VII.H Transportation Systems and Balance-of-Plant

VII.H.1 Cost and Performance Enhancements for a PEM Fuel Cell System Turbocompressor

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Projected End Date: September 2006

Objectives

- Develop an optimum turbocompressor configuration by working with fuel cell system manufacturers
- 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 barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Multi-Year Research, Development and Demonstration Plan:

- E. Compressors/Expanders

Approach

- Use automotive and aerospace turbomachinery technology to develop a low cost and low weight/volume design
- Build upon previous turbocompressor experience
- Use variable nozzle turbine (VNT) inlet geometry for improved performance across the desired flow range
- Use a mixed flow type compressor for improved low flow performance
- Use contamination/oil free and zero maintenance compliant foil air bearings
- Use a modular approach to improve design flexibility
- Use a high efficiency, low cost two pole motor
- Use a low cost, no sensor required variable speed motor-controller topology design

Technical Targets

Table 1. Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor Update

DOE Parameters	2005 DOE Targets	Honeywell Turbocompressor
Input Power[a] at Full Load, 40°C Ambient Air (with Expander/without Expander)	6.3/13.7	9.4/15.7[b]
Input Power[a] at Full Load, 20°C Ambient Air (with Expander/without Expander)	5.2/12.4	8.0/14.3[b]
System Weight[c]	15 kg total (w/o heat exchangers)	Turbocompressor and motor: 11 kg Controller: 6.5 kg
System Volume[c]	15 L total (w/o heat exchangers)	Turbocompressor and motor: 6.5 L Controller: 8.5 L
System Cost[d]	600	700[e]

[a] Projected

[b] Input power includes leakages, bearing losses, cooling flows, and motor and motor controller losses. Testing will have to be completed to verify a Honeywell method to lower the input power at the 40°C and 20°C ambient air conditions to 8.6/15.7kW_e and 7.3/14.3 kW_e or lower, respectively, and to determine if surge is a significant issue at low flows. The input power at part load is within specification.

[c] Weight and volume include the motor and motor controller.

[d] Cost targets based on a manufacturing volume of 100,000 units per year, includes cost of motor and motor controller.

[e] The estimate is in 2005 dollars. The estimate is for hardware only and does not include labor, testing, nonrecurring engineering or capital equipment costs.

Accomplishments

- Structural integrity and detailed design have been completed
- Assembly of the motor is completed and testing has been initiated with the design speed demonstrated
- Analysis and design of the motor controller is underway
- Assembly of the turbocompressor has been initiated with a majority of the parts received

Future Directions

- Complete fabrication of a reduced cost and enhanced performance turbocompressor
- Complete testing of the reduced cost and enhanced performance motor
- Complete the design and fabrication of a reduced cost and enhanced performance motor controller with no sensor requirements
- Complete testing of a reduced cost and enhanced performance turbocompressor and associated motor controller
- Complete testing of the existing turbocompressor VNT

Introduction

The objective of this project 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, reliable and 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, and motor magnet rotor incorporated onto a common shaft operating up to a speed of 110,000 rpm 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 fuel processor, where applicable. 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 which are conducive to low cost and improved packaging.

Both the mixed flow compressor impeller and VNT 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 comes from various aerospace applications and the VNT variable nozzle turbine from the automotive turbocharging division Garrett Engine Boosting Systems.

Results

After working with various system developers, the DOE and the FreedomCAR Tech Team, a set of specifications was completed for the Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor project. The detailed analyses and design have been completed for the turbocompressor and motor. Motor hardware has been fabricated and is currently under test that is to be completed in 2005.

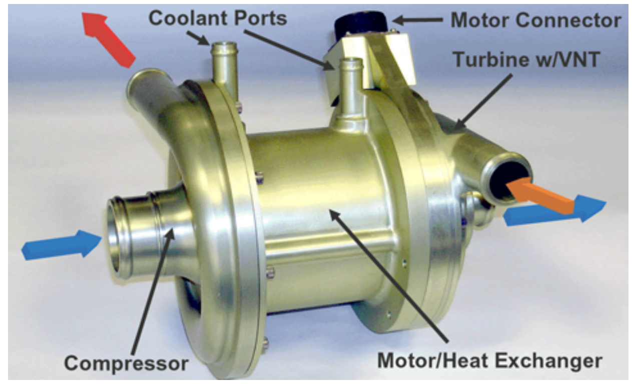

Figure 1. Honeywell PEM Turbocompressor

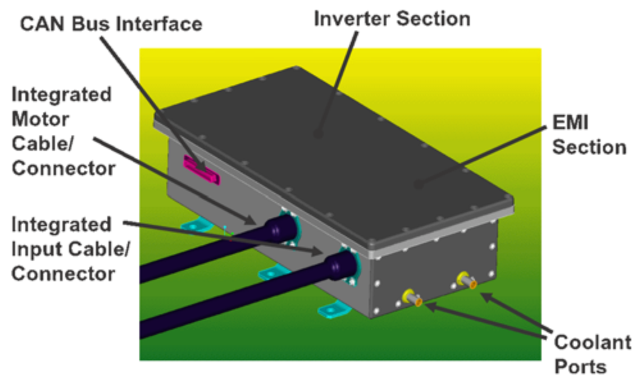

Figure 2. Honeywell PEM Turbocompressor Motor Controller

A majority of the turbocompressor parts have been fabricated and assembly is underway as shown in Figure 1. The motor controller analysis is complete with the detailed design underway as shown in Figure 2. Parts for the motor controller are currently being ordered and fabricated, with assembly and initial testing with the turbocompressor scheduled to be completed in the third quarter of 2005.

The testing of the VNT on the existing turbocompressor with a mixed flow compressor shown in Figures 3 and 4 has been delayed and is to be tested in 2006.

Summary

- The enhanced motor design has been fabricated and testing is currently underway
- The enhanced turbocompressor detailed design is complete with parts fabrication almost complete and assembly initiated

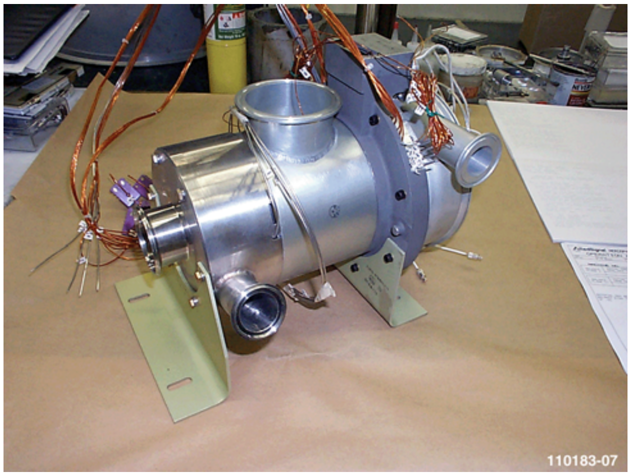

Figure 3. Existing Honeywell Fuel Cell Turbocompressor Design with Mixed Flow Compressor and VNT

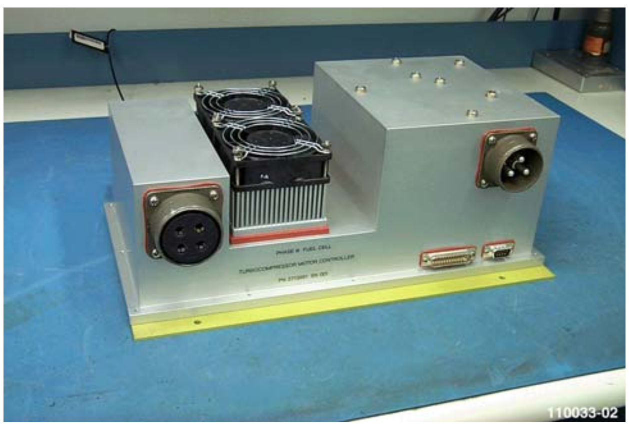

Figure 4. Existing Fuel Cell Turbocompressor Motor Controller

- The enhanced motor controller analysis is completed with the detailed analysis and parts fabrication underway

FY 2005 Publications/Presentations

1. Air, Water and Thermal Management for PEM Fuel Cell Systems; 2005 Fuel Cell Seminar; November 3, 2004
2. Cost and Performance Enhancements For a PEM Fuel Cell Turbocompressor; 2005 DOE Hydrogen Program Review Presentation; May 25, 2005