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ORIGINAL

Modeling of flow boiling heat transfer coefficient of R11 in mini-channels using support vector machines and its comparative analysis with the existing correlations

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Abstract
In recent years, extensive research efforts have been devoted to flow boiling heat transfer mechanisms in macro and mini-channels. However, it is still difficult to predict the flow boiling heat transfer coefficient with satisfactory accuracy. In this study, support vector regression (SVR) models have been constructed using a respectable experimental database (767 samples) from the literature to predict the heat transfer coefficient of R11 in mini-channels for subcooled (324 samples) and saturated (443 samples) boiling regions. The prediction performance of the SVR-based models have been evaluated based on the statistical parameters. SVR-based models have been found to exhibit an average absolute relative error (AARE) of 1.7% and correlation coefficient (R) of 0.9996 for subcooled boiling, while for saturated boiling the values of AARE and R are 1.6% and 0.9993, respectively. Also, the developed SVR-based models have been compared with the well-known existing correlations. The superior prediction performance of SVR-based models has been observed with the lowest value of AARE and the highest value of correlation coefficient (R). Furthermore, parametric effects of mass flux, vapor quality, heat flux and pressure on the flow boiling heat transfer coefficient have also been investigated and the SVR-based models have been found to agree well with the experimental results.

Nomenclature

Bo	Boiling number
C	Cost function
Co	Convective number
C_p	Specific heat, J/kg.K
D_h	Hydraulic diameter, m
$f(x)$	Regression function
G	Mass flux, kg/m^2.s
h	Heat transfer coefficient, kW/m^2.K
h_{lg}	Enthalpy of vaporization, J/kg
k	Thermal conductivity, W/m.K
$K(x_i,x_j)$	Kernel function
L	Dual form of the Lagrangian function
P	Fluid pressure, kPa
Pe	Peclet number
Pr	Prandtl number
Q^2_{ext}	Leave-one-out cross validation for the test set
Q^2_{Loo}	Leave-one-out cross validation for the training set
R	Correlation coefficient
Re	Reynolds number
S	Suppression factor
T	temperature, K
q	heat flux density, W/m^2
x_i	Input vector
X_{tt}	Lockhart-Martinelli parameter
y_i	Output vector

Subscripts

l	Liquid phase
nb	Nucleate boiling
sat	Saturated
tp	Two-phase
v	Vapor phase
w	Wall

Greek symbols

Γ	Surface development parameter
σ	Width parameter of RBF kernel
ε	Loss function
γ	Regularization parameter
λ and λ*	Lagrange multipliers
$\phi(x_i)$	High dimensional mapping feature function for input vector x
K	Thermal conductivity, W/m.K

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