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. (4)

Heat transfer from a rectangular fin

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Experiment (4)

أسم التجربة: أداء زعنفة ذات مقطع مستطيل.

Experimental Title: Heat transfer from a rectangular fin.

Objective: To study the performance of a rectangular 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:

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0 \qquad (4.1)$$

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

The general solution of the equation is:

$$\theta = C_1 e^{mx} + C_2 e^{-mx} \qquad (4.2)$$

The end of the fin is insulated so that

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

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

B.C 2: $at\ x = L \qquad \frac{d\theta}{dx} = 0$

Substitute the boundary conditions in Eq. (4.2) we get,

$$\frac{\theta}{\theta_b} = \frac{T - T_\infty}{T_b - T_\infty} = \frac{\cosh m(L - x)}{\cosh mL} \qquad (4.3)$$

This is the equation for the temperature distribution along the length of the fin. It is seen from the equation that for a fin of given geometry with uniform cross section, the temperature at any point can be calculated by knowing the values of T_b, T_∞ and the location (*x*).

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

$$q = \sqrt{kAhP}\,\theta_b \tanh mL \qquad (4.4)$$

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

$A_c = Wt \quad and \quad P = 2(W + t)$

Fin Efficiency (η_f):

$$\eta_f = \frac{q_f}{q_{max}} = \frac{q_f}{hA_f\theta_b} \qquad (4.5)$$

Where A_f is the surface area of the fin, $A_f = 2(W + t)L$

Fin Effectiveness (ε_f):

$$\varepsilon_f = \frac{q_f}{q_{without\ fin}} = \frac{q_{fin}}{hA_c\theta_b} \qquad (4.6)$$

Experimental procedure

Apparatus:

Figure (4.1) the experimental Apparatus

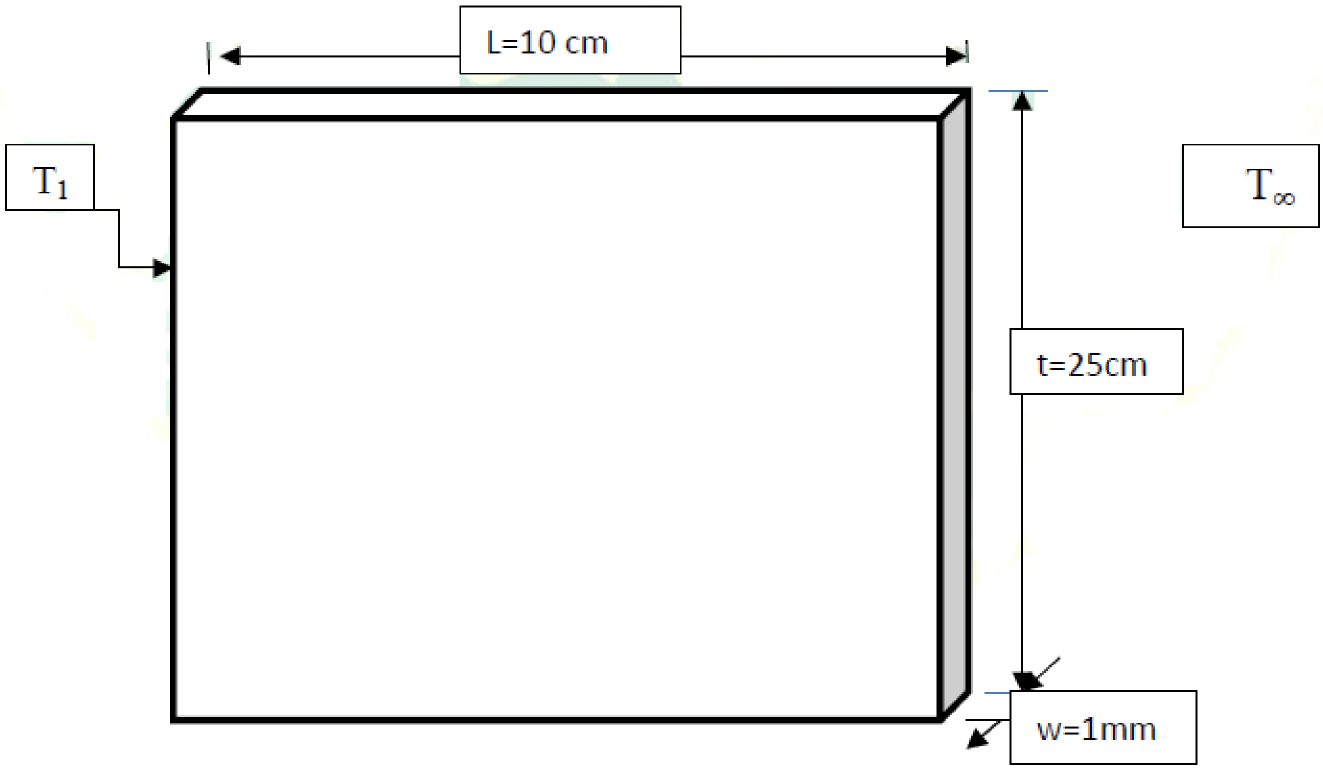

Figure (4.2) Schematic diagram of the rectangular fin

Detailed information of the experimental set up is as follows:

1. Duct size = 25 cm x 1 mm.
2. Length of the fin (L) = 10 cm.
3. Thickness of the fin (t) = 25 cm
4. Width of the fin (w) = 1 mm
5. No. of thermocouples mounted on the fin = 3.
6. Thermocouple (4) reads the ambient temperature inside of the duct.
7. Thermal conductivity of fin material (Aluminum) = 200 W/m.ºC.
8. Convection heat transfer coefficient (*h*) = 3.7 W/m^2.ºC.

Procedure:

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

2. When steady-state temperature is reached, record the final readings 1 to 3 and as well as the ambient temperature reading 4.

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)
1.							
2.							
3.							
4.							
5.							

Discussion:

1. Using Equation (4.3), calculate the temperature value at various locations along the fin and make a comparison with the experimental measurements.

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

3. What is the main purpose of the fin and why it is used, as well as mention some of its applications.