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Heat exchanger network retrofit optimization involving heat transfer enhancement

Yufei Wang [a], Robin Smith [a,*], Jin-Kuk Kim [b]

[a] Centre for Process Integration, School of Chemical Engineering and Analytical Science, The University of Manchester, Manchester M13 9PL, UK
[b] Department of Chemical Engineering, Hanyang University, 17, Haengdang-dong, Seongdong-gu, Seoul, Republic of Korea

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ABSTRACT

Heat exchanger network retrofit plays an important role in energy saving in process industry. Many design methods for the retrofit of heat exchanger networks have been proposed during the last three decades. Conventional retrofit methods rely heavily on topology modifications which often result in a long retrofit duration and high initial costs. Moreover, the addition of extra surface area to the heat exchanger can prove difficult due to topology, safety and downtime constraints. Both of these problems can be avoided through the use of heat transfer enhancement in heat exchanger network retrofit. This paper presents a novel design approach to solve heat exchanger network retrofit problems based on heat transfer enhancement. An optimisation method based on simulated annealing has been developed to find the appropriate heat exchangers to be enhanced and to calculate the level of enhancement required. The physical insight of enhanced exchangers is also analysed. The new methodology allows several possible retrofit strategies using different retrofit methods be determined. Comparison of these retrofit strategies demonstrates that retrofit modification duration and payback time are reduced when heat transfer enhancement is utilised. Heat transfer enhancement can be also used as a substitute for increased heat exchanger network surface area to reduce retrofit investment costs.

1. Introduction

Heat exchanger network retrofit is an important way to increase energy saving in an existing network. In conventional heat exchanger network retrofit, additional surface area is created to accommodate increasing heat load requirements. However, in practice, heat exchanger network retrofit through additional area can be difficult due to topology, safety and downtime constraints. Additionally, conventional retrofit design requires many topology modifications which can result in a high capital cost.

Many practical heat transfer enhancement techniques have been developed for shell-and-tube heat exchangers for both tube side and shell side. The most common techniques for tube side heat transfer enhancement are internal fins, twisted-tape inserts, coiled wire inserts and hiTran. From the work of Huq et al. [1], Manglik and Bergles [2] and García [3] it can be seen that for laminar flow, internal fins have little effect in both heat transfer and pressure drop, coiled wire results in a medium increase in heat transfer with a low pressure drop, and twisted-tape will increase both heat transfer and pressure drop significantly. For turbulent flow, internal fins can improve heat transfer significantly along with a low pressure drop, coiled wire can highly increase the heat transfer but also results in a medium pressure drop, and twisted-tape will again give a large improvement in both heat transfer and pressure drop. For shell side heat transfer enhancement, the most common techniques are helical baffles and external fins. Taborek [4] and Zhang [5] demonstrate that helical baffle cannot improve heat transfer but it can reduce pressure drop, and external fins can give a medium improvement in heat transfer with a low pressure drop.

One benefit of using heat transfer enhancement in heat exchanger network retrofit design is that it can increase the heat transfer coefficients of exchangers. An enhanced exchanger can exchange more heat in comparison with a non-enhanced exchanger of the same area. When compared to conventional retrofit methods, the implementation of heat transfer enhancement is relatively simple and therefore requires a lower capital investment and less time is needed to carry out the modifications. In some situations, heat transfer enhancement can also reduce the pressure drop. This is because heat exchange can occur with a higher overall film heat transfer coefficient with smaller velocities. Enhancement of exchangers may reduce the shell number of exchangers or number of tube passes. These advantages, along with

* Corresponding author. Tel.: +44 1613064382.
E-mail address: robin.smith@manchester.ac.uk (R. Smith).

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