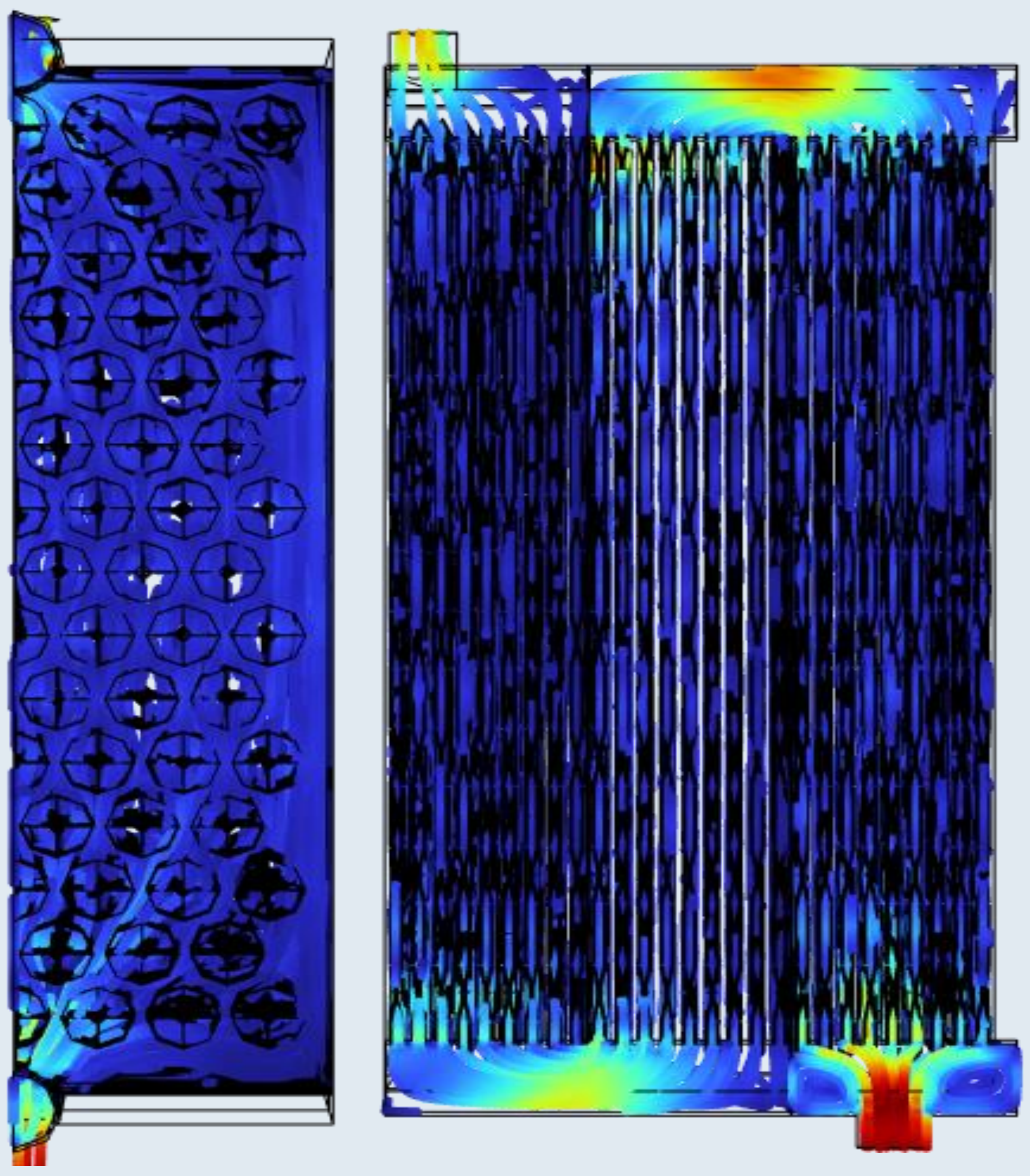

Simulation of a Heat Exchanger Operated with Supercritical Water Using COMSOL® Software

Optimization of the heat exchanger´s design and operating conditions

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Abstract

One interesting application of supercritical water is the recovery of materials and energy from aqueous wastes. iGas energy has developed a process that yields nutrients, as well as chemical energy stored contained aqueous wastes such as liquid manure, sewage sludge, etc. through supercritical water gasification (SCWG). As we provide simulation services for process engineering, especially hydrogen application we have delivered cutting-edge solutions for this process.

In the proximity of the critical point of water, a drastic change in the material properties in dependence of the temperature is observable. A corresponding material model was implemented and a sequence of plate heat exchanger was simulated. The goal is to gain understanding of how the phase change influences material and heat transport within the heat exchanger.

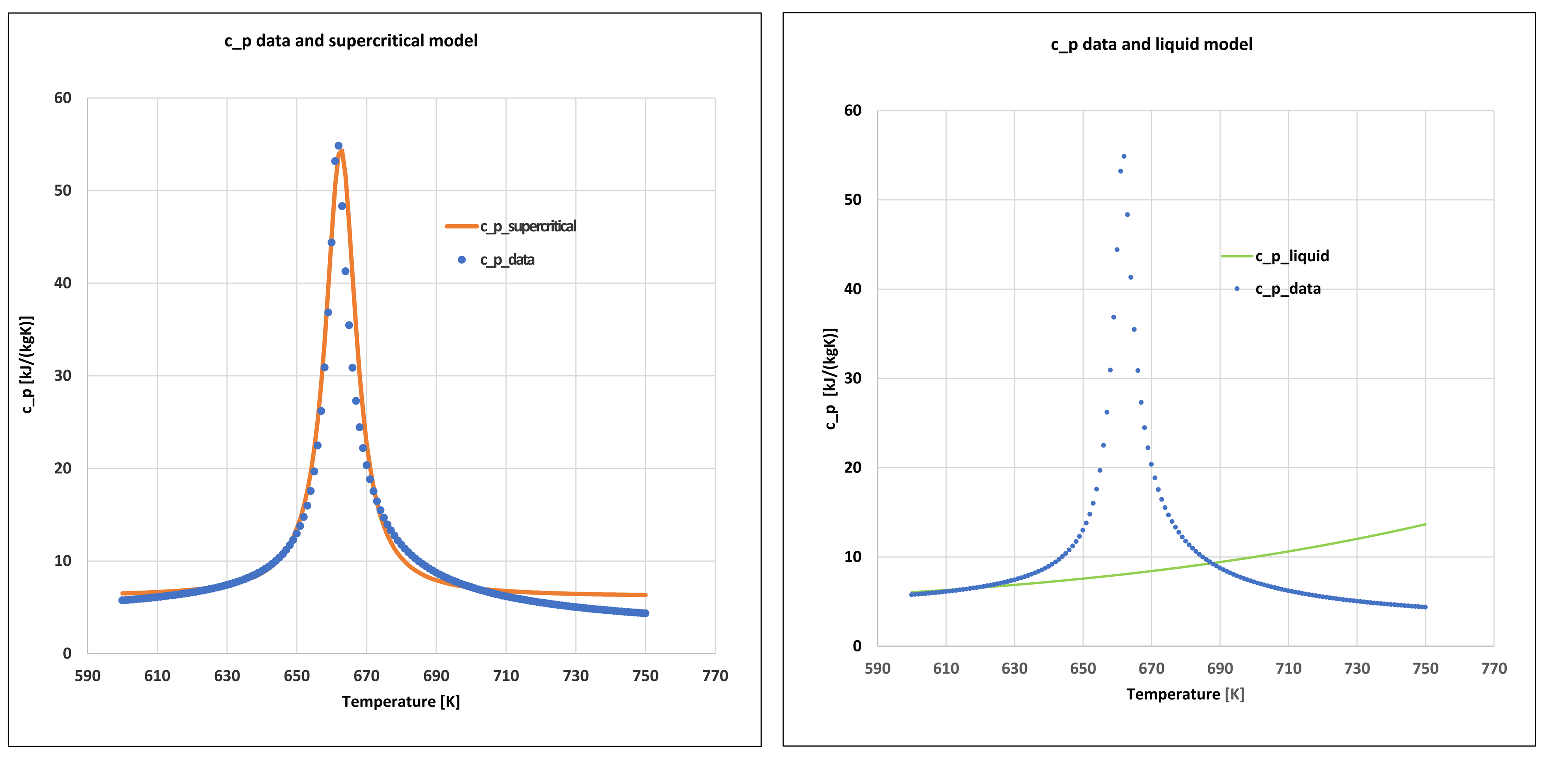

FIGURE1. Left: Illustration of the specific heat capacity fitted model in comparison to the data

Right: Illustration of the built-in liquid specific heat capacity model in comparison to the data

Methodology

The standard material library does not account for the exponential temperature dependent change in heat capacity, density and thermal conductivity near the critical point. Based on data from NIST non-linear models for those material properties were built and implemented within a simulation environment in order to calculate the heat and turbulent material flows. The data from the NIST database was fitted via the GRG solution method from Microsoft® Excel®.

The supercritical fluid was assumed to be a weakly incompressible flow. In order to improve convergence, a ramping method was applied.

Results

The counter-current plate heat exchanger simulation yielded the pressure and heat distributions as well as the velocity profile. The results allow for an analysis of the heat transfer efficiency, as well as ensuring that velocity limits are respected.

Two phenomena were observed. On one hand the occurrence of dead zones within the plates, thus not uniform flow, in addition to the unequal inflow of hot stream mass flow, lead to large discrepancies in terms of heat exchange.

Furthermore, the spike in heat capacity is visible at a temperature around 388 °C. The sudden rise in temperature in the cold stream leads to an undesired temperature level.

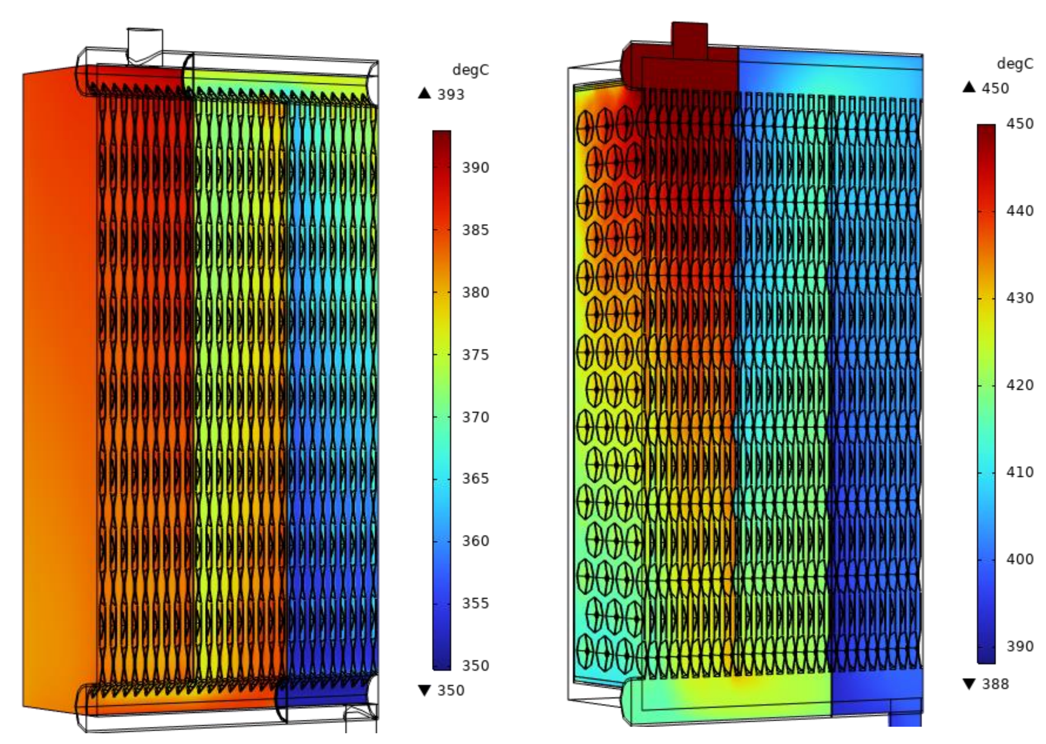

FIGURE 2. Left: Temperature profile of cold stream side

Right: Temperature profile of hot stream side

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