Distilling Exergy Savings

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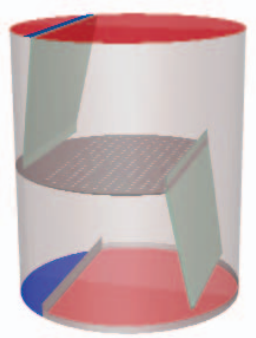
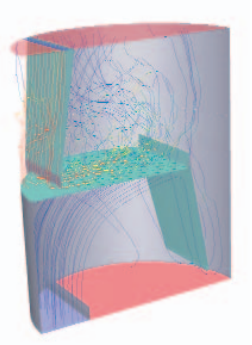
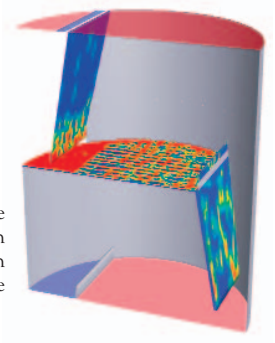
The diabatic distillation pilot plant



The geometry of one stage of the diabatic distillation tower



Pathlines, colored by liquid naptha volume fraction, illustrate the flow of the liquid and gaseous components: gas enters through the inlet at lower left, passes around the plate at right, and enters the upper region; liquid naptha enters through a slot inlet on the top left and drips down the left-hand plate onto the horizontal condenser plate



Contours of liquid naptha volume fraction show the liquid running down both vertical plates and collecting on the horizontal plate

IT IS NO SECRET that oil makes the world's economies go around. Because oil processing can be expensive, energy intensive, and detrimental to our environment, efforts to make the oil refining process cleaner and more efficient are ongoing at a number of research laboratories. At the Instituto Mexicano del Petroleo-Exergy Group, engineers have been focusing on distillation. At refineries, distillation is used to separate crude oil – a mixture of hydrocarbon compounds – into a number of constituents. Of particular interest to this group is diabatic distillation technology, whose benefit is measured in terms of exergy savings. Exergy, simply stated, is usable energy that can do work, and is a quantity that tends to decrease over time. It is emerging as an increasingly useful measure of efficiency as process improvements are considered throughout the refining industry [1].

In a classical adiabatic distillation tower, heat is supplied externally by means of a heater. As the exhaust vapors rise, the temperature drops and condensation occurs on plates positioned in stages at different heights. The condensed liquids are extracted separately, since condensation occurs at different temperatures for the exhaust constituents. Any remaining exhaust vapors exit after the uppermost condenser, carrying with them excess heat that is extracted externally by means of another condenser. In a diabatic distillation tower, heat is supplied or extracted not only by an external source or sink, but from process fluids inside the distillation process itself, which is why diabatic distillation is considered exergy efficient. There are a number of studies that support this technology for its future potential in the refinery industry worldwide [2, 3, 4].

A numerical and experimental study is currently underway to gain a better understanding of a diabatic distillation tower. In the first phase of the study, the isothermal flow of liquid and gaseous naptha is considered in a typical stage. The process simulation package ASPEN is used to generate gas and liquid mole fractions and flow rates at various zones within the stage. These are used as boundary conditions in a FLUENT calculation that makes use of the volume of fluid (VOF) model to track the motion of the two fluids on a mesh of 425,000 cells.

The early results have provided a clear view of where the liquid tends to collect on the plates within the stage, and they are serving as a basis for the first round of physical testing. Using the numerical results, proposals for modifications to the tower will be made and tested in a quicker, less expensive way than would be required if only experiments had been run. In the future, heat and mass transfer (condensation) will be included, and different diabatic designs will be compared numerically prior to fabrication, to save time and money. ■

References

1 United Nations Environment Programme. DTIE. hwww.uneptie.org/energy/act/wssd/index.htm

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3 Linnhoff, B., Polley, G.T. and Sahdev, V.: "General Process Improvements Through Pinch Technology", Chemical Engineering Progress, June 1988.

4 Rivero, R.: "L´Analyse d´Exergie: Application à la Distillation Diabatique et aux Pompes à Chaleur à Absorption", Thäse de Doctorat, Institut National Polytechnique de Lorraine, Nancy 1993.