IV.E.3 Hot Anode Recirculation Blower for SOFC Systems

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Objectives

- Develop configuration that can pump anode gas at 750°C.
- Develop thermal choke design and component test at full temperature (750°C).
- Verify bearing/seal selection and design.
- Integrate and evaluate controller/motor.
- Develop low-cost integrated assembly to provide required performance and offer low cost in high volume.
- Develop technology that will service FutureGen requirements.

Accomplishments

- Completed pump head configuration study and down selected final low cost pumphead design. This pumphead is novel and is currently being reviewed for a patent application.
- Developed two bearing rigs and initiated endurance testing. Goal is 40,000 hours of life. Additionally, a novel bearing system has been developed that is intended to help meet this very long life requirement.
- Developed method for protecting motor components from process flow while operating at high-speed (20,000 RPM).
- Completed design suitable for servicing FutureGen configurations up to 1 MW in size. Conducted design review with Department of Energy (DOE) personnel.
- Participated in Commercialization Assistance Program with Dawnbreaker to help insure the marketability of the final product.

Introduction

The thrust of this research and development (R&D) effort is to develop technology that serves the solid oxide fuel cell (SOFC) industry and helps developers in this industry to succeed. The starting point for success rests with understanding the needs of the companies involved and this has been done through substantial discussions with these companies and the development of specifications with them. The designs that are now emerging can service some of the FutureGen requirements for SOFCs. Additionally, a derivative design is being developed that will service the smaller SOFC requirement.

The challenge is to develop a blower that is durable and can survive in a very harsh environment. Unlike proton exchange membrane fuel cell (PEMFC) systems, SOFC systems operate at very high temperatures (~850°C). Depending on system architecture, the proposed pump may very well be exposed to these extreme conditions (or close to it). Yet, the electric motor, controller, and bearings in the system must be kept at much cooler temperatures than the process flow. Therefore, the focus of this project is to develop an innovative approach to pump this hot process flow while providing cool temperatures for the sensitive pump components. Additionally, innovation is required to provide this capability and maintain low costs in high-volume production.

Approach

The approach used to develop this pump emphasizes design iterations with a reduction to working prototypes in rapid succession. Because of the complexities involved, side testing is used extensively. Side testing implies a test of some sub-system, or even a component, to ensure suitability. Finite element analysis is used liberally whenever detailed analysis can provide insight into design tradeoffs.

Additionally, the success of this project will be dependent on close collaboration between PADT and SOFC developers. The requirements for the developers is changing continually and to glean the most out of the prototypes we build, regular feedback is needed. We are conducting design reviews with likely users of hot anode recycle blower (HARB) technology. Lastly, for some of the applications we are looking to service, partnership with high volume manufacturers will be required to achieve the DOE cost objectives.

Results

Unfortunately, many of the most important results of our recent work are either PADT proprietary information or proprietary to our customers. Therefore, we can only provide high level summaries here.

One high-level accomplishment was the successful testing of our proof-of-concept blower. This blower, shown in Figure 1, was tested to almost 600°C. Still, the sensitive motor and bearing components were kept well under 80°C. This testing has provided a proof-of-concept for our thermal management approach.

A second major accomplishment of the last years' effort is the down selection and design of a novel aerodynamic solution to the specifications we have been receiving. This has lead to a pumphead investigation that included the following options:

- Regenerative, or side channel pumphead. We looked at many variations here.
- Cast centrifugal pumphead.
- Multistage options.

The results of this effort has lead us to the lowest cost solution that can still meet the durability and aerodynamic specifications required by our customers. We are now manufacturing a prototype with this pumphead style. Unfortunately, we cannot show any details regarding this solution because of proprietary issues. A patent is now being evaluated.

A third important result of our effort deals with bearing life. To support this work, we have constructed two bearing rigs and mule motor, which are now running as much as possible with various bearing options. The bearing rigs are shown in Figure 2. These tools have provided us with much early bearing data. This data

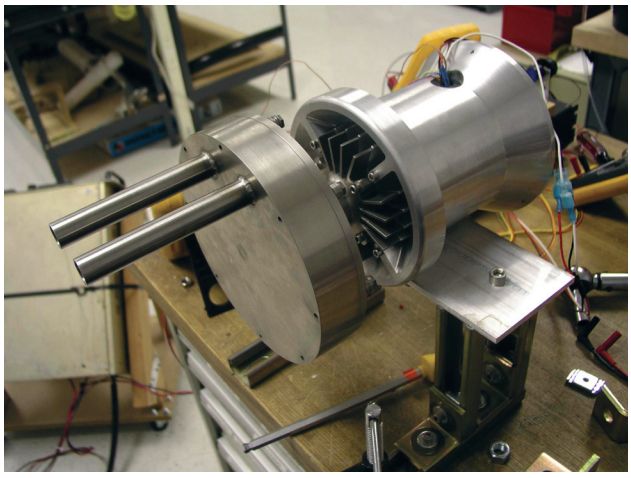

FIGURE 1. PADT HARB Prototype

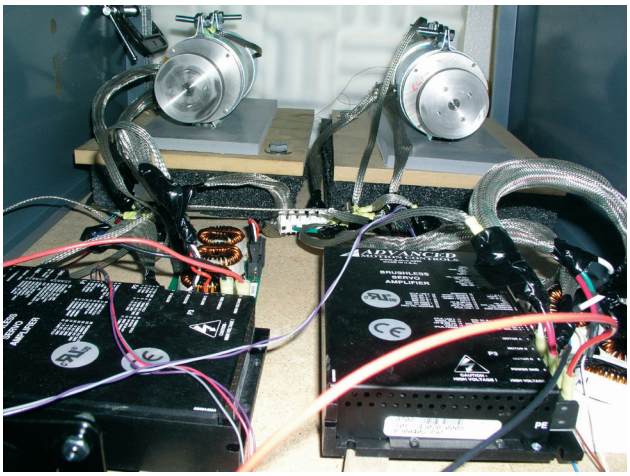

FIGURE 2. Bearing Rigs for Life Evaluation and Extension

along with expert consultation has lead to a very long life bearing system which is now incorporated in our HARB baseline blower. Again, we cannot show a cross-section of the bearing system because of proprietary issues. Also, we are investigating the patentability of this design.

Two other important results include:

1. Development of a motor and controller system that is integrated with the blower housing but protected from the process flow.
2. Build up of clear understanding of customer requirements in both the FutureGen effort and the smaller (3 kW – 10 kW) SOFC effort.

Conclusions and Future Directions

The work we have done so far has led us to the conclusion that we really need two types of blower solutions: one for FutureGen and one for small SOFC power plants. Fortunately, the technologies for the pumphead, bearing life, and thermal management will support both requirements. Additionally, we have concluded that close interaction with SOFC developers and manufacturing partners will be important for overall commercial success of our efforts.

Future work will now focus on demonstrating the durability and performance of the designs we have developed. We anticipate a number of endurance tests will be run and some of these blowers will be tested at customer's facilities.

FY 2007 Publications/Presentations

1. We are planning a presentation for the upcoming SECA Workshop in San Antonio.