Example 8.20: *20 mm OD copper tubes are arranged in line at 30 mm pitch perpendicular to flow and 25 mm pitch along the flow. The entry velocity of air is 1 m/s, and the air temperature is 20°C. The tube wall is at 40°C. Determine the value of convection coefficient if the number of tubes along the flow is 6 (or Bank is 6 rows deep).*

Solution:

$S_p = 30$ mm, $D = 20$ mm, $S_p/D = 1.5$

$S_n = 25$ mm $S_n/D = 1.25$

From tables, $C = 0.367$, $n = 0.586$ (look carefully for S_p/D and S_n/D)

Property values at $T_f = 30°C$ are

$$\nu = 16 \times 10^{-6}\ m^2/s,\ Pr = 0.701,\ k = 0.02675\ W/mK$$

$$V_{max} = [S_p/(S_p - D)]\ u_\infty = \frac{30}{10}.1 = 3\ m/s$$

$$\therefore \quad Nu = 0.367\ Re^{0.586}$$

$$Re = 3 \times 0.02/16 \times 10^{-6} = 3750 > 2000$$

Hence equation is applicable:

$$Nu = 45.61 \quad \therefore \quad \mathbf{h = 61.0\ W/m^2K}$$

But the bank is only 6 rows deep

$$\therefore \quad h_6 = h_{10} \times 0.95 = \mathbf{57.95\ W/m^2K}$$

(Value 0.95 is read from tables 8.2).

Problem 2 Work out the value of h for staggered arrangement using data

From tables for $S_p/D = 1.5$ and $S_n/D = 1.25$

$$C = 0.451,\ m = 0.568$$

$$V_{max} = [S_p/2(S_D - D)]\ u_\infty = 3\ m/s$$

$$S_D = \left[Sn^2 + \left(\frac{S_p}{2}\right)^2\right]^{0.5} = [25^2 + 15^2]^{0.5} = 29.15$$

$$\therefore \quad V_{max} = [20/2\ (29.15 - 20)] = 1.6385,\ \text{lower}$$

$\therefore$ 3 *m/s* is taken as from $[S_p/(S_p - D)]\ u_\infty$

$$\therefore \quad Nu = 0.451\ (3750)^{0.568} = 48.33$$

$$\therefore \quad \mathbf{h = 64.64\ W/m^2K}$$

For 6 rows: correction factor is 0.94

$$\mathbf{h_6 = 64.64 \times 0.94 = 60.76\ W/m^2K}$$

For increasing the value of h, S_p should be reduced.