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Modeling and optimization of fuel cell systems combined with a gasifier for producing heat and electricity

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Abstract

In this research, a proton-conducting membrane fuel cell is used in conjunction with a gasifier for producing electricity with air considered as the gasification agent. The simultaneous electricity, heat, and hot water generation of these two when coupled with an Organic Rankine Cycle (ORC) installed within a Thermoelectric Generator (TEG) was studied. Additionally, to utilize the electricity generated from various parts of the process; i.e. the fuel cell, organic Rankine cycle turbine, and the thermoelectric generator, the reverse osmosis (OR) water desalination unit was coupled to the process. The aforementioned system was studied and analyzed based on thermodynamic and thermos-economic aspects. A parametric study was also carried out to analyze the effect of main factors on power output, energy/exergy yield, and the total cost of each system. Finally, a dual objective optimization was achieved by taking the main factors into consideration and using a genetic algorithm. Results indicated that the work generated by the system was not significant; however, the amount of hot water produced was relatively promising. Based on exergy and exergoeconomic evaluation, the After-Burner is an important non-renewable energy source while the fuel cell has a higher inefficiency cost which could be due to low work generation. Results indicate that the moisture in the biomass and the figure of merit, are important parameters that have to be kept as low as possible. The energy yield of the fuel cell was calculated to be 45.05%. Additionally, considering the optimized operating point, pure power output and system cost rate will be 1.81 KW and 5.15 $/hr respectively.