

Using machine learning for comparative optimizing a novel integration of molten carbonate and solid oxide fuel cells with CO₂ recovering and gasification

Tao Hai^{a,b,c}  , Farhan A. Alenizi^d, Muhsin H. Ubeid^e, Vishal Goyal^f,
Fahad Mohammed Alhomayani^g, Ahmed Sayed Mohammed Metwally^h

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Abstract

The effects of global warming on the environment and society are substantial, making it a major global concern. Finding strategies to reduce CO₂ output from energy systems that rely on chemical processes is one of the biggest problems in this area. In order to address this challenge, researchers are looking into creative solutions, such as carbon capture and storage and developing alternative energy systems with low carbon footprints. For this, the present work introduces a creative integration of molten carbonate and solid oxide fuel cells to maximize efficiency while reducing energy costs. This system also has a recovery unit to reuse the generated CO₂ as the gasification agent for reduced environmental impact. Besides, the surplus heat is exploited through the vanadium chloride cycle for clean hydrogen production. A techno-economic, sustainability, and exergo-environmental assessment is carried out to evaluate the system's feasibility from all facets. According to the parametric results, there is a conflictive trend among performance indicators by changing the fuel utilization factor and compressor pressure ratio. Therefore, a comparative analysis of various multi-objective optimization scenarios is performed to find the best condition from various perspectives. According to the findings, compared to the system without a recovery unit, the proposed model produces optimal hydrogen of 1.3 kg/s with a very low environmental effect and power costs of 5.3 kg/GWh and 19.4 \$/MWh. The results further reveal that when power is considered an additional optimization goal, it increases up to 494.95 MWh, resulting in the lowest environmental effect and the cost of 4.4 kg/GWh and 16.3 \$/MWh, respectively. The scatter distribution of the key variables ultimately reveals that, while the current density should be maintained at its highest level, the optimal points of utilization factor are distributed throughout the entire domain.