Performance Analysis of a Direct Carbon Fuel Cell Cogeneration System Combined with a Two-Stage Thermoelectric Generator

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A new cogeneration system model consisting of a DCFC (direct carbon fuel cell), a TTEG (two-stage thermoelectric generator) and a regenerator is proposed, where the DCFC directly and efficiently converts the chemical energy of carbon into electricity and waste heat, and the TTEG harvests the waste heat for additional electricity production. For a given heat flow rate, the TTEG is optimized using maximum power output as an objective function. An analytic relationship between the operating current density of DCFC and the dimensionless electric current of optimized TTEG is derived. The mathematical formulas for the power output and efficiency of the cogeneration system are specified under different operating conditions. The proposed hybrid system is found to be more efficient than the sole DCFC and DCFC-TEG hybrid system. It is found that the maximum attainable power density allows about 50% larger than that of the stand-alone DCFC. Furthermore, the effects of operating current density, operating temperature, heat conductivity, number of thermocouples, figure of merit of the thermoelectric materials and DCFC anode dimension on the cogeneration system performance are discussed in detail.

Keywords: Direct carbon fuel cell; Two-stage thermoelectric generator; Cogeneration system; Performance analysis; Parametric study

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