Thermodynamic Performance Study of Biomass Gasification, Solid Oxide Fuel Cell and Micro Gas Turbine Hybrid Systems - DTU Orbit (18/10/2019)

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A system level modelling study of three combined heat and power systems based on biomass gasification is presented. Product gas is converted in a micro gas turbine (MGT) in the first system, in a solid oxide fuel cell (SOFC) in the second system and in a combined SOFC–MGT arrangement in the third system. An electrochemical model of the SOFC has been developed and calibrated against published data from Topsoe Fuel Cells A/S and the Risø National Laboratory. The modelled gasifier is based on an up scaled version (~500 kW_th) of the demonstrated low tar gasifier, Viking, situated at the Technical University of Denmark. The SOFC converts the syngas more efficiently than the MGT, which is reflected by the energetic electrical efficiency of the gasifier and MGT system in opposition to the gasifier and SOFC configuration – η_{el} = 28.1% versus η_{el} = 36.4%. By combining the SOFC and MGT, the unconverted syngas from the SOFC is utilised in the MGT to produce more power and the SOFC is pressurised, which improves the efficiency to as much as η_{el} = 50.3%. Variation of the different operating conditions reveals an optimum for the chosen pressure ratio with respect to the resulting electrical efficiency. Furthermore, the SOFC operating temperature should be kept high and the cathode temperature gradient maximised.

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