

## Development of a 1D simulation model for a steam cracker convection section

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The radiant and the convection section of a steam cracker are thermally coupled by process gas and flue gas flow, illustrated by Figure 1. A correct simulation of the convection section is one of the essential requirements to fully optimize the cracker's operation, in particular when heavy liquid feeds are used. One of the consequences is an incomplete evaporation of the heavy tail leading to fouling problems. To locate the fouling problems an accurate model of the convection section describing evaporation and predicting inner tube wall temperatures is needed. In this work a 1D simulation model describing flow boiling and convective heat transfer is developed. Modeling both flue gas and process gas side allows a coupled simulation of the convection section.

At the process gas side both single and two phase (feed evaporation) flow need to be simulated. For the former, it is observed that the three most popular heat transfer correlations<sup>1-3</sup> give equal results. Heat transfer in the evaporating feed is more challenging to model. Models using empirical correlations, and mechanistic methods using feed-specific flow pattern maps considering flow regimes are applied. Modeling results are observed to differ, especially in the low and high vapor fraction range. In this work, these mechanistic models, for single component evaporation, are extended to model evaporation of a multicomponent mixture, based on its true boiling point curve. Since the models are not yet applied to complex mixtures, validation data is obtained by performing CFD simulations. CFD modeling is done using the VOF model combined with an evaporation model.

Heat transfer at the flue gas side is mainly due to convection. The convective heat transfer is calculated using the Zukauskas correlation<sup>4</sup> and an analytical method<sup>5</sup>. Given the typical layout of tube banks, Prandtl and Reynolds numbers are within the validity range of the correlation. No differences in simulation results are observed when using the two methods. In the last step, an iterative procedure is developed to couple the process gas and the flue gas side simulations.

The developed 1D model for the coupled simulation of a steam cracker convection section is validated using plant data. The results show that the applied heat transfer models are applicable over a wide range of operating conditions. A correct modeling of heat transfer in the evaporating hydrocarbon mixture is the main challenge to develop a reliable 1D simulation model for the convection section.

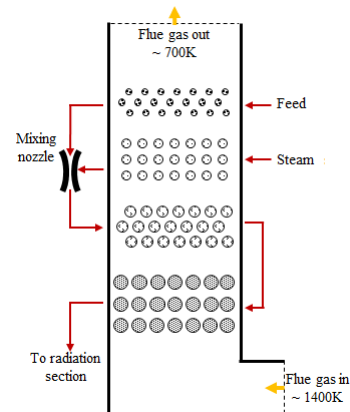


Figure 1: A schematic of the convection section

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