) Repeat the experiment for different flow rates.

RESULT:

The heat transfer rate LMTD overall heat transfer coefficient and effectiveness Parallel flow heat exchange are

a) Overall heat transfer coefficient -Effectiveness -
b) LMTD of a counter flow heat exchange setup –



Sl no		Millivolt	Solar radiation(wm^{-2})
1	Horizontal Surface		
2	Vertical Surface		
3	Slope Surface		

The direct Solar radiation component (ID) is then obtained by the relation,

$$ID = IT - Id$$

Where IT -Total radiation

Id- Diffuse radiation

SOLAR RADIATION MEASUREMENT

Ex no: Date:

Aim

To measure the total and diffuse solar radiation incident on horizontal, vertical and sloping surfaces and thence to determine the direct components

Apparatus

Lintronic Dome type Solarimeter

Working principle

Solarimeter is basically designed for detecting the radiant energy in the short wavelengths. The sensing elements are essentially accurate .Thermopiles of several junctionsencapsulatedbetween absorbent black plates and provides output in the D.C e.m.f in the millivolt range, proportional to the incident radiant. The calibration factor of the instrument for short wave radiation is

$$CF = mv / kW / m2$$

Procedure

Fix the solarimeter on the stand securely with screws. Mark the 8 Compass directions on the floor. (N,NE....). For total solar radiation, adjust the instrument such that the sensing head with the dome faces upwards and is perfectly horizontal. Take the reading of the D.C Millivoltmeter.Shade the sensing head from direct Sun's rays with the shading disc. Note the reading of D.C Millivoltmeter. For total solar radiation, adjust the instrument such that the sensing head with the dome is vertical. Take the reading of the D.C Millivoltmeter. For diffuse radiation, Adjust the instrument such that the sensing head with the dome makes 30^o slope from the horizontal and faces north. Take the reading for the D.C Millivoltmeter. Now shade the sensing head from direct Sun's rays with the shading disc. Note the reading of D.C Millivoltmeter. To convert the mv readings into corresponding radiation intensities divide it by the calibration factor i.e., (mv/C.F).

Result

The values of Diffuse, Direct and Total Solar Radiation have been calculated

TABULATION:

S.No.	Pressure P_1& P_4 Psi	Pressure P_2& P_3 Psi	Energy meter reading	T_1	T_2	T_3	T_4	Anemometerreading (V) m/sec	(T_5) air inlet temp	(T_6) air oulet temp

CALCULATION:

Area of duct= bxh

Q= A.V

Mass of air=Q x ρ_{air}

Q_r= m.C_p.ΔT

Work done=$\frac{x}{t} \times 3600 \times \frac{1}{3200}$ kJ

$$C.O.P_{pract}=\frac{Q}{W.D}$$

$$C.O.P_{theor}=\frac{h_1-h_4}{h_2-h_1}$$

Determination of COP of an Air conditioning system.

Ex.no: **Date:**

Aim:

To Determine the COP of an Air conditioning system**.**

Apparatus required:

1. Air conditioning test rig,
2. Thermometer.

Procedure:

1) All the hand shut off valves should be opened except charging line valve which should not be touched.
2) P_1/P_2 indicate suction pressure in the pressure P_2/P_3 indicate discharge pressure in the gauges.
3) Provide a single phase 15 amps 3 pin socket power supply close to the unit. See the voltage is not above 250 V and below 220 Volts. Do not operate if voltage is not proper. Please see that a proper earth is provided for unit.
4) Keep main SV, TH switches in off position and take down the readings in two energy meters (initial reading).
5) Now put the main switch on and check the voltage in the meter provided.

6) Decide which system you are going to use first. For (a) solenoid valve (SV) with thermostat expansion valve (TEV) close S_2, S_3, S_4, S_5 (b) for capillary system close S_4 and S_5

Result:

Thus the C.O.P of the air conditioning are found out

$_{theo}=$

$_{Exper} =$

Viva-voce questions and answers

Thermal conductivity measurements by guarded plate method

1. What is the formula to find out K?

$K = (Q / A)*(\Delta L/\Delta T)$

2. What is meant by ΔL?

It is the length between two points L_1 and L_2.

3. What is meant by ΔT?

Temperature Difference between two points T_1 and T_2

4. What is the unit of area?

Square meter.

5. What is the unit for heat transfer (Q)?

Watts.

6. What is the unit for Thermal conductivity?

$W/m^2.K$

7. Define thermal conductivity.

Thermal conductivity is a physical property of the substance and is defined as the ability of a substance to conduct heat. The unit of thermal conductivity is W/m°K.

8. State Fourier's law of heat conduction.

Fourier's law of heat conduction is stated as the rate of heat conduction is proportional to the area measured perpendicular to the direction of heat flow and to the temperature gradient along the direction i.e.,

$$Q = -KA \frac{dT}{dx}$$

9. Define Conduction?

Conduction is defined as the mode of heat transfer from one part of a substance to another part of the same substance or a substance having physical contact with it, without any appreciable displacement of the molecules of the substance.

10. Define Heat transfer.

The transmission of heat energy from one region to another region due to temperature gradient is known as heat transfer.

Thermal conductivity of pipe insulation using lagged pipe apparatus.

1. What is lagged pipe?

The apparatus consists of 3-concentric pipe mounted in suitable stands

2. What is the formula used for Q?

$Q = 0.86*V*I$

3. What is the formula used for Heat through composite materials?

$Q=2\pi l (T_i-T_0) / (\ln [(r_2/r_1)/k_1) + (\ln (r_3/r_2) /k_2])$

4. What is the material used for insulation?

Saw duct and glass wool.

5. What is **K_{eff} ?**

Effective thermal conductivity.

6. How to measure the temperature?

Using thermometer with help of thermocouple.

7. Define Heat transfer.

The transmission of heat energy from one region to another region due to temperature gradient is known as heat transfer.

8. What are the different modes of heat transfer?

The different modes of heat transfer are,

a) Conduction
b) Convection
c) Radiation

Natural convection heat transfer from a vertical cylinder.

1. What is natural convection?

Convection heat transfer takes place by the movement of fluid particles in free convection. Fluid motion is due to buoyancy force within the fluid. The buoyancy force is due to the presence of the fluid density gradient and body force that is proportional to density. Density variation in fluid occurs due to the presence of temperature difference between the body force and gravitational force.

2. What is free convection?

Natural convection also called as free convection.

3. What is Nusselt number?

It is a dimensionless number (N_u) = $\frac{hL}{k}$

4. What is the formula for prandl number?

$P_r = (V/ Q)$

5.What is the formula Grashoff's number?

$Gr = (g\beta L^3\Delta T)/ V^4$

6. What is h?

Heat transfer coefficient.

7. What is the formula for heat transfer coefficient?

$H = Q / (A * \Delta T)$

8. What is the meaning for β?

Volumetric expansion coefficient of fluid.

9. What is T_w ?

Wall temperature.

10. What is T_∞?

Ambienttemperature

Forced convection inside tube.

1. What is Forced Convection?

Convection heat transfer takes place by the movement of fluid particles with help of external aid.

2. What is the formula for h?

$$h = \frac{Q}{A\,\Delta T}$$

3. What is the unit for h?

$$\frac{w}{m^2 k}$$

4. What is the formula for m_a?

m_a – discharge of air = $\rho AV = \rho Q$.

5. How to find out discharge?

$Q = aC_d\sqrt{2gh\text{air}}$.

6. What is Reynolds number?

It is the ratio of inertia force to the viscous force.

Mathematically, $Re = \frac{V \times d}{v}$

7. How to find out q and also units of Q?

Heat input, Q = V x I, watts.

Heat Transfer from Pin-fin (Natural & Forced convection modes).

1. Define fins.

Fins are the extended surface in order to increase the effective surface area for heat convection.

2. What are the applications of fins?

The fins are widely used in,

a) Economizers used in steam power plants.
b) Automobile radiators.
c) Cooling of IC engines.
d) Cooling of air compressors, electric motors and transformers.
e) Estimation of error in temperature measured by thermometers.

3. Mention some common types of fin configurations available.

Some common types of fin configurations are,

a) Rectangular fin
b) Triangular fin
c) Circular fin

4. Define efficiency of fin.

The efficiency of fin is defined as the ratio of actual heat transferred by fin to the maximum possible heat transferred if the entire fin area is maintained at base temperature.

5. How to find Nusselt number?

$Nu = C.Re^{n}.Pr^{0.333}$

6. What is the formula for efficiency for the fin?

Efficiency (η) $=\tanh(ml)/ML$

7. What is the formula for Effectiveness?

$$\text{Effectiveness, E}=\frac{\tanh(mL)}{\sqrt{\frac{hA}{k\emptyset}}}$$

8. How to find out heat transfer coefficient?

$h_e = Nu.K/d_f$

Determination of Stefan- Boltzmann constant.

1. Define Stefan Boltzmann law?

Stefan Boltzmann law states that the total emissive power of a perfect black body is proportional to fourth power of absolute temperature.$E_b = \sigma T^4$

2. What is the area of hemisphere?

Area of hemisphere (A_s) = $(\pi/4)d_s^2$

3. What is the area of disc?

(A_e) = $(\pi/4)d_c^2$

4. What is emissive power?

Emissive power is defines as the energy emitted per unit time from an unit surface area.

5. Define radiation Heat transfer.

It is defines as the transfer of heat energy from one region to another region by means of an electro magnetism due to temperature difference.

6. What is the range of electromagnetic waves used in heat transfer?

The electromagnetic waves lies between 0.1 to 100 are used for heat transfer.

7. Define Reflectivity?

It is defined as the ratio of total energy reflected from the surface to the total energy incident upon the surface.

8. Define Transmissivity?

It is defined as the ratio of total energy transmitted through the surface to the total energy incident upon the surface.

9. What is the value for Emissivity of hemisphere?

0.725

10. What is the value for Emissivity of disc?

E_e – Emissivity of disc = 0.6

Determination of Emissivity of a Gray surface.

1. Define emissive power.

   Emissive power is defines as the energy emitted per unit time from an unit surface area.

2. Define. Reflectivity?

   It is defined as the ratio of total energy reflected from the surface to the total energy incident upon the surface.

3. Define. Transmissivity?

   It is defined as the ratio of total energy transmitted through the surface to the total energy incident upon the surface.

4. Define. Black body.

   Black body is defined as an ideal body which absorbs all the incident rays and also completely emits all the absorbed energy.

5. Define Gray body.

   Gray body is defined as the real body which does not absorb the all incident rays and also does not completely emit the absorbed energy.

6. Define Radiosity?

   It is defined as the total amount of heat energy leaving the surface which includes the reflected energy and emitted energy.

7. State Kirchhoff's law.

It states that, for all substances which are in thermal equilibrium with its surroundings, the ratio of total power to absorptivity is constant.

8. Define Radiosity.

It is defined as the total amount of heat energy leaving the surface which includes the reflected energy and emitted energy.

9. What is the value for Stefan-Boltzmann constant?

$5.6697*10^{-8}$ w/m^{2}k^4.

Effectiveness of parallel/ Counter flow heat Exchanger

1. Define LMTD?

Logarithmic Mean temperature Difference is defined as the constant temperature difference between the hot and cold fluid that would give the same rate of heat transfer as actually occurs under variable conditions of temperature difference.

2. Define number of transfer units.

Number of transfer Units is defined as a measure of the heat transfer size of the heat exchanger.

3. Define Heat capacity of the Fluid.

Heat capacity of the fluid is defines as the total heat available in the fluid and is given by the product of mass and specific heat of the fluid.

4. Define Overall heat transfer coefficient.

Overall heat transfer coefficient is defined as the average heat transfer coefficient for the combined modes of heat transfer. The increase in heat transfer coefficient increases the heat transfer.

5. Define Heat exchanger.

It is defined as equipment which transfers heat from a hot substance to cool substance.

6. What is the formula for Heat exchange rate for hot fluid (Q_h)?

$Q_h = C_h(T_{h1}-T_{h2})$ Kw

$C_h = M_h \times C_{ph}$

7. What is the formula for Heat transfer rate for cold fluid (Q_c)?

$Q_c = C_c(T_{c2}-T_{c1})$

$C_c=M_C \times C_{PC}$

8. What is the formula for Logarithmic mean temperature difference (ΔT_x)?

$\Delta T_M= \quad (\Delta T1 - \Delta T2)/ \ln [\Delta T1/\Delta T2]$

$\Delta T=T_{h1}-T_{c1}$

$\Delta T=T_{h2}-T_{c2}$

9. What is the formula for Overall heat transfer coefficient (u)

$U=Q/A\ \Delta T_m$,W/mk

A – Surface area of heat exchange.

10. What is the formula for Effectiveness (E)?

$E= M_C C_{PC} (T_{c2}- T_{c1})/ (C_{min} (T_{h1}- T_{c1})$

C_{min} – Minimum of C_c and C_h

SOLAR RADIATION MEASUREMENT

1. Write a note on total solar energy received in India.

The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India. India's theoretically calculated solar energy incidence on its land area alone, is about 5,000 trillion kilowatt-hours (kWh) per year.

2. Give three types of solar energy collectors.

Flat plate collector, Evacuated tube collectors&Parabolic troughs, dishes and towers described in this section are used almost exclusively in solar power generating stations

3. Mention any two applications of solar energy.

Power plants,Solar LightingSolar Cars & Power pump

4. Define solar isolation.

Solar insolation is a measure of solar radiation energy received on a given surface area in a given time. It is commonly expressed as average irradiance in watts per square meter (W/m2) or kilowatt-hours per square meter per day (kW•h/(m2•day)) (or hours/day).

5. Define solar constant.

The solar constant is the amount of energy that normally falls on a unit area (1 m2) of the earth's atmosphere per second when the earth is at its mean distance from the sun. The value of the solar constant is found experimentally to be 1.35 kW m-2.

6. Define solar attitude angle.

The solar zenith angle is the angle between the zenith and the centre of the sun's disc. The solar elevation angle is the altitude of the sun, the angle between the horizon and the centre of the sun's disc.

7. Define Solar irradiance

Solar irradiance is the power per unit area produced by the Sun in the form of electromagnetic radiation. Irradiance may be measured in space or at the Earth's surface after atmospheric absorption and scattering.

8.What is diffuse radiation?

Diffuse sky radiation is solar radiationreaching the Earth's surface after having been scattered from the direct solar beam by molecules or suspensions in the atmosphere. It is also called skylight, diffuse skylight

REFRIGERATION AND AIR CONDITIONING

1. Define Refrigeration

It is defined as the process of providing and maintaining a temperature well below that of surrounding atmosphere.in other words refrigeration is the process of cooling a substance

2. Define Refrigerators?

It is the machines which are used to extract heat from a body at low temperature and then reject this heat to a high temperature body. If the main purpose of the machine is to cool some object, the machine is named as refrigerator

3. Define heat pumps?

When the main purpose is to heat a medium which is warmer than its surroundings, the machine is termed as heat pump.

4. What are the different types of Types of Refrigerators?

a. Ice refrigerators is kept in the cabinet of refrigerators and this acts as the refrigerating means.

b. Air refrigerators here air is used as a working agent in these type of Refrigerators

Air Refrigerators are of two types:

- ❖ Cold air Refrigerators working on reversed Carnot cycle or the ideal Refrigerators
- ❖ Cold air Refrigerators working on bell-Coleman cycle.

5. What are the two types of Vapour Refrigerators?

- ❖ Vapour compression refrigerators
- ❖ Vapour absorption refrigerators

6. What is the Application of refrigeration?

- ❖ In chemical industries for separating and liquefying gases and vapours
- ❖ In manufacturing and storing ice.
- ❖ For the preservation of perishable food items in cold storages for cooling water.
- ❖ For controlling humidity of air in the manufacture and heat treatment of steel.
- ❖ For chilling the oil to remove wax in oil refineries.
- ❖ For the preservation of tablets and medicines in pharmaceuticals industries.
- ❖ For the preservation of blood, tissues,etc..In medical fields.
- ❖ For comfort a/c in hospitals, theatres etc.

7. What is Psychometry?

The study of behavior of moist air (mixture of air and water vapour) together with their measurement and control is known as Psychrometry.the properties of air-vapour mixture are known as Psychometric properties

8. Define air conditioning?

A/C is defined as the simultaneous control of temperature, humidity (moisture content present in air), motion (movement and circulation of air) and purity of air within an enclosed space.

9. What are the Applications of A/C?

Industrial application, food industry, photographic industry, textile industry, printing industry, machine tool industry, commercial applications, transport air-conditioning, hospital application.

10. What is the Classification of A/C system?

I. According to the purpose

1. Comfort air conditioning
2. Industrial air conditioning

II.According to the season

1. Summer air conditioning system
2. Winter air conditioning system
3. Year-round air conditioning system

III.According to the arrangement of equipment

1. Unitary air conditioning system
2. Central air conditioning system

11. What is c.o.p?

Coefficient of performance (c.o.p).

12. What is the formula for actual c.o.p?

Actual COP = Heat extracted / work done = Q/W

13. What is the formula for theoretical c.o.p?

Theoretical COP = $(h_1-h_4)/ (h2-h_1)$

AIR COMPRESSOR

1. How the compressors are classified?

- According to the number of stages: Single stage and Multi stage
- According to the number of cylinder: Single cylinder and Multi cylinder.
- According to the method of cooling: Air cooled compressor and Water cooled compressor
- According to working: Reciprocating compressor and Rotary compressor
- According to the action of air: Single acting compressor and Double acting compressor
- According to the pressure limit: Low pressure, Medium pressure and High pressure compressor.
- According to the capacity: Low capacity, Medium capacity and High capacity compressor.

2. What are the advantages of rotary compressor over reciprocating compressor?

Maximum free air delivery is as high as 3000 m^3/min.Air supply is continuous, cleaner. Small size is required for the same discharge. No balancing problem.

3. What are the differences between centrifugal and axial flow compressors?

Centrifugal compressor axial flow compressor The flow of air is perpendicular to the axis Of compressor the flow of air is parallel to the axis of compressor. It has low manufacturing and running cost It has high manufacturing and running cost

.

4. What is the purpose of inter cooling and explain its process?

The purpose of inter cooling in multistage compression is to reduce the temperature without reduction in pressure. It is placed between LP cylinder and HP cylinder. When air flows through it, the temperature is reduced by maintaining the water circulation.

5. Why a Clearance volume is necessary and explains its importance?

In actual compressor, the clearance volume is provided to give cushioning effect Otherwise the piston will strike the other end of the cylinder. It is generally expressed as percentage of piston displacement. Importance of clearance volume:

To give cushioning effect to the piston and To provide space for valve movement.The maximum pressure may also be controlled by clearance volume. The volumetric efficiency and pressure ratio are depends upon the clearance Volume. If clearance volume is more, it reduces the volumetric efficiency.

6. What are the advantages of multi stage compressor over single stage compressor?

- ❖ Less work is done by the compressor to deliver the same quantity of air.
- ❖ It improves the volumetric efficiency for the given pressure ratio.
- ❖ The size of the two cylinders may be adjusted to suit the volume and pressure of the air.
- ❖ It reduces the leakage losses considerably and provides effective lubrication.
- ❖ It provides more uniform torque and thus smaller size of the flywheel is required.
- ❖ It reduces the cost by selecting a cheap material for construction

.

7. Define volumetric efficiency of the compressor.

It is the ratio of actual volume of air drawn in the compressor to the stroke volume of the compressor.

8. Define mechanical efficiency.

It is the ratio of indicated power to shaft power or brake power of motor.

9. Define isentropic efficiency.

It is the ratio of the isentropic power to the brake power required to drive the compressor.

10. What is the purpose of inter cooling and explain its process?

The purpose of inter cooling in multistage compression is to reduce the Temperature without reduction in pressure. It is placed between LP cylinder and HP cylinder. When air flows through it, the temperature is reduced by maintaining the water circulation.