A Hybrid Fuel Cell – Battery Power Supply

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Introduction

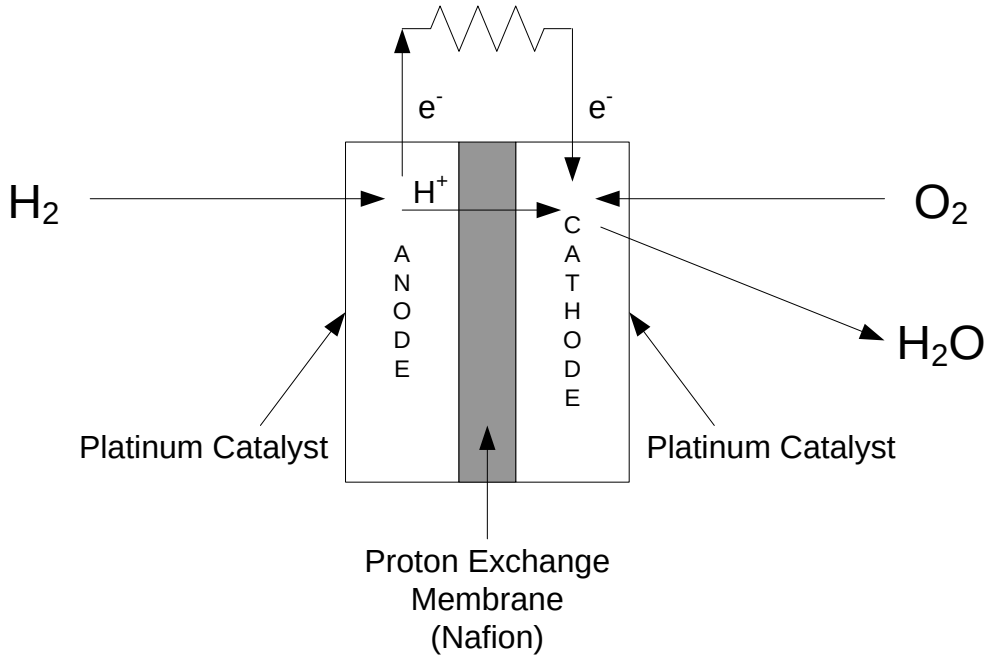
- Combine the Fuel Cell and the Battery together into one integrated Power Supply
  - Batteries and Fuel Cells are complementary devices
- Real World Example: U31 German Submarine
- Purpose of Thesis / Research:
  - Develop basic models of the Battery and the Fuel cell
  - Examine the power electronics that are required to link the Fuel Cell and Battery together
  - Proof of Concept Small Scale Hardware Demonstration

Lead Acid Batteries

- Some Properties of Lead Acid Batteries:
  - Low Cost, Rechargeable, and Recyclable
- Advantages
- Disadvantages
- One Modeling Approach:
  - Peukert's Equation: $K = (I_{\text{discharge}})^n t_{cut}$
  - Coulomb Counting Method:
    - To keep track of the battery's state of charge during discharging and charging events

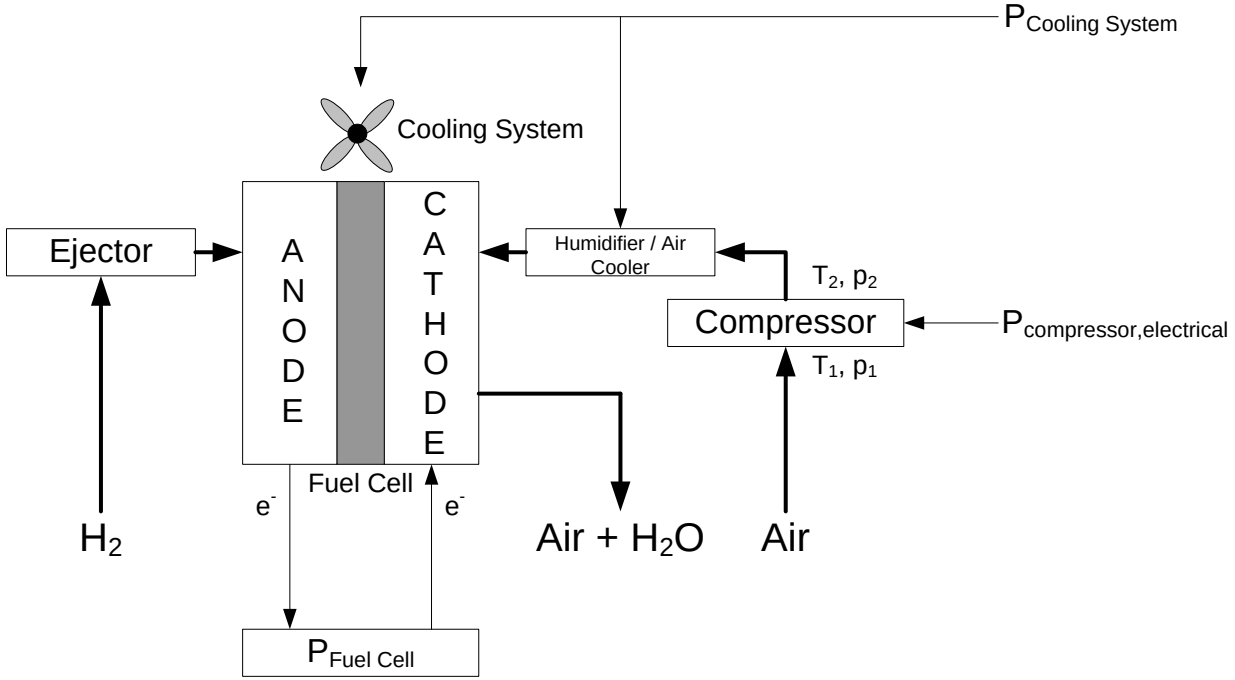
Fuel Cells

- Fuel cells generate electricity by combining hydrogen and oxygen together (“reverse electrolysis reaction”)
- The Proton Exchange Membrane (PEM) Fuel Cell
- Advantages
- Disadvantages



Modeling the PEM Fuel Cell

- Purpose of the Model
  - To determine how much fuel is consumed by the fuel cell for a given output power level
    - "Balance of Plant" Components
    - Different types of input fuels (Hydrogen gas, Hydrocarbons)



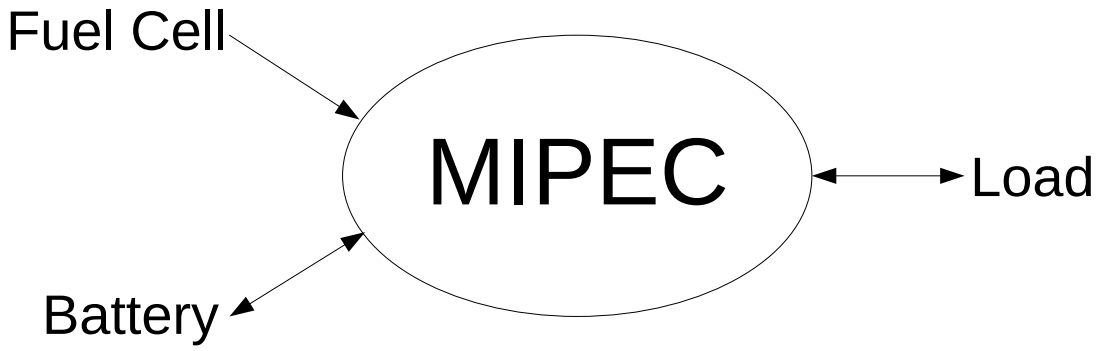
Linking the Battery and Fuel Cell

- Types of Hybrids: Passive vs. Active
  - Passive – Direct connection between the Fuel Cell, Battery, and the Load
  - Active – Fuel Cell and Battery are connected using a converter to the Load
  - Advantages and Disadvantages of each type

- Sizing in Active Hybrids:
  - Large Fuel Cell (to handle average power) + Small Battery (to handle peak power)
  - Large Battery (handles all instantaneous power demands) + Small Fuel Cell (continuously recharges the battery), also known as a “Range Extender”

Power Electronics

- Role of the Converter in an Active Hybrid:
  - Multiple Input Power Electronic Converter (MIPEC)
    - Link between the two power sources and the load is accomplished via a DC link or by magnetic coupling
  - Regulates the Power Flow between the battery, fuel cell, and the load
    - Load Regeneration, Recharging the Battery, Preventing power from flowing into the Fuel Cell



Hybrid Design Example

- Active Hybrid Design
  - Range Extender Design
  - Minimizes transient power demands on the fuel cell
  - Smaller fuel cell = lower costs
  - Boost Converter + DC Link Power Electronics Topology
  - Ideally suited for light load applications