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Full Length Article

Proposal of a tri-generation system by co-combustion of groundnut shell biomass and synthesis gas exiting from a solid oxide fuel cell: Environmental assessment and multi-objective optimization

Jincheng Zhou [a b c] ✉, Masood Ashraf Ali [d] ✉, As'ad Alizadeh [e] ✉, Pradeep Kumar Singh [f], Sattam Fahad Almojil [g] ✉, Abdulaziz Ibrahim Almohana [g], Abdulrhman Fahmi Alali [g]

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Abstract

Developing tri-generation energy systems is of interest, and in this regard, a novel tri-generation system of electrical power, distilled water and hot water was proposed in this study. The system composed of a solid oxide fuel cell, a combustion chamber, a supercritical carbon dioxide Brayton cycle, a desalination unit and a heat recovery system. Groundnut shell biomass was co-combusted with the synthesis gases exhausted from the solid oxide fuel cell and the resulted stream drove the supercritical carbon dioxide Brayton cycle and the desalination unit. Its waste heat was recovered to produce the hot water. Central composite design and analysis of variance were used to evaluate the system performance. Current density most contributed on the electrical power and the distilled water and the mass flow rate of biomass had the first rank on the hot water production. The electrical power and the distilled water were promoted when the current density increased and increasing mass flow rate of biomass boosted the hot water. The system performance was tri-objectively optimized using response surface methodology and the tri-generation system has 27.4% of electrical energy efficiency and 69.08% of thermal energy efficiency in the optimal conditions.The environmental assessment shows that the CO_2 emission rate of the system is 2653 kg/KWh.