CO2 PARTICULARITIES

CO2 is a novel refrigerant which is currently being benchmarked by the industry. As a consequence of the thermodynamic position of its critical point, a CO2 cycle can operate in transcritical mode, which represents many practical challenges and as discussed in this thesis, numerical challenges for simulation. A literature review of CO2 specific correlations is also carried out in this thesis.

NUMERICAL CHALLENGES RELATED TO COMBINED OPERATION

A. Adjustment of correlations
   1. Merging for multiple phases
   2. Merging for two operation modes (illustrated)
   3. Adjustment for combined operation, which includes the adoption of thermophysical properties at the critical point.

B. Zero-flow problem
   The zero-flow problem occurs for very low mass flow. It is due to the quadratic nature of the pressure drop-mass flow relationship, of which the derivative approaches zero when approaching zero mass flow. The problem was addressed through linearisation and the derivative control.

OPERATION MODE SWITCH

The control system design, which includes the IHX, allows both subcritical and transcritical modes. The control system is shown in red and blue. One could imagine a study of control mechanisms for operation mode switch.

PRESENTATION OF THE SYSTEM

The heat pump system data is obtained from [Jakobsen et al., 2004] which presents a residential reversible heat pump. The Modelica model is shown to the right. The red pipes are in use during heating and the blue pipes function while cooling. The control system is in black.

ARCHITECTURE AND CONTROL

Optimal control for transcritical and subcritical are different:

- Transcritical operation requires high side pressure control
- Subcritical operation relies on high side temperature control

Both include heat load control through compressor power adjustment.

The solution for which is opted in the control system design, is superheat control, which is a widespread solution. It allows control in both subcritical as well as transcritical operation but is not the optimal thermodynamic set up.

POSSIBLE APPLICATIONS

The model can be used for optimisation of internal heat exchanger length as illustrated by the above graph. The usage of an IHX is largely dependent on the refrigerant.

The above graph shows the system response for a change in setpoint. One could imagine a study of control mechanisms for operation mode switch.

VALIDATION

For validation of the heat pump, experimental data was compared to simulation data for both individual components as well as the heat pump as a whole. To illustrate the process, various physical quantities are assessed for three different components. To the very right is the validation of the total heat pump.