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A heat-powered ejector chiller working with low-GWP fluid R1233zd(E) (Part2: Numerical analysis)

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ABSTRACT

This paper numerically investigates the performance of a high capacity, industrial ejector chiller working with the non-flammable, low GWP refrigerant R1233zd(E). The test procedures adopted to acquire the experimental data are explained in part 1 of this work. Different turbulence models were examined in order to accurately predict the ejector off-design transition and critical pressure. A peculiar difference has been noticed between the numerical results obtained when initializing the CFD simulation from the solution of a case with lower or higher condenser pressure. This difference may partly explain the difficulties in the accurate predictions of the critical conditions reported by this and other works in the literature. A detailed discussion is presented on the nature and possible cause of this phenomenon, which is identified as typical of non-linear fluid dynamics.

Un refroidisseur à éjecteur alimenté par la chaleur fonctionnant avec du fluide R1233zd(E) à faible PRP (Partie 2 : analyse numèrique)

Mots clés: Refroidisseur à éjecteur; R1233zd(E); CFD; Rénovation; Hystérésis

1. Introduction

The birth of the fourth generation of synthetic refrigerants was pushed by attention to global warming set forth by the Kyoto Protocol and by the newly enforced EU "F-gas" directive (European Commission 2017), which sets binding targets for greenhouse gas emissions. Many studies and review papers investigating the properties of these new refrigerants, termed Hydro-Fluoro-Olefins (HFOs) and featuring very low GWP, are available (Calm, 2008, Calm and Hourahan, 2011). Fang et al. (2017) presents a CFD analysis of the behaviour of two HFOs as replacements for R134a in an ejector heat-driven refrigeration cycle. A thermodynamic comparison involving various fluids including HFOs was presented in Milazzo and Rocchetti (2015), highlighting the good performance of R1233zd(E). Among many options, R1233zd(E) has been proposed as the drop-in refrigerant for the hydrofluorocarbon R245fa also in Yang et al. (2019) and Eyerer et al. (2019). Recently, preliminary experimental and numerical investigations were carried out in our lab to test the performance of this new refrigerant inside our ejector refrigeration system (Mahmoudian et al., 2019). The present work represents the prosecution of those investigations, yielding additional experimental results, presented in part 1 of this paper, and a CFD analysis based on these results, presented in this second part.

When considering the specific field of ejector refrigeration, CFD modeling has a relatively short history. The review paper by Matsuo et al. (1999) cited pioneering papers modeling shock trains like Carroll et al. (1993) and Yamane et al. (1995), although these works were not specific to ejector applications. Ejector computational investigations gathered more importance in the last decade, thanks to improved computational resources and the advent of advanced CFD software. Authors have focused their studies on the analysis of several numerical aspects among which turbulence models and 2D–3D approximations had a central role.

Pianthong et al. (2007) showed that there is no remarkable difference in wall pressure distribution along the ejector between the 2D and 3D approximation. Mazzelli et al. (2015) found good

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