Fluid Mechanics and Heat Transfer

Advances in Nonlinear Dynamics Modeling

Kaveh Hariri Asli, PhD
Soltan Ali Ogli Aliyev, DSc

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LIST OF ABBREVIATIONS

ACQ	Ammonium Copper Quat
CCA	Chromated Copper Arsenate
CFD	Computational Fluid Dynamics
CV	Control Volumes
DNS	Direct Numerical Simulation
EDL	Electric Double Layer
FD	Finite Differences
FE	Finite Elements
FEM	Finite Element Method
FSP	Fiber Saturation Point
FV	Finite Volume
FVM	Finite Volume Method
GIS	Geography Information Systems
LES	Large Eddy Simulation
MC	Moisture Content
MR	Moisture Ratio
MOC	Method of Characteristics
PDE	Partial Differential Equation
PLC	Program Logic Control
RANS	Reynolds-Averaged Navier-Stokes
RE NO	Reynolds Number Magnitude
RMS	Root-Mean-Square
RTC	Real-Time Control
SGS	Sub Grid-Scale
VCF	Velocity Correction Factor
WCM	Wave Characteristic Method

LIST OF SYMBOLS

A	cross-sectional area
a_l	thermal diffusivity
B	universal gas constant
C	velocity of Surge wave
C_1	pipe support coefficient
C^-	characteristic lines with negative slope
C^+	characteristic lines with positive slope
D	diameter of pipe
D_b	bound water diffusion coefficient
D_v	water vapor diffusion coefficient
Dh	hydraulic diameter
D_{bt}	wood and the vapor diffusion coefficient
d	outer diameter of pipe
dp	static pressure rise
dV	incremental change in liquid volume with respect to initial volume
$(d\rho/\rho)$	incremental change in liquid density with respect to initial density
E	modulus of elasticity for pipeline material Steel
E_P	pipe module of elasticity
E_W	module of elasticity of water
f	angular frequency
g	acceleration of gravity
h_p	head gain from a pump
h_L	combined head loss
h_0	ordinate denotes the free surface of liquid
H_P	surge wave head at intersection points of characteristic lines
H_{ri}	surge wave head at right hand side of intersection points of characteristic lines
H_{le}	surge wave head at left hand side of intersection points of characteristic lines
H_1	channel height
H_2	total height

J_{vf}	water vapor flow flux
J_f	liquid free water flow flux
K_l	specific permeability of liquid water
K	wave number
K_g	superficial gas permeability
K_r	relative permeability
K_w	conductivity of water
K_{cw}	conductivity of cell wall substance
k	volumetric coefficient
$k_{**}(\omega)$	damping vibrations in length
L	length of specimen parallel to the direction of flow
Lh	heated length
M_w	molecular weight
M_{Cr1}	first critical moisture content
M_{Cr2}	second critical moisture content
N_v	moisture flux
n_i	number of moles
n_{param}	number of parameters
$\overline{P}$	average pressure across the specimen
P_{sat}	saturated vapor pressure
P	surge pressure
p_c	capillary pressure
q	heat flux
R	radius
R_0	radiuses of bubble
SG	specific gravity
T	period of motion
T_k	kelvin temperature
T_P	pipe thickness
T_v	temperature of mixture
T_{in}	inlet temperature
T_{max}	maximum temperature
t	time
u	fluid velocity
V	volume
V_P	surge wave velocity at pipeline points-intersection points of characteristic lines

V_{ri} Surge wave velocity at right hand side of intersection points of characteristic lines
V_{le} Surge wave velocity at left hand side of intersection points of characteristic lines
V_0 liquid with an average speed
v fluid dynamic viscosity
W_2 substrate width
x water transfer distance
Y_{max} Max. Fluctuation
Z elevation

GREEK SYMBOLS

ΔH_{wv} water evaporation
ΔT overheating of the liquid
ΔP pressure difference between ends of specimen
δ wall thickness
χ water transfer distance
λ wavelength
λ_l coefficient of thermal conductivity
ρ'i density component of mix of steam in a bubble
ρ_S basic density of wood
ρ_s density of wood
ρ_v vapor density
$\partial p_c/\chi$ capillary pressure gradient
ρ_v, μ_v density and viscosity of water vapor respectively
$\partial p_V/\partial\chi$ vapor partial pressure gradient
Φ function of frequency and wave vector
μ_i molecular weight
μ_l viscosity of liquid water
ω wave number
σ surface tension coefficient of liquid
ψ relative humidity

PREFACE

It is with great sense of gratitude and humility that we take this blessed moment to offer this edition of *Fluid Mechanics and Heat Transfer: Advances in Nonlinear Dynamics Modeling*. The challenge presented for the success of this volume, coupled with our objective to enhance its reference value and widen its scope, motivated us to reach out and draw upon the recognized expertise on fluid mechanics and heat transfer. In addition, we directed our synergetic efforts to enhance the contents of the volume to include the latest advances and developments in the field of fluid mechanics and heat transfer and related technologies.

Fluid Mechanics and Heat Transfer is unique because it covers topics related to the subject that are not covered in any other book. The inclusion of metric and/or SI units along with US customary units is intended to accommodate the growing needs of the shrinking world and the realities of the international market. The book includes the research of the authors as well as the development of optimal mathematical models.

The authors present the subject means of theoretical and experimental research and use modern computer technology and mathematical methods for analysis of nonlinear dynamic processes. The book attempts to provide as wide coverage as possible on those technologies applicable to both fluid mechanics and heat transfer problems. The methods and technologies discussed are a combination of physical, mechanical, and thermal techniques. This research collection develops a new method for the calculation of mathematical models by computer technology. The process of entering input for the calculation of mathematical models was simplified for the user through the use of mechanical systems. The authors used parametric modeling techniques and multiple analyzes for mechanical systems.

Incorporated into each chapter are sidebar discussions. These highlighted boxes contain information and facts about each subject area that will help to emphasize important points to remember and will assist plant managers in training technical staff, especially in training operators on the specific technologies relied upon in their operations. In addition there is a glossary of several hundred terms at the end of the book. This will prove

useful to you not only when reading through the chapters but as a general resource reference.

The authors believe that the results of this handbook of research can lead to new ideas and can help to reduce the risk of system damage or failure of mechanical systems. It is the authors' experience in teaching that the subject matter as presented in this volume is best suited for students with at least three years of engineering education under their belts, and the book will also serve as a valuable reference for plant managers and training technical staff in the field of fluid mechanics and heat transfer and related technologies.

— Kaveh Hariri Asli
Soltan Ali Ogli Aliyev

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