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Ejector performance analysis under overall operating conditions considering adjustable nozzle structure

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Highlights

- A theoretical model was proposed to ejector performance evaluation in both double and single choking conditions.
- The method of characteristics is incorporate to consider the driving flow expansion process.
- Performance of ejector equipped with both fixed and variable-nozzle can be accurately predicted.
- The theory contribute to the application of unstable energy resources to ejectors.

Abstract

The variable-geometry ejector (VGE) is feasible for unstable heat-source utilization; the ejector can be adjusted to its design point to obtain high efficiency. Moreover, as the adjustable nozzle in the VGE significantly affects the performance of the ejector, a theoretical model is necessary to evaluate VGE performance. In this study, a two-dimensional theoretical model was proposed based on an adjustable-nozzle theory. Method of characteristics was employed to accurately predict the driving-flow development in the mixing section. In addition, the suction-flow velocity distribution on the effective area was considered. The proposed model was validated by employing the data from literature and additional experimental data obtained from a VGE test setup using R134a. The validation result shows that the proposed model predicts the ejector performance accurately; moreover, the model is more adaptive while the nozzle configuration changes. The theoretical model, proposed herein, is practical for the design and application of the VGE.

Keywords: variable-geometry ejector, nozzle configuration, theoretical model, Mach wave

Nomenclature

Notations		subscripts	
A	Area, m^2	b	Ejector outlet
a	Local sonic velocity, m s^{-1}	d	Driving flow
d	Diameter, m	e	Nozzle exit
F	Gas dynamic function	ev.	Evaporator
M	Mach number	gr.	Generator
m	Mass flow rate, kg s^{-1}	m	Mixing section
n_d	Velocity-distribution factor	s	Suction flow
P	Pressure, MPa	t	Nozzle throat
r	Radius, m	y	Effective area
T	Temperature, °C		
u	Axial-velocity component, m s^{-1}	Abbreviations	
v	Radial-velocity component, m s^{-1}	AR	Area ratio
w	Entrainment ratio	PR	Pressure-recovery ratio
		FR	Factor that decides the driving-flow condition
Greek letters			
η, ϕ	Efficiency factors		
σ	Nozzle opening		
λ, θ, β	Angles		

1. Introduction

1.1 Ejector theory

Recently, ejector-refrigeration systems have received a renewed attention (Elbel and Lawrence, 2016) because of their potential to utilize clean energy resources, such as solar or waste heat. Several advantages—simple design, low