Development of a 1-Dimensional boiling model: Part I – A two-phase flow pattern map for a heavy hydrocarbon feedstock

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Nowadays, the use of heavy fossil fractions as steam cracker feed is growing. Consequently, fouling problems are extended to heat exchangers in the steam cracker convection section. In order to limit this fouling, the design and operating conditions of the different heat exchangers in the steam cracker convection section need to be optimized. One such heat exchanger in the convection section is the evaporator. Optimization of the evaporator based on CFD simulations is not possible in an acceptable time period. Therefore, the development of a 1-Dimensional boiling model will result in considerable speedup of evaporator simulations.

The numerous available 1D models to simulate heat transfer in a boiling flow are developed for refrigerants. Since, the operating conditions, geometry and feed properties in a convection section significantly differ from cooling applications, a new flow boiling model should be constructed. The boiling model is developed following the mechanistic method[1]. Parameters characterizing the flow pattern, e.g. liquid holdup, film thickness, etc. can be determined based on a flow regime map. Based on these parameters, the heat transfer coefficient can be calculated. In literature it is stated that such models are valid in the complete range of vapor qualities (0 to 1)[2]. The first step developing a mechanistic model is the construction of a flow regime map.

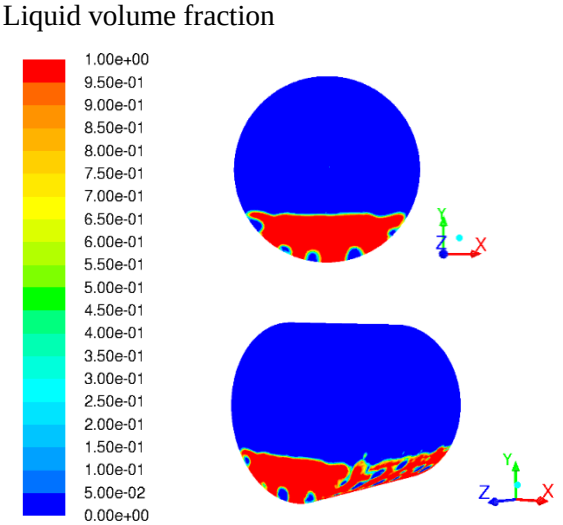

Figure 1. Simulation results of wavy flow

CFD modelling is done using the Volume-Of-Fluid model with a piecewise linear interface interpolation scheme. Combined with an evaporation model, an accurate description of the flow characteristics is obtained. In a first step regime maps for a heavy hydrocarbon component are constructed. Several CFD simulations for different combinations of wall temperature, vapor quality and mass flux are performed. The obtained regime maps show a good agreement with regime maps available in literature, thus validating the applied models. Similar regimes are observed, e.g. wavy flow illustrated in Figure 1.

After the construction of the flow regime map, the parameters characterizing the flow patterns are determined based on the results of the CFD simulations. These parameters are detrimental to calculate the required heat transfer coefficient.

References

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