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The performance of steam ejector refrigeration system based on alternative analysis

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Abstract

The performance of a steam ejector refrigerator was analyzed based on an "alternative analysis". The alternative analysis reflects an actual operation of an ejector refrigerator. In this analysis, the evaporator saturation temperature associated with cooling load was varied while the boiler saturation temperature and the condenser pressure were fixed. Form this test, the critical evaporator temperature was determined. The critical evaporator temperature is the lowest point that ejector still operated under choked flow condition. A 1 kW experimental ejector refrigerator was constructed. Variation of operating conditions and primary nozzles were implemented. It was found that the variation in operating conditions and the nozzle throat diameters significantly affected the critical evaporator temperature. Variation of condenser pressure had a strong effect on critical evaporator temperature Meanwhile the entrainment ratio in the choked flow condition was independent of the condenser pressure. The critical evaporator temperature decreased with increasing the condenser pressure and vice versa. Variations of the boiler saturation temperature and the primary nozzle throat diameter affect the mass flow of primary fluid. Either increasing the boiler saturation temperature or the primary nozzle throat diameter, the mass flow of primary fluid increased. When the primary fluid mass flow was increased, the critical evaporator temperature was reduced. On the other hand, entrainment ratio in the choked flow condition decreased. However, if the primary fluid mass flow was increased to a certain value, evaporator temperature didn't decrease as expected.

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Keywords: Ejector,:Refrigeration: Entrainment ratio

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1. Introduction

Among the heat powered refrigeration systems, the ejector refrigeration system is seem to be the most feasible system due to its simplicity and low capital cost. The ejector refrigeration system also has a few moving parts, so it requires low maintenance and has long lifetime. However, the coefficient of performance (COP) of the ejector refrigeration system is relatively low. Therefore, the study to understand and improve the system is needed in order to make it competitive with other refrigeration systems.

Most of previous studies, performance of the ejector refrigeration system is usually described by the traditional performance curve as shown in Fig.1a. To implement this condition, this make possible only by conducting the experiment in laboratory.

To make more clarification in an actual operation of ejector refrigerator, some researchers were proposed the alternative way to study the system performance which is called "alternative analysis" [1-3]. The typical performance curve based on alternative analysis is shown in Fig. 1b. In this analysis, the evaporator saturation temperature associated with cooling load of the ejector refrigerator is varied while the condenser pressure, and the boiler saturation temperature (T_{boiler}) are fixed. The mass entrainment ratio (Rm), which is the ratio of secondary mass flowrate to primary mass flowrate, is measured with variation of evaporator saturation temperature. By means of implementation, the critical evaporator temperature ($T_{cri,evap}$) can be determined. This particular point indicates the lowest possible evaporator saturation temperature that the system can operate at desired condition (choked flow of secondary fluid). The comparison of alternative analysis and traditional analysis is in Table 1. Both performance curves can be divided into three regions; Choked flow, Unchoked flow, and Reverse flow. The principle of these three regions were well described in the previous work by Thongtip [1]

In this study, a 1kW experimental steam ejector refrigerator was designed and constructed. The performance of the experimental steam ejector refrigerator was analyzed based on alternative analysis. The ejector refrigerator was tested with various primary nozzle geometries and operating conditions. Three primary nozzles were used. The results showed that the operating conditions and nozzle geometries have strong effect to the ejector performance.

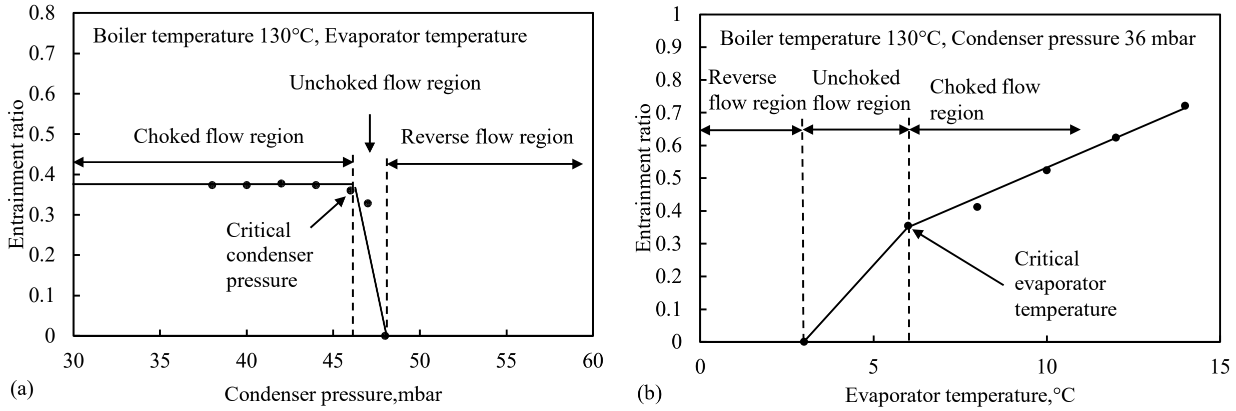

Fig. 1. (a) Typical performance curve based on traditional analysis; (b) Typical performance curve based on alternative analysis.

Table 1. Comparison of alternative analysis and traditional analysis.

	Boiler saturation temperature	Condenser Pressure	Evaporator saturation temperature	Expected parameter
Alternative	Fixed	Fixed	Varied	Critical evaporator temperature
Traditional	Fixed	Varied	Fixed	Critical condenser pressure