Available online at www.sciencedirect.com

ScienceDirect

International Journal of Refrigeration 30 (2007) 1004–1017

REVUE INTERNATIONALE DU FROID
INTERNATIONAL JOURNAL OF
refrigeration

www.elsevier.com/locate/ijrefrig

Assessment of boiling heat transfer correlations in the modelling of fin and tube heat exchangers

J.R. García-Cascales[a,*], F. Vera-García[a], J.M. Corberán-Salvador[b],
J. Gonzálvez-Maciá[b], David Fuentes-Díaz[b]

[a]*Thermal and Fluid Engineering Department, Universidad Politécnica de Cartagena, 30202 Murcia, Spain*
[b]*Applied Thermodynamics Department, Universidad Politécnica de Valencia, Spain*

Received 4 September 2006; received in revised form 7 November 2006; accepted 9 January 2007
Available online 18 January 2007

Abstract

A new way to assess the performance of refrigeration system models is presented in this paper, based on the estimation of cycle parameters, such as the evaporation temperature which will determine the validity of the method. This paper is the first of a series which will also study the influence of the heat transfer coefficient models on the estimation of the refrigeration cycle parameters. It focuses on fin and tube evaporators and includes the dehumidification process of humid air. The flow through the heat exchanger is considered to be steady and the refrigerant flow inside the tubes is considered one-dimensional. The evaporator model is discretised in cells where 1D mass, momentum and energy conservation equations are solved by using an iterative procedure called SEWTLE. This procedure is based on decoupling the calculation of the fluid flows from each other assuming that the tube temperature field is known at each fluid iteration. Special attention is paid to the correlations utilised for the evaluation of heat transfer coefficients as well as the friction factor on the air and on the refrigerant side. A comparison between calculated values and measured results is made on the basis of the evaporation temperature. The experimental results used in this work correspond to an air-to-water heat pump and have been obtained by using *R*-22 and *R*-290 as refrigerants.

Keywords: Refrigeration; Air conditioning; Heat exchanger; Finned tube; Survey; Correlation; Boiling; Heat transfer; Comparison; Experiment

---

Evaluation des corrélations de transfert de chaleur lors de l'ébullition dans la modélisation des échangeurs de chaleur du type tube aileté

Mots clés : Réfrigération ; Conditionnement d'air ; Échangeur de chaleur ; Tube aileté ; Enquête ; Corrélation ; Ébullition ; Transfert de chaleur ; Comparaison ; Expérimentation

---

* Corresponding author. Tel.: +34 968 325 991; fax: +34 968 325 999.
E-mail address: jr.garcia@upct.es (J.R. García-Cascales).

0140-7007/$35.00 © 2007 Elsevier Ltd and IIR. All rights reserved.
doi:10.1016/j.ijrefrig.2007.01.006

Nomenclature

A	cross section area (m^2)
A_o	total surface area
$A_{p,o}$	outer surface area of tubes
$A_{T_{ji}}$	extended surface area
b_w	slope of i vs. T curve
C_p	specific heat (J/kg K)
C_F	function of the molar weight
CV	$G[(x^2/\rho_g\alpha)+((1-x)^2/\rho_f(1-\alpha))]$
D	diameter (m)
D_c	fin collar outside diameter ($D_o+2\delta_f$)
D_h	hydraulic diameter (m)
D_o	tube outside diameter
e	wall thickness (m)
$f()$	set of equations
f	friction factor
f_1, f_2, f_3, f_4	friction factor coefficient in air side correlation
$F()$	general function
F_1, F_2, F_3	friction factor coefficient in air side correlation
F_p	fin pitch
g	gravity (m/s^2)
G	mass velocity (kg/s m^2)
i	enthalpy (J/kg)
j	Colburn factor
k	thermal conductivity (W/m K)
$\dot{m}$	mass flow rate (kg/s)
N	number of tube rows
Nu	Nusselt number
p	pressure (Pa)
P	perimeter (m)
$P_1, P_2, P_3, P_4, P_5, P_6$	Colburn factor coefficients
P_l	longitudinal pitch
P_t	transverse tube pitch
Pr	Prandtl number
q	heat flux (W/m^2)
Q	heat (W)
R	thermal resistance
Re	Reynolds number
S	slip ratio
T	temperature (K)
u	velocity (m/s)
W	humidity (kg vap/kg dry air)
x	vapour quality
z, y	spatial co-ordinates (m)

Greeks

α	heat transfer coefficient (W/m^2 K)
α_c	convection heat transfer coefficient (W/m^2 K)
α_D	convection mass transfer coefficient (W/m^2 K)
δ	film thickness
δ_f	fin thickness
Δ	Increment
ϵ	void fraction
η	dynamic viscosity (Ns/m^2)
η_T	extended surface efficiency
∇^2	Laplacian operator
Φ_f^2	2-phase fric. multiplier
ϕ, φ	generic variable
ϕ	friction multiplier
ρ	density (kg/m^3)
σ	surface tension
θ	angle characterising the volume occupied by the vapour phase

Subscripts and superscripts

a	air
cb	convective boiling
cri	critical
eq	equivalent
f	saturated liquid (liquid phase)
g	saturated vapour (vapour phase)
GO	vapour only
i	inlet, cell index
j	cell index
LO	liquid only
mom	momentum
nb	nucleate boiling
o	outlet, cell index
PB	pool boiling
r	refrigerant
s	saturation
tp	two-phase flow
VO	vapour only
w, W	wall
wat	water
0	reference value
*	reduced parameter

1. Introduction

In this paper, a new way to assess the goodness of published boiling heat transfer correlations for horizontal tubes in fin and tube evaporators calculations is presented.

Normally when a model for fin and tube evaporators is based on cell discretisation, the uncertainties associated with the heat transfer coefficients in both sides overcome those associated with the modelling assumptions. It is also usual to find that the modeller doubts about the application