Multi-objective optimization of shell and tube heat exchangers

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Abstract

The effectiveness and cost are two important parameters in heat exchanger design. The total cost includes the capital investment for equipment (heat exchanger surface area) and operating cost (annual energy expenditures related to pumping). Tube arrangement, tube diameter, tube pitch ratio, tube length, tube number, baffle spacing ratio as well as baffle cut ratio were considered as seven design parameters. For optimal design of a shell and tube heat exchanger, it was first thermally modeled using $\varepsilon - NTU$ method while Bell-Delaware procedure was applied to estimate its shell side heat transfer coefficient and pressure drop. Fast and elitist non-dominated sorting genetic algorithm (NSGA-II) with continuous and discrete variables was applied to obtain the maximum effectiveness (heat recovery) and the minimum total annual cost as two objective functions. The results of optimal designs were a set of multiple optimum solutions, called 'Pareto optimal solutions'. The sensitivity analysis of change in optimum effectiveness and total annual cost with change in design parameters of the shell and tube heat exchanger was also performed and the results are reported.

Keywords: shell and tube heat exchanger; heat recovery; effectiveness; total annual cost; Multi-objective optimization; NSGA-II

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