5.7 Fuel Cells Combined with Industrial Aeroderivative Turbines

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Abstract

Aeroderivative gas turbines in the 5-15 MW range are evolving to be higher pressure ratio power sources with inherently high simple cycle efficiency. Molten carbonate and solid oxide fuel cells require an input of heated air, produce an increased voltage when pressurized, and deliver hot gases. These type of fuel cells are suited to operate in the gas path of a gas turbine, contributing to the temperature rise between core compressor and turbine.

Higher pressure ratio aeroderivatives closely approach the correct temperature environment required by the fuel cell, minimizing the need for additional combustion, and producing a substantially higher efficiency gain from the combination. Typically, the engine fuel consumption for a given power output is reduced 20-30%. Recuperators are not very effective in such a cycle. Recuperated engines usually recover and use up most of the energy from the turbine exhaust. The aeroderivatives offer simple low cost solution, which is attractive for small and medium industrial power applications, and leaves the system exhaust hot enough to raise steam for cogeneration applications.

Boosting applied to an aeroderivative core proves to be an excellent mechanism to increase overall power output and reduce the dollars per kilowatt of a powerplant. Application of intercooling can be achieved with minimum increase in capital cost. Intercooling influences the integration of an engine with a fuel cell due to its impact on compressor discharge temperature.

An advantage of the aeroderivative/fuel cell system is the ability to operate at low turn-down ratio. It is conceivable to achieve less than 50% partial power sustained operation with these systems, with a minimum reduction in the efficiency of the overall system.

The cycle performance of an industrial aeroderivative engine combined with the candidate fuel cells is explored, both with and without booster and intercooler. Consideration is given to off-design performance and operation.

The need to evaluate several issues pertaining to gas turbine/fuel cell combined systems is defined. Fuel cells serve as large energy storage sources. Load shedding becomes a major concern under this situation. Other conditions are: emergency shut-down, system start-up, operation as peakers, and operation under part load.

The following aspects of combined fuel cell/gas turbine systems deserve further evaluation:

1. Product development and commercialization status of candidate fuel cells.

2. Current and planned gas turbines and their operating characteristics when coupled with candidate fuel cells.

3. Start-up, load shedding, shut down, and other malfunctions both in the gas turbines and fuel cells, and the impact of normal and malfunction conditions on system cycles and performance.

4. Realistic assessment of losses in gas turbines, fuel cells, and balance of plant equipment, and their impact on system performance.

5. Turn-down ratio capability of the combined system.

6. System economics, and commercialization potential.