Ministry of Higher Education and Scientific Research
Al-Mustaqbal University College
Air Conditioning and Refrigeration Technologies

Heat Transfer Laboratory

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Experiment No. (3)

Heat transfer from a pin fin

Supervisor

Dr. Athraa Hameed Alabbasi

Prepared by

Eng. Rusul Abbas Alwan

Experiment (3)

أسم التجربة: أداء زعنفة ذات مقطع دائري

Experimental Title: Heat transfer from a pin fin.

Objective: To study the performance and the efficiency of a pin fin.

Theoretical Part:

Fins are used to enhance convective heat transfer in a wide range of engineering applications, and a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation transformers. Other applications include IC engine cooling, such as in a car radiator. It is important to predict the temperature distribution within the fin in order to choose the configuration that offers maximum effectiveness.

Consider the fin connected at its base to a heated wall and transferring heat to the surroundings.

Assume,

q_f = heat transfer rate from the fin.

A_f = Surface area of the fin.

A_c = Cross sectional area of the fin.

d = diameter of the fin.

P = Fin perimeter.

L = Length of the fin.

T_b = Temperature of the fin at the base.

T_∞ = Duct fluid temperature.

$\theta = (T - T_\infty)$ = Rise in temperature.

The heat is conducted along the rod and also lost to the surrounding fluid by convection.

h = Convection heat Transfer coefficient.

K = Thermal conductivity of the fin material.

Applying the first law of thermodynamics to a controlled volume along the length of the fin at x, the resulting equation of heat balance appears as:

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0 \qquad (3.1)$$

$$where \quad m = \sqrt{\frac{hP}{kA_c}}$$

The general solution of the equation is:

$$\theta = C_1 e^{mx} + C_2 e^{-mx} \qquad (3.2)$$

The fin is of finite length and loses heat by convection from its end.

B.**C 1:** $at\ x = 0 \qquad T = T_b$

$T - T_\infty = T_b - T_\infty = \theta_b$

B.C 2: $at\ x = L \qquad q_{cond} = q_{conv}$

$$-kA\frac{d\theta}{dx}\bigg]_{x=L} = hA(T - T_\infty)_{x=L}$$

Substitute the boundary conditions in Eq. (3.2) we get,

$$\frac{\theta}{\theta_b} = \frac{\cosh m(L-x) + \frac{h}{km}\sinh m(L-x)}{\cosh(mL) + \frac{h}{km}\sinh(mL)} \qquad (3.3)$$

To determine the heat loss from the fin, as well as the fin efficiency and fin effectiveness, we may use:

$$q_f = \sqrt{kA_c hP}\,\theta_b \left[\frac{\sinh mL + \frac{h}{km}\cosh mL}{\cosh(mL) + \frac{h}{km}\sinh(mL)}\right] \qquad (3.4)$$

For a fin of circular cross-sectional area and perimeter are:

$$A_c = \frac{\pi}{4} d^2 \quad and \quad P = \pi d$$

Fin Efficiency (η_f):

$$\eta_f = \frac{q_f}{q_{max}} = \frac{q_f}{hA_f\theta_b} \qquad (3.5)$$

Where A_f is the surface area of the fin, $A_f = \frac{\pi}{4} d^2 L$

Fin Effectiveness (ε_f):

$$\varepsilon_f = \frac{q_f}{q_{without\ fin}} = \frac{q_{fin}}{hA_c\theta_b} \qquad (3.6)$$

The use of fins may rarely be justified unless $\varepsilon_f \geq 2$.

Experimental procedure

Apparatus:

Figure (2.1) the experimental Apparatus

As shown in Figure (3.1) a brass fin of circular cross section in fitted across a long rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flows past the fin perpendicular to the axis. One end of the fin projects outside the duct and is heated by a heater. Temperature is measured at five different points along the fin Figure (3.2).

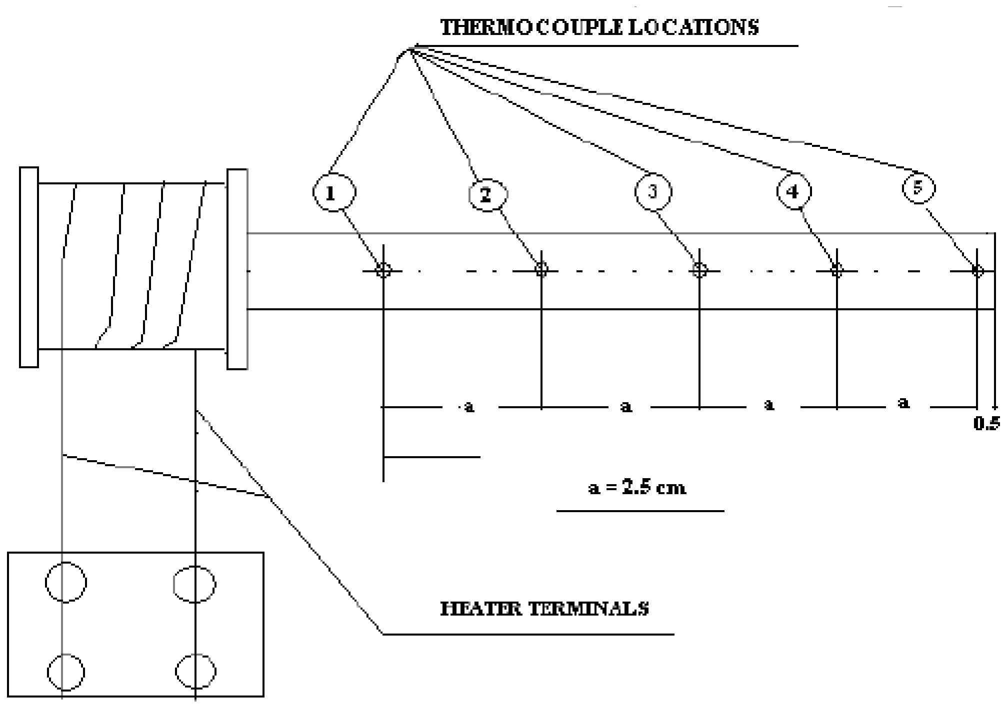

Figure (3.2) schematic diagram shows the locations of the thermocouples

Detailed information of the experimental set up is as follows:

1. Duct size = 150 cm x 130 mm.
2. Fin diameter = 12.5 mm.
3. No. of thermocouples mounted on the fin = 5
4. Another thermocouple (No.6) is used to read the ambient temperature inside of the duct.
5. Thermal conductivity of fin material (Brass) = 110W/m.°C.
6. Convection heat Transfer coefficient (h) = 3.7 W/m^2.°C.

Procedure:

1. Start heating the fin by switching ON the heater element and adjust the voltage on dimmer-stat to say 80 volt (Increase slowly from 0 to onwards)

2. When steady-state is reached, record the final temperature readings 1 to 5 as well as the ambient temperature reading 6.

3. Repeat the same experiment with 100 volts and 120 volts.

Observation Table:

Sr.No	V (Volt)	I (Amp)	Q = V*I (Watt)	Fin Temperature					Ambient Temperature
				T_1 (°C)	T_2 (°C)	T_3 (°C)	T_4 (°C)	T_5 (°C)	T_6 (°C)
1.									
2.									
3.									
4.									
5.									

Discussion:

1. Plot the temperature distribution along the length of the fin from your readings.

2. Using Equation (3.3), calculate the temperature value at various locations along the fin and make a comparison with the experimental measurements.

3. Calculate the value of heat transfer rate (q_f), effectiveness (ε_f) and efficiency (η_f).

4. Explain the main objective of using the fin and the effect of its length, the surface area and number of fins on the heat transfer rate.