Understanding Heat Transfer and Complex Buoyancy-driven Circulation in Sulphur Condensers

Thomas Ralston, Abdulqadir Aziz Singapore Walla, Michel Van Vorselen, Kranji Solutions Pte. Ltd.

Abstract

Troubleshooting and Root Cause Failure Analysis (RCFA), of process equipment operations, is often hampered by an inability to measure all key quantities of interest. Frequently the only recourse is to utilise simulation techniques. The ease of use and accuracy of Computational Fluid Dynamics (CFD) continues to improve, however, successful CFD modelling frequently requires supporting analysis from process simulation and other analytical software.

When considering troubleshooting studies on process systems with similar complexity to that presented here, it is important to appreciate how different simulation and analysis techniques can complement one another in obtaining the necessary process insight.

Where the operator has not developed a simulation-based “digital twin” to properly characterise process streams and unit operations, it will be necessary to provide one. This may entail estimates and approximations needing verification. Here, commercial shell and tube heat exchanger modelling software was used in conjunction with the industry’s leading process simulator to benchmark thermal performance predictions against those of the original process licensor.

Plant data historian records were used to define Reference Operating Conditions (ROC) and these were modelled by a commercial exchanger modelling program. From this a set of Agreed Modelling Conditions (AMC) were defined, to account for process upsets. The AMC conditions provided flow, temperature, and pressure boundaries for CFD simulations.

CFD modelling was conducted for the process side system to establish the magnitude and impact of tube side maldistribution in the condensers. This was found to be modest and was demonstrated to have minimal impact on thermal behaviour.

CFD simulation of the shell side circulation system, including fully coupled heat transfer representation of both process side cooling and evaporation on the shell side was central to the studies. This revealed disruption of liquid recirculation was occurring within the shells, attributed to the way BFW was distributed within the shell.

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