ABSTRACT

In the regulation of a refrigeration system the expansion device have a fundamental role. The precise understanding of the way in which it works with different refrigerants is of crucial relevance in order to perform a precise design of these systems, as well as, to assist to its proper selection as a function of its capacity and the employed refrigerant.

This thesis presents on the one hand the experimental characterization of the mass flow rate through an expansion valve with three different refrigerants: R22 (HCFC) as reference; R290 (propane) as a natural refrigerant, and R410A (HFC), currently one of the most common refrigerants, in a wide range of operating conditions and for different valve lifts. On the other hand, the work also includes the study of the modeling of the refrigerant flow through the expansion valve, and the development of a model based on the flashing process, with sufficient predictive ability to determine the mass flow rate circulating through the expansion valve according to the upstream fluid conditions and the opening valve.

In order to determine accurately and precisely the minimum geometric area and the effective single-phase area of the expansion valve, it has been measured in the metrological center of UPV. In addition detailed hydraulic and pneumatic studies of the vale in two different test benches have been carried out.

The analysis of experimental results obtained for the three refrigerants has shown that the mass flow rate through the expansion valve is strongly dependent on the upstream pressure and the degree of subcooling, but also slightly dependent on the downstream pressure. For the range of typical operation of heat pump and refrigeration systems, unlike some studies in literature have observed, the first-stage choking phenomena was not observed in our case. Instead, all the obtained

results seem to be in the second-stage choking non-ideal flow. Obviously, the effect of the flow area on the mass flow is very important.

The developed model of mass flow rate through expansion valves is basically derived from the Bernoulli equation for incompressible single-phase flow through orifices from assuming that the flow at vena contracta section is almost entirely liquid. The pressure at the vena contracta section is determined from the correlations obtained by Alamgir et al. [1981] and Abuaf et al. [1983] for water depressurization in "flashing" type expansions, in which a sudden depressurization occurs and subcooled liquid passes to metastable liquid and finally to two-phase flow.

An adjustment coefficient, $C_{two\text{-}phase}$, was added to the model in order to take into account the effect of bubbles formation in the flow restriction, depending on the opening of the valve. This coefficient depends only on the flow area and it is close to the unit at high values of the flow area.

The obtained results were found to be in good agreement with the measured data with approximately 95% of the measured data falling within a relative deviation of ±7%.