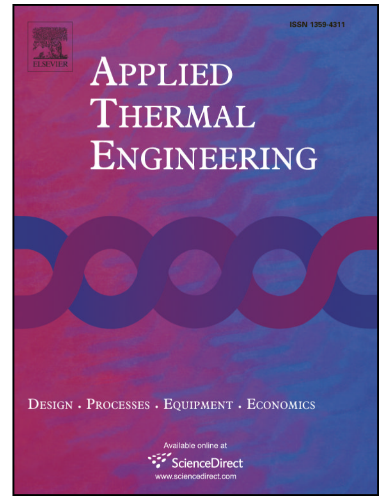
Accepted Manuscript



Research Paper

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PII: S1359-4311(17)35366-8
DOI: https://doi.org/10.1016/j.applthermaleng.2017.10.040
Reference: ATE 11238

To appear in: *Applied Thermal Engineering*

Received Date: 17 August 2017
Revised Date: 3 October 2017
Accepted Date: 9 October 2017

Please cite this article as: J. Roux, M. Santarelli, S.K. Aggarwal, Design of a Compact Heat Exchanger in a Methanation Plant for Renewable Energy Storage, *Applied Thermal Engineering* (2017), doi: https://doi.org/10.1016/j.applthermaleng.2017.10.040

Design of a Compact Heat Exchanger in a Methanation Plant for Renewable Energy Storage

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Keywords
Compact heat exchanger design; CFD; optimization, Renewable energy; P2G (Power to Gas); Methanation

Abstract

Power-to-Gas (P2G) is a viable technology for renewable energy storage. In one of its preferred configurations, a hot gaseous mixture of H_2O and CO_2 is fed to a high temperature electrolysis module (SOEC) and gets converted to CO and H_2, which are subsequently converted into methane in a methanation module. Here the SOEC is powered by using the excess energy of the renewable source. For such a system to work efficiently, it is necessary that the gaseous mixture enter the SOEC at a sufficiently high temperature. The present study aims at designing a compact heat exchanger (HE) to heat the inlet mixture to the required temperature of 850°C, using a regenerative solution. The design process consists of two complementary steps. The first step involves an analytical sizing procedure based on the known *ε-NTU* method along with semi-empirical correlations, which rapidly provides a cost-effective, preliminary heat exchanger design (construction type, flow configuration and fin geometry). In the second step, the preliminary design is refined and optimized using 3-D CFD simulations, resulting in an ultra-compact HE with elliptical fin shape. The optimization procedure was aimed at maximizing the device thermo-hydraulic performance and compactness index, benchmarked with respect to other notable designs so as to highlight the current design soundness. The optimum HE design has an effectiveness of 96%, pressure losses as low as 5.5 and 4.3 mbar on the cold and hot sides, respectively, and a heat transfer area density of 3600 m^2/m^3.