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Author: Mirza M. Shah

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COMPREHENSIVE CORRELATION FOR DISPERSED FLOW FILM BOILING HEAT TRANSFER IN MINI/MACRO TUBES

Mirza M. Shah

10 Dahlia Lane, Redding, CT06896, USA

mshah.erc@gmail.com

Phone 1-860-869-1328

FAX 1-203-244-0799

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HIGHLIGHTS

- Presents physically based correlation for dispersed flow film boiling in tubes.
- Verified with data from 38 sources for horizontal, vertical, mini and macro tubes.
- Data include 10 fluids and extreme range of pressure, flow rates, and diameters.
- Accuracy much better than of other correlations.

ABSTRACT

A general correlation for heat transfer during dispersed flow film boiling is presented which is applicable to horizontal and vertical tubes. It is based on the two-step model. It has been verified with data for 10 fluids in horizontal and vertical upflow. The fluids include refrigerants, hydrocarbons, cryogenes, CO₂ and water. The range of data included diameters from 0.98 to 25.0 mm, reduced pressures from 0.0046 to 0.99, mass flux from 3.7 to 5176 kg m⁻²s⁻¹, and qualities from 0.1 to 2.96. The 1481 data points from 38 sources are predicted with mean absolute deviation of 19.4 % . Several other correlations are also compared to the same data and found to have much larger deviations.

KEY WORDS: film boiling; heat transfer; correlation; tubes; minichannels

NOMENCLATURE

Bo	Boiling number = $q (G H_{fg})^{-1}$, (-)
C _{pf}	Specific heat of liquid at constant pressure, (J kg ⁻¹ K ⁻¹)
D	Inside diameter of tube, (m)
F _{dc}	Droplet cooling factor, (-)
F _{ent}	Entrance effect factor, (-)
Fr _L	Froude number for all mass flowing as liquid = $G^2 (\rho_f^2 g D)^{-1}$, (-)
Fr _{TP}	Two-phase Froude number, defined by Eq. (28), (-)
G	Total mass flux (liquid + vapor), (kg m ⁻² s ⁻¹)
g	Acceleration due to gravity, (m s ⁻²)
h	Heat transfer coefficient, (Wm ⁻² K ⁻¹)
h _g	Heat transfer coefficient of vapor, (Wm ⁻² K ⁻¹)
H _{fg}	Latent heat of vaporization, (J kg ⁻¹)
H _g	Enthalpy of vapor at actual temperature, (J kg ⁻¹)
H _{gSAT}	Enthalpy of vapor at saturation temperature, (J kg ⁻¹)
h _{TP}	Two-phase boiling heat transfer coefficient defined by Eq. (16), (Wm ⁻² K ⁻¹)
k	Thermal conductivity, (Wm ⁻¹ K ⁻¹)
K _{hor}	Factor defined by Eq. (24), (-)

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