STATUS OF THE SULZER HEXIS SOFC STACK AND SYSTEM DEVELOPMENT

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ABSTRACT

The SULZER HEXIS (Heat Exchanger Integrated Stack) SOFC system is being developed for small and medium power range cogeneration applications. HEXIS is a ceramic/metal hybrid design, where each stack repeat element has a multiple function as electrochemical cell, heat exchanger and after burner. The circular ceramic elements are developed and fabricated by CERAMATEC INC. and the ceramic-metal bonding technology and the thermal system are developed by SULZER. Presently, elements of 120 mm diameter are under endurance testing. A thermally self sustaining stack with 40 elements, producing about 1 kW DC-power is expected by the end of 1993.

1. THE HEXIS CONCEPT

The HEXIS concept is described in detail in [1]. Figure 1 shows a 5 cell HEXIS stack of 120 mm diameter. Figure 2 shows the HEXIS Stack repeat element containing the active cell, LaMnO₃ interconnect, ceramic seal rings in the center and a heat exchanger plate with metallic current collectors. HEXIS is a system concept that leads to a high energy density of the total system, not only of the cell stack. The main features of the patented HEXIS design are:

- Minimized mechanical and thermal stresses on the ceramic elements
- No tight seals necessary
- Minimum stoich ratio possible
- Minimized ohmic losses
- Low manufacturing costs

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Figure 1. The HEXIS five-cell stack.

Figure 2. The HEXIS stack repeat element.

1 Fuel distribution passages
2 Support body
3 Electrochemically active plate
4 Air inlet
5 Heat exchanger plate
6 Reaction chamber
7 Ceramic interconnect plate
8 Current collectors
2. MATERIALS DEVELOPMENT

A key element in the HEXIS design is the metal/ceramic bonding on the air- and the fuel side. In an extensive materials development program, materials and processes were developed that allow a simple integration of the electrochemically active ceramic components into the HEXIS surrounding. The electrochemically active components were developed and produced by CERAMATEC. The basic material and bonding development is done with small circular elements, containing electrodes, current collectors, interconnects and heat exchanger plates as in the real stack repeat element. These elements are called "HEXIS sandwiches". Figure 3 shows the actual performance of a HEXIS sandwich of 2.5 cm² active area.

![Figure 3. Performance of a HEXIS sandwich of 2.5 cm² area.](image)

3. STACK DEVELOPMENT AND CHARACTERISATION

Figure 4 shows a two cell stack which was electrochemically characterized. This stack bases on 70 mm diameter components with an active area of 31.4 cm². Figure 5 shows the V-I curve of that stack. The goal of 1992 is the electrochemical test of a 5 cell stack with 120 mm diameter cells.
Figure 4. Two-cell stack based on 70 mm diameter components.

Figure 5. V-I curve of the two-cell stack.
The characterisations of the HEXIS stacks are done along the NEDO guidelines for stack evaluation [2]. Figure 6 shows the influence of a thermal transient on the open circuit voltage of the two-cell stack. The heat up rate in that transient was 180 Celsius per hour.

![Figure 6. Effect of a thermal transient on the open circuit voltage of the two-cell stack.](image)

A comparison of the stack performance with the performance of small HEXIS sandwiches shows that optimisation is necessary to improve the stack performance. These optimisations will include the central seal, the geometry of the anode gas chamber and the current collectors on the anode side. The performance goal for 1993 is a current density of 0.2 A/cm² at a voltage of 0.5 volts in 120 mm diameter stacks. The goal for the stack degradation is 1 % per 100 hours.

4. PROOF OF CONCEPT

In a "Proof of Concept" program special features of the HEXIS design such as the after burner zone at the circumference of each stack element were studied. The Figure 7 shows a Platinum mesh contacted 70 mm cell that was prepared to study different parameters of the electrochemical performance as a function of the radius on the cell.
Reference electrodes on different locations of the cell along the gas flows give important data for the optimisation of the HEXIS cell geometry, for example gas channel geometry and central seal. The Figure 8 shows the reference voltages as a function of the fuel massflow.

Figure 7. Platinum mesh contacted 70 mm cell.

Temperature: 920 °C  Fuel: H2  Area: 31.4 cm²

"Inner" ref.  "Middle" ref.  "Outer" ref.

Figure 8. Voltage vs. fuel massflow.

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Figure 9 shows a 120 mm diameter cell, and Figure 10 the corresponding V-I curve. These tests were carried out as a preparation of the first 5 cell stack test, where the HEXIS current collectors as they are described in chapter 2 were applied to the 120 mm diameter geometry.

Figure 9. A 120 mm diameter cell.

Figure 10. V-I curve for the 120 mm diameter cell.

In 70 mm diameter cells, a fuel utilisation of 35 % was achieved. In 120 mm cells this value was above 50 %.
5. CONCLUSION

The HEXIS concept, which was initiated in 1991, has proved some of its advantages over the two years time. The main advantage of the HEXIS concept will be demonstrated when the cells are integrated in a system. The goal for 1993 is a demonstration of a thermally self sustaining 1 kW system. In parallel, cell and stack optimisation will continue to achieve greater durability and higher fuel utilisation.

ACKNOWLEDGMENTS

From 1991 to 1993 the project is supported by the Swiss Federal Office of Energy and the Swiss National Energy Research Fund. In 1993 additional funding will come from the Swiss Gas Industry.

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