International Journal of Refrigeration 121 (2021) 1–9

Contents lists available at ScienceDirect

International Journal of Refrigeration

journal homepage: www.elsevier.com/locate/ijrefrig

Research Paper

A heat-powered ejector chiller working with low-GWP fluid R1233zd(E) (Part 1: Experimental results)

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ARTICLE INFO

Article history:
Received 19 February 2020
Revised 19 July 2020
Accepted 12 October 2020
Available online 14 October 2020

Keywords:
Ejector chiller
CRMC
R1233zd(E)
Experimental method
Drop-in low-GWP fluid

ABSTRACT

A prototype ejector chiller with nominal cooling power of 40 kW, designed according to the "CRMC" criterion, has been tested by our research group since 2011. The prototype has undergone several refinements and finally has been upgraded to R1233zd(E), which is non-flammable, has low-GWP and favourable thermodynamic properties, i.e. "dry-expansion" and moderate pressure at generator. In terms of saturation pressure curve, the new fluid is similar to R245fa, which was previously used in the prototype. Hence, R1233zd(E) has been basically used as a "drop-in" replacement. The ejector chiller was tested at different evaporation temperatures (2.5 to 10°C), typical of air conditioning applications. Saturation temperatures at generator from 95 to 105°C have been selected as representative of waste-heat recovery. The experimental findings prove that the CRMC ejector has a satisfactory performance with the new working fluid.

Un refroidisseur à éjecteur alimenté par la chaleur fonctionnant avec du fluide R1233zd(E) à faible PRP (Partie 1 : résultats expérimentaux)

Mots clés: Refroidisseur à éjecteur; Méthode de variation de la quantité de mouvement à vitesse constante (CRMC ou Constant Rate Momentum Change); R1233zd(E); Méthode expérimentale; Fluide de substitution immédiate à faible PRP

1. Introduction

Heat driven refrigeration plays a crucial role among the many options for waste heat recovery. Currently, the most successful technology for heat driven refrigeration is undoubtedly absorption. Alternative technologies are actively sought, but none of them seems a clear winner. Low cost, efficiency, flexibility and robustness are the most important issues for any competing technology. Ejector refrigeration may be promising under some of these respects and has been the main research topic of our research group since many years.

The idea of using ejectors to produce vacuum and hence low-temperature evaporation of water in order to perform a cooling effect is commonly credited to Leblanc (1912) and dates back to the first decade of the 20th century. Specific advantages of ejector refrigerators are mechanical simplicity, ability to work with "environmental friendly" refrigerants, low investment cost and relatively high efficiency in comparison with other heat operated refrigerators (Eames et al., 1995). A detailed account of heat-driven ejector refrigeration system analysis, design and operation is presented in Grazzini et al. (2018). A comprehensive review of studies has been offered in Besagni et al. (2016) and more recently in Aidoun et al. (2019). A discussion of the interaction between component and system efficiency is presented in Little and Garimella (2016).

Ejector refrigeration cycles replace the mechanical compressor by a liquid feed-pump, a vapour generator and a supersonic ejector. The ratio between cooling load and total heat and power inputs yields the Coefficient of Performance (COP), which summarizes the system performance:

$$COP = \frac{\dot{Q}_E}{\dot{Q}_G + \dot{W}_{pump}} = \frac{\dot{m}_s}{\dot{m}_m} \frac{\Delta h_E}{(\Delta h_G + \Delta h_{pump})}$$

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https://doi.org/10.1016/j.ijrefrig.2020.10.015
0140-7007/