Calculations on NLC Target

![Diagram of NLC Target]

(1.) Only about one-half of each coil is active for heat transfer (top half)

(2.) Coil II takes perhaps about twice the heat load as coil I.

Active average heat transfer area of each coil at wetted interface:

\[ A = \frac{\pi D_c}{2} \]
\[ 2\pi R = \pi^2 D_c R = \pi^2 (0.505)(3.95) = 19.7 \text{ in}^2 \]
\[ 2A = 39.4 \text{ in}^2 \]

\[ \theta_{c_{coil}} = \frac{Q}{2A} = \frac{23 \times 3.4/13}{(39.4/144) \times 2} = 2.87 \times 10^5 \text{ B} / \text{h}^2 \text{C} \]

\[ \theta_{c_{coil} II} = \frac{2\theta_{c_{coil}}}{4} = 5.74 \times 10^5 \text{ B} / \text{h}^2 \text{C} \]
\[ u = \sqrt{u_0^2 + \frac{\pi (0.2535)^2}{12}} = 29.5 \ \text{fps} \]

\[ \rho = \rho_0 \frac{u}{u_0} = 62 - 29.5 \frac{3}{6} = 6.6 \times 10^6 \ \text{lb} \frac{\text{ft}^3}{\text{hr}^2} \]

\[ \Delta T = \frac{(23.1) \frac{3.443}{(9.74)(4)}}{1} = 4.3 \ \text{°F} = 2.4 \ \text{°C} \]

\[ \Delta T = \frac{(4.3)}{1} = 8.6 \ \text{°F} = 4.8 \ \text{°C} \]

\[ Re = \frac{\rho \bar{D}_c}{\mu} = 29.5 \times 0.5 \frac{0.5}{12} = 8.1 \times 10^5 \]

\[ 11 \times 10^{-3} \]

\[ \frac{1}{11} \]

\[ h D_c = 0.023 \ Re^0.8 \mu = 366 \]

\[ h = 2.608 \frac{Btu}{\text{hr} \cdot \text{ft}^2} = 14.8 \ \text{W/m}^2 \cdot \text{°C} \]

Since this is lower than 17 W/m²·°C specified in Table 1.5, use it for conservation.

\[ \Delta T = \frac{2}{\mu} = 5.74 \times 10^5 \]

\[ \mu = \frac{2}{5.74 \times 10^5} = 220 \ \text{°F} \]

\[ u \approx 68.6 + 220 = 288.6 \ \text{°F} > T_{sat} = 230 \ \text{°F} \]

Subcooled
CHF = Critical Heat Flux (use MacBeth) High Viscosity Region

\[ \alpha = 1.77 (0.585) (4.4) = 1.58 \]

\[ \varepsilon = 0.0166 (0.585)^{-1.4} (4.4) = 0.00074 \]

\[ \frac{\dot{q}_{\text{crit}}}{10^6} = \frac{1.58 + \frac{1}{2} (0.00074) (0.585) (6.4) (230 - 68)}{1 + (0.00074) (2\pi + 3.14)} = 2.18 \]

Since \( \frac{\dot{q}_{\text{crit}}}{10^6} = 0.574 \times 10^6 \frac{B}{k \cdot m^2} \) \( \frac{\dot{q}_{\text{crit}}}{10^6} = 2.18 \times 10^6 \frac{B}{k \cdot m^2} \)

\[ \frac{\dot{q}_{\text{crit}}}{10^6} < 2.18 \times 10^6 \frac{B}{k \cdot m^2} \]

a crisis will not develop, but D/N = \( \frac{2.18}{0.574} = 3.8 \) is not a lot of margin!

CHF = Onset of significant boiling (Saha - Zuber)

\[ \text{Re} \cdot Fr = (6.13 \times 10^3) 3 = 3.4 \times 10^7 > 0.7 \times 10^5 \]

1 pump
2 parallel units in circuit

\[ \frac{\dot{q}_{\text{crit}}}{\rho u (T - T_{\text{sat}})} = 0.0065 \leftarrow \]

\[ \dot{q}_{\text{crit}} = 6.15 \times 10^6 \frac{B}{k \cdot m^2} \]

Since \( \dot{q}_{\text{crit}} = 0.574 \times 10^6 \frac{B}{k \cdot m^2} \), it is

\[ \text{Pe} = \left( \frac{G D_h S_p^2}{k} \right) \frac{1}{k} = \text{Re} \cdot Fr \]
Summary

- Subcooled boiling is likely on the outer regions of coil II

- Time-averaged heating is not large enough to cause a burnout crisis, but $\text{DBR} \approx 3.8$ is not much margin
  - Need to consider superimposed transient flux caused by beam near coils
  - Should consider better orientation of target to coils to avoid overheating either and increasing DBR

- Two-phase flow instabilities are not likely since $\text{flow} \gg \text{heat}$. Therefore, both coils may operate in parallel using a single pump.