Modeling and Analysis of Maldistribution and Thermohydraulic Oscillations of Low GWP Refrigerants in Plate Heat Exchanger Evaporator-Part 1

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Abstract:

Demand for refrigeration technology and heat pumps and therefore also for refrigerants is constantly increasing globally. The evaporator, as a key component of every refrigeration system, is of paramount importance in terms of energy efficiency, performance flexibility, safety and costs. During start-up and capacity modulation, additional measures must be taken to stabilize evaporation, such as oversizing or major overheating, which have a negative impact on energy efficiency and thus increase CO_2 emissions not only from refrigerant emissions but also from operation (TEWI - Total Equivalent Warming Impact). The aim of this research is to investigate the problem that existing evaporators have been developed and optimized for the refrigerants currently in use with a high GWP, but that optimized solutions for future "low-GWP" refrigerants with their significantly different evaporation properties are still missing. The objective is to develop a novel evaporation technology for low-GWP refrigerants based on compact and low-cost plate evaporators, which can offer a significantly more energy-efficient, more flexible and safer operation of compression refrigeration systems and heat pumps than the state of the art. Furthermore, uneven distribution of the mass flow and the phase fractions of the evaporating refrigerant lead to a reduction in performance, which has a negative impact on the energy efficiency of the overall process. A test facility consisting of refrigeration test bench is designed and developed on which the evaporation behavior of plate evaporators under stationary and transient load conditions can be analyzed in fully automated test series. System simulation software Dymola is used for Thermohydraulic system modeling using discrete-time simulation. A novel optical measuring method consisting of a light source, high speed cameras, an optical sensor for refrigerant liquid droplets detection and evaluation electronics that is suitable for characterizing the liquid components in two-phase refrigerant flows is designed and is integrated with the test bench.

Keywords:

Refrigerant Maldistribution, Thermohydraulic Oscillations, Plate Evaporator, Dymola, Optical Measurement.