PREDICTION OF STEAM EJECTOR PERFORMANCE IN REFRIGERATION APPLICATION BY USING COMPUTATIONAL FLUID DYNAMICS

MR. TONGCHANA THONGTIP
ID: 51910416

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING
IN ENERGY TECHNOLOGY AND MANAGEMENT

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

1ST SEMESTER 2010

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Topic Prediction of Steam Ejector Performance in Refrigeration Application by Using Computational fluid dynamics

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Abstract

A steam jet refrigeration cycle is one of the distinctive appliances that can be used the low grade thermal energy (100°C-200°C) to produce useful refrigeration. However, the drawback of this cycle is its relatively low COP when compared to the other types of refrigeration cycle. Past researches showed that the, system's COP is dependent on the ejector. Therefore, performance and design of the ejector must first be considered. The clear understanding of the flow behavior and mixing process inside the ejector are necessary. Currently, due to the rapid development of computational fluids dynamics (CFD technique), the flow behavior and mixing process inside the ejector can be proposed graphically by the filled contour of Mach number. This helps to improve the ejector's performance efficiently.

The aim of this study is to investigate the performance of an ejector used in a steam jet refrigeration cycle. The steam ejector's performance was investigated experimentally and numerically (using CFD technique) at various operating conditions (boiler saturation temperature, evaporator saturation temperature, and condenser pressure) and various primary nozzle's throat size. Performance of the steam ejector was evaluated in the term of an entrainment ratio and a critical condenser pressure. In the experimental part, the experimental steam jet refrigerator was tested to provide the actual steam ejector's performance. Meanwhile, in the numerical part, two commercial CFD software packages, Gambit 2.3 and FLUENT 6.3 were used to develop the ejector model and to provide the simulated steam ejector's performance. Two turbulence viscosity model, relizable k-ε and k-ω-sst were used. The simulated results were validated with the experimental results to ensure that the ejector model was correctly developed. The simulated results showed the similarities in the ejector's performance characteristics were found to be not more than 10% when compared to the actual values.

Graphical contours of Mach number obtained from CFD technique were employed to explain the flow behavior and mixing process inside the ejector. It was used to explain the effect of interested parameter on the ejector's performance. It found that the entrainment ratio was related to the size of converging duct and a critical condenser pressure was related to the location of 2nd series of oblique shock.

Overall, it can be concluded that the CFD technique is an efficient tool in predicting the steam ejector's performance. In addition, it also provides a better understanding of the flow and mixing process inside the ejector.

Keywords: Jet refrigeration cycle, Ejector, Heat-powered refrigeration cycle, COP, Flow visualization, CFD.

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COP	Coefficient of performance	
CFD	Computational Fluid Dynamics	
Rm	Entrainment ratio	
$\dot{Q}$	Heat load or cooling load	kJ/s
$\dot{m}$	Mass flow rate	kg/s
$\dot{W}$	Work	kJ/s
NXP	Primary nozzle's exit position	mm
P	Primary fluid or Pressure	
S	Secondary fluid	
h	Enthalpy	kJ/kg
s	Entropy	kJ/kg.k
1,2,3,4,5,6,7	State of refrigerant in the jet refrigeration	

SUBSCRIPTS

cond	Condenser
evap	Evaporator
boil	boiler
mix	Mixing chamber
surr	Surrounding (ambient condition)
pump	Liquid pump
o	Stagnation point
f	Saturated liquid
g	Saturated vapour