Innovative Design of a Compact Reformer for PEMFC

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Research Goals and Objectives

Objective:

Development of a micro-reformer for mobile PEMFCs

Approach:

- Modular reformer design:
  - Base unit for 10W power (0.3 mol-H_2/hr)
  - Volume of the base unit smaller than 100 cm^3.
- Combination of exothermic *catalytic partial oxidation* (CPOX) and endothermic *stream reforming reactions* to eliminate the need for an external energy source
- Single-pass tubular reactor with a catalyst on granular support for higher efficiency.

Relevance to Current State-of-the-Art

- Mobile PEMFC applications require an integrated reformer due to the difficulty of making a hydrogen storage system portable.
- New design by the current research offers
  - Improved catalyst incorporation for better efficiency
  - Improved temperature control
  - Improved stacking of modular units

Relevance to NASA

Compact reformer for aviation applications

Budget, Schedule and Deliverables

- Total budget: $35,000
- Schedule & Deliverables:

  - 1st Quarter: Design of a new reformer meeting the criteria
  - 2nd Quarter: Simulation of a gaseous flow through the reformer
  - 3rd Quarter: Experiment with a glass bead packing
  - 4th Quarter: Experiment with a granular catalyst

  Deliverable: Compact, modular reformer

Anticipated Technology End Use

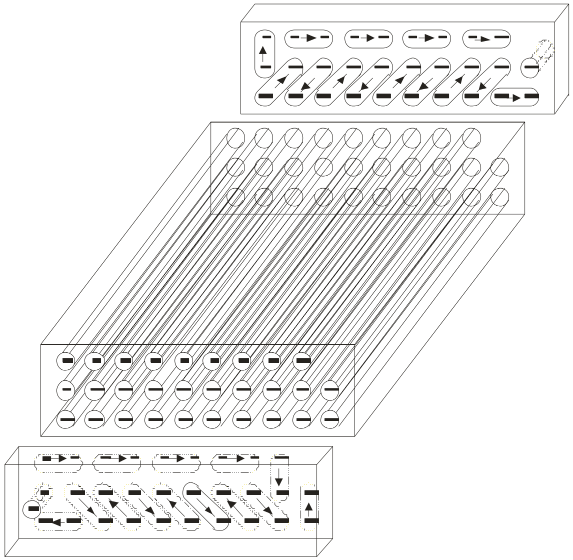
A compact reformer developed by this project should be applicable to a broad range of sizes from a very small micro-reformer for laptops or cell phones to a much larger yet compact one for aviation and automobiles.

Accomplishments and Results

- **Accomplishments:**
  - Simulation of a gaseous flow through a packed tube to determine the structure and the dimension of a compact reformer
  - Design of a new reformer
  - Experiment using 200 μm glass bead as a packing material
  - Provisional US Patent (Serial No. 60/722,469)

Results:

- Simulation results suggested that the reaction channel diameter of 2.5mm and 200μm catalyst particles would meet the design criteria. (*Feb 05 Report*)
- New reformer design: (*July 05 Report*)



Features:

- 76 x 76 x 18 mm (~104 cm^3)
- Interlacing of the exothermic reaction zone with the endothermic reaction zone by the end plate design

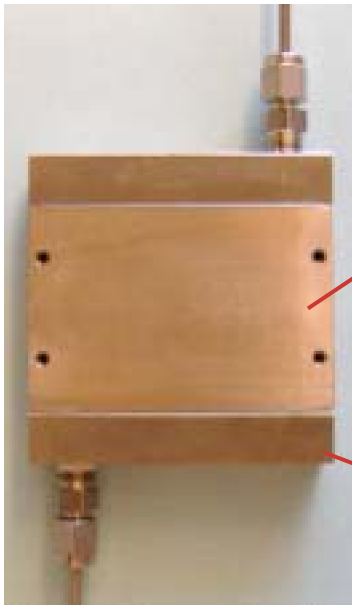
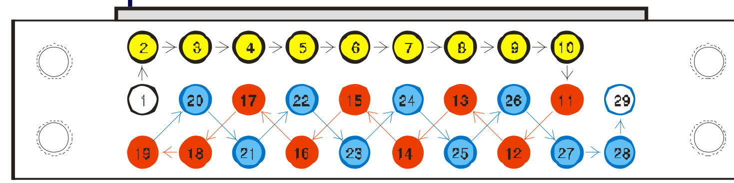
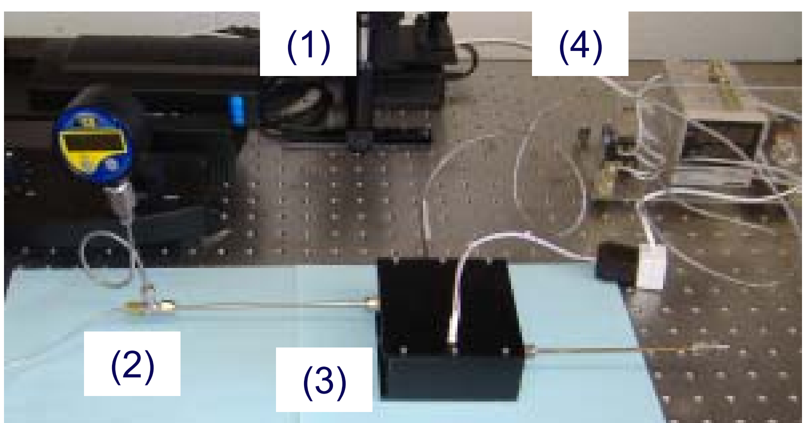


plate heater for initiation



- evaporation zone
- CPOX (exothermic)
- steam reforming (endothermic)

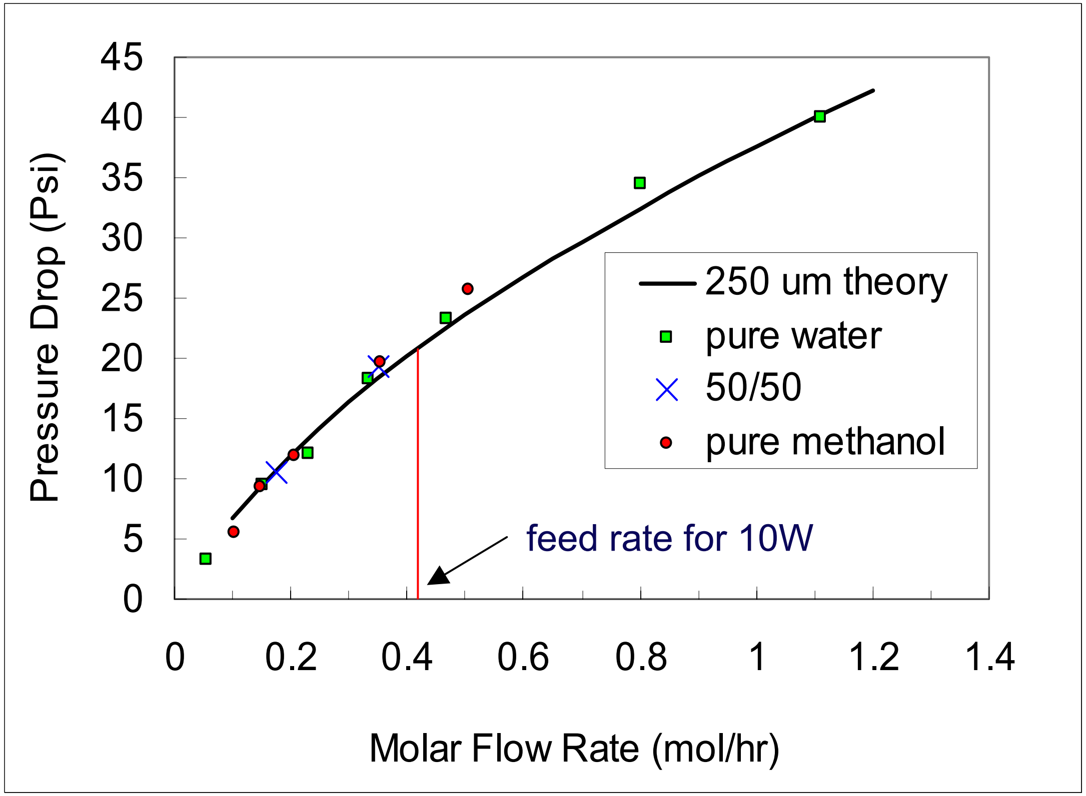
Interlaced flow channels by the end plate design



- **Overall setup:**
  1. Syringe pump for feed
  2. Pressure gauge
  3. Insulated reformer
  4. Temperature controller

Results: *Theoretical calculation vs. measurement*

- **Theory:** Ergun equation with quasi-steady approximation
- **Experiment:** methanol, water, 50/50 mixture of the two



Future Plans

- **Experiment with catalyst:**
  - CuO/ZnO catalyst (MDC-3 of Süd-Chemie)
    42% CuO, 47% ZnO, 10% Al_2O_3 (3.2mm cylindrical pellet)
  - Granulate into 200 μm particles using a ball mill and sieves
  - Monitor heat generation and analyze gas output