Direct Fuel Cell/Turbine Power Plant

Technical Progress Report
For
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ABSTRACT

Project activities were focused on the design and construction the sub-scale hybrid Direct Fuel Cell/turbine (DFC/T®) power plant and modification of a Capstone Simple Cycle Model 330 microturbine. The power plant design work included preparation of system flow sheet and performing computer simulations based on conservation of mass and energy. The results of the simulation analyses were utilized to prepare data sheets and specifications for balance-of-plant equipment. Process flow diagram (PFD) and piping and instrumentation diagrams (P&ID) were also completed. The steady state simulation results were used to develop design information for modifying the control functions, and for sizing the heat exchangers required for recuperating the waste heat from the power plant. Line and valve sizes for the interconnecting pipes between the microturbine and the heat recuperators were also identified.

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1.0 EXPERIMENTAL

Figure 1 shows a simplified flow diagram for the sub-scale test facility. In addition to the microturbine, an air blower was also used in the power plant to supplement the microturbine airflow for high load operations. The air blower also makes it feasible to run the power plant in two modes: 1) fuel cell/turbine integrated mode, 2) fuel cell only mode. The dual mode capability will be used to evaluate of the benefits of the DFC/T cycle over the fuel cell-only cycle.

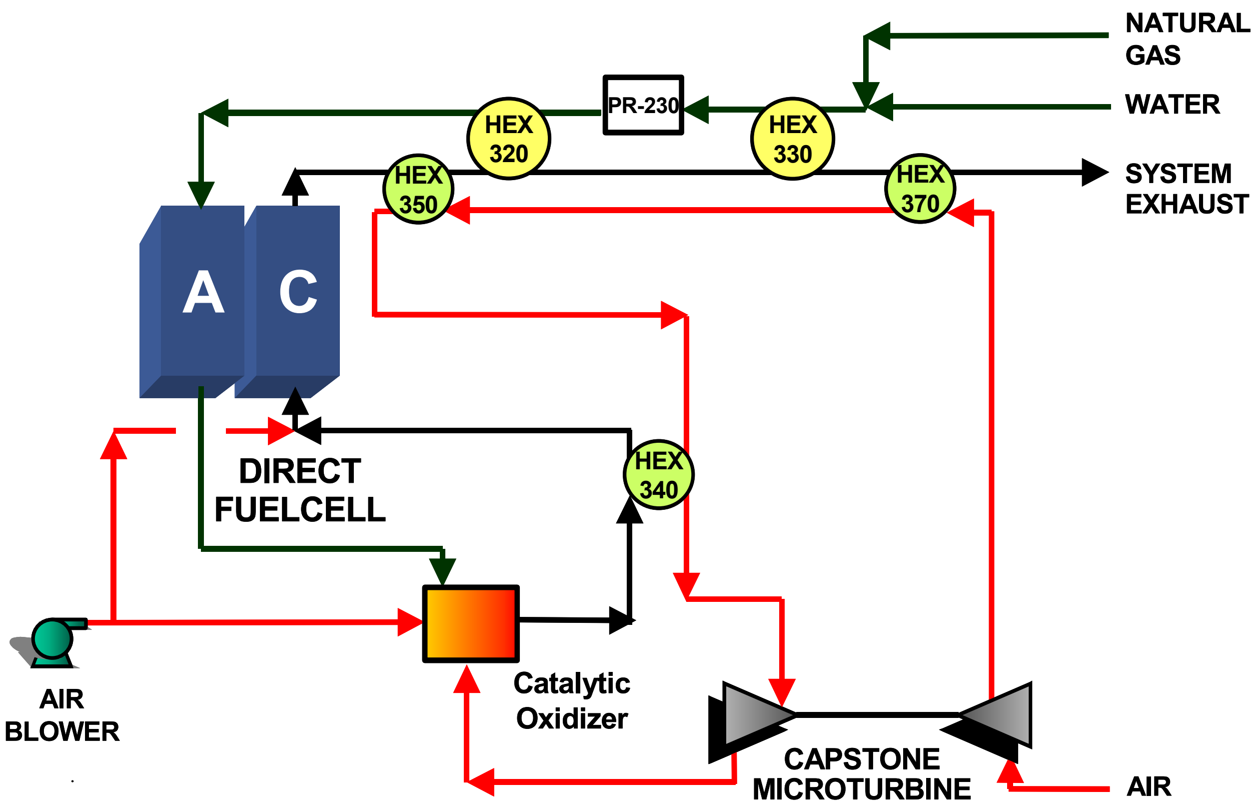

Figure 1. SubMW DFC/T Process Flow Diagram

2.0 RESULTS AND DISCUSSIONS

The microturbine design modifications were completed and the unit was delivered to FCE. The Capstone Model 330 is a variable speed (up to 96000 rpm), single shaft engine with air bearings for oil-free operation. The microturbine modifications included special casing design with provisions for flow of gases to and from heat exchangers in the balance-of-plant. The microturbine was constructed with a compressed air exhaust port and expander inlet pipe to provide flow connections to the fuel cell system.

Figure 2 shows a picture of the microturbine viewed from the turbine (expander section) exhaust pipe. As viewed in the picture, the compressor exit pipe is on the right and the turbine (expander section) pipe is on the left.

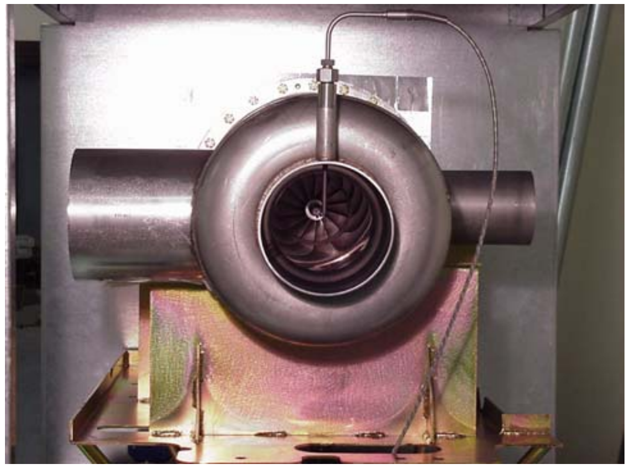

Figure 2. Frontal View of the modified Capstone Microturbine™

The microturbine was fitted with a thrust bearing capable of withstanding more than 20 inches of water column due to the back pressure caused by the fuel cell and exhaust heat recovery units. The microturbine control software was also modified to incorporate the power plant operational requirements based on the fuel cell airflow and microturbine speed relationship. The microturbine was delivered to FCE in a packaged unit, which included an air-cooled high-speed alternator, and a power conversion unit for connection to the grid. Figure 3 show the picture of the modified microturbine delivered

Figure 3. Capstone Model 330 Microturbine™

to FCE.

The DFC/T system utilizes an indirectly heated Brayton cycle to supplement the fuel cell power. Various heat exchanger technologies were investigated during the design phase, including: compact brazed plate-fin, shell-and-tube, and finned tube. Specifications for gas-to-gas recuperators were prepared. Proposals received from suppliers of heat exchangers were reviewed. The shell-and-tube heat recuperators were selected for implementation in the system. Three recuperators were acquired for installation (HEX 340, HEX 350 and HEX 370 shown in Figure 1).

Design of a catalytic reactor for oxidation of fuel cell anode exhaust at high temperatures was completed. Specifications for oxidation catalyst operating at higher than 800 °C (1472 °F) were prepared. The catalyst was ordered subsequent to review of proposals from suppliers. The catalyst will be evaluated for its performance during the power plant testing period. Figure 4 shows a picture of the monolith catalyst for anode gas oxidation.

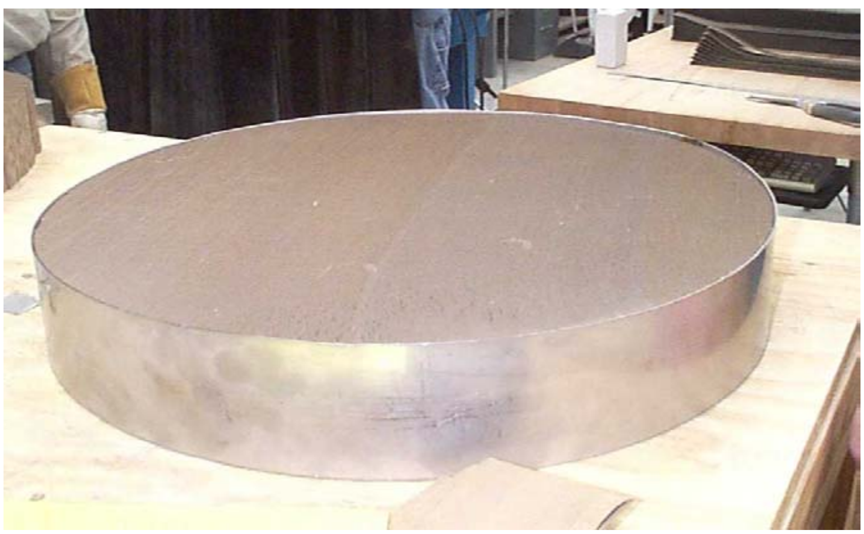

Figure 4. Anode Exhaust Oxidation Monolith

All the power plant equipment including the microturbine, heat exchangers, anode exhaust oxidation monolith, valves, piping, expansion joints, water seal, exhaust stack, instrumentation, and insulation were either received or fabricated in house. Installation of equipment, loading of catalysts and process piping were completed. Software and controls for the distributed control system (DCS) were updated and fully prepared for process and control (PAC) testing. An input/output list for data acquisition and control was prepared.

The microturbine interface requirements including grid connection, instrumentation, and software for communication over modem were reviewed with Capstone Turbine

Corporation. The data communication hardware between the plant's supervisory control and the microturbine was also implemented. The control logic of the power plant facility was reconfigured in order to accommodate a dual mode of operation: fuel cell stack standalone tests and fuel cell/turbine hybrid tests. The insulation specification was developed and insulation work was 50 percent completed. Instrumentation of the facility was initiated, including installation of pressure taps, GC lines, instrument airlines, and thermocouples. Work was also initiated on preparation of the hybrid test plan and procedures for power plant start-up, load ramp and shutdown.

3.0 CONCLUSION

The hybrid sub-MW power plant design was completed. The procurement and installation of key components, including the Capstone 330 microturbine, heat exchangers, catalytic reactor, control logic and software modifications, and piping were completed. Instrumentation, insulation, and the hybrid test plan will be completed in the next reporting cycle.

4.0 REFERENCES

None