NOMENCLATURE

Latin Symbols

A: defined in eqs.3-7e, 3-7f and 3-7h, dimensionless

Bo: boiling number, dimensionless

b: empirical parameter used in Dix void fraction model (eq.6-12, 6-22), dimensionless

C_D: drag coefficient, dimensionless

C_P: specific heat at constant pressure, [J/kgK]

C_0: vapor concentration parameter, dimensionless

CHF: critical heat flux, [W/m^2]

CHF_D: CHF for a diameter of interest in eq.2-1, [W/m^2]

$CHF_{D=8mm}$: CHF for 8mm tube in eq.2-1, [W/m^2]

D: tube inner diameter, [m]

D_B: vapor blanket equivalent diameter, [m]

F_B: buoyancy force exerted on vapor blanket, [N]

F_D: drag force exerted on vapor blanket, [N]

FDB: fully developed boiling

f: friction factor, dimensionless

g: gravitational acceleration, [m/s^2]

G: mass flux, [kg/m^2s]

G_b: mass flux in bubbly layer in fig.2-1, [kg/m^2s]

G_c: mass flux in core region in fig.2-1, [kg/m^2s]

G'': mass flow rate into the bubbly layer in Weisman –Pei model, eq.2-9, [kg/m^2s]

H: enthalpy, [J/kg]

H_l: liquid enthalpy, [J/kg],

H_f: liquid saturation enthalpy, [J/kg]

H_{fg}: latent heat of vaporization, [J/kg]

h_l: Dittus-Boelter's liquid heat transfer coefficient, [$W/(m^2K)$]

h_l: liquid phase height in chapter 6.2, [m]

$h_{l\text{-}A}$: subcooled liquid-phase heat transfer coefficient in Ahmad NVG model, [$W/(m^2K)$]

h_g: gas phase height in chapter 6.2, [m]

K: proportional constant in eq.2-15

k: thermal conductivity, [W/mK]

L: heated length, [m]

L_B: length of vapor blanket, [m]

Nu: Nuselt number

NVG: net vapor generation point

ONB: onset of nuclear boiling

P: system pressure, [MPa]

Pe: Peclet number, dimensionless.

Pr: Prandtl number, dimensionless

q: heat flux, [W/m^2]

q_b: boiling heat flux (eq.6-15), [W/m^2]

q_m: assumed heat flux exerted on tube, [W/m^2]

q_{cond}: heat flux transferred to subcooled fluid by vapor condensation in eq.6-13, [W/m^2]

q_{FDB}: minimum heat flux needed for FDB establishment at tube exit, [W/m^2]

q_{HN}: heat flux at which the highest wall temperature reaches homogeneous nucleation temperature, [W/m^2]

q_{SAT}: heat flux needed for heating the subcooled coolant to saturation at tube exit, [W/m^2]

q_{NVG}: heat flux needed for the NVG establishment at tube exit, [W/m^2]

Re: Reynolds number, dimensionless

St: Stanton number, dimensionless.

S: slip ratio, dimensionless.

T: temperature, [K]

T_B: temperature at tip of bubbles in Levy NVG model, [K]

T_{cr}: thermodynamic critical temperature, [K]

T_{HN}: homogeneous nucleation temperature, [K]

T_B^+: non-dimensional temperature at the tip of vapor bubble in Levy NVG model

T_{SAT}: saturation temperature, [K]

T_w: wall temperature, [K]

U: velocity, [m/s]

U_B: velocity of vapor blanket; [m/s]

U_{BL}: liquid velocity at the centerline of vapor blanket, [m/s]

U_g: gas phase velocity in chapter 6.2, [m/s]

U_l: liquid phase velocity in chapter 6.2, [m/s]

U_δ: local velocity of homogeneous two-phase flow at distance δ from the wall in katto model, eq.2-17, [m/s]

U_τ: friction velocity, [m/s]

U^+: non-dimensional velocity, dimensionless

U_{BL}^+: non-dimensional liquid velocity at the centerline of vapor blanket, dimensionless

u^*: friction velocity, [m/s]

V_{gj}: drift velocity, [m/s]

V_c: core region average velocity, [m/s]

V_l: liquid velocity in straight tube, [m/s]

V_{yl}: resultant velocity by Gambill in eq.5-1, [m/s]

y: distance from the heated wall to the bubble central line, [m]

y^+: non-dimensional distance from heated wall, dimensionless.

y*: superheated layer thickness in Celata model, [m].

Y_B: distance from wall to tip of vapor bubble in Levy NVG model, [m]

Y_B^+: non-dimensional distance to tip of bubble in Levy NVG model, dimensionless

Z_0: length from tube inlet to the NVG point, [m]

Zsb: Significant boiling length, calculated by ($L-Z_0$), [m]

ΔT_l: liquid subcooling, [K]

ΔT_d: liquid subcooling at NVG point, [K]

ΔT_{in}: liquid subcooling at tube inlet, [K]

Greek Symbols

α: void fraction, dimensionless

α_b: bubbly layer void fraction, dimensionless

α_c: core region void fraction, dimensionless

δ: liquid sublayer thickness, [m]

ε: surface roughness in friction factor computation, eq.3-10, [m]

ε: the ratio of the heat flux due to pumping to that causing vapor formation (eq.6-15), dimensionless

η: wave height [m]

ϕ: velocity potential

λ: wavelength [m]

φ: thinned part angle in Nariai peripheral non-uniform heating experiment, [°]

ρ: density, [kg/m^3]

ρ_c: core region density, [kg/m^3]

γ: twist ratio of tape, dimensionless

γ: parameter used in Dix void fraction model (eqs.6-12, 6-22), dimensionless

σ: surface tension, [N/m]

τ: passage time of vapor blanket, [s]

τ_w: wall shear stress, [MPa]

μ: viscosity, [kg/ms]

χ: true quality, dimensionless

χ_b: bubbly layer true quality in Weisman-Pei model, dimensionless

χ_c: core region true quality in Weisman-Pei model, dimensionless

χ_d: thermal equilibrium quality at NVG point, dimensionless

χ_1: true quality from Jafri model in chapter 6.1.2, dimensionless

χ_2: true quality from profile-fit model in chapter 6.1.2, dimensionless

χ_3: true quality from mechanistic model with considering condensation effect in chapter 6.1.2, dimensionless

χ_{eq}: thermal equilibrium quality, dimensionless

χ_{eqout}: thermal equilibrium quality at exit point, dimensionless

Subscripts

-1: at interface I

-2: at interface II

-Ahmad: calculated result from the Ahmad model

-avg: average

-B: vapor blanket

-b: bubbly layer

-c: core region

-Dryout: CHF caused by liquid sublayer dryout for the first kind of flow pattern

-d: net vapor generation point

-eq: thermal equilibrium

-Film-boiling: CHF caused by the happening of film boiling

-f: liquid at saturation

-g: gas

-in: tube inlet

-l: liquid at unsaturation

-Levy: calculated result from the Levy model

-max: maximum

-min: minimum

-out: tube exit

-SAT: at saturation condition

-Saha: calculate from the Saha-Zuber model