EXPERIMRNT 7: TO STUDY THE TEMP. DISTRIBUTION ALONG THE LENGTH OF A PIN FIN UNDER FORCED 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

FORCED CONVECTION

1. Connect the sensor socket & heater to the fin which to be tested(SS,BRASS,ALUMINIUM)
2. Start heating the fins by switching ON the heater and adjust the dimmerstat voltage
3. Start the blower and adjust the difference of level in the manometer H
4. Note down the temp. sensor readings (1) to (5) When the steady state is reached, record the final readings (1) to (5) and also record the ambient temp. readings by (6)
5. Repeat the same experiment with another velocity.

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 & calculations

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

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-efficientofdischarge = 0.64

H = Differenceofwaterlevelin manometer = 0.061m

ρ_w =Densityofwater =1000kg/m^3

g =GravitationalAcceleration = 9.81m/s^2

ρ_a =Densityof air =1.128 kg/m^3

Velocityofair(V)

V=Q/A

Where,

A =__________ m^2

For forced convection:

Velocity of Air, V = ________m/s

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 =_____________

Reynold no.R_e =VL/υ

Where, L = _____m

Using co-relation for Forced convection:

Nusselt No. Nu $= 0.615 (Re)^{0.466}$

Nu $= h D / K_{air}$

Heat Transfer Coefficient, h $= Nu K_{air} / D$

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

Thermal Conductivity of brass	k_b	=	110 w/mk
Perimeter	P	=	π D =3.14 x 0.016 =0.0502 m
Cross sectional area of fin	A	=	π/4 X D^2 =3.14/4 x 0.016^2=0.0002 m^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 $H = h / K_b m$

Here,

K_b = thermal conductivity of Brass fin

P	=	Perimeter
T_m	=	Fin mean temp.
T_f	=	Fin temp. at any point
X	=	Distance of sensor at the base of the fin
g	=	Acc. Due to gravity
D	=	Fin Diameter
Gr	=	Grashof Number
Pr	=	Prandlt Number
Nu	=	Nusselt Number
K_{air}	=	Air conductivity at mean temp.
h	=	heat transfer coefficient
m	=	Fin perimeter
A	=	Cross sectional are of Fin
L	=	Fin Length
ε	=	Fin effectiveness

Theoretically,

1) X = 0.040 m

Theoretical Temp. Profile within the Fin=

θ/θ0 = [T1-Tf]/[Tb-Tf] = cos h m(L-x)/cos h m L

2) X = 0.070 m

Theoretical Temp. Profile within the Fin=

θ/θ0 = [T1-Tf]/[Tb-Tf] = cos h m(L-x)/cos h m L

3) X = 0.10 m

Theoretical Temp. Profile within the Fin=

θ/θ0 = [T1-Tf]/[Tb-Tf] = cos h m(L-x)/cos h m L

4) X = 0.130 m

Theoretical Temp. Profile within the Fin=

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

5) X = 0.160 m

Theoretical Temp. Profile within the Fin=

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

Graph:

Conclusion :

Marks Obtained **Sign of Faculty**