PAFC cost challenge

Manufacturing Cost reduction opportunities

Summary
PAFC SYSTEM OVERVIEW

Overview

Powerplant modules

- Power Supply System (CSA’s)
- Fuel Processing System
- Thermal Management System / Water Treatment System
- Electrical System Module
- Blower Skid

Cell stack Assembly

- Pressure Plates
- Axial load system
- Manifold adaptors
- Reactant manifolds
- Heaters
- Coolant hoses
- Insulation
- H frame
Cost reduction is being accomplished by incremental changes in technology and manufacturing.

**Closing commercialization gap**
Continuous manufacturing methods for cell components
Low cost FPS & high temperature BOP components
Technology advances
Volume based cost reductions
Current manufacturing cost reduction initiatives at UTC Power
Current design

- Header Tube
- Branch Tube
- Pressure Drop Device
- Flow Splitter + Hose Barbs
- # of Parts: 7 per cooler

New design

- Header Tube
- Orifices within Barb
- Hose
- # of Parts: 4 per Cooler

Part count:
Before DFA: 4720 parts
After DFA: 2688 parts
43% reduction

Assembly operations:
Before DFA: 3552 operations
After DFA: 3072 operations
14% reduction

Cost savings: 34%
Defects in matrix layer need touchup to prevent reactant crossover and cell shorting.

- **Active area pinhole defect**: 1/32” diameter
- **Leading edge defect**: ~1/8” width

Use of latest digital camera technologies to analyze defects for QC and reduction in manufacturing value add is being evaluated.
Combines three distinct components into one
Increases production capacity by ~ 10%

Acid migration measurement
Future manufacturing cost reduction opportunities
Current process of PAFC electrode manufacture is capital intensive

**PAFC electrode manufacturing**

- CATALYST FLOC DRYING
- MICROPULVERIZOR
- CLOUD TOWER
- COMPACTION ROLLER
- SINTERING OVEN
- COMPACTION ROLLER
- FINISHED PART

**Low cost electrode manufacturing concepts**

Spraying mix of Catalyst, Teflon® directly onto a substrate with subsequent heat treatment to manufacture electrodes

**Lab scale electrode manufactured using low cost manufacturing method**

Next steps are to scale up using a low cost manufacturing method

**Graph:**

- Improved Mass transport behavior

**Current process:**

- Free Cell Voltage
- Current Density (mA/cm²)
Current process of PAFC flow-field and cooler manufacturing is a batch process & is labor intensive

**Current process**
- Dry powder blending
- Cold & Hot Lamination
- Trimming & Flow Channel Machining

**Future process**
- Continuous screw extruder & double belt press

**Low cost manufacturing concepts**
Continuously extrude graphite-polymer composite into a slab of desired thickness followed by net-shape molding of channels using a double-belt system for continuous channel formation.

**Lab scale bipolar plates manufactured using low cost manufacturing method**

Next steps are to scaleup using a low cost manufacturing method.
PAFC MANUFACTURING R&D
Reduced weight and volume

Fuel processing system

- **AMMONIA SCRUBBER**
  - removes ammonia from fuel

- **EXHAUST CONDENSER**
  - recovers water from exhaust gas

- **REFORMER**
  - converts fuel to H2 rich gas

- **ILS**
  - cleans fuel
  - removes CO from anode inlet gas

**Activity**

- BOM
- Advanced catalyst

Improved activity & heat transfer can reduce the volume of FPS by ~ 50%

Chemical reactions:

\[ \text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + \text{CO}_2 + 3\text{H}_2 \]

\[ \text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2 \]

\[ \text{CH}_4 + 2\text{H}_2\text{O} \rightarrow \text{CO}_2 + 4\text{H}_2 \]
Brazed plate HEXs and automotive radiators offer a significant BOP cost reduction opportunity for stationary power plants.

Technology challenges involve thermal cycle stability and coating development to endure high temperature $\text{H}_3\text{PO}_4$ environment.

**Advantages:**
- Light weight and compact
- Low pressure drop for the gas side
- Low cost due to volume production and simple structure
First cost is a significant challenge for all stationary fuel cell power plants.

Continuous high volume manufacturing techniques can enable significant cost reduction in cell component manufacturing:
- Advanced electrode manufacturing
- Net shape molding of bipolar plate

Significant cost reduction opportunities exist in BOP with FPS having highest cost reduction potential.

Accelerated commercialization requires investments in manufacturing R&D along with technology R&D.