EXPERIMRNT 5: TO DETERMINE THE FORCED CONVECTION HEAT TRANSFER COEFFICIENT FOR THE FLOW THROUGH THE GIVEN HORIZONTAL TUBE

Introduction

Convection is heat transfer by mass motion of a fluid such as air or water when the heated fluid is caused to move away from the source of heat, carrying energy with it. Convection above a hot surface occurs because hot air expands, becomes less dense, and rises. Convection can either be Natural or Forced

Natural convection results from the tendency of most fluids to expand when heated—i.e., to become less dense and to rise as a result of the increased buoyancy. Circulation caused by this effect accounts for the uniform heating of water in a kettle or air in a heated room: the heated molecules expand the space they move in through increased speed against one another, rise, and then cool and come closer together again, with increase in density and a resultant sinking.

Forced convection involves the transport of fluid by methods other than that resulting from variation of density with temperature. Movement of air by a fan or of water by a pump is examples of forced convection.

Description

The apparatus consists of Blower unit fitted with a test pipe. The test section is surrounded by Nichrome band heater. Four thermocouples are embedded on the test section the thermocouples are placed in the air stream at the entrance & exit of the test section to measure the temperature. Test pipe is connected to the delivery side of the blower along with an orifice to measure flow of air through pipe. Input to the heater is given through a dimmer stat & measured by meters. It is to be noted that only a part of the total heat supplied is utilized in heating the air. A temperature indicator with cold junction compensation is provided to measure temperature of pipe wall at various points in the test section. Air flow is measured with the help of orifice meter & the water manometer fitted on the board.

Specifications

1. Brass rodDia.(D_i) : 32mm.
2. Pipe dia(d) : 25 mm
3. Lengthof Test Section(L) : 400mm.
4. OrificeDia. (d) :15mm.
5. Dimmer sat :0 to 2 Amp, 230 Volt AC
6. Wattmeter :400Watt
7. Heater : BandType
8. Test Section Insulation : GlassWool

Instrument Image

Procedure

1. Starttheblower&adjusttheflowbymeansofgatevalvetosomedesireddifferenceinmanometer level.
2. Starttheheatingoftestsectionwithhelpofdimmer stat&adjustdesiredinputwiththehelpofWattmeter
3. Takereadings ofallthermocouplesafteran intervalof10minuntilsteadyisreached.
4. Notetheheater input.

Observation

Sr. No.	Voltmeter V (Volt)	Ammeter I (Amp)	Temperatures							Manometer Reading Difference H in mm of Water
			T_1	T_2	T_3	T_4	T_5	T_6 Air Inlet	T_7 Air Outlet	
1.										
2.										
3.										
4.										

Calculations

Experimental Method

1. q=Actual Rate of Heat Transfer= V * I
2. Surface heat transfer co-efficient (h_a)

$$h_a = \frac{q}{A(T_s - T_a)}$$

Where,

A= Test section area m^2

= π DL m^2

T_a= Average Temp. of air

= $(T_6 + T_7)/2$ °c

T_s = Average surface Temp.

$$= \frac{T_1 + T_2 + T_3 + T_4 + T_5}{5} \text{ °c}$$

Theoretical Method

1. Air flow rate (Q)

$$Q = C_d * \frac{\pi}{4} * d^2 \sqrt{\frac{2\, g\, H\, \rho_w}{\rho_a}}$$

Where,
d =dia.oforifice=15 mm
C_d = Co-efficient of discharge= 0.64
H = Difference of water level in manometer= m
ρ_w = Density of water=1000 kg/m^3
g =GravitationalAcceleration = 9.81m/s^2
ρ_a =Density of air at T_6+T_7 mean bulk Temp = ----------- kg/m^3

2. Velocity of air (V)

$$V = \frac{4\, Q}{\pi\, d^2}$$

Where, d=pipe dia. =0.025 m

3. Reynolds's Number (Re)

Re= VD_i/υ

υ = Kinematic viscosity to be evaluated at average bulk Temp________

4. Prandtl Number (Pr)

Pr=Prandtl number at average bulk Temp. $(T_6 + T_7)/2$________________

5. The appropriate correlation for turbulent flow through closed Conduits is Dittus – Boelter correlation.

N_u = $0.023 Re^{0.8} Pr^{0.4}$ ....for Re>10000

OR

N_u $= 0.036Re^{0.8}Pr^{0.4}$ ....for Re>2300

6. **Nusselt Number (Nu)**

$$Nu = \frac{h_d X\ D}{k_{air}}$$

Where, K = Thermal conductivity of air at average bulk Temp.$=T_6+T_7/2^{\circ}c$

Conclusion

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Marks Obtained **Sign of Faculty**

Propertiesof Air

Temp ^0C	Density Kg/m^3	Kinematic Viscosity $V \times 10^{-6} m^2/s$	Prandil Number Pr	Thermal Diffusivity m^2/nr	Specific Heat Cp J/Kg K	Thermal Conductivity $K \times 10^{-3}$	Coefficient of Viscosity x $10^6 Ns/m^2$orKg/m
-50	1.584	9.23	0.728	45.7	1013	20.35	14.61
-40	1.515	10.04	0.728	49.6	1013	21.17	15.20
-30	1.453	10.80	0.723	53.7	1013	21.98	15.69
-20	1.395	11.61	0.716	68.3	1009	22.79	16.18
-10	1.342	12.43	0.712	52.8	1009	23.61	16.67
0	1.293	13.28	0.707	67.7	1005	24.42	17.16
10	1.247	14.16	0.705	72.2	1005	25.12	17.65
20	1.205	15.06	0.703	77.1	1005	25.93	18.14
30	1.165	16.00	0.701	82.3	1005	26.75	18.63
40	1.128	16.69	0.699	87.5	1005	27.56	19.12
50	1.093	17.95	0.698	92.6	1005	28.26	19.61
60	1.060	18.97	0.696	97.9	1005	28.96	20.10
70	1.029	20.02	0.694	102.8	1009	29.66	20.59
80	1.000	21.09	0.692	108.7	1009	30.47	21.08
90	0.972	22.10	0.690	114.8	1009	31.28	21.48
100	0.946	23.13	0.688	121.1	1009	32.10	21.87
120	0.898	25.45	0.686	132.6	1009	33.38	22.85
140	0.854	27.80	0.684	145.2	1013	34.89	23.73
160	0.815	30.09	0.682	158.0	1017	36.40	24.52
180	0.779	32.49	0.681	171.0	1022	37.80	25.30
200	0.746	34.85	0.680	184.9	1026	39.31	25.99
250	0.674	40.61	0.677	210.6	1038	42.68	27.36
300	0.615	48.20	0.674	257.6	1047	46.05	29.71
350	0.566	55.46	0.676	294.7	1059	49.08	31.38
400	0.524	63.09	0.678	335.2	1067	52.10	33.05
500	0.456	79.38	0.687	415.1	1093	57.45	36.19
600	0.404	96.99	0.699	499.0	1114	62.22	39.13
700	0.362	115.40	0.706	588.2	1135	66.87	41.78
800	0.329	1347.80	0.713	682.0	1156	71.76	44.33