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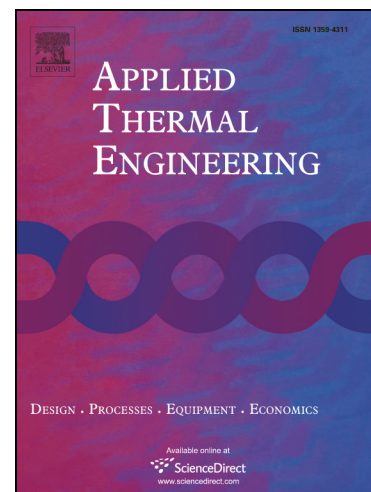
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## Design of a Compact Heat Exchanger in a Methanation Plant for Renewable Energy Storage

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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<sub>2</sub>O and CO<sub>2</sub> is fed to a high temperature electrolysis module (SOEC) and gets converted to CO and H<sub>2</sub>, 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  $\varepsilon$ - $NTU$  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<sup>2</sup>/m<sup>3</sup>.

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