Pool Boiling Correlations for Structured Fin Tubes

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Introduction
Since the 1950s, many researchers have investigated boiling on enhanced surfaces. Tubes with enhanced boiling surfaces are now widely used in commercial applications. Refrigeration, hydrocarbon processing, and other industries benefit from enhanced boiling, and many studies of the phenomena have been published. Heat Transfer Research, Inc. (HTRI) conducted a comprehensive literature review, compiling experimental data on structured fin tubes that are commercially available.

Experimental Data
HTRI has compiled over seven hundred pool boiling data points for commercially available structured fin tubes.

- Many enhanced tubes by Wieland Thermal Solutions, Wolverine Tube, Inc., and Hitachi
- Test fluids including refrigerants and hydrocarbons
- Reduced pressures ranging from 0.011 to 0.222
- Heat fluxes varying from 0.13 to 446.5 kW/m²

Based on the evolution of structured fins and the heat flux dependence, we divided the enhanced pool boiling data into two groups:

- **Group One**, for which the pool boiling heat transfer coefficient increases as heat flux increases
  - These data were mostly taken using earlier commercial enhanced tubes, like GEWA-T and Turbo-B.
  - The trend is similar to that of plain tubes, but with enhancement.
- **Group Two**, for which the pool boiling heat transfer coefficient does not significantly vary with heat flux, instead staying constant or decreasing slightly with heat flux
  - These data were collected on more recent commercial enhanced tubes, like GEWA-BS and Turbo-BS.
  - Boiling coefficients stay high even at low heat fluxes.

\[ D^* = \frac{2\sigma}{\sqrt{\rho_2 - \rho_1}} \]

Both groups of data indicate that the boiling coefficient is higher for:
- higher fin density or smaller fin pitch \( (P_{fin}) \)
- narrower fin tip gap \( (\delta_{gap}) \)

**Group One:**
\[ h_{\text{cal}} = 180 \left( \frac{k}{D_0} \right) \left( \frac{D_0}{L_0} \right)^{0.8} \left( \frac{\rho_2}{\rho_1} \right)^{0.31} \left( \frac{P_{fin}}{D_0} \right)^{0.2} \left( \frac{\delta_{gap}}{D_0} \right)^{0.5} \]

**Group Two:**
\[ h_{\text{cal}} = 0.35 \left( \frac{k}{D_0} \right) \left( \frac{D_0}{L_0} \right)^{0.8} \left( \frac{\alpha_1}{D_0} \right) \left( \frac{\rho_2}{\rho_1} \right)^{0.32} \left( \frac{P_{fin}}{D_0} \right)^{0.2} \left( \frac{\delta_{gap}}{D_0} \right)^{0.5} \]

In summary
- Fin structure evolution results in higher heat fluxes and boiling heat transfer coefficients.
- Nucleate pool boiling coefficient for recent tubes does not vary much with heat flux, unlike for earlier structured fin tubes.
- Two correlations developed for these two groups of data predict most data within ±25%.