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Heat exchanger network synthesis based on environmental impact minimization

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Abstract This article presents a mathematical model for heat exchanger network synthesis with environmental and economic impacts considered simultaneously, and an example of its application is presented. The mathematical model deals with environmental impact as a factor of objective function. At first, economic and environmental factors are normalized by their maximum values over the parameter space ($\Delta T_{\min}$). On this basis, economic and environmental values are converted into hundred-mark scores, respectively. Finally, the economic and environmental scores are aggregated into a single objective function using proper quantitative weight attributes. The maximum benefits of the economy and the environment are obtained by trading off between the two indices. Numerical results demonstrate that when the new $\Delta T_{\min}$ is less than that of the primary system, waste release decreases dramatically.

Keywords Heat exchanger network · Synthesis · Environmental impact · Minimization

List of variables

BE (−)	Boiler efficiency
C_i (US$)	Capital cost
C_{op} (US$)	Annual operation cost
C_{ost} (US$)	Annual average cost
$C_{\text{ost,max}}$ (US$)	Maximum economic value through the parameter space ($\Delta T_{\min}$)
ED (kW)	Calculated external energy duty of public utilities
EF (kg/kg)	Pollutant emission factors for the combustion of fuel
E_i (kg/year)	Emission rate of criteria, greenhouse gas, hazardous, and toxic pollutants
E_{t} (kg/year)	Total emission rate of criteria pollutants with the given $\Delta T_{\min}$
$E_{\text{t,max}}$ (kg/year)	Maximum emission rate through the parameter space ($\Delta T_{\min}$)
HV (kJ/kg)	Heating value of fuel
I_{cost} (−)	Normalized economic impact
I_{env} (−)	Normalized environmental impact
W_i (−)	Pollutant index weight factor
α (−)	Economic weight factor
β (−)	Environmental weight factor
$\Delta T_{\min}$ (°C)	Minimum approach temperature

Introduction

Heat exchanger network (HEN) synthesis has played an important role in saving energy, decreasing waste release, and establishing environment-friendly society. Many methods have been proposed to deal with the HEN synthesis problems. These methods include simulating annealing (Zhao et al. 2012; Athier et al. 1997; Dolan et al. 1989), mathematical programming (Floudas and Ciric 1989), artificial intelligence (Chen et al. 1989), and genetic algorithms (Lewin 1998; Lewin et al. 1998; Allen et al. 2009). Such methods for HEN synthesis only sought for economic maximum. They did not take environmental factor into account in HEN design.

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