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A Comprehensive Study of a Hybrid System Integrated Solid Oxide Fuel cell, Gas Turbine, Organic Rankine Cycle with Compressed air Energy Storage

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Abstract : Compressed air energy storage become increasingly vital for solving intermittency problem of some renewable energies. In this study, a new hybrid system on a combination of compressed air energy storage (CAES), solid oxide fuel cell (SOFC), gas turbine (GT), and organic Rankine cycle (ORC) is proposed. In the new system, excess electricity during off-peak time is utilized to compress air. Then, the compressed air is stored in compressed air storage tank. During peak time, the compressed air enters the cathode of SOFC directly instead of combustion chamber of traditional CAES. There is no air compressor consumption of SOFC-GT in peak demand, so SOFC- GT can generate power with high-efficiency. In addition, the waste heat of exhaust from GT is recovered by applying an ORC. Three different organic working fluid (R123, R601, R601a) of ORC are chosen to evaluate system performance. Based on Aspen plus and Engineering Equation Solver (EES) software, energy and exergoeconomic analysis are used to access the viability of the combined system. Besides, the effect of two parameters (fuel flow and ORC turbine inlet pressure) on energy efficiency is studied. The effect of low-price electricity at off-peak hours on thermodynamic criteria (total unit exergy cost of products and total cost rate) is also investigated. Furthermore, for three different organic working fluids, the results of round-trip efficiency, exergy efficiency, and exergoeconomic factors are calculated and compared. Based on thermodynamic performance and exergoeconomic performance of different organic working fluids, the best suitable working fluid will be chosen. In conclusion, this study can provide important guidance for system efficiency improvement and viability.

Keywords : CAES, SOFC, ORC, energy and exergoeconomic analysis, organic working fluids
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