Advanced fuel cell based plants with CO_2 capture and H_2 coproduction

OVERVIEW

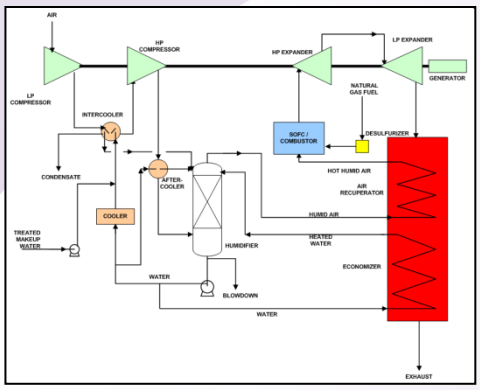
Integration of key components and subsystems into advanced natural gas and coal fueled power plant systems to be built in the future are being defined; a key component identified for such advanced power plants being the high temperature solid oxide fuel cell (SOFC). The operating and control features of an electrochemical power production device (SOFC) are quite different from those of gas and steam turbine power devices. As a result, attention to the detailed integration of the SOFC components in novel system configurations is required to optimize overall plant performance. SOFC requirements for fuel inlet temperature, pressure and species concentrations differ significantly from those of a gas turbine, which does not allow simple insertion of an SOFC power block into a gas and steam turbine based combined cycle design without significant modifications. In an integrated gasification fuel cell (IGFC) system, designs that capture the unique synergies between the SOFC and gasification subsystems are required. Coal and / or biomass fueled gasification plants utilizing a pressurized SOFC can duty cycle between production of high purity H_2 versus power while taking advantage of other synergies of coproduction such as energy integration.

GOALS

- Develop natural gas fueled SOFC power plant concepts that meet all criteria pollutant emission standards and generate electric power at 75% efficiency (LHV to AC)
- Develop coal fueled power plant concepts that meet all criteria pollutant emission standards, 90% CO_2 capture and generate electric power at of 60% efficiency (HHV to AC)

RESULTS

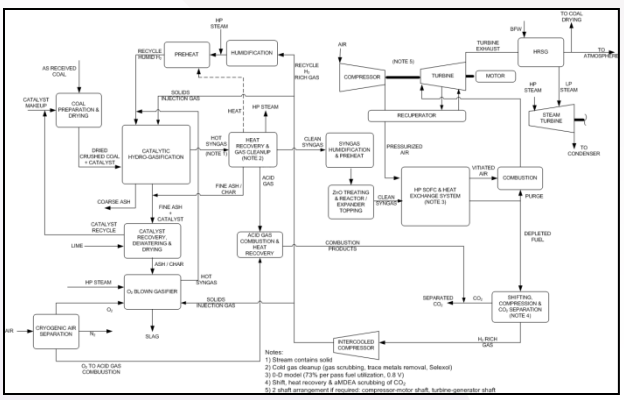
Natural gas based hybrid configuration consisting of a pressurized SOFC integrated with an intercooled-recuperated gas turbine cycle that utilizes humidification of compressor discharge air, the Humid Air Turbine (HAT) cycle, can reach the 75% efficiency goal. Cathode materials that can withstand a gas stream containing large concentration of water vapor are required.



PRESSURIZED SOFC – HAT HYBRID

RESULTS (continued)

Required characteristics for a planar SOFC stack in an IGFC for ultra high efficiency (> 60%) with CO_2 separation include operating pressure of 10 atm or higher, separate anode and cathode exhausts and internal reforming to minimize excess air used for stack heat management without excessive temperature gradients. Meeting these requirements is not without challenges. The cathode and anode streams must be maintained at similar pressures, as the planar SOFC itself is very thin and cannot support large pressure differentials. Transient pressure spikes on one side of the cell have the potential to damage the SOFC. In addition to high thermal efficiencies, raw water usage of an IGFC is about half that of an integrated gasification combined cycle when wet cooling towers are employed and produces essentially no NO_x emissions.



IGFC POWER PLANT WITH PRESSURIZED SOFC

RECENT PUBLICATIONS/PAPERS

Li, M., A.D Rao, J. Brouwer and G.S. Samuelsen, G.S. "Effects of Carbon Capture on the Performance of an Advanced Coal-Based IGFC System," Special Issue Article, Proceedings of the Institution of Mechanical Engineers, Part A, *J. of Power and Energy* (in press)

Li, M., A.D Rao, J. Brouwer and G.S. Samuelsen, G.S. "Design of Highly Efficient Coal-Based Integrated Gasification Fuel Cell Power Plants," *J of Power Sources*, V 195, 5707-5718, 2010

Verma, A., A.D. Rao and G.S. Samuelsen, "Sensitivity analysis of a Vision 21 coal based zero emission power plant," *J. of Power Sources*, V 158, pp 417-427, 2006

Rao, A.D., Y. Yi and G.S. Samuelsen, "Gas Turbine based High Efficiency 'Vision 21' Natural Gas and Coal Central Plants," *J. of Power and Energy,* V 219, Part A, 2005

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