A COMPUTATIONAL MODEL FOR TWO-PHASE EJECTOR FLOW

by

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(ABSTRACT)

A CFD model to simulate two-phase flow in refrigerant ejectors is described. This work is part of an effort to develop the ejector expansion refrigeration cycle, a device which increases performance of a standard vapor compression cycle by replacing the throttling valve with a work-producing ejector. Experimental results have confirmed the performance benefit of the ejector cycle, but significant improvement can be obtained by optimally designing the ejector. The poorly understood two-phase, non-equilibrium flow occuring in the ejector complicates this task.

The CFD code is based on a parabolic two-fluid model. The applicable two-phase flow conservation equations are presented. Also described are the interfacial interaction terms, important in modelling non-equilibrium effects. Other features of the code, such as a mixing length turbulence model and wall function approximation, are discussed. Discretization of the equations by the control volume method and organization of the computer program is described.

Code results are shown and compared to experimental data. It is shown that experimental pressure rise through the mixing section matches well against code results. Variable parameters in the code, such as droplet diameter and turbulence constants, are shown to have a large influence on the results. Results are shown in which an unexpected problem, separation in the mixing section, occurs. Also described is the distribution of liquid across the mixing section, which matches qualitative experimental observations. From these results, conclusions regarding ejector design and two-phase CFD modelling are drawn.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

x	axial distance
r	radial distance
$\bar{x}$	body fitted coord. system axial distance
$\bar{r}$	body fitted coord. system radial distance
r_t	top boundary of domain
r_b	bottom boundary of domain
r_t'	slope of top boundary
r_b'	slope of bottom boundary
u	axial velocity
uu	upstream axial vel.
v	radial velocity
vu	upstream radial velocity
P	pressure
T	temperature
α	void fraction
h	enthalpy or convection coefficient
h_{fg}	latent heat
d	droplet/bubble diameter
ρ	density
μ	viscosity
σ	surface tension
k	conduction coefficient
c_p	specific heat
β	coefficient of thermal expansion
τ_w	wall shear stress
l_m	mixing length

κ turbulence constant

κ_o turbulence constant

A turbulence constant

C_o turbulence constant

C_d drag coefficient

We_{crit} critical Weber number to find size of droplets/bubbles

D pipe diameter

F interfacial drag force

M interfacial momentum transfer due to mass transfer

Γ interfacial mass transfer (evaporation/condensation)

E_{ht} interfacial heat transfer

E_{mt} interfacial thermal energy transferred due to mass transfer

E_{ke} interfacial kinetic energy transferred due to mass transfer

E_{wt} interfacial work transfer

Re Reynold's number resulting from non-dimensionalization

Pr Prandtl number resulting from non-dimensionalization

Ec Eckert number resulting from non-dimensionalization

RINTE

RINTW

RINT2N

RINT2S

RINT4N

RINT4S

RINT3M Area/volume terms in body fitted coordinate system subscripts/superscripts

c, cont	continuous phase
d, disc	discontinuous phase
int	interfacial
l	liquid
v	vapor
m	mixture
r	relative
s	saturated
t	turbulent
1	first phase
2	second phase
e	east face of control volume
w	west face
n	north face
s	south face