EXPERIMRNT 6: TO STUDY THE TEMP. DISTRIBUTION ALONG THE LENGTH OF A PIN FIN UNDER FREE CONVECTION HEAT TRANSFER.

Theory

Extended surfaces or fins are used to increase the heat transfer rate from a surface to a fluid wherever it is not possible to increase the value of the surface heat transfer coefficient of the temperature difference between the surface and the fluid. The use of this is very common and they are fabricated in a variety of shapes circumferential fins around the cylinder of the motor cycle engine and fins attached to condenser tubes of a refrigerator are few fins and tube heat exchanger examples.

Fin effectiveness = ε = tan h m L/m L

The temp. Profile within a pin fin is given by:

$\theta/\theta_O = [T-T_f]/[T_b-T_f] = \cos h\ m(L-x)/\cos h\ m\ L$

Where

T_f is the free stream temp. of air,

T_b is the temp. of fin at its base,

T is the temp. Within the fin at any x,

L is the length of the fin

D is the fin diameter.

m is the fin parameter defined as Fin parameter m $= \sqrt{\frac{hP}{K_b\ A}}$

K_b =Thermal conductivity of Brass fin = w/m k

P = Perimeter = π D

A=Cross sectional area of Fin = $(\pi/4)\ D^2$

h is the convective heat transfer coefficient that can be estimated from :

For free convection

Nu	=	1.1 (Gr Pr)1/6	for 0.1<Gr Pr<10,000
Nu	=	0.53 (Gr Pr)1/4	for 10,000<GrPr<10^9
Nu	=	0.13 (Gr Pr)1/3	for 109<Gr Pr<10^{12}

For Forced Convection

Nu	=	$0.615\ (Re)^{0.466}$	for 40<Re<4000
Nu	=	$0.174\ (Re)^{0.618}$	for 4000<Re<40,000

Description

Fins made of M.S of circular cross section are fitted along a rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flows past the fins perpendicular to its axis. One end of the fins projects inside the duct and is heated by a heater. Temperatures at five points along the length of the fins are measured by k- type temperature sensors. The flow rate is measured by an anemometer supplied separately with instrument.

Instrument Image

Experimental procedure

NATURAL CONVECTION

1. Connect the sensor socket & heater to the fin which to be tested(SS,BRASS,ALUMINIUM)
2. Start heating the fin by switching ON the heater element and adjust the voltage up to a certain level by adjusting the dimmerstat.
3. Note down the temp. Sensor readings (1) to (5) when steady state is reached, record the final readings of Temp. Sensor No. 1 to 5 and also the ambient temp. Reading fromtemp. Sensor No.6

Specifications

Duct Size : 200 x 200 x500 mm

Diameter of the fin : 16mm

Length of the fin : 150 mm

Material of fin : (stainless steel, Brass, Mild steel)

Control Panel : Digital Voltmeter (0-300 V)

Digital Ammeter (0-2 A)

Dimmer stat (0-230 V), 2 A

Digital Temp. Indicator (0-200 ˚C)

ON/OFF switch, mains indicator, etc.

Temperature Sensors : k- type (19 Nos.

Thermal conductivity of different material

Sr.no	Material	Thermal conductivity(w/m k) AT 20˚C
1	ALUMINIUM	204
2	BRASS	109
3	STAINLESS STEEL	14

Observation & calculation

MATERIAL	Power input W=V X I		Fin temp.˚c					Ambient temp. ˚c
			T_1	T_2	T_3	T_4	T_5	T_6
	V	I	4 cm	7cm	10 cm	13 cm	16 cm	

Mean Temp. of the Fin, T_m = $(T_1 + T_2 + T_3 + T_4 + T_5)/5$

Ambient Air Temp. T_6 = T_f = ˚C

Mean Fluid Temp. T_{mf} = $(T_m + T_f)/2$

Properties of air at mean fluid temp. (From material properties handbook)

Density, ρ = _____________ kg/m^3

Viscosity μ = _____________ kg/ms

Kinematic Viscosity, ν = ____________ m^2/sec

Thermal Conductivity, K = _____________ w/m k

Specific Heat C_p = _____________ kj/kg k

Prandlts's No. Pr = ------------------

β = $1/(T_{mf} + 273.15)$

Grashof No. $G_f = (g \times \beta \times D^3 \times \Delta T)/ \nu^2$

ΔT = $(T_m - T_f)$

Using the Correlation for Free Convection :

Nusselt No. Nu = $0.53\ (Gr\ Pr)^{0.25}$

Free convective heat transfer co eff. h = $Nu\ k_{air} / D$

Fin Parameter, $m = \sqrt{\frac{hP}{K_b\ A}}$

Thermal Conductivity of brass	k_b	= ______w/mk
Perimeter	P	= π D
Cross sectional area of fin	A	= π/4 X D^2
Fin Dia.	D	= 16 x 10^{-3} m
Fin Length	L	= 175 x 10^{-3} m
Fin effectiveness	ε	= tan h m L/ mL
Parameter	H	= h / k_b m
Take Base Temp.	T_b	= T_1

Theoretically,

1) X = 0.040 m

Theoretical Temp. Profile within the Fin=

$\theta/\theta_0 = [T_1-T_f]/[T_b-T_f]$ = cos h m(L-x)/cos h m L

2) X = 0.070 m

Theoretical Temp. Profile within the Fin=

$\theta/\theta_0 = [T_1-T_f]/[T_b-T_f]$ = cos h m(L-x)/cos h m L

3) X = 0.10 m

Theoretical Temp. Profile within the Fin=

$\theta/\theta_0 = [T_1-T_f]/[T_b-T_f]$ = cos h m(L-x)/cos h m L

4) X = 0.130 m

Theoretical Temp. Profile within the Fin=

$\theta/\theta_0 = [T_1\text{-}T_f]/[T_b\text{-}T_f] = \cos h\ m(L\text{-}x)/\cos h\ m\ L$

5) X = 0.160 m

Theoretical Temp. Profile within the Fin=

$\theta/\theta_0 = [T_1\text{-}T_f]/[T_b\text{-}T_f] = \cos h\ m(L\text{-}x)/\cos h\ m\ L$

Graph:

Conclusion:

Marks Obtained **Sign of Faculty**