UTC Power
A United Technologies Company

DOE Hydrogen Program

Technologies for Mass Manufactured Manifolds and Seals for PEM Fuel Cells in Transportation Applications

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Berkeley Lab

National Center for Manufacturing Sciences

Freudenberg NOK™

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Overview – Low Cost/High Volume Fuel Cell Seals

Timeline

Phase 1

- Start : May 2005
- Finish : August 2008
- 75% Complete

Budget

- $1,184,222 – Total Project
  - $579,436 – NCMS/DOE share
  - $604,786- Contractor share
- Funding received in FY07
  - $448,207 total funding
- Funding for FY08
  - $736,015 total funding

Barriers

Phase 1 and Phase 2

- Long assembly time
- Lack of high speed manufacturing
- Assembly/life cycle cost
- Material Yield
- Material Contamination

Partners

- Freudenberg NOK
- Project Lead - Jeff Ludwig – UTC Power

Overview – Low Cost/High Volume Manufacturing Technologies -

Timeline

- March 2006
- December 2007
- 80%

Barriers

- Barriers addressed
  - Material compatibility
  - Low volumes resulted in welded configuration

Budget

- Total Project Funding
  - $235K - NCMS/DOE share
  - $262K – UTC Power share
- Total funding received $498K

Partners

- Lawrence Berkeley National Labs
- General Pattern
- Project Lead: Tom Donahue UTC Power

Objectives – Low Cost/High Volume Fuel Cell Seals

- **PEM Fuel Cells require inter cell seals (interfacial seals) to separate reactants and coolant streams.**
- **Fuel Cells utilizing external manifolds require a high-speed system for sealing the manifold to the to the exterior of the stack.**
- **The current design for both these seals is expensive and has low yields.**

The Objectives of this program are to:

1. **Evaluate/select Material**
2. **Develop Manufacturing process**
3. **Assemble a short-stack using the new seals**
4. **Assemble the seal into a full-size unit for in-house or field testing.**

Objectives - Low Cost/High Volume Manufacturing Technologies

- Due to initial low volumes of the PureMotion® 120 powerplant, connecting manifolds were fabricated utilizing low volume/high cost manufacturing methods
- The Objectives of this program were to：
  - Utilize low cost manufacturing methods to reduce cost of assemblies in PEM Fuel Cell System (PEMFCS)
  - Test for PEMFCS material compatibility

Milestones and Decision Gates

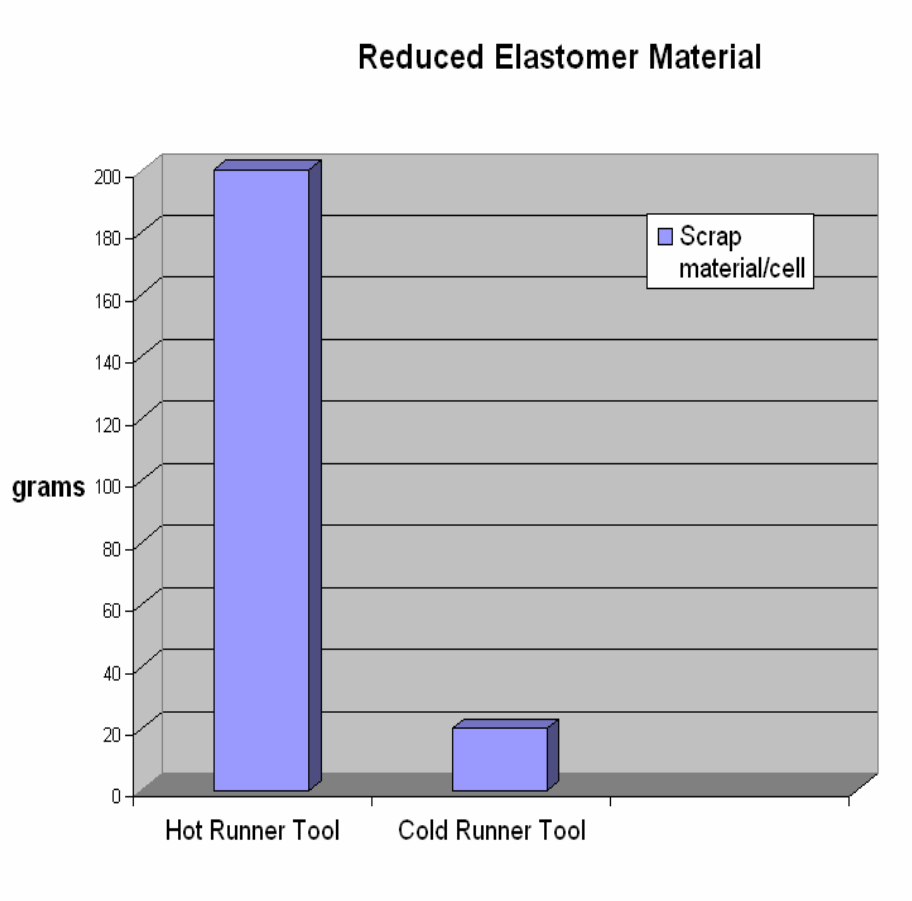
Month/Year	Milestone or Go/No-Go Decision
Sept-06 *Phase 1* Mar-07 *manifolds* Jan 08 *Phase 2*	Go/No-Go Decision: Material Property Selection
Feb-07 *Phase 1*	Milestone : Tool Design and Fabrication
Dec-07 *Phase 1* May -08 *Phase 2*	Milestone: Short Stack Verification (2,000 hours) Assemble and test Short Stack to 2,000 Hours
July-07 *manifolds* Aug-08 *seals* *Phase 1 and* *Phase 2*	Milestone: Full Size Stack Validation Assemble a full size power plant for runtime in the field or in house testing.

Approach

Material Selection	Design / Process Development	Full Size Testing
•Determine basic material properties •Test materials for compatibility •Perform fuel cell compatibility testing •Ex-Situ testing (Aging) •In-Situ Testing (Short Stack)	•Seal Design – FEA, seal geometry •Material Processing Parameters •Qualify Process Equipment •Application Trials: sub-scale and full size •Fabricate/procure parts	•Test on full-size power plant •Operate in real world conditions •Analyze durability and performance

Technical Accomplishments/ Progress/Results Seals Phase 1

- **Reduce Scrap**
  - **Cold-Runner tool design eliminated the need to scrap runner material**
  - **10x reduction in material scrap**

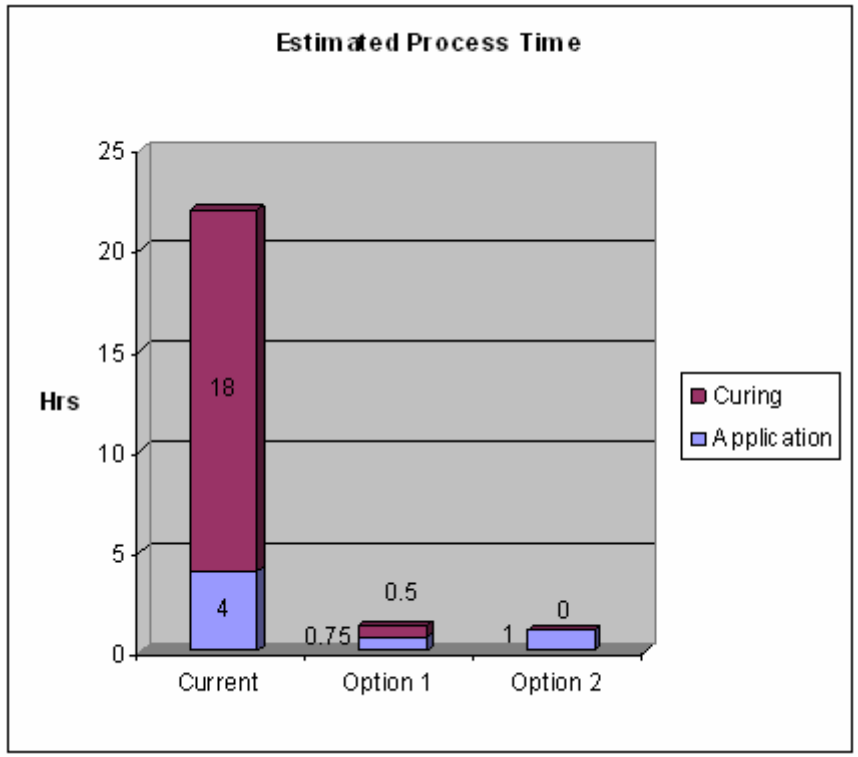


Technical Accomplishments/ Progress/Results Seals Phase 1

- **Improve Process Capability**
  - **Implement better tools to achieve acceptable tolerances to a CPk and CP of 1.33 or better**
  - **Reduced Scrap**
  - **Reduced inspection from 100% to < 5%**
- **Improve Material Selection**
  - **Use more robust proprietary material**
  - **Design seal configuration such that contamination is eliminated**

Technical Accomplishments/ Progress/Results Seals Phase 2

- Material down select to two potential materials complete
- New materials have improved compatibility and durability.
- Option 1 – UV cured material
- Option 2 – Die cut gasket material
- Estimated process times reduced ~ 15x (22 hrs to less than 1.25hrs).



Technical Accomplishments/ Progress/Results Seals Phase 2

- Identified process and equipment for highly automatable application and curing.
- Reduced # of seal components from 4 to 2, with the design potential to further reduce to a single seal component.
- Successfully applied seal material to short stack for in-situ testing.
- Commenced in-situ testing on short stack.
- Full size application trials to begin 6/08

Technical Accomplishments/ Progress/Results Manifolds

- Qualified 4 new plastics for use in PEMFCS
- Developed method to identify potential contamination sources within molded material
- Fabricated components using new plastics
- >90% cost savings
- >70% weight savings

Future Work

- **FY08**
  - **Long term short stack testing**
    - **Seal durability**
    - **Performance impacts**
  - **Full size stack validation that incorporates low-cost, high durability seal design.**
  - **Implement integration of automated process into actual production.**

Summary

- **Low cost/high volume manufacturing a key to success of PEM Fuel Cell technology**
- **Previous seal material and processing**
  - **High cost**
  - **Difficult processing**
- **New interfacial and manifold seal design**
  - **Meets stringent contamination requirements**
  - **High volume manufacturing**
  - **Reduction in cycle time and scrap material**
- **Implementation into fielded Stack assemblies**

Summary

- **New manifold design/processing**
  - **Material compatibility**
  - **Low cost material**
  - **Low cost/high volume processing**
- **Implementation into fielded Stack assemblies**