Ph.D. THESIS REVIEW

Title:
Non-equilibriumtwo-phase model of transcritical CO_2 flow for ejector design in state-of-the-art refrigeration systems

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Review:
The PhD. Thesis developed by the doctoral candidate presents a very interesting work about modelling, validating, and proposing new design arrangements for a CO_2 ejector, taking into account the non-equilibrium two-phase effects on the motive flow. The quality of main publications that define the document, the summary of the developed work, and the author's contribution in additional publications about using ejectors in CO_2 refrigeration systems demonstrate the doctoral candidate's proficiency researcher and the excellent support of the supervisors in the development of this work.

This document revolves around the modelling and studying of the internal effects that define the ejector to improve its operations and provide an accurate design for its rear building and usage. This part is essential in this kind of element, especially in refrigeration systems such as supermarkets where the operating conditions depend on the cooling load and are quite variable. Furthermore, the ejector design focuses on carbon dioxide (CO_2) is considered a long-term refrigerant solution due to its excellent environmentally compatibility, low cost, and superior heat transfer properties. Therefore, this PhD Thesis follows a current topic.

Advanced CFD investigations with different calculation methods (turbulence models, two-phase flow models, cavitation model... etc.) define a high grade of knowledge in this specific area and the excellent usage of these methods. Regarding the results, the methodology followed to reach them is correct, and it is well-structured and presented in the document. Moreover, the results are solid and are corroborated with experimental tests in a refrigerating setup at the SUT University. Especial interest is focused on developing and studying the suction motion by-pass as a new arrangement to enhance the efficiency of the ejector and control it. This design seems very attractive for future developments, and it opens a new research line where not only CO_2 are applicable but also other natural fluids as hydrocarbons or ammonia.

One thing I missed reviewing this document is how this element affects the main energy parameters of a refrigerating plant, such as cooling capacity, power consumption, or even operating parameters such as evaporating and heat rejection pressures. However, this topic will be covered for sure in future analysis, so it does not affect the document's quality.

To sum up, considering the reviewed document, I recommend this work for the honours degree distinction of *summa cum laude*

Prof. Daniel Sánchez García-Vacas