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Thermoeconomic optimization for a finned-tube evaporator configuration of a roof-top bus air-conditioning system

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SUMMARY

This paper presents a methodology of a design optimization technique that can be useful in assessing the best configuration of a finned-tube evaporator, using a thermoeconomic approach. The assessment has been carried out on a direct expansion finned-tube evaporator of a vapor compression cycle for a roof-top bus air-conditioning (AC) system at a specified cooling capacity. The methodology has been conducted by studying the effect of some operational and geometrical design parameters for the evaporator on the entire cycle exergy destruction or irreversibility, AC system coefficient of performance (COP), and total annual cost. The heat exchangers for the bus AC system are featured by a very compact frontal area due to the stringent space limitations and structure standard for the system installation. Therefore, the current study also takes in its account the effect of the variation of the design parameters on the evaporator frontal area. The irreversibility due to heat transfer across the stream-to-stream temperature difference and due to frictional pressure drops is calculated as a function of the design parameters. A cost function is introduced, defined as the sum of two contributions, the investment expense of the evaporator material and the system compressor, and the operational expense of AC system that is usually driven by an auxiliary engine or coupled with the main bus engine. The optimal trade-off between investment and operating cost is, therefore, investigated. A numerical example is discussed, in which a comparison between the commercial evaporator design and optimal design configuration has been presented in terms of the system COP and evaporator material cost. The results show that a significant improvement can be obtained for the optimal evaporator design compared with that of the commercial finned-tube evaporator that is designed based on the conventional values of the design parameters. Copyright © 2007 John Wiley & Sons, Ltd.

KEY WORDS: thermoeconomic; design optimization; finned-tube heat exchanger; direct expansion evaporator; exergy destruction; modeling

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