Applied Research in Hydraulics *and* Heat Flow

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APPLIED RESEARCH IN HYDRAULICS AND HEAT FLOW

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LIST OF ABBREVIATIONS

ACQ	ammonium copper quaternary
CCA	chromated copper arsenate
CFD	computational fluid dynamics
CM	condition base maintenance
DVCM	discrete vapor cavity model
EDL	electric double layer
FD	finite differences
FE	finite elements
FSI	fluid-structure interaction
FSP	fiber saturation point
FV	finite volume
FVM	finite volume method
GIS	geography information systems
MOC	method of characteristics
PLC	program logic control
Re. No	Reynolds number
RMS	root-mean-square
RTC	real-time control
UFW	unaccounted for water
VCF	velocity correction factor
WCM	wave characteristic method

LIST OF SYMBOLS

k = Permeability [cm^3 (liquid)/(cm atm sec)]

V = Volume of liquid flowing through the specimen (cm^3)

t = Time (sec)

A = Cross-sectional area of the specimen perpendicular to the direction of flow (cm^3)

ΔP = Pressure difference between ends of the specimen (atm)

L = Length of specimen parallel to the direction of flow (cm)

K_g = Superficial gas permeability [cm^3 (gas)/(cm atm sec)]

V = Volume of gas flowing through the specimen (cm^3 (gas))

P = Pressure at which V is measured (atm)

$\overline{P}$ = Average pressure across the specimen (atm)

J_f = Liquid free water flow flux, kg/$m^2 \cdot$s

K_l = Specific permeability of liquid water, $m^3(liquid)/m$

ρ_l = Density of liquid water, kg/m^3

μ_l = Viscosity of liquid water, $p_a.s$

p_c = Capillary pressure, p_a

χ = Water transfer distance, m

$\partial p_c / \partial \chi$ = Capillary pressure gradient, p_a / m

J_{vf} = Water vapor flow flux, kg/$m^2 \cdot$s

K_V = Specific permeability of water vapor, $m^3(vapor)/m$

ρ_v, μ_v = Density and viscosity of water vapor respectively, kg/m^3 and $p_a.s$

$\partial p_V / \partial \chi$ = Vapor partial pressure gradient, p_a / m

ρ_S = Basic density of wood, kg/m^3

MC = Moisture content of wood, %

t = Time, s

$\partial(MC)/\partial t$ = The rate of moisture content change, %/s

x = Water transfer distance, m

ρ_S = Basic density of wood, kg/ m^3

D_V = Water vapor diffusion coefficient, m^2/s

V = Water flow or discharge $\left(m^3/s\right)$, $\left(lit/s\right)$

C = The wave velocity $\left(m/s\right)$

$E_{жс}$ = Modulus of elasticity of the liquid (water), $E_{жс} = 2.10^9 Pa$ $\left(kg/m^2\right)$

E = Modulus of elasticity for pipeline material Steel, $E = 2.11^9 Pa$, $\left(kg/m^2\right)$

d = Outer diameter of the pipe (m)

δ = Wall thickness (mm)

V_0 = Liquid with an average speed $\left(m/s\right)$

T = Time (S)

h_0 = Ordinate denotes the free surface of the liquid (m)

u = Fluid velocity $\left(m/s\right)$

λ = Wavelength

$(hu)_x$ = Amplitude a

$\frac{\partial h}{\partial t} dx$ = Changing the volume of fluid between planes in a unit time

h_0 = Phase velocity $\left(m/s\right)$

v_Φ = Expressed in terms of frequency

f = Angular frequency

ω = Wave number

Φ = A function of frequency and wave vector

$v_\Phi(k)$ = Phase velocity or the velocity of phase fluctuations $\left(m/s\right)$

$\lambda(k)$ = Wavelength

k = Waves with a uniform length, but a time-varying amplitude

$k_{**}(\omega)$ = Damping vibrations in length

ω = Waves with stationary in time but varying in length amplitudes

p_{si0}= Saturated vapor pressure of the components of the mixture at an initial temperature of the mixture T_0, (Pa)

μ_2, μ_1 = Molecular weight of the liquid components of the mixture

B = Universal gas constant

p_i = The vapor pressure inside the bubble (Pa)

T_{ki}= Temperature evaporating the liquid components (^oC)

l_i = Specific heat of vaporization

D = Diffusion coefficient volatility of the components

N_{k_0}, N_{c_0} = Molar concentration of 1-th component in the liquid and steam

c_l and c_{pv}= The specific heats of liquid and vapor at constant pressure, respectively

a_l = Thermal diffusivity

ρ_v = Vapor density (kg/m^2)

$R = r = R(t)$ = Radius of the bubble (mm)

λ_l = Coefficient of thermal conductivity

ΔT = Overheating of the liquid (^oC)

β = Positive and has a pronounced maximum at $k_0 = 0{,}02$

p_1 and p_2 = The pressure component vapor in the bubble (Pa)

p_∞ = The pressure of the liquid away from the bubble (Pa)

σ = Surface tension coefficient of the liquid

v_1 = Kinematic viscosity of the liquid

k_R = The concentration of the first component at the interface

n_i = The number of moles

V = Volume (m^3)

B = Gas constant

T_v = The temperature of steam (^oC)

$\rho_i^/$ = The density of the mixture components in the vapor bubble (kg/m^2)

μ_i = Molecular weight

P_{si} = Saturation pressure (Pa)

l_i = Specific heat of vaporization

k = The concentration of dissolved gas in liquid

v_{Φ} = Speed of long waves

h = Liquid level is above the bottom of the channel

ξ = Difference of free surface of the liquid and the liquid level is above the bottom of the channel (a deviation from the level of the liquid free surface)

u = Fluid velocity $\left(m/s\right)$

τ = Time period

a = Distance of the order of the amplitude

k = Wave number

$v_{\Phi}(k)$ = Phase velocity or the velocity of phase fluctuations

$\lambda(k)$ = Wavelength

$\omega_{**}(k)$ = Damping the oscillations in time

λ = Coefficient of combination

q = Flow rate $\left(m^3/s\right)$

μ = Fluid dynamic viscosity $\left(kg/m.s\right)$

γ = Specific weight $\left(N/m^3\right)$

j = Junction point (m)

y = Surge tank and reservoir elevation difference (m)

k = Volumetric coefficient $\left(GN/m^2\right)$

T = Period of motion

A = Pipe cross-sectional area $\left(m^2\right)$

dp = Static pressure rise (m)

h_p = Head gain from a pump (m)

h_L = Combined head loss (m)

E_{υ} = Bulk modulus of elasticity (Pa), $\left(kg/m^2\right)$

α = Kinetic energy correction factor

P = Surge pressure (Pa)

g = Acceleration of gravity $\left(m/s^2\right)$

K = Wave number

T_P = Pipe thickness (m)

E_P = Pipe module of elasticity (Pa) $\left(kg/m^2\right)$

E_W = Module of elasticity of water (Pa), $\left(kg/m^2\right)$

C_1 = Pipe support coefficient

Y max = $Max.$ Fluctuation

R_0 = Radiuses of a bubble (mm)

D = Diffusion factor

β = Cardinal influence of componential structure of a mixture

N_{k_0}, N_{c_0} = Mole concentration of 1-th component in a liquid and steam

γ = Adiabatic curve indicator

c_l, c_{pv} = Specific thermal capacities of a liquid at constant pressure

a_l = Thermal conductivity factor

ρ_v = Steam density $\left(kg/m^3\right)$

R = Vial radius (mm)

λ_l = Heat conductivity factor

k_0 = Values of concentration, therefore

w_l = Velocity of a liquid on a bubble surface $\left(m/s\right)$

p_1 and p_2 = Pressure steam component in a bubble (Pa)

p_∞ = Pressure of a liquid far from a bubble (Pa)

σ and ν_1 = Factor of a superficial tension of kinematics viscosity of a liquid

B = Gas constant

T_v = Temperature of a mixture $\left({}^oC\right)$

$\rho_i^{/}$ = Density a component of a mix of steam in a bubble $\left(kg/m^3\right)$

μ_i = Molecular weight

j_i = The stream weight

i = Components from an $(i = 1,2)$ inter-phase surface in $r = R(t)$

w_i = Diffusion speeds of a component on a bubble surface $\left(m/s\right)$

l_i = Specific warmth of steam formation

k_R = Concentration 1^{-th} components on an interface of phases

T_0, T_{ki} = Liquid components boiling temperatures of a binary mixture at initial pressure p_0, (^oC)

D = Diffusion factor

λ_l = Heat conductivity factor

N_{ul} = Parameter of Nusselt

a_l = Thermal conductivity of liquids

c_l = Factor of a specific thermal capacity

Pe_l = Number of Pekle

Sh = Parameter of Shervud

Pe_D= Diffusion number the Pekle

ρ = Density of the binary mix $\left(kg/m^3\right)$

t = Time (s)

λ_0 = Unit of length

V = Velocity $\left(m/s\right)$

S = Length (m)

D = Diameter of each pipe (mm)

R = Pipe radius (mm)

ν = Fluid dynamic viscosity $\left(kg/m.s\right)$

h_p = Head gain from a pump (m)

h_L = Combined head loss (m)

C = Velocity of Surge wave $\left(m/s\right)$

P/γ = Pressure head (m)

Z = Elevation head (m)

$V^2/2g$ = Velocity head (m)

γ = Specific weight $\left(N/m^3\right)$

Z = Elevation (m)

H_P = Surge wave head at intersection points of characteristic lines (m)

V_P = Surge wave velocity at pipeline points- intersection points of characteristic lines $\left(m/s\right)$

V_{ri}= Surge wave velocity at right hand side of intersection points of characteristic lines $\left(m/s\right)$

H_{ri} = Surge wave head at right hand side of intersection points of characteristic lines (m)

V_{le} = Surge wave velocity at left hand side of intersection points of characteristic lines $\left(m/s\right)$

H_{le} = Surge wave head at left hand side of intersection points of characteristic lines (m)

p = Pressure (bar), $\left(N/m^2\right)$

dv = Incremental change in liquid volume with respect to initial volume

$\left(d\rho/\rho\right)$ = incremental change in liquid density with respect to initial density

SUPERSCRIPTS

C^- = Characteristic lines with negative slope

C^+ = Characteristic lines with positive slope

SUBSCRIPTS

$Min.$ = Minimum

$Max.$ = Maximum

$Lab.$ = Laboratory