I N D E X

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STD: B.tech (M.E) DIV: 5th Sem ROLL NO. 1708240036

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08.	To determine total thermal Resistance of composite wall & also plot temp gradient along thickness of c.w	16/Aug/2019	04	A 16/8/19
02	find the emmissivity of a gray plate with R. to black plate	30/Aug/2019	06	B 30/8/19
01	Determine the surface heat transfer coefficient for vertical cylinder	30/Aug/2019	10	B 06/9/19
11.	To determine the thermal Conductivity of an Insulating Powder	6/Sept/2019	12	A 06/09/19
05.	To determine the heat transfer coefficient at fin Surface, temp distribution & efficiency of fin in forced Convection.	20/sept/19	15	A 24/09/19
10.	To study the pool Boiling phenomenon up to Critical heat flux point	27/sept/19	19.	P1 27/9/19
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~~9.~~	~~To compare the heat transfer rate by using heat pipe apparatus~~	~~11/10/2019~~	~~24~~	
3.	To determine, effectiveness, heat transfer Rate & overall heat transfer Coefficient in Parallel flow heat exchanger	10/10/19	26	10/10/19
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EXPERIMENT No. 07

OBJECT :- To determine heat flow Rate through the lagged pipe and thermal Conductivity of lagging material.

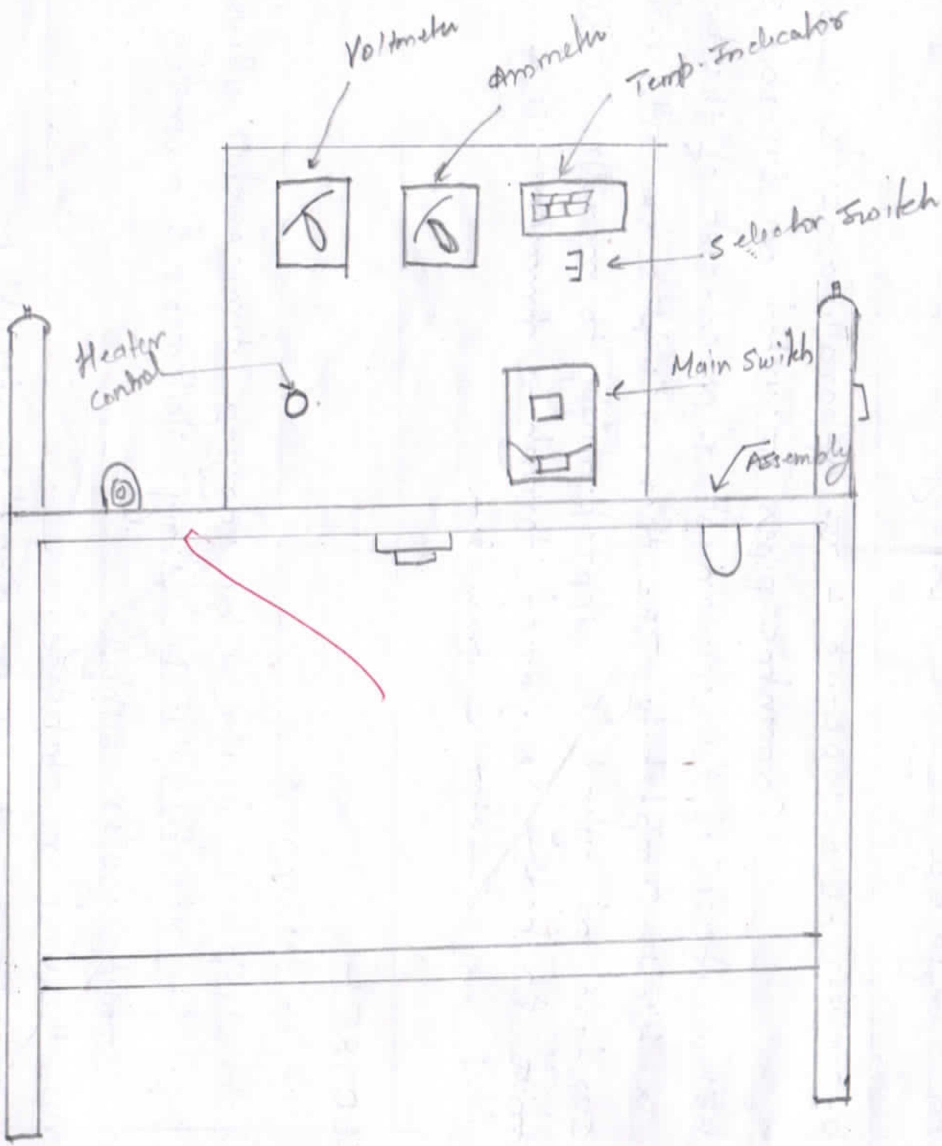
THEORY :- Multi-layer Cylindrical walls are frequently employed to Reduce heat losses from metallic pipes meant for handling hot fluid. A layer of insulating material and then a layer of protecting plaster. The arrangement is called lagging of the pipe system.

DESCRIPTION OF APPARATUS :- The apparatus consists of 3 Concentric pipes mounted on suitable stand. The hollow space of the innermost pipe consist of the be done is filled completely. The thermocouples are attached to the surface of cylinders appropriately to measure the temp. The Input to heater is varied through a dimmerstate & measured on Voltmeter & ammeter.

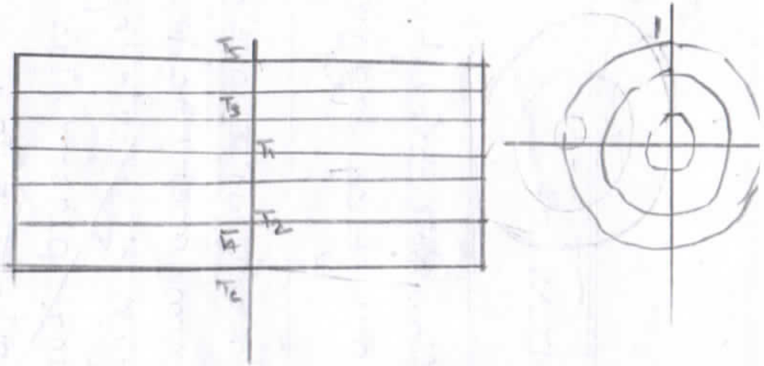
PROCEDURE :-

1. Switch on the mains
2. Start the supply of heater & by varying dimmerstate adjust the Input for desired value by using voltmeter & ammeter.
3. Also start water supply.
4. Allow the unit to stabilize.
5. Take readings of all the Six thermocouples.

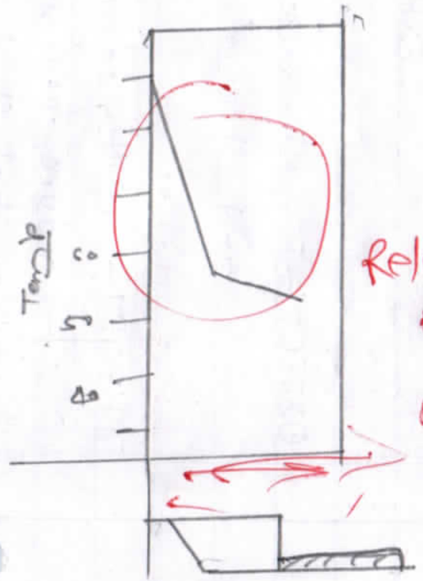
Signature of the checker



LAGGED PIPE APPARATUS



T_1, T_2, T_3 — ??



Relate with Readings.

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OBSERVATION

1. Inner pipe Radius = 0.03 m
2. Outer pipe Radius = 0.0535 m
3. Mean Radius of middle pipe = 0.0425 m
4. Length of the pipe (l) = 1 m

S.No	V (volt)	I (Amp)	t_1	t_2	$t_1 = (t_1 + t_2)/2$	t_3	t_4	$t_m = (t_3 + t_4)/2$	t_5	t_6	$= (t_5+t_6)/$
	125	1.18	105	105	105	70	71	70.5	40	40	40

CALCULATION

k_1 (Thermal conductivity) of asbestos Powder

$$k_1 = \frac{q \cdot \ln(r_m/r_i)}{2\pi \cdot l (t_1 - t_m)} \quad W/mk$$

k_2 (Thermal Conductivity of Saw dust)

$$k_2 = \frac{q \cdot \ln(r_o/r_m)}{2\pi \cdot l \cdot (t_m - t_o)} \quad W/mk$$

Now heat flow Rate through the Composite cylinder Can be found using following Relation:

$$q = \frac{t_1 - t_o}{\frac{1}{2\pi \cdot l}\left[\frac{1}{k_1}\ln\left(r_m/r_i\right) + \frac{1}{k_2}\ln\left(\frac{r_o}{r_m}\right)\right]} \quad W$$

Signature of the checker

Calculation :-

$$k_1 = \frac{q \cdot \ln(r_m/r_i)}{2\pi l(t_i - t_m)}$$

$$= \frac{147.5 \times \ln(0.0425/0.03)}{2 \times \pi \times (105 - 70.5)}$$

$$= 0.237 \ W/mK$$

$$k_2 = \frac{q \cdot \ln(r_o/r_m)}{2\pi l(t_m - t_o)}$$

$$= \frac{147.5 \times \ln\left(0.0535/0.0425\right)}{2\pi(70.5 - 40)}$$

$$= 0.177 \ W/mK$$

$$q = \frac{t_i - t_o}{\frac{1}{2\pi l}\left[\frac{1}{k_1}\ln\left(\frac{r_m}{r_i}\right) + \frac{1}{k_2}\ln\left(\frac{r_o}{r_m}\right)\right]}$$

$$q = \frac{105 - 40}{\frac{1}{2\pi l}\left[\frac{1}{0.237}\ln\left(\frac{0.0425}{0.03}\right) + \frac{1}{0.177}\ln\left(\frac{0.0535}{0.0425}\right)\right]}$$

$$= 147.44 \ W$$

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RESULT:-

1. Thermal Conductivity of asbestos Powder 0.237 W/mk
2. Thermal Conductivity of Saw dust 0.177 W/mk
3. heat flow rate through the Composite Cylinder 147.44 W

PRECAUTION

1. Keep dimmerstats to zero position Before start.
2. Increase voltage slowly.
3. Keep the assembly undisturbed while testing
4. Do not increase voltage above 150 volts.

16/8/19

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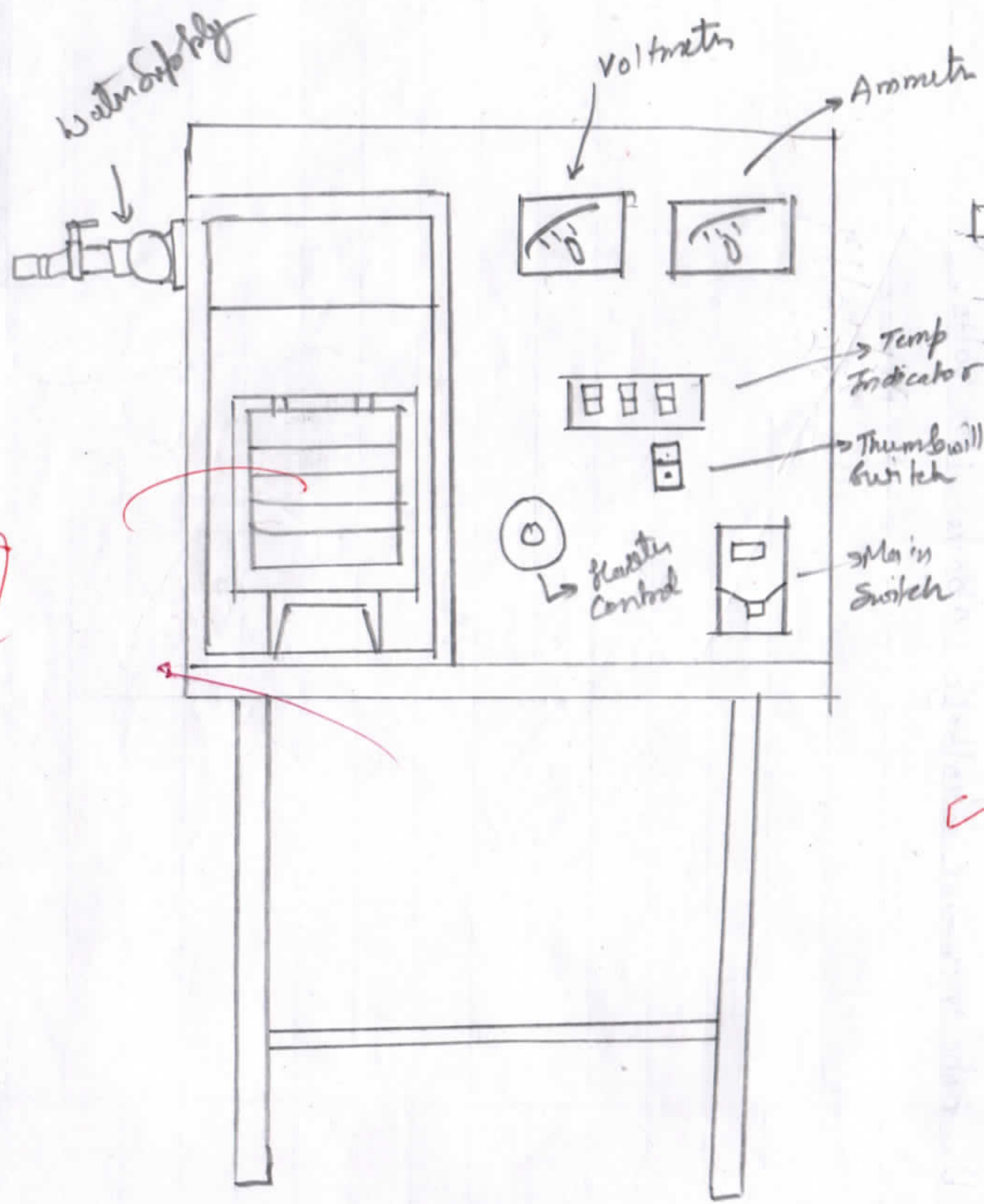
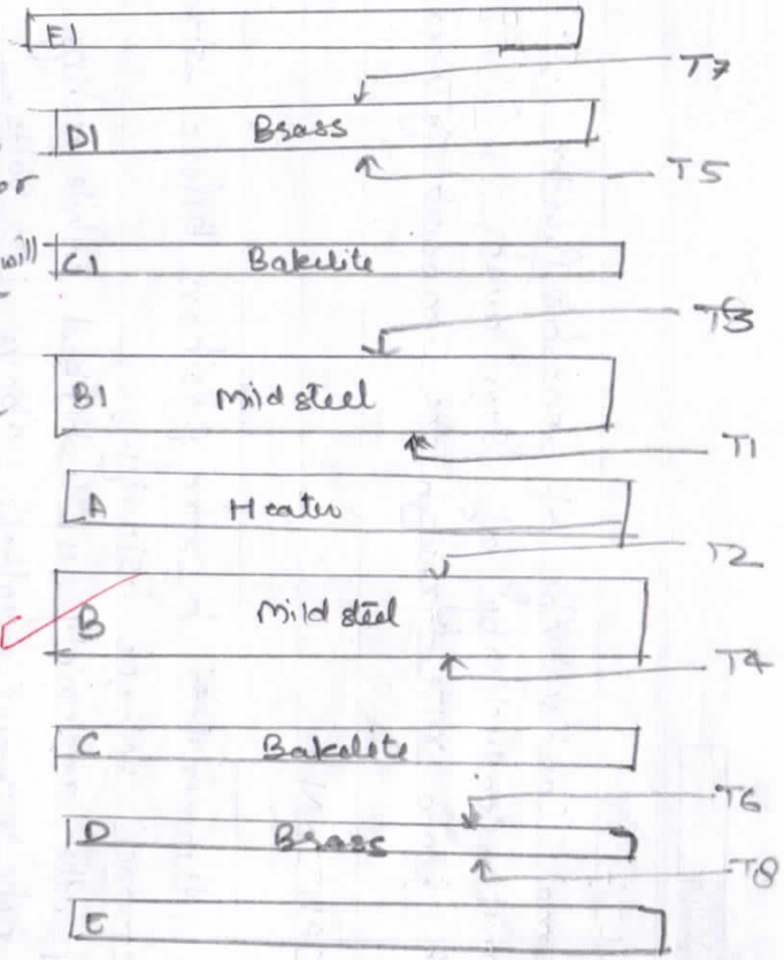


Composite Wall



Thermocouple setting

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EXPERIMENT NO. 08.

OBJECT :- To determine total thermal Resistance of Composite wall and also plot temperature Gradient along thickness of Composite Wall.

Theory :- A Composite wall Refers to a wall of Several heterogeneous layes e.g. Walls of dwelling houses where bricks are given a layer of plaster on either side. The Concept of thermal Resistance is advantageously applied while making Computations for heat flow in a Composite Wall. Likewise heat flow in a material is governed by temp. potential & thermal Resistance of material.

Description of Apparatus :-

The apparatus consists of plate of different materials sandwiched b/w two aluminum plates. Three type of slabs are provided on both side of heater which forms a Composite structure. Thermocouples are embedded b/w interfaces of slabs to read the temp at the surface.

Procedure :- Arrange the plates properly on both Sides of heater plate.

2. Operate the hand press properly to ensure perfect Contact b/w the plates.

3. start Supply of Water

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Calculations

$$R_{th} = \frac{t_A - t_D}{q}$$

= where $q = V \cdot I$

$$R_{th} = \frac{t_A - t_D}{V \cdot I}$$

$$= \frac{52 - 30}{150 \times 0.55}$$

$$= \frac{22}{82.5}$$

$$R_{total} = 0.2667 \text{ deg/w}$$

4. By varying the dimmerstat, adjust the input wattage.
5. Let the System to stabilize for 30 minutes.

OBSERVATION.

Wall thickness of plates:

1. Mild steel $\underline{2.5}$ cm
2. Bakelite $\underline{1.0}$ cm
3. Brass $\underline{1.0}$ cm

S.N	V(Volt)	I(Amp)	t_1	t_2	$t_A = \frac{t_1+t_2}{2}$	t_3	t_4	$t_B = \frac{t_3+t_4}{2}$	t_5	t_6	$t_C = \frac{t_5+t_6}{2}$	t_7	t_8	$t_D = \frac{t_7+t_8}{2}$
1.	150	0.55	52	52	52	52	51	51.5	30	29	29.5	30	30	30
											$t_C =$			$t_D =$

CALCULATION:-

$$R_{total} = \frac{t_A - t_D}{q} \quad \text{deg/W}$$

where $q = V \cdot I$

16/8/19

Result:- Total thermal Resistance of Composite slab is $\underline{0.2667 \text{ deg/W}}$

Precaution:- Keep the dimmerstat zero before start

2. Increase voltage slowly.
3. Keep all the assembly undisturbed.
4. Do not increase voltage above 200 V
5. operate selector switch of temp indicator slowly.

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EXPERIMENT NO. 02

OBJECTIVE :- To find the emmissivity of a gray plate with respect to a black plate.

Theory :- All substances at all temp emit thermal radiation. Thermal Radiation is an electromagnetic wave and does not require any material medium for propagation.

$$\rho + \alpha + \tau = 1$$

ρ = fraction reflected

α = fraction absorbed

τ = fraction transmitted

for a black body. ρ & $\tau = 0$

$$\boxed{\alpha = 1}$$

The emissive power of a body is defined as the energy emitted by the body per unit time.

$$\epsilon = E/E_b$$

Emissivity depend on the surface temp & Nature of Surface.

A Gray body is defined such that monochromatic emissivity of body is independent of wavelength

power input to the black body

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$$q_b = \epsilon_b A_b (T_s^4 - T_a^4) = V_b \times I_b$$

Power input to gray plate

$$q_g = \epsilon A_g (T_s^4 - T_a^4) = V_g \times I_g$$

The surface temp of two plates will be maintained at same temp. T_s

$$\boxed{\epsilon = \epsilon_b - \frac{q_b - q_g}{\sigma A (T_s^4 - T_g^4)}}$$

Description of Apparatus

The experimental set up consists of two circular copper plates identical in size & is provided with heating coils sand watches. The plates are mounted on bracket and are kept in an enclosure so as to provide undisturbed natural convection surroundings. When the surface temp are same the difference in the heater input readings is Bcoz of the difference in Radiation characteristics due to their different emissivities.

Specifications :-

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Calculation

$$q_b = V_b \times I_b$$
$$= 50 \times 0.45$$
$$= 22.5$$

$$q_g = V_s \times I_s$$
$$= 45 \times 0.40$$
$$= 18$$

$$E = \epsilon_b - \frac{q_b - q_s}{\epsilon A (T_s^4 - Ta^4)}$$

$$A = \frac{\pi}{4} D^2 = \frac{3.14}{4} \times (0.16)^2 = 0.02011$$

$$E = 1 - \frac{(22.5 - 18)}{5.67 \times 10^{-8} \times 0.02011 (343^4 - 308)^4}$$

$$E = 1 - \frac{4.5}{5.5}$$
$$= 1 - 0.81$$
$$E = 0.19$$

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Test plate diameter = 160 mm
Black plate diameter = 160 mm
RTD temp Sensor = 3 Nos

OBSERVATIONS

S.N	Ambient temp (°C) Ta T_3 (°C)	Surface temp of Plate (°C) T_1(°C) T_S	T_2(°C)	Black Plate V_b(V)	I_b(A)	Gray Plate V_g(V)	I_g(I)(A)
	35	70	70	50	0.45	45	0.40

Take one more reading

Calculation :-

S.N	Ta (Ambient temp)	Ts (surface temp. of plate)	Black plate q_b	Gray Plate q_g	Emiss. of G.P (E)
	35 + 273	70 + 273			
	308	343	22.5	18	0.19

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Result:-

(1) The emissivity of gray plate is 0.19

(2) At different surface temp of plate, the value of emissivity ~~......~~

Precautions:-

1. Use the stabilize A.C. single phase supply only
2. Never switch on main power supply before ensuring that all the ON/OFF switches.
3. Voltage to heater starts & increases slowly.
4. Keep all the assembly undisturbed.
5. Always keep the apparatus free from dust.
6. Operate selector switch of temp indicator gently

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Cal

Run-1

$$t_s = \frac{58+78+115+160+174+165+137}{7}$$

$$= 126.714°C$$

$$h = \frac{q}{A_s(t_s-t_a)} = \frac{1.4}{6.3617\times10^{-2}(126.714-39)}$$

$$h = 20.429 \ W/m^2°C$$

Run 2

$$t_s = \frac{55+75+111+155+168+159+134}{7}$$

$$= 122.428°C$$

$$h = \frac{q}{A_s(t_s-t_a)} = \frac{120}{6.3617\times10^{-2}(122.428-38)}$$

$$21.3857 \ W/m^2°C$$

$$\text{Avg value} = \frac{20.4296+22.3418}{2}$$

$$= 21.3857 \ W/m^2°C$$

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Experiment No. 01

Object :- To determine the surface heat ~~Surface Co~~ transfer coefficient for heated vertical cylinder in Natural Convection.

Theory :- When a hot body is kept in still air, it looses heat to the surroundings by the Process of Natural Convection. The layer of fluid adjacent to the hot body get heated up. A Convective Motion is initiated with a continuous motion of hot fluid flowing upwards along the plate & Replacement of this fluid by the Cooler fluid.

Description of Apparatus

The experimental apparatus Consist of a vertical tube enclosed in a Rectangular duct open at both top & bottom. One Side of the duct is made of transparent section to facilitate Visual observation. The temp are measured at different heights of tube using thermoCouples.

Procedure :-

1- Switch on the Mains.
2. Keep the Input power to a lowest Range.
3. Allow the unit to Stabilize.

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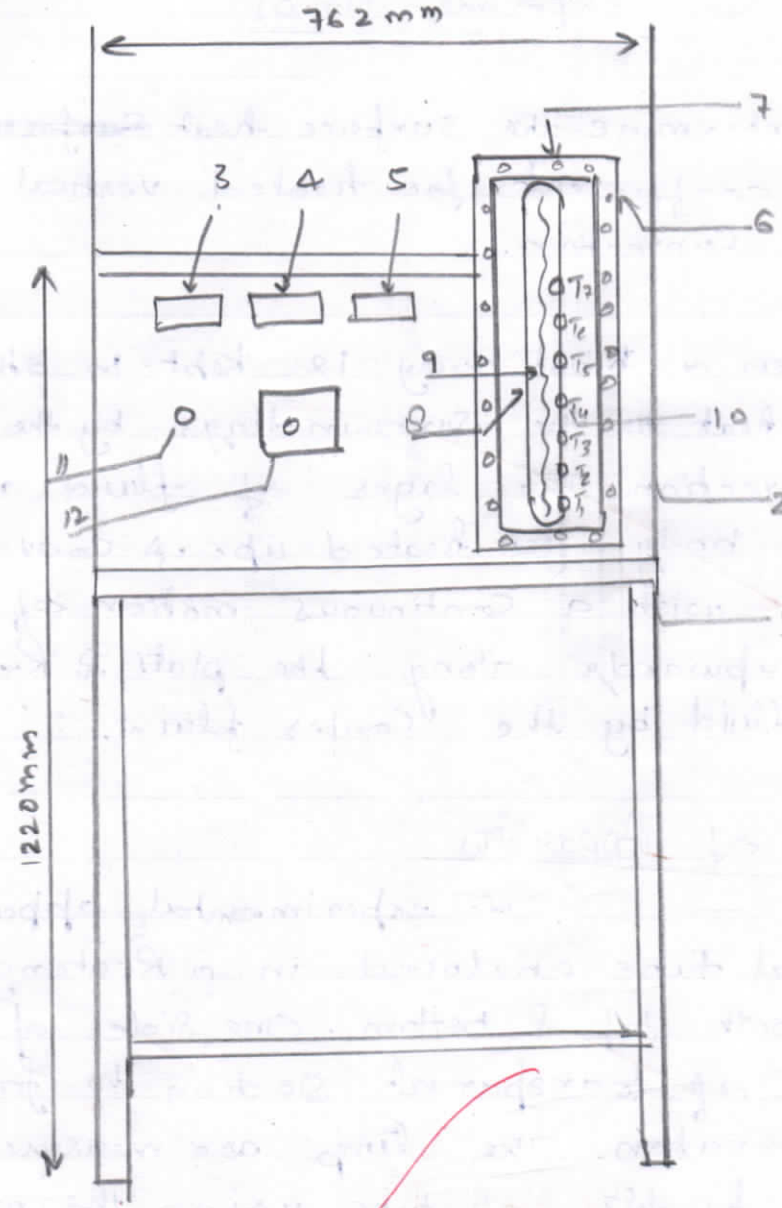

1- Tube frame
2- Panel Board
3- Digital Voltmeter, 0-300 V
4 Digital Temp Indicator, 0-400°c
5. Digital Ammeter, 0-15A
6. Wooden Chamber
7. Top & Bottom End caps
8. S.S pipe
9. Heater, 250 W
10. Thermocouples
11. Dimmer, 15 KW
12. Temp

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4. Switch on the band Switch no. 1 & See that Readings should not change.
5. Repeat the experiment for different inputs & tabulate the Readings for calculations.

OBSERVATIONS

Diameter of tube (d) = 0.045 m
Length of tube (l) = 0.45 m

Voltage (V) Volts	Current (I) Amps	Heat Input (q) watt	Surface temp $t_1, t_2, t_3, t_4, t_5, t_6$ Unit of Temp	Avg Surface	Ambient temp t_0
95	1.2	114	56, 78, 115, 160, 174, 165, 137	126.714 122.428	39 30
100	1.2	120	59, 95, 118, 155, 168, 152, 134	Heat t/f coefficient 20.429 22.3418	Avg heat t/f coefficient 21.3857

Calculate :- Heat t/f coefficient is given by

$$h = \frac{q}{A_s(t_s - t_a)}$$

Result :- The avg value of heat t/f is 21.3857 $W/m^2{}^{\circ}C$

Precaution :-

1. Keep dimmerstate to zero position before start.
2. Increase voltage slowly.
3. Keep the assembly undisturbed while testing.
4. operate selector switch of temp. Indicator gently.
5. Take Reading after the system is stabilized.

Signature of the checker

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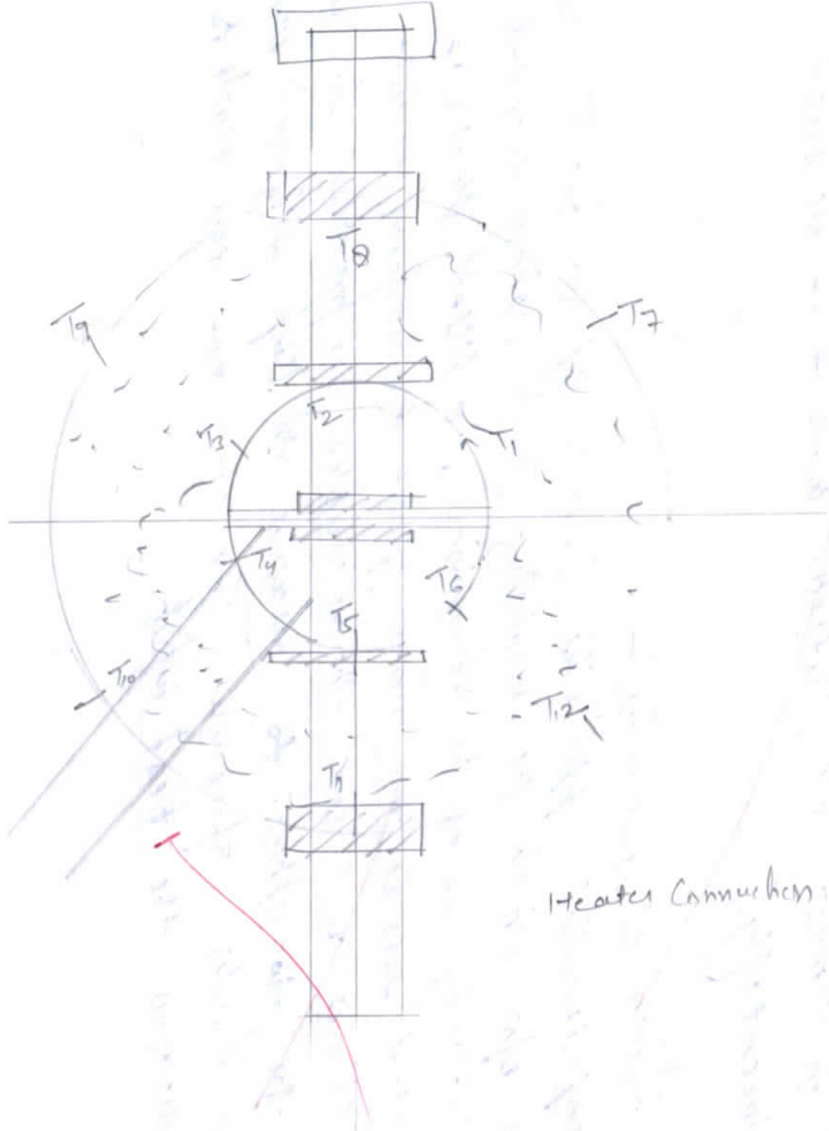
EXPERIMENT NO. 11

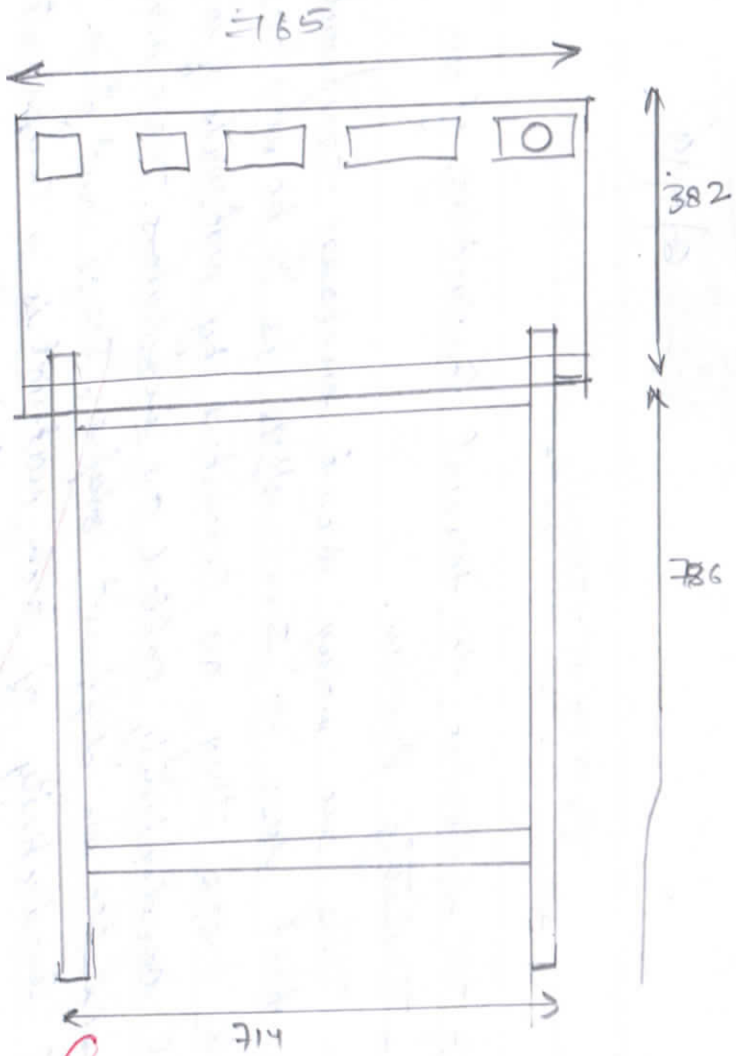
OBJECT:- To determine the thermal Conductivity of an Insulating powder.

Theory:- There are many heat exchange equipments where heat loss to surroundings is to be minimized. In such cases they are covered by materials of lower thermal conductivity called as insulators. These materials are available in different shapes, sizes and form. Thermal Conductivity of such material is a complicated function of the geometry of particles, thermal Conductivity of particles, the Nature of heat transfer in airspaces which is determined by the air space size and temp. level etc. thus it is very difficult quality to estimate and in almost all practical cases it is measured experimentally.

Description of Apparatus:-

The experimental apparatus consists of two Concentric Copper spheres b/w which the insulating powder, whose thermal Conductivity is to be determined, is filled. Heater is provided inside the inner sphere for uniform heating of spheres and six thermocouples are provided in each of the two sphere to measure the temp difference across the powder specimen. Provision has been made to measure the heat input.





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Procedure :-

1- Switch on the Mains.
2. Switch on the Heaters
3. Set the dimmer to Suitable value of voltage
4. Allow the unit to stabilize for half an hour.
5. Note the Readings of heat input to heater.

OBSERVATION :-

1- Radius of inner sphere (r_1) = 50 mm
2. Radius of outer sphere (r_o) = 100 mm

S.No	V	I	Heat Input (q) Watt	Thermocouple Readings			
				Inner Sphere t_1 t_2 t_3 t_4 t_5 t_6 °C	Avg t_i °C	Outer Sphere t_7 t_8 t_9 t_{10} t_{11} t_{12} °C	Avg t_o °C
	120	1.06	127.2	186 186 183 202 199 196	192	55 53 54 59 58 60	56.5

Thermal Conductivity of Powder is given by :-

$$k = \frac{q \times (r_o - r_i)}{4\pi r_i r_o (t_i - t_o)}$$

Where q = Rate of heat i/p = V · A

k = Thermal Conductivity, W/m-°C

Calculation

$$k = \frac{q \times (r_o - r_i)}{4\pi r_i r_o (t_i - t_o)}$$

$$= \frac{127.2 \times (0.1 - 0.05)}{4 \times 3.14 \times 0.1 \times 0.05 \times (192 - 56.25)}$$

$$\boxed{k = 0.7474\ W/m^2\,°C.}$$

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Result :-

The avg value of thermal Conductivity is 0.7474 W/m-°C

Precaution :-

1- Keep dimmerstate to zero Position before start.
2. Increase voltage slowly.
3. keep the assembly undisturbed while testing.
4. Do not Increase voltage above 150 Volts
5. operates Selector Switch of temp Indicator Gently
6. Take reading after system is stabilized.

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Experiment No. 5.

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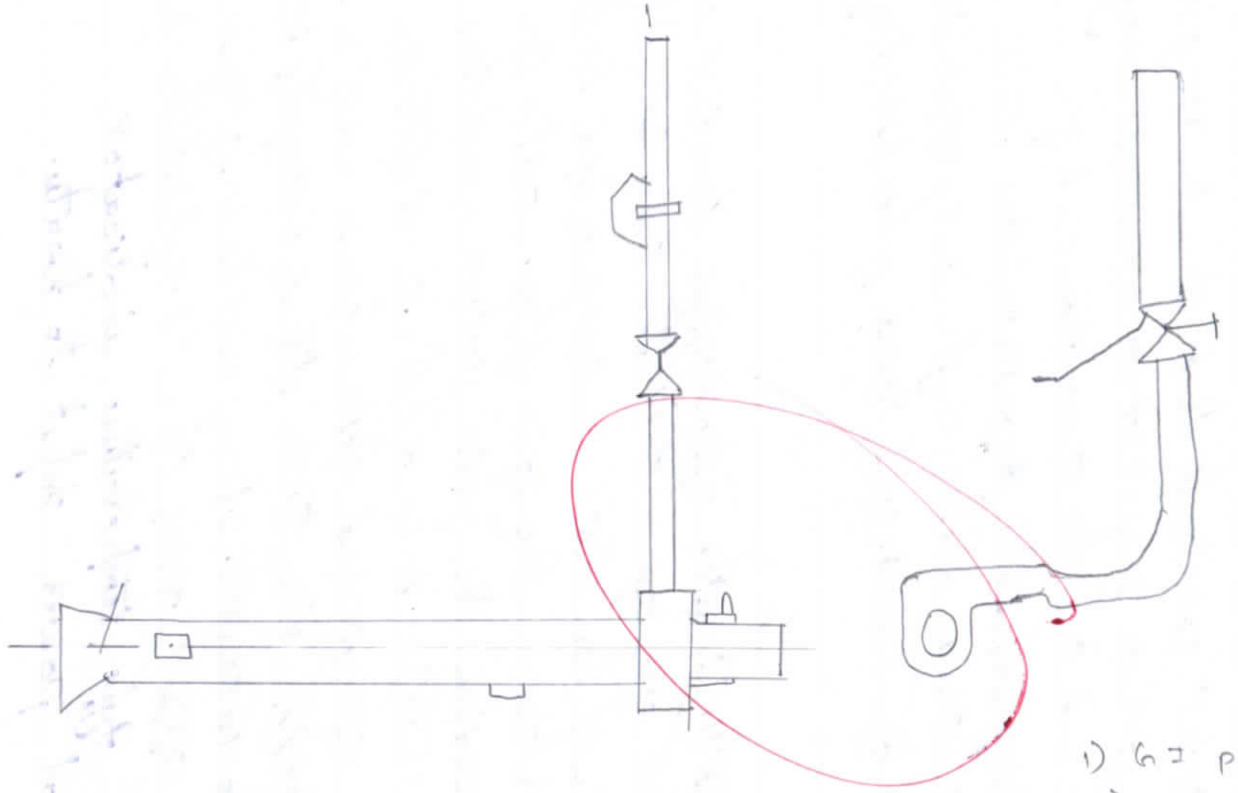
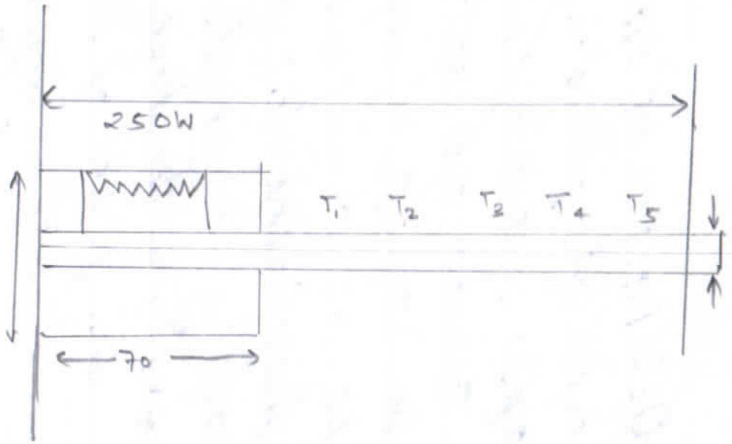
OBJECTIVE: To determine the heat transfer coefficient at the fin surface, temperature distribution and efficiency of fin in forced convection.

THEORY: In many engineering situations, means are often caught to improve heat dissipation from a surface to its surrounding. The Newton-Rikhman relation $Q = hA(t_s - t_a)$ reveals that the convective $(t - t_a)$ the surface area exposed to surroundings is frequently increased by the attachment of protrusion to the surfaces. The protrusion are called fins or spines and. Thus a fin represents a thin cylindrical or conical rod protruding from a wall.

DESCRIPTION OF APPARATUS: The apparatus consist of a pin fin placed inside an open duct, the one side is open and other end of the duct is connected to the suction side of the blower. The air flow rate can be varied by operating the gate valve and can be is connected to the base of fin and five thermocouples are connected equidistance all along the length of the fin. Sixth thermocouple is left in the duct to measure temperature of air. The panel of the apparatus consist of voltmeter ammeter digital type temperature indicator, dimmer to control power input to heater.





1) G.I pipe 300 mm Long
2) M.S flange
3) Manometer
4) Gate Value
5) G.I Bend
6) M.S Duct
7) Digital Ammeter
8) Blower on Switch
9) Dimmer
10) Tube frame
11) Heater Plug socket

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Procedure :-

1- Switch on the Mains.
2. Keep the thermocouple selector switch in zero position.
3. Turn the dimmer knob clockwise & set the power Input to heater to any desired value.
4. Switch on the blower switch mounted on blower
5. Set the air flow Rate any desired value.
6. Allow the Unit to stabilize.

OBSERVATION

S.No.	V(volt)	A(Amp)	Manometer reading h_m (m)	Temp. along axis of fin t_1 t_2 t_3 t_4 t_5	Temp of air $t_6 = t_\infty$
1-	84	0.44	0.031	124 97 80 66 53	31

CALCULATION

1) Calculation for heat transfer Coefficient

Velocity of air at orifice $V_o = \frac{C_d \, d_1^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{2 \cdot g \cdot h_m \left(\frac{\rho_m}{\rho_a} - 1\right)}$

Velocity of air in the duct $V_a = \frac{V_o \cdot \pi/4 \, d_o^2}{w \cdot b}$

Calculation

1) Cal. for heat t/f coefficient

$$V_0 = C_d \frac{d_1^2}{\sqrt{d_1^4 - d_2^4}} \sqrt{2 g h_m \left(\frac{\rho_m}{\rho_a} - 1 \right)}$$

$$= \frac{0.61 \times 0.038^2}{\sqrt{0.038^4 - 0.02^4}} \sqrt{2 \times 9.81 \times 0.031 \left(\frac{13.6 \times 10^3}{1.1774} - 1 \right)}$$

$$= 53.21 \text{ m/s}$$

$$V_a = \frac{V_0 \, \pi/4 \, d_2^2}{l \times b} = \frac{53.21 \times \pi/4 \times 0.02^2}{0.15 \times 0.1}$$

$$= 1.11 \text{ m/s}$$

$$Re = \frac{d_{eq} V_a \rho_a}{\mu_a} = \frac{0.12 \times 1.11 \times 1.1774}{1.983 \times 10^{-5}}$$

$$= 7908.708$$

Since $4000 < Re < 40000$

$$Nu = 0.193 \, Re^{0.618} \, Pr^{1/3} = 0.193 \times 7908.708^{0.618} \times 0.708^{1/3}$$

$$= 44.12$$

$$h = \frac{Nu \, k_a}{d_f} = \frac{44.12 \times 0.02624}{0.012}$$

$$= 96.475 \text{ W/m}^2 \, {}^\circ C$$

Reynolds No. $= \dfrac{d_{eq} V_a \rho_a}{\mu_a}$

where $d_{eq} = \dfrac{2 b \cdot w}{b + w}$ is equivalent or hydraulic dia.

Depending upon value of Reynold's No. find out Nusselt No.

$Nu = 0.903\, Re^{0.33} P_r^{1/3}$ if $1 < Re < 4$

$Nu = 0.911\, Re^{0.385} P_r^{1/3}$ if $4 < Re < 40$

$Nu = 0.683\, Re^{0.466} P_r^{1/3}$ if $40 < Re < 4000$

$Nu = 0.193\, Re^{0.618} P_r^{1/3}$ if $4000 < Re < 40000$

$Nu = 0.0266\, Re^{0.805} P_r^{1/3}$ if $Re > 40000$

$$\boxed{Nu = \frac{h \cdot d_f}{k_a}}$$ k_a is thermal Conductivity

② Calculation for temp distribution in fin

$$\frac{t - t_\infty}{t_s - t_\infty} = \frac{\cosh M(L-x)}{\cosh ML}$$

where $M = \sqrt{\dfrac{h \cdot P}{k_b \cdot A}}$ P = Perimeter of fin $= \pi d_r$

A = Cross Sectional area of fin $= \dfrac{\pi}{4} d^2$

③ Calculation for fin efficiency

$$\boxed{\eta_f = \frac{\tanh(M \cdot L)}{ML}}$$

② Cal. for temp distribution.

$$\frac{t - t_\infty}{t_s - t_\infty} = \frac{\cosh M(L-x)}{\cosh ML} \quad \text{—(1)}$$

$$M = \sqrt{\frac{hP}{k_b \cdot A}}$$

$$= \sqrt{\frac{96.475 \times \pi \times 0.012}{107 \times \pi/4 \times 0.012^2}}$$

$$\boxed{M = 17.904}$$

$\eta_f = 0.369$

$x = 0.015\,m \quad t = 124°C$

$\boxed{\eta_f = 36.8\%}$

put in (1)

$$\frac{124 - 31}{t_s - 31} = \frac{\cosh[17.904(0.15 - 0.015)]}{\cosh(17.904 \times 0.15)}$$

$$= 0.767$$

Therefore $t_s = 152.25°C$

eq (1)

$$\frac{t - 3.1}{152.25 - 3)} = \frac{\cos[17.904(0.15 - x)]}{\cosh(17.904 \times 0.15)}$$

$$t = 31 + 16.45 \cosh(2.685 - 17.904x]$$

Result :-

(1) Heat Transfer Coefficient (h) = 98.475 $W/m^2\,°C$

(2) Temp. distribution in fin = $t = 31 + 16.45 \cosh[2.685 - 17.904x$

(3) Efficiency of fin = 36.8%

Precaution

1- Keep dimmersate to zero position before start
2. Increase voltage slowly.
3. keep the assembly undisturbed while testing
4. Do not increase voltage above 130 volts.

Date 27/9/19

EXPERIMENT No. 10

OBJECT:- To study the pool Boiling phenomenon up to Critical heat flux point.

Theory:- When heat is added to a liquid from a Submerged solid surface which is at a temp. higher than the Saturation temp. of the liquid. The heat flux supplied to surface is plotted against excess temp. ($\Delta t = t_s - t_{sat}$) i.e diff. b/w the temp. of surface & saturation temp of the liquid.

Different type of boiling

1- Interface Evaporation:- The boiling take place in a thin layer which adjoint the heated surface.

2. Nucleate Boiling:- With the inc. in Δt, the formation of bubbles on the surface starts at certain favorable spots Called Nucleation or Active Sit

3. film Boiling:- In this region the bubble formation is very rapid. It is possible that the metal may get damaged or it may even be melt.

Description of Apparatus:- The apparatus consist of a cylindrical glass housing the test

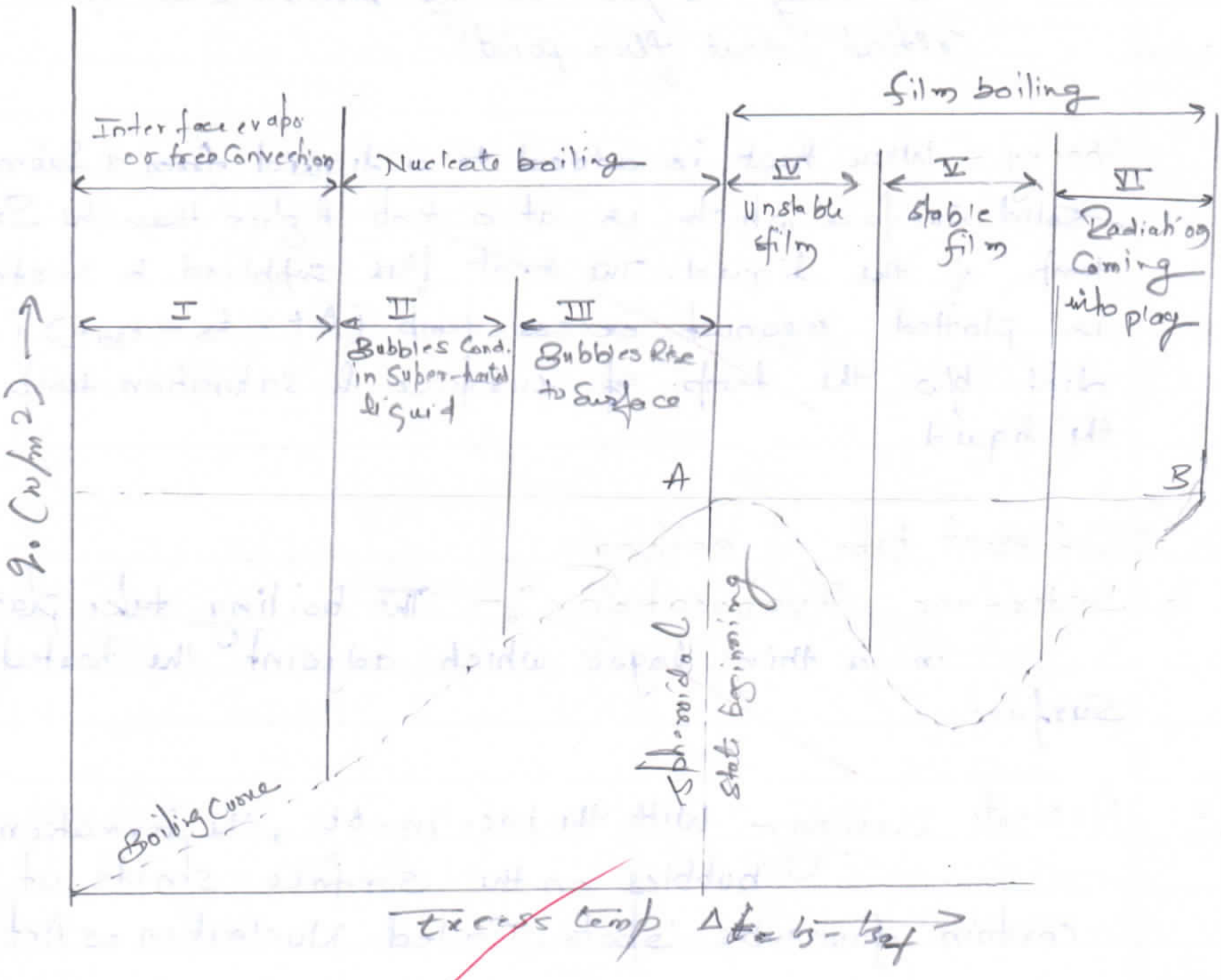
film boiling
Inter face evapo or free Convection
Nucleate boiling
IV
Unstable film
V
Stable film
VI
Radiation Coming into play
I
II
Bubbles Cond. in Super-heated liquid
III
Bubbles Rise to Surface
A
B
Spheroidal State beginning
Boiling Curve
excess temp

fig Caption ??

Date
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heater and heater coil for heating the water. There is Provision of observing the test heater wire the help of a lamp light from back.

Procedure:-

1- Take sufficient amount of distilled water in Container.
2. See that both the heaters are Completely Submerged.
3. switch off heater R-1.
4. Go on increasing the voltage till wire breaks.
5. Repeat the experiment by altering the bulk temp of water

OBSERVATION

1- Diameter of test heater wire (d) = 0.17 mm
2. length of test heater wire (L) = 0.1 m
3. Surface Area of wire, $A = \pi d L$ = 53.41×10^{-6} m^2

S.No	Bulk temp of water, °C	Experimental Critical heat flux			Theoritical C.H.F Using Zuber eqn
		I, Amp	V, Volt	$\frac{Q}{A} = \frac{VI}{A}$	
1.	40°	8	50	7.49×10^6	5.088×10^6
2.	50°	10	60	9.50×10^6	7.089×10^6

Cal :-

$$q = \frac{Q}{A} = 0.18\, h_{fg} (\rho_v)^{1/2} \left[g \sigma (\rho_l - \rho_v) \right]^{1/4} \ W/m^2 \quad \text{—} (1)$$

$h_{fg} = 2570.8 \times 10^3$ J/kg

$\sigma = 696$ N/m

$\rho_l = 1000$ kg/m3

$\rho_v = 0.0462$ kg/m^3

put in (1)

$$q = Q/A = 0.18 \times 2570.8 \times 10^3 \times 0.0462^{0.5} \left[696 \times 9.81 \times (1000 - 0.0462) \right]^{0.25}$$

$$\boxed{q = 5.088 \times 10^6 \ W/m^2}$$

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Calculation :-

$$q = \frac{Q}{A} = 0.18\, h_{fg} (\rho_v)^{1/2} [g \sigma (\rho_l - \rho_v)]^{1/4} \; W/m^2$$

where h_{fg} = Latent heat of vaporization
σ = Liquid vapour surface tension
ρ_l = Density of liquid
ρ_v = Density of vapour

Result :- The experimental value of Critical heat flux at 40°C Bulk Temp of water is 7.50×10^6 W/m²

2. The experimental value of Critical heat flux at 50°C bulk temp of water is 10×10^6 W/m²

Ans mismatched.

Precaution

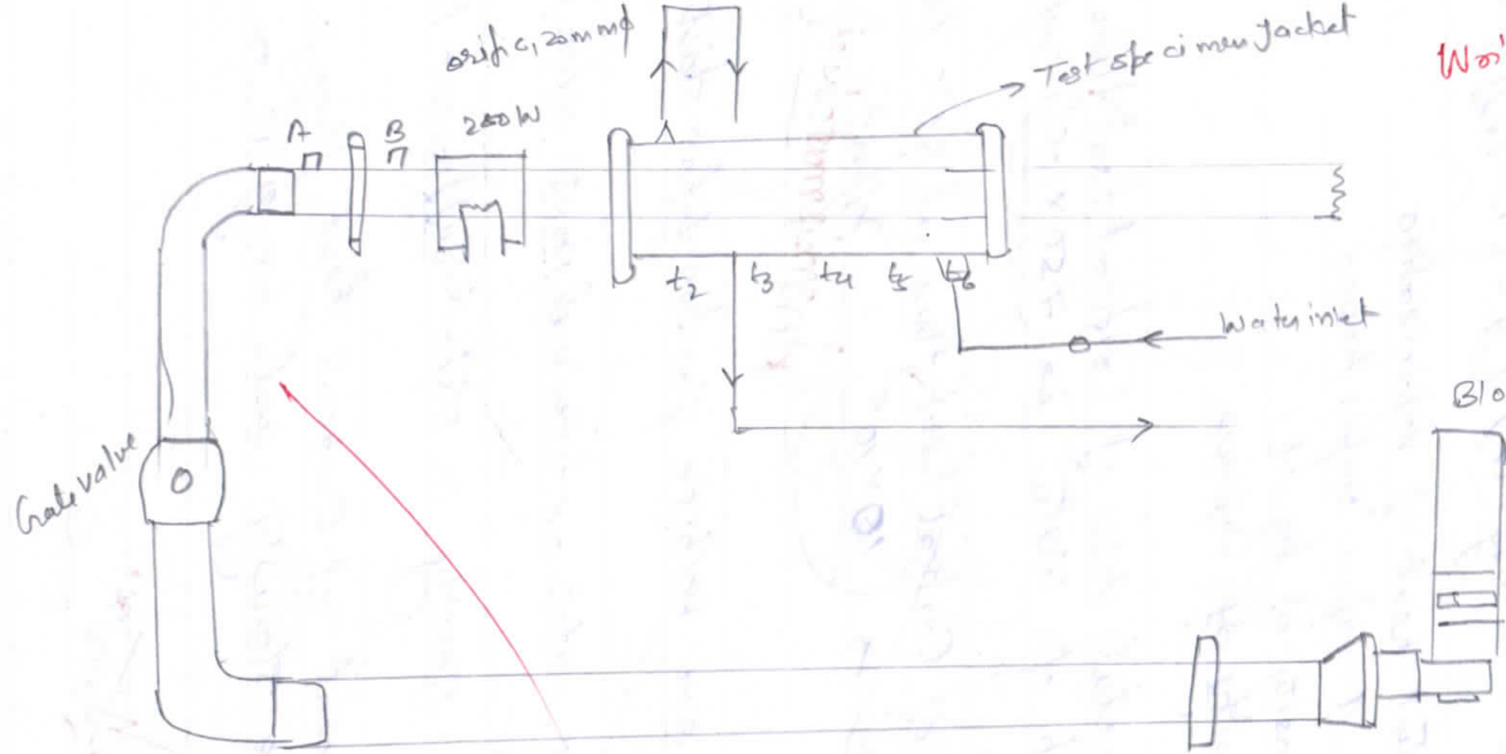
① Keep the variac to zero voltage position before starting the experiment

② Do not touch the water or terminal points when the main switch is on.

③ Operate the variac gently in steps & sufficient time is b/w.

④ After the attainment of Critical heat flux, dec. the voltage slowly and bring it to zero position.

07/04/2021



Write A — ?
B — ?
t_1, t_2, t_3 — ?

fig ← Caption — ?

Date 4/oct/2019
Page

Experiment No. 4

Forced Convection Apparatus

Object → To determine heat transfer Coefficient for heated tube in forced Convection.

Theory:- Convection is a process involving mass movement of fluids. Thus the mechanism of Convection is simply the transfer of energy by actual physical movement from one molecule to another of fluid in which the energy is stored.

Description of Apparatus:
The apparatus consist of a blower for supply of air. Air from blower passes through a flow passage and an air heater and then to test section. Test Section wall Surface temperature are measured using thermocouples embedded in the walls at different axial distance from the entrance. The test Section is enclosed in a water Jacket where the Circulating water removes heat from air.

OBSERVATION :-

1- Coeff. of discharge of orifice (C_d) = 0.62
2. Tube diameter (d_1) = 0.04 m
3. Orifice diameter (d_2) = 0.02 m
4. Density of Water (ρ_w) = 1000 kg/m^3

Cal-

Run 1

Mass flow Rate of air :- $m_a = \frac{C_d \pi/4 \, d_1^2 d_2^2}{\sqrt{d_1^4 - d_2^4}} \rho_a \sqrt{2 g h_w \left(\frac{\rho_w}{\rho_a} - 1\right)}$ kg/s

$$= \frac{0.62 \times \pi/4 \times 0.04^2 \times 0.02^2}{\sqrt{0.04^4 - 0.02^4}} \times 1.174 \times \sqrt{2 \times 9.81 \times 0.032 \times \left(\frac{1000}{1.174} - 1\right)}$$

$$= 5.46 \times 10^{-3} \text{ kg/s}$$

Therefore $h = \frac{m_a C_{pa} (t_1 - t_2)}{A_s (t_{av} - t_a)} = \frac{5.46 \times 10^{-3} \times 1.005 \times 10^3 (42 - 39)}{\pi \times 0.025 \times 0.4 (40.5 - 32.4)}$

$$= 64.73 \text{ W/m}^2 {}^\circ C$$

Run 2

$$= \frac{0.62 \times \pi/4 \times 0.04^2 \times 0.02^2}{\sqrt{0.04^4 - 0.02^4}} \times 1.174 \times \sqrt{2 \times 9.81 \times 0.018 \times \left(\frac{1000}{1.174} - 1\right)}$$

$$= 4.09 \times 10^{-3} \text{ kg/s}$$

Therefore

$h = \frac{m_a C_{pa} (t_1 - t_2)}{A_s (t_{av} - t_a)} = \frac{4.09 \times 10^{-3} \times 1.0057 \times 10^3 (43 - 40)}{\pi \times 0.025 \times 0.4 (41.5 - 31.8)}$

$$= 40.51 \text{ W/m}^2 {}^\circ C$$

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5. Diameter of test specimen (d) = 0.025 m
6. Length of test specimen (l) = 0.4 m

Run no.	Heater wattage V	I	Air Temp t_1	t_7	Reading of Water manometer h_w (M)	Tube surface temp t_2 t_3 t_4 t_5 t_6	Avg Surface temp of specimen t_s	Avg. Air $t_{av} = \frac{(t_1+t_7)}{2}$
1.	100	0.68	42	39	0.032	34. 33 32 32 31	32.4	40.5
2.	110	0.72	43	40	0.018	34 32 31 31 31	31.8	41.5

Result :-

Run No. 1 Heat transfer Coeff. is 64.73 W/m^2°C
Run No. 2 Heat transfer Coeff. is 40.51 W/m^2°C

Precaution :-

Keep dimmerstate to zero position before start.
Increase Voltage slowly.
Keep the assembly undisturbed while testing.
Do not inc. voltage above 150 volts.
operate Selector switch of temp. Indicator gently.

4/10

Serial No.

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Experiment No. 03

Object → To determine, effectiveness, heat transfer Rate and overall heat transfer coefficient in parallel flow heat exchanger.

Theory :- Heat exchangers are devices in which heat is transferred from e-fluid to another.

(I) Transfer type (II) storage type (III) Direct Contact type.

Transfer type of heat exchangers are most widely Used classified as -

1. Parallel flow type - in which fluid flow in Same direction
2. Counter flow type - in which fluid flow in opposite direction.
3. Cross flow type - in which fluid flow at any angles to each other.

Description of Apparatus.

The apparatus Consist of a Concentric tube heat exchanger. The hot fluid i.e. hot water is obtained from an electrical geyser and it flows through the Inner tube. The outer tube is provided with adequate asbestos Rope Insulation to minimize the heat losses to Surroundings.

Procedure :- keep the thermometers in position.
Start the flow on hot water Side.
Start the flow on Cold water Side.
Put on the electric geyser
Note the temperatures and measure the flow Rates.

Signature of the checker

Cal-

$$LMTD = \frac{(39.3-26.7)-(36.4-29)}{\ln\left[\frac{39.3-26.7}{36.4-29}\right]} = 9.71$$

Heat transfer from hot water

$$q_h = 0.05\times4.18\times10^3\times(39.3-36.4)$$
$$= 606.1 \text{ W}$$

Heat transfer from Cold water =

$$q_c = 0.05\times4.18\times10^3\times(29.1-26.7)$$
$$= 527.68 \text{ W}$$

$$\text{Avg Rate } (q_{av}) = \frac{606.1+527.68}{2}$$
$$= 566.90 \text{ W}$$

$$\text{Overall heat transfer Coeff } (U) = \frac{q_{av}}{A(LMTD)}$$
$$= \frac{566.90}{0.065\times9.71} = 898.20 \text{ W/m}^{2}{}^{\circ}\text{C}$$

Effectiveness

$$\varepsilon = \frac{0.0526\times(29.1-26.7)}{0.05\times(39.3-26.7)}$$

$$\boxed{\varepsilon = 0.20049}$$

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Date :

Project No.

OBSERVATION

1- Length of heat exchanger = 1.2 m
2. Surface Area of heat exchanger (A) = 0.065 m2

	Hot Water			Cold Water					
Effectiveness E	Mass flow (m_h) kg/s	Inlet temp t_{hi}	Outlet temp kg/s	Mass (m_c)	Inlet t_{ci}	Outlet t_{co}	LMTD	Avg. Rate heat t/f (W) $Q_{av} = (q_h + q_c)/2$	Overall heat transfer coeff (U) $w/m^2 {}^\circ C$
0.200 ~~49~~	0.05	39	37	0.0526	24	25	9.71	566.90	898.2

Calculation :-

$$LMTD = \frac{(t_{hi} - t_{ci}) - (t_{ho} - t_{co})}{\ln \frac{(t_{hi} - t_{ci})}{(t_{ho} - t_{co})}}$$

Heat t/f from hot water $q_h = m_h \cdot C_h (t_{hi} - t_{ho})$

Cold water $q_c = m_c \cdot C_c (t_{co} - t_{ci})$

where $C_h = C_c$ specific heat of water $= 4.18$ kJ/kg-K.

Overall heat transfer $(U) = \frac{q_{av}}{A\,(LMTD)}$

Effectiveness $E = \frac{m_c C_c (t_{co} - t_{ci})}{C_{min} (t_{hi} - t_{ci})}$

where $C_{min} = mC$ or mC (whichever is less)

Result :-

Signature of the Checker

EXPERIMENT

EXPT. NO.
DATE.

Heat transfer Rate (q_{av}) = $\underline{566.90}$ W

Over all heat transfer coeff = $\underline{898.20}$ W/m²°C

Effectiveness = $\underline{0.20049}$

Precaution :- Keep dimmer state to Zero position before start.

Keep the assembly undisturbed while testing.

Do not increase voltage above 150 volts

Put on geyser after water flow is started

Increase voltage slowly.

1/11/2019

EXPERIMENT NO. 06

OBJECT:- To determine ness, heat transfer Rate and overall heat transfer coefficient in Counter flow heat exchanger.

Theory:- Heat exchangers are devices in which heat is transferred from on e fluid to another.

(i) Transfer type (ii) storage type (iii) Direct Contact type.

Transfer types of heat exchangers are mostly widely used.

(a) parallel flow type - in which fluids flow in same direction
(b) Counter flow type - in which fluid flow in opposite direction
(c) Cross flow type - in which fluid flow at any angle to each other.

DESCRIPTION OF APPARATUS.

The apparatus Consist of a Concentric tube heat exchanger. The hot fluid i.e. hot water is obtained from an electrical geysar and it flows through the inner tube. The Cold fluid i.e. cold water can be admitted at any one of the ends enabling the heat exchanger to Run as a Counter flow or parallel apparatus.

PROCEDURE:- keep the thermometers in position.
Start the flow on hot water side.
Put on electric geysar
Note the temp and Measure the flow Rates.

Calculation

$$LMTD = \frac{(t_{hi} - t_{co}) - (t_{ho} - t_{ci})}{\ln \frac{[t_{hi} - t_{co}]}{[t_{ho} - t_{ci}]}}$$

$$= \frac{(39.3 - 29.3) - (37 - 26.8)}{\ln \frac{(39.3) - 29.3}{(37 - 26.8)}} = 10.10$$

Heat t/f hot H_2O $(q_h) = m_h C_h (t_{hi} - t_{ho})$

$$= 0.05 \times 4.18 \times 10^3 \times (39.3 - 37)$$

$$= 480.7 \text{ W}$$

Cold H_2O $= m_c C_c (t_{co} - t_{ci})$

$$= 0.05 \times 4.18 \times 10^3 \times (29.3 - 26.8)$$

$$= 522.5 \text{ W}$$

$$\text{Avg Rate} = \frac{480.7 + 522.5}{2} = 501.60 \text{ W}$$

Overall

$$(U) = \frac{q_{av}}{A(LMTD)} = \frac{501.60}{0.065 \times 10.10}$$

$$= 764.05 \text{ W/m}^2$$

Effectiveness

$$\epsilon = \frac{m_c C_c (t_{co} - t_{ci})}{C_{min} (t_{hi} - t_{ci})} = \frac{0.05 \times (29.3 - 26.8)}{0.05 \times (39.3 - 27.1)}$$

$$= 0.20492$$

OBSERVATION :-

1- Length of heat exchanger = $\underline{1.2}$ m

2. Surface Area of heat exchanger (A) = $\underline{0.065\ m^2}$

Hot water			Cold water						
Mass flow	Inlet Temp	outlet Temp	Mass flow	Inlet temp	outlet Temp	LMTD	Avg Rate heat t/f (W) $Q_{av} = (q_h + q_c)/2$	overall heat t/f coeff. (U) $W/m^2 {}^\circ C$	Effectiveness ε
0.05	39.3	37	0.05	26.8	29.3	10.10	501.6	764.05	0.2049

Result :-

Heat transfer Rate (q_w) = $\underline{501.60}$ W

Overall heat transfer coefficient = $\underline{764.05}$ $W/m^2 {}^\circ C$

Effectiveness = 0.20492

Precaution.

Keep Dimmer state to zero position before start.

Keep the assembly undisturbed while testing.

Do not increase voltage above 150 Volts.

operate Selector switch of temp. Indicator Gently.

Put on geyser after water flow is started.