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Ejector refrigeration: A comprehensive review

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ABSTRACT

The increasing need for thermal comfort has led to a rapid increase in the use of cooling systems and, consequently, electricity demand for air-conditioning systems in buildings. Heat-driven ejector refrigeration systems appear to be a promising alternative to the traditional compressor-based refrigeration technologies for energy consumption reduction. This paper presents a comprehensive literature review on ejector refrigeration systems and working fluids. It deeply analyzes ejector technology and behavior, refrigerant properties and their influence over ejector performance and all of the ejector refrigeration technologies, with a focus on past, present and future trends. The review is structured in four parts. In the first part, ejector technology is described. In the second part, a detailed description of the refrigerant properties and their influence over ejector performance is presented. In the third part, a review focused on the main jet refrigeration cycles is proposed, and the ejector refrigeration systems are reported and categorized. Finally, an overview over all ejector technologies, the relationship among the working fluids and the ejector performance, with a focus on past, present and future trends, is presented.

Contents

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1. Introduction

The increasing demand for thermal comfort has led to a rapid increase in cooling system use and, consequently, electricity demand due to air-conditioning in buildings [1]. Deployment of thermal energy refrigeration, using low-grade heat or solar energy, would provide a significant reduction of energy consumption [2–6]. Among the various technologies for thermal refrigeration, heat-driven ejector refrigeration systems (ERSs) seem a promising alternative to the traditional compressor-based technologies owing to their reliability, limited maintenance needs and low initial and operational costs. Moreover, ERSs may help in the reduction of greenhouse effect emissions through both saving in primary energy and avoidance of environmental harmful refrigerants [7,8]. Nevertheless, ejector refrigeration has not been able to penetrate the market due to its low performance coefficient and severe degradation in performance when not operating under idealized design conditions [9].

In the existing literature, different reviews on ejector technologies have been presented [10–23]. All of the previous reviews are focused on a particular aspect or aspects of ejector refrigeration, whereas the goal of the present review is to propose a comprehensive view of all ejector refrigeration technologies and the impact of working fluids on their performance. This review has four main parts that each have sub-sections. In the first part, ejector technologies are described. In the second part, a detailed description of refrigerant properties and their influence over ejector performance is presented. In the third part, a review focused on the main jet refrigeration cycles is proposed and analyzed. This section is divided into eight subsections and covers all of the main refrigeration technologies presented in the literature (Fig. 1): the concepts and main aspects of each study have been described in detail and linked to other studies. Finally, an overview is presented covering all of the ejector technologies, the relationships between working fluids and ejector performance, with a focus on past, present and future trends.

2. Ejectors technology

2.1. Technology

An ejector is a simple component: a primary flow enters into a primary nozzle accelerating and expanding entraining a secondary flow entering from a suction chamber. The flows mix and a diffuser compresses the stream (Fig. 2).

2.2. Ejector classification

An ejector can be classified by (i) the nozzle position, (ii) nozzle design and (iii) the number of phases, as outlined in Table 1. In the following paragraphs, these classifications will be detailed.