IV.H.5 Cost and Performance Enhancements for a PEM Fuel Cell System

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Objectives

- Develop an optimum turbocompressor configuration by working with fuel cell system manufacturers and continuing the work currently underway.
- Reduce turbocompressor/motor controller costs while increasing design flexibility.
- Develop and integrate the turbocompressor/motor controller into a fuel cell system.

Technical Barriers

This project addresses the following technical barrier from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A Compressors/Expanders

Approach

- Use automotive and aerospace turbomachinery technology to develop low cost and low weight/volume design.
- Build upon previous turbocompressor experience.
- Use VNT® variable nozzle turbine inlet geometry for improved performance across the desired flow range.
- Use a modular approach to improve design flexibility.

Accomplishments

- Completed aerodynamic, rotordynamic, thermal, bearing and motor analyses.
- Structural integrity analysis and detailed design are being completed.
- Initiated analysis and design of the motor controller.
- Initiated motor and turbocompressor parts fabrication.

Future Directions

- Complete testing of the existing turbocompressor VNT® variable nozzle turbine.
- Complete the structural integrity analysis, detailed design, and fabrication of reduced cost and enhanced performance turbocompressor.
- Complete fabrication of reduced cost and enhanced performance motor
- Complete analysis, design, and fabrication of reduced cost and enhanced performance motor controller with no sensor requirements.

Introduction

The objective of this work is to develop an air management system to pressurize an automotive fuel cell system with contamination free air. The turbocompressor is a motor-driven compressor/expander operating on air bearings that pressurizes the fuel cell system with contamination free air and recovers subsequent energy from the high-pressure exhaust streams. Under contract by the Department of Energy, Honeywell designed and developed the motor driven compressor/expander and evaluated performance, weight, and cost projection data. As compared to positive displacement compressor/expander technology, the turbocompressor approach offers high-efficiency and reliable,low-cost potential in a compact and lightweight package.

Approach

The turbocompressor design currently underway for the 'Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor' project consists of a mixed flow compressor impeller, a VNT® variable nozzle turbine, and motor magnet rotor incorporated onto a common shaft operating up to a speed of 110 krpm on compliant foil air bearings. A motor controller drives and controls the motor, which is capable of driving the turbocompressor to the maximum design speed. The air bearings are lubrication-free in addition to being lightweight and compact. The bearings are also self-sustaining; therefore, no pressurized air is required for operation.

The turbocompressor will operate by drawing in ambient air and compressing it, then delivering it to the fuel cell stack and, if necessary, to the fuel processor. The exhaust streams will then be expanded through the turbine to aid in the overall turbocompressor/fuel cell system efficiency. The design will be modular to enhance system developer flexibility. In addition to the liquid cooled motor stator and motor controller, the motor and bearing cavities are air cooled. The motor is of the two pole toothed type and the motor controller will incorporate controls that do not require separate sensors for operation. Both of these features are conducive to low cost and improved packaging.

Both the mixed flow compressor impeller and VNT® variable nozzle turbine improve system performance by improving the flow, pressure ratio, and power characteristics of the turbocompressor over the flow range. The mixed flow compressor impeller design is used in various aerospace applications, and the VNT® variable nozzle turbine is a design from the automotive turbocharging division of Garrett Engine Boosting Systems.

Results

The VNT® variable nozzle turbine on the existing turbocompressor with a mixed flow compressor shown in Figures 1 and 2 is currently under test and is scheduled to be completed in mid 2004.

After working with various system developers and the DOE, a set of specifications was completed for the 'Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor' project. Detailed aerodynamic, rotordynamic, thermal, bearing, and motor analyses has been completed. Detailed design has been completed for the motor and is being completed for the turbocompressor. A model of the turbocompressor is shown in Figure 3 and the physical parameters are listed in Table 1. The motor controller design and analysis is underway. Parts are currently being ordered and fabricated, with assembly and initial testing to be completed by 2004.

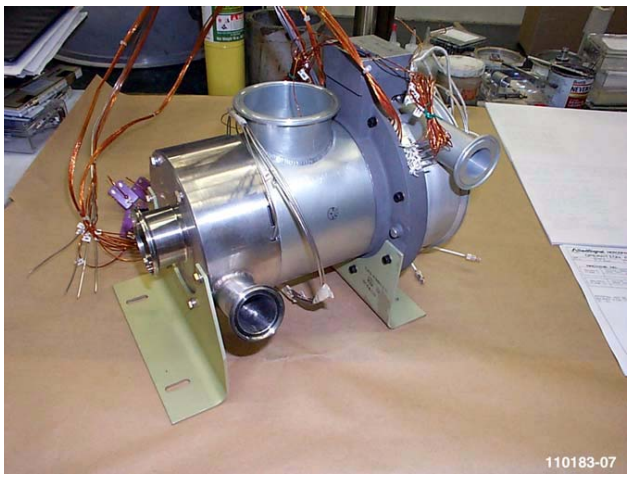

Figure 1. Honeywell Fuel Cell Turbocompressor with Mixed Flow Compressor and VNT® Variable Nozzle Turbine

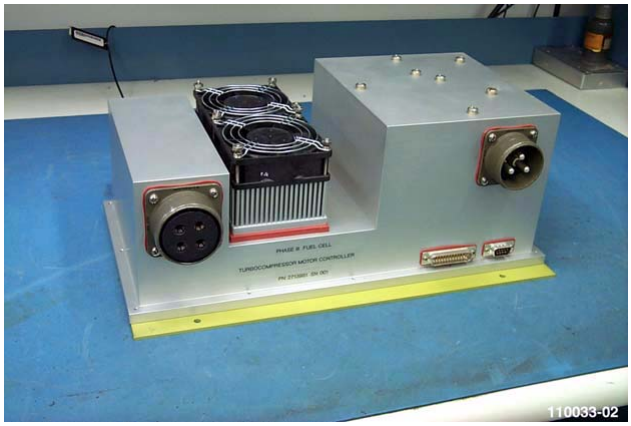

Figure 2. Fuel Cell Turbocompressor Motor Controller

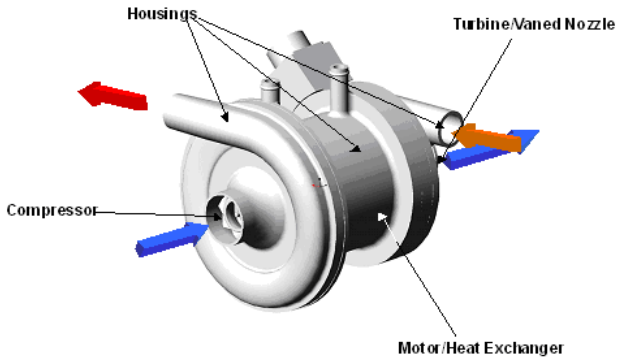

Figure 3. Honeywell Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor with a Mixed Flow Compressor and VNT® Variable Nozzle Turbine

Table 1. Fuel Cell Turbocompressor Physical Parameters

DOE Parameters	DOE Targets	Honeywell Turbocompressor
Weight	15 kg total (w/o heat exchange)	Turbocompressor and motor: 9.0 kg Controller: 5.0 kg
Volume	15 L total (w/o heat exchange)	Turbocompressor and motor: 12.5 L Controller: 3.0 L

Conclusions

- A mixed flow type compressor improves low flow performance
- Contamination/oil free and zero maintenance compliant foil air bearings should be used
- A high efficiency and low cost motor can be achieved with a two pole type motor
- A low cost motor controller can be achieved with low cost topology that includes sensorless technology

FY 2004 Publications/Presentations

1. "Fuel Cell Turbocompressor," presentation at the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Review, May 26, 2004.