Problem. 3: (a) Compute the fin effectiveness of a bar fin made of aluminum that is 0.12 mm thick and 20 mm long when h_f = 28 W/m^2.K, the base temperature is 4 C, and the air temperature is 20 C.
(b) If you are permitted to use twice as much metal for the fin as originally specified in part (a) and you can either double the thickness or double the length, which choice would be preferable in order to transfer the highest rate of heat flow. Why?
Solution:

(a) Aluminum fins

k = 202 W/m.K

2y = 0.12 mm = 0.00012 m

y = 0.00006 m

L = 20 mm = 0.020 m

$$M = \sqrt{\frac{h_f}{ky}}$$

$$M = \sqrt{\frac{28}{(202)(0.00006)}}$$

$M = 48.1\ m^{-1}$

$$\eta = \frac{\tanh ML}{ML}$$

$ML = (48.1\ m^{-1})(0.020\ m) = 0.962$

$$\eta = \frac{\tanh(0.962)}{0.962}$$

η = 0.7746 - - - - Ans.

(b) If the fin thickness is doubled.

2y = 0.24 m = 0.00024 m

y = 0.00012 m

$$M = \sqrt{\frac{28}{(202)(0.00012)}}$$

$M = 33.99\ m^{-1}$

$$\eta = \frac{\tanh ML}{ML}$$

$ML = (33.99\ m^{-1})(0.020\ m) = 0.6798$

$$\eta = \frac{\tanh(0.6798)}{0.6798}$$

$\eta = 0.87 > 0.7746$

If the length L is doubled

L = 40 mm = 0.040 m

$$M = \sqrt{\frac{28}{(202)(0.00006)}}$$

$M = 48.1\ m^{-1}$

$$\eta = \frac{\tanh ML}{ML}$$

$ML = (48.1\ m^{-1})(0.040\ m) = 1.924$

$$\eta = \frac{\tanh(1.924)}{1.924}$$

$\eta = 0.498 < 0.7746$

Ans. Therefore double the fin thickness to improve rate of heat flow with an efficiency of 87 % compared to 77.46 %.

Problem. 4: Compute the fin effectiveness of an aluminum rectangular plate fin of a finned air-cooling evaporator if the fins are 0.18 mm thick and mounted on a 16-mm-OD tubes. The tube spacing is 40 mm in the direction of air flow and 45 mm vertically. The air-side coefficient is 55 W/m^2.K.

Solution

$h_f = 55$ W/m^2.K

Alumimum Fins, k = 202 W/m.K

$2y = 0.00018$ mm

$y = 0.00009$ mm

$$M = \sqrt{\frac{h_f}{ky}}$$

$$M = \sqrt{\frac{55}{(202)(0.00009)}}$$

$M = 55\ m^{-1}$.

Equivalent external radius.

$$\pi\left[(r_e)^2 - \left(\frac{16}{2}\right)^2\right] = (40)(45) - \pi\left(\frac{16}{2}\right)^2$$

$r_e = 23.94$ mm = 0.02394 m

$r_i = 8$ mm = 0.008 m

$(r_e - r_i)M = (0.02394 - 0.008)(55) - 0.88$

$r_e/r_i = 23.94$ mm / 8 mm = 3

From Fig. 12-8/

Fin Effectiveness = 0.68 - - - Ans.

Problem. 5: A shell-and-tube condenser has a U value of 800 W/m2 .K based on the water-side are and a water pressure drop of 50 kPa. Under this operating condition 40 percent of the heat-transfer resistance is on the water side. If the water-flow rate is doubled, what will the new U value and the new pressure drop be?

U_1 = 800 W/m2.K

h_1 = Water-side coefficient

$$h_1 = \frac{1}{(0.40)\left(\frac{1}{800}\right)} = 2{,}000$$

Eq. 12-13, replace 0.6 by 0.8 for condenser.

Water-side coefficient = (const)(flow rate)$^{0.8}$

For $w_2 / w_1 = 2$

$$\frac{h_2}{h_1} = \left(\frac{w_2}{w_1}\right)^{0.8}$$

$h_2 = (2000)(2)^{0.8} = 3482.2$ W/m^2.K

Remaining resistance = (0.60)(1 / 800) = 0.00075

New U-Value:

$$\frac{1}{U_2} = \frac{1}{3482.2} + 0.00075$$

U_2 = 964 W/m^2.K - - - Ans.

New Pressure Drop:

$$\Delta p_2 = \Delta p_1\left(\frac{w_2}{w_1}\right)^2$$

$$\Delta p_2 = (50)(2)^2$$

Δp_2 = 200 kPa - - - Ans.

1.6. Gas flowing over finned tubes; heat transfer and pressure drop

A precise prediction of the air-side heat-transfer coefficient when the air flows over finned tubes is complicated because the value is a function of geometric factors, e.g., the fin spacing, the spacing and diameter of the tubes, and the number of rows of tubes deep. Usually the coefficient varies approximately as the square root of the face velocity of the air. A rough estimate of the air-side coefficient h_f can be computed from the equation derived from illustrative data in the ARI standard

$$h_f = 38V^{0.5}$$

Rich[7] conducted tests of coils of various fin spacings and correlated the dimensionless heat-transfer numbers with specially defined Reynolds numbers.

The drop in pressure of the air flowing through a finned coil is also dependent upon the geometry of the coil. Figure 12-10 shows the pressure drop of a commercial cooling coil when the finned surfaces are dry. As expected, the pressure drop is higher for coils with a large number of fins per meter of tube length. The ordinate is the pressure drop per number of rows of tubes deep, so the values would be multiplied by 6 for a six-row coil, for example.

For the coil series whose pressure drops are shown in Fig. 12-10 the pressure drop for a given coil varies as the face velocity to the 1.56 power. That exponent is fairly typical of commercial plate-fin coils.

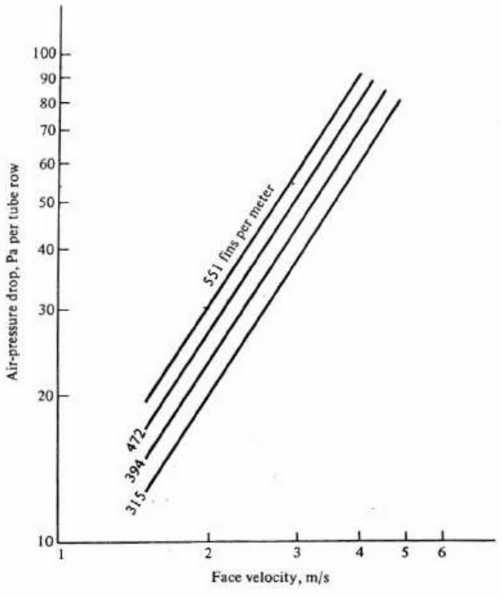

Figure 12-10 Pressure drop of air flowing through a finned coil *(Bohn Heat Transfer Division of Gulf & Western Manufacturing Company.)*