SUMMARY
An engineering, procurement, and construction company needed to enhance the performance of a bank of API 661 air-cooled heat exchangers (ACHEs) at a refinery. HTRI was asked to optimize the installation of two new forced-draft ACHEs, which were to be appended to seven existing induced-draft ACHEs.

THE CHALLENGE
Mitigate the potential for hot air recirculation, which can reduce the performance of both the existing and new air coolers.

ACHEs are designed to cool process fluids inside the tubes with ambient air. As the air flows over the bundle, the temperature of the air rises. If this hot air leaving the ACHE is allowed to recirculate around the cooler, the effective air inlet temperature will increase, thereby reducing the cooling capacity of the heat exchanger. Hot air leaving an ACHE can either recirculate around the same unit or enter an adjacent ACHE. Thus, the ACHEs fail to meet the required end process conditions, which can mean a significant loss of revenue for the plant.

THE RESULTS
Several factors were found to affect the level of hot air recirculation. Computational fluid dynamics (CFD) simulations show that the air entering the ACHE had a greater maximum velocity than the air exiting the ACHE with insufficient ground clearance; winds also promoted hot air recirculation. In addition, the simulations revealed that the lateral spaces between the ACHEs and the variation in fan ground clearance provided obvious paths for hot air recirculation.

HTRI proposed solutions to eliminate hot air recirculation, such as
• allowing all fans to be at the same vertical elevation when adding the new ACHEs to the existing units
• implementing solid plate seals to close off short lateral gaps between the ACHEs
• adding wind walls and wind screens around the outer periphery of the ACHEs

Plan view drawing of multi-bay ACHEs. An ACHE’s natural operating environment often includes pipe racks, mechanical equipment, and other ACHEs. Such surroundings can affect the ACHE’s performance by up to 50% and cannot be accounted for in a simple, idealized design.
HTRI used CFD and Xace® software to determine the potential for hot air recirculation of an ACHE. Xace models of the forced-draft ACHEs were used to calibrate CFD simulations (i.e., Xace results were used to choose appropriate boundary conditions and submodels in the simulation).

The CFD results provided additional details (e.g., velocity vectors and temperature contours) that complemented Xace predictions. The combined approach made it possible to confidently assess the maldistribution.

The model used porous media to represent the finned portion of the tubes. To match Xace predictions, the model of the new ACHEs assumed an appropriately fixed pressure jump with fan swirl speed. The combination of these boundary conditions better mimicked the flow-static pressure behavior of normal fan performance curves.

HTRI simulated the ACHE with and without obstructions. After successfully simulating the single-bay unit, additional CFD simulations were conducted on a multi-bay air cooler. The lateral location, fan ground clearance, and wind speed and direction were varied in order to determine how each change augmented or diminished hot air recirculation. Finally, HTRI simulated wind walls and wind screens to see how they reduced hot air recirculation. The CFD simulations showed that closing gaps, maintaining same fan elevation, and adding winds walls and wind screens would help improve ACHE efficiencies.

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