This appendix presents a sample calculation for the calculation of condensing-side heat transfer coefficient and $\Delta T_v$ from the measured experimental data. The sample experimental observation taken is for tube: E3, test run no.4 (Table.A.1.4b).

(1) Tube and other related data

- Diameter of the tube at fin root, $d_r = 0.01908$ m
- Inner diameter of the tube, $d_i = 0.01342$ m
- Finned length of the tube, $L = 0.12$ m
- Fin cross section, Rectangular
- Fin half angle, $\theta = 0^\circ$
- Fin spacing, $b = 1.5$ mm
- Fin thickness, $t = 1.0$ mm
- Fin height, $e = 3.0$ mm
- Diameter of the condensate measuring jar, $d_c = 0.03$ m
- Height of condensate collected, $X_c = 0.2$ m
- Thermal conductivity of the tube material, $k_w = 330$ W/mK

(2) Experimental observations

- Table. A1.4b, run no: 04
  - Vapour temperature, $T_v = 101.41$ °C
  - Inlet temperature of the cooling water, $T_{cw,i} = 66.0$ °C
  - Temperature rise of cooling water across the test condenser tube, $\Delta T_{cw} = 4.15$ °C
  - Cooling water flow rate, $m_{cw} = 0.3667$ kg/s (22 LPM)
  - Condensate temperature, $101.39$ °C
  - Time taken for 20 cm rise of condensate in the condensate measuring jar, $\tau = 48.80$ s
Constants from Wilson plot data (Table. AI.4a),
\[ C_1 = 4.6070 \times 10^{-04} \]
\[ C_2 = 4.5568 \times 10^{-03} \]

(3) Fluid properties

Density of the condensate, \[ \rho_c = 960.24 \text{ kg/m}^3 \]
Density of the cooling water, \[ \rho_{cw} = 1000 \text{ kg/m}^3 \]
Specific heat of water, \[ C_p = 4186 \text{ J/kgK} \]
Latent heat of vapourization of steam at \( T_v \), \[ h_{fg} = 2255070 \text{ J/kg} \]

(4) Calculation of LMTD

LMTD can be calculated by using the Eqn.3.5, which are reproduced here for convenience.

\[
(LMTD) = \frac{(\Delta T_1 - \Delta T_2)}{\ln(\Delta T_1/\Delta T_2)}
\]

\[ \Delta T_1 = (T_v - T_{cw}); \quad \Delta T_2 = (T_v - T_{cw0}); \]

\[ T_{cw0} = T_{cw} + \Delta T_{cw} \]

Thus,
\[ T_{cw0} = 66.0 + 4.15 = 70.15 \degree C \]
\[ \Delta T_1 = 101.41 - 66.0 = 35.46 \text{ K} \]
\[ \Delta T_2 = 101.41 - 70.15 = 31.26 \text{ K} \]

\[ LMTD = \frac{(35.46 - 31.26)}{\ln (35.46 / 31.26)} = 33.29 \text{ K} \]

(5) Calculation of heat rejected during condensation (\( Q_c \))

Cross-section area of the condensate measuring jar (\( A_c \)), the volume flow rate of condensate collected (\( V_c \)) and \( Q_c \) are calculated as follows.

\[ A_c = \frac{\pi d_c^2}{4} = \frac{(22 \times 0.03)^2}{(7 \times 4)} = 7.0714 \times 10^{-04} \text{ m}^2 \]

\[ V_c = \frac{A_c \times x}{\tau} = \frac{(7.0714 \times 10^{-04} \times 0.2)}{48.80} = 2.8982 \times 10^{-06} \text{ m}^3/s \]

\[ Q_c = \rho_c \cdot V_c \cdot h_{fg} = 960.24 \times 2.8982 \times 10^{-06} \times 2256270 = 6279.12 \text{ W} \]

(6) Calculation of heat carried away by the cooling water (\( Q_{cw} \))

\[ m_{cw} = [\rho_{cw} \cdot (LPM) \times 10^{-3}] / 60 = [1000 \times 22 \times 10^{-3}] / 60 = 0.3667 \text{ kg/s} \]

\[ Q_{cw} = m_{cw} \cdot C_p \cdot \Delta T_{cw} = 0.3667 \times 4186 \times 4.15 = 6370.28 \text{ W} \]
(7) Calculation of average heat transfer rate \( (Q_{awg}) \) and heat flux \( (q) \)

Surface area of the tube (based on fin root diameter) \( A_r \) is

\[
A_r = \pi \cdot d_r \cdot L = (22 \times 0.01908 \times 0.12) / 7 = 7.1959 \times 10^{-3} \text{ m}^2
\]

\[
Q_{awg} = (Q_{cw} + Q_c) / 2 = (6370.28 + 6279.12) / 2 = 6324.7 \text{ W}
\]

\[
q = Q_{awg} / A_r = 6324.7 / 7.1959 \times 10^{-3} = 878.93 \times 10^3 \text{ W/m}^2
\]

(8) Calculation of average heat transfer coefficient \( (h_e) \)

The average heat transfer coefficient can be calculated using the Eqn.3.6, which is reproduced below for convenience.

\[
\left( \frac{LMTD}{Q_{avg}} \right) = \left[ \frac{C_i}{(m_{cw}^{0.8})} \right] + \left[ \ln \left( \frac{d_i}{d_t} \right) \right] / (2\pi k_w L) + \left[ \frac{1}{(h_e \cdot A_r)} \right] \quad -(3.6)
\]

i.e., \( R_{tot} = R_i + R_w + R_o \)

Substituting the values in the above equation and solving for \( h_e \):

\[
R_{tot} = \left( \frac{LMTD}{Q_{avg}} \right) = \left[ \frac{33.29}{6324.7} \right] = 5.2635 \times 10^{-3} \text{ K/W}
\]

\[
R_i = \left[ \frac{C_i}{(m_{cw}^{0.8})} \right] = \left[ 4.6070 \times 0.04 / (0.3667^{0.8}) \right] = 1.028 \times 10^{-3} \text{ K/W}
\]

\[
R_w = \left[ \ln \left( \frac{d_i}{d_t} \right) / (2\pi k_w L) \right] = \left[ \ln \left( \frac{0.01908}{0.01342} \right) / (2\pi \times 330 \times 0.12) \right]
\]

\[
= 1.4137 \times 10^{-3} \text{ K/W}
\]

\[
R_o = R_{tot} - (R_i + R_w) = 2.8218 \times 10^{-3} \text{ K/W}
\]

\[
h_e = \left[ \frac{1}{(R_o \cdot A_r)} \right] = \left[ \frac{1}{(2.8218 \times 10^{-3} \times 7.1959 \times 10^{-3})} \right] = 49254 \text{ W/m}^2\text{K}
\]

(or)

\[
\left( \frac{33.29}{6324.7} \right) = \left[ 4.6070 \times 0.04 / (0.3667^{0.8}) \right] + \left[ \ln \left( \frac{0.01908}{0.01342} \right) / (2\pi \times 330 \times 0.12) \right]
\]

\[
+ \left[ \frac{1}{(h_e \times 7.1959 \times 10^{-3})} \right]
\]

Solving for \( h_e \), \( h_e = 49254 \text{ W/m}^2\text{K} \)

(9) Calculation of vapour-side temperature difference \( (\Delta T_v) \)

Using the Eqn.3.7, i.e., \( (\Delta T_v) = Q_{avg} / (h_e \cdot A_r) \)

\[
(\Delta T_v) = 6324.7 / (49254 \times 7.1959 \times 10^{-3}) = 17.84 \text{ K}
\]

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