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Using nanoparticles for performance enhancement of a solar energy-driven power/hydrogen cogeneration plant based on thermochemical cycles: **Multi-aspect analysis and environmental assessment**

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Highlights

- Parabolic trough solar collectors are coupled with thermochemical hydrogen production.
- Nanoparticles are used to enhance thermal performance of solar loop.
- Improvement of 3–5% is found with nanoparticles' utilization on overall system.

Abstract

A cogeneration of power and hydrogen plant driven by clean solar energy is developed, analyzed and optimized in this paper. For hydrogen production in the suggested plant, a thermochemical cycle with Vanadium–Chlorine (VCl) working pair is integrated with parabolic trough collectors and an auxiliary heater to provide the required temperature level. For power generation, however, an organic Rankine cycle is applied to generate electricity from extra heat which is not utilized in VCl thermochemical cycle. For performance improvement of developed cogeneration framework, nanoparticles are applied for enhancing thermal behavior of collector field. A comprehensive analysis is conducted to determine system performance enhancement with nanufluid as compared to basefluid case in thermal loop of collectors. Thermodynamic investigations paying more attention on exergy evaluations are carried out along with economic considerations to assess system performance. Furthermore, to address the proposed plant's environmental impacts, the overall plant's performance and carbon dioxide emission reduction are estimated. Parametric appraisal is implemented to specify operating factor impacts on power and hydrogen production and unit cost of product. Also, multi-objective optimization is performed based on cost and efficiency indices. It is found that, addition of nanoparticles to basefluid can enhance system performance roughly by $3-5\%$. The nanofluid based framework attains efficiency of 40.16% and unit product cost of 39.93 $/GJ under optimum conditions. Finally, based on the findings of the environmental impact analysis, the designed system in cogeneration mode was able to mitigate CO_2 emissions by 1173 kg/h.