

**A COMPUTATIONAL MODEL FOR
TWO-PHASE EJECTOR FLOW**

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Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY
in
Mechanical Engineering

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January 29, 1997

Blacksburg, Virginia

Key Words: CFD, Non-equilibrium, Refrigeration, Two-fluid, Jet

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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 occurring 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.

ACKNOWLEDGEMENTS

I would first like to thank the individual who made this project possible and my advisor throughout my entire time as a graduate student, Dr. Alan A. Kornhauser. His patient guidance and insight into a poorly understood topic proved to be invaluable. He has contributed more to my engineering education than any other single individual, and in the process taught me what independent research is all about.

I would also like to thank my advisory committee, Drs. Nelson, Telionis, Thomas, and Vick. My meetings with them were always educational and they often provided me with a much needed reality check for what I was attempting to do. Dr. Nelson and Dr. Vick are also thanked for teaching background courses without which I could not have undertaken the project described here.

Special thanks also go to Drs. Ganeshan, Joan Moore, and Nelson for taking time out to advise me individually during the course of my work. There were many occasions when I was having trouble seeing the next step and they gave me the push I needed to continue on my own.

Thanks go to Calmac, Inc., our industrial partner and sponsor of this research. Their financial assistance and technical expertise proved indispensable in getting the EERC project launched. The Department of Commerce - Advanced Technology Program is thanked for providing the bulk of the financial assistance for the EERC project in its later years.

Finally, thanks go to my colleagues and friends who have worked with me on this project. Greg Harrell, Mike Alexandrian, Tommy Bunch, Kristoffer Ogebjer, and Håkan Snis

provided me with useful data and insight into two-phase ejector modelling. They also proved to be great lab companions during our work breaks.

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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_0	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