A Working Model to Demonstrate Combined Cooling, Heating, and Power

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Technology Spotlight: Combined Cooling, Heating, and Power

Messiah College: Committed to Sustainability

“…Preparation for lives of service, leadership and reconciliation…”
Messiah’s CCHP Installation

- Frey Hall: Hot water and chilled water
- Eisenhower Campus Center & Sollenberger Sports Center: Electricity, hot water, and chilled water
- Kline Hall & Jordan Science Center: Hot water and chilled water
Designing the CCHP Educational Experience

**Requirements:**

- **Heat source:**
  - Gas-electric generator

- **User interfaces:**
  - Hot water
  - Hot air
  - Refrigeration
Thermodynamics
Generator Analysis

- Known:
  - 1800 Watt

- Assumptions:
  - Generators are approximately 35 percent efficient
  - 30 percent of total power is exhaust heat
  - Output temperature of generator is 1200 degrees F
  - Pressure drop through system is small
Heat Exchanger - Heating Water Analysis

- **Known:**
  - Entering exhaust temperature
  - Flow rate of exhaust

- **Assumptions:**
  - Water starts at room temperature
  - Leaving exhaust temperature
  - Water flow rate

- **Estimate:**
  - 113°F water output
Absorption Refrigeration

- **Condenser**
- **Evaporator**
  - Heat Absorbed
- **Absorber**
  - Refrigerant dissolves in water
  - Hydrogen returns to top of unit
  - Refrigerant-water solution cools and refrigerant liquefies
- **Boiler**
  - Start of Cycle
- **Hydrogen & Vaporized Refrigerant**
- **Pressure Drop**
- **Liquid Refrigerant**
- **Water & Liquid Refrigerant**
- **Refrigerant Vapor**
Absorption Chiller Heat Exchanger Analysis

- Known:
  - Surface temperature: 620°F
  - Power rating: 65W

- Assumptions:
  - Uniform gas stream temperature

- Estimate:
  - 450°F required exhaust temperature
Heat Exchanger- Heating Air Analysis

• Known:
  • Entering exhaust temperature
  • Mass flow rate of exhaust

• Assumptions:
  • Air has ideal gas properties
  • Air starts at room temperature
  • Mass flow rate of air
  • Leaving exhaust temperature

• Estimate:
  • 200°F air output
Heat Exchanger Fabrication
Heating Water

Concept

Prototype

Final Version
Heating Air
Heating Air
Absorption Chiller Fabrication
Interconnections
Validation
Integration
Interfaces
Final Insulation
Thermocouples and Displays

Type K Thermocouple Range: -454 to 2300F (-270 to 1260C)
Each part of our design functioned properly

- Water went from 69°F to 110°F at a flow rate of 10 mL/s
- Absorption chiller reached 40°F
- Air temperature reached 220°F
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