Microturbine Performance Testing and Heat Transfer Analysis

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Michael P. Thake, Jr.

Gas Turbine Industrial Fellow, Energy Systems, Ingersoll Rand
Graduate Research Assistant, Department of Aerospace Engineering, The Ohio State University

Industrial Mentor: Jeffrey P. Armstrong

Manager, Core Technologies, Energy Systems, Ingersoll Rand

Industrial Mentor: Brian R. Finstad

Manager, Life Cycle and Recuperator Engineering, Energy Systems, Ingersoll Rand

Academic Advisor: Jeffrey P. Bons, Ph. D

Professor, Department of Aerospace Engineering, The Ohio State University

THE OHIO STATE UNIVERSITY

UTSR University Turbine Systems Research

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Outline

- Microturbine Performance Testing
  - Motivation
  - Test Setup
  - Results and Discussion
- Heat Transfer Analysis
  - Motivation
  - Model
  - Results and Discussion
- Acknowledgments

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MICROTURBINE PERFORMANCE TESTING

Motivation

- Need for a redesign of major subsystems of current microturbine (MT250)
  - Easier to service and maintain
  - Improve performance
  - Simplify manufacturing
- Result is the Generation 3 microturbine (G3)
  - Reliable engine core assembly remained unchanged
  - Redesigned enclosure, casing and fuel/cooling subsystems
- Must test a production of the G3 for risk identification, performance improvement and endurance

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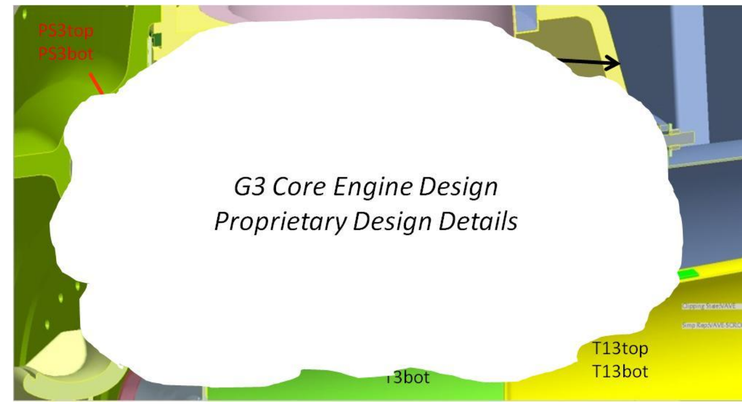
Test Setup

- PP2
  - Simplified, easily accessible test cell for engine only
- PP1
  - Full scale production package
  - Indoor setup with inlet ducting
  - Outdoor setup with inlet louvers
- Instrumentation
  - Normal monitoring instrumentation
  - 36 additional thermocouples and resistance temperature detectors
  - 4 additional pressure taps
  - Emissions and fuel measuring devices



Test Setup (cont.)

- Subject the G3 core engine to 40 cold cycles, 460 hot cycles, and 506 hours of operation at 103% power
- Goals
  - No significant performance drop-off running under typical field conditions
  - No repairable conditions found in the core engine static hardware (cracks, excessive distortion) after final inspection
- Test Schedule
  - 5 hot cycles and 1 cold cycle per day
  - Each cycle lasts 1 hour with ~3 hours for cooling
  - Average last 10 minutes of data

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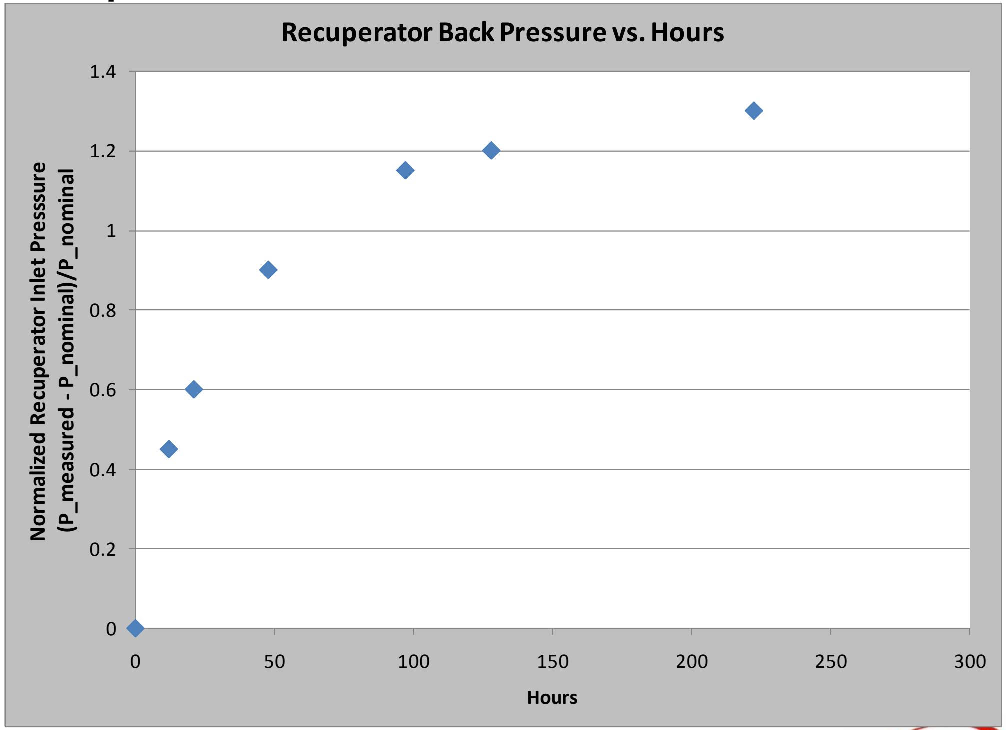
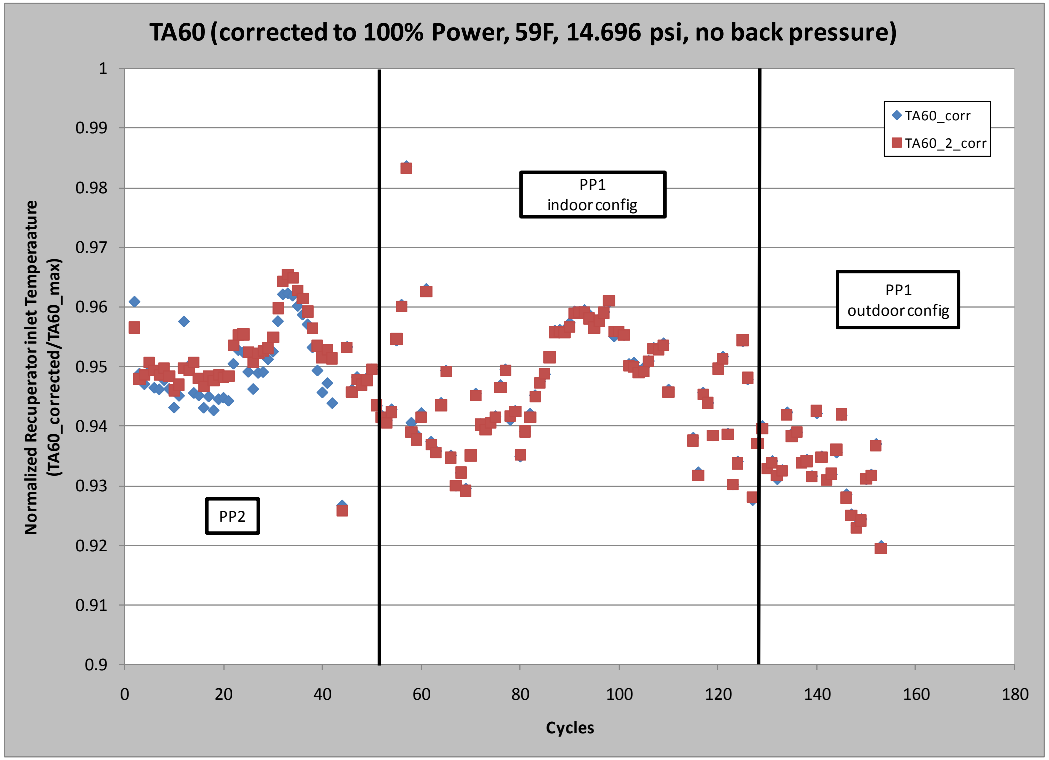
Minor Setbacks

- Clogging due to assembly error which admitted lose insulation into recuperator
  - Test results are measuring worst case conditions and hotter temperatures



Performance Data

- Recuperator Inlet Temperature is key
  - Monitors engine health
  - Limiting temperature



HEAT TRANSFER ANALYSIS

Motivation

- No previous theory-based heat transfer model
  - Predictions derived from correlation curves from measured water and exhaust gas temperatures at inlet and outlet of cogen
- Need for a robust model
  - Adapt to changing inlet conditions and properties without knowing exit conditions
  - Implement into cycle analysis tool
    - Enables part-power analysis
    - Account for fuel changes, alt. changes, geometries
  - Use as a model to provide customers with reliable heat recovery data

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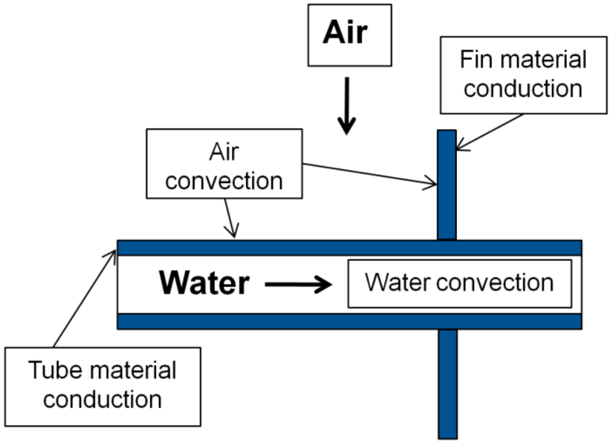
Model

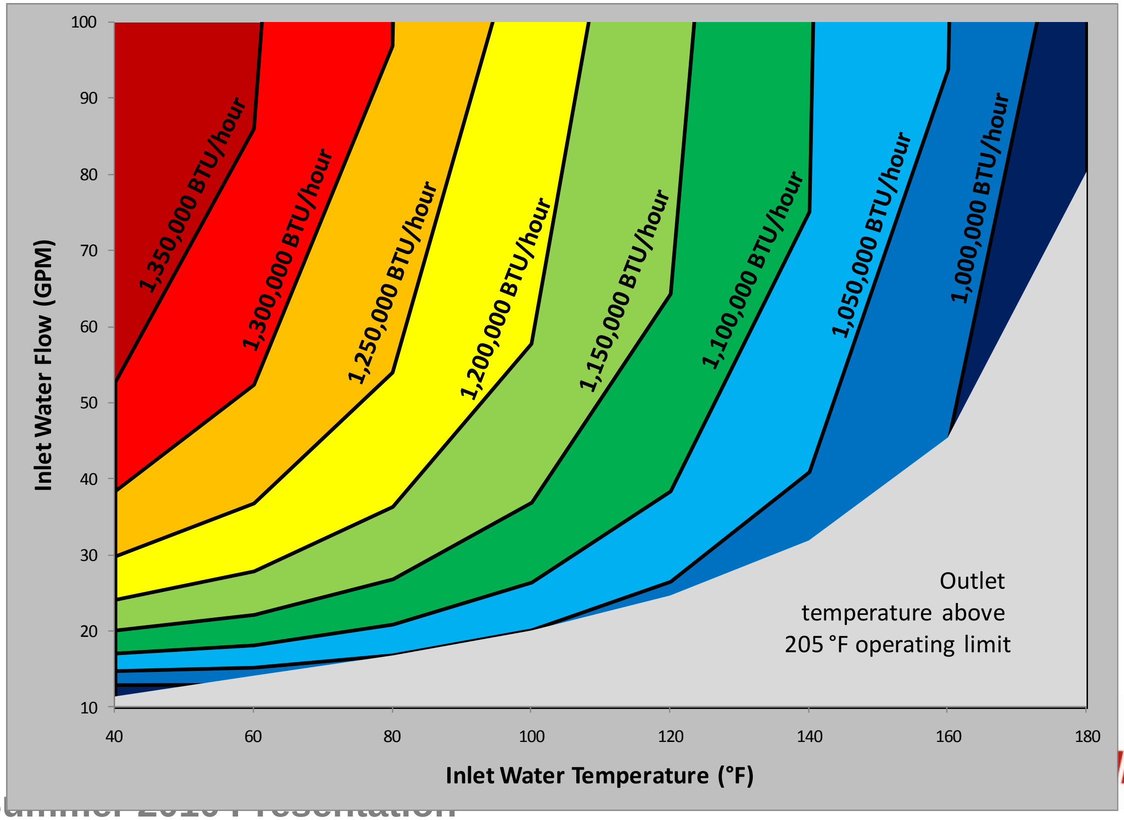
- Calculate pressure drop across air- and water-side
- Calculate mass flows and velocities
- Calculate exhaust gas, water, and material properties
- Setup heat transfer model (tube and fin)
- Calculate convective heat transfer coeff. of each component independently
- Calculate resistivity of each component and combine
- Calculate effectiveness and heat transfer

$$q = \varepsilon * m\_dot_{air} * Cp_{air} * (T_{in,air} - T_{in,water})$$



Heat Recovery

- Low inlet water temperatures → heat recovery sensitive to inlet water flows rates
- High inlet water flow rates → heat recovery sensitive to inlet water temperatures



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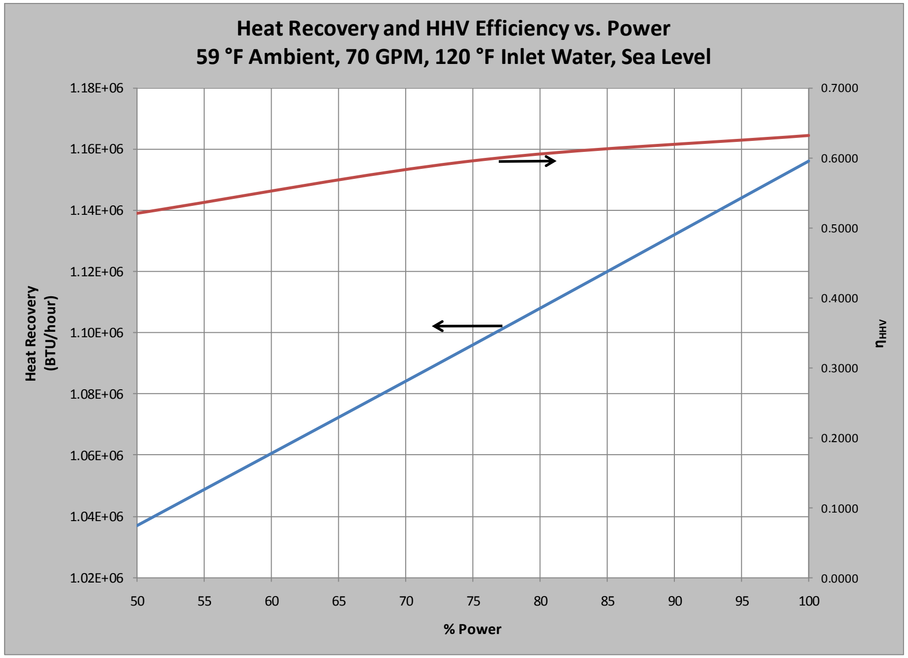
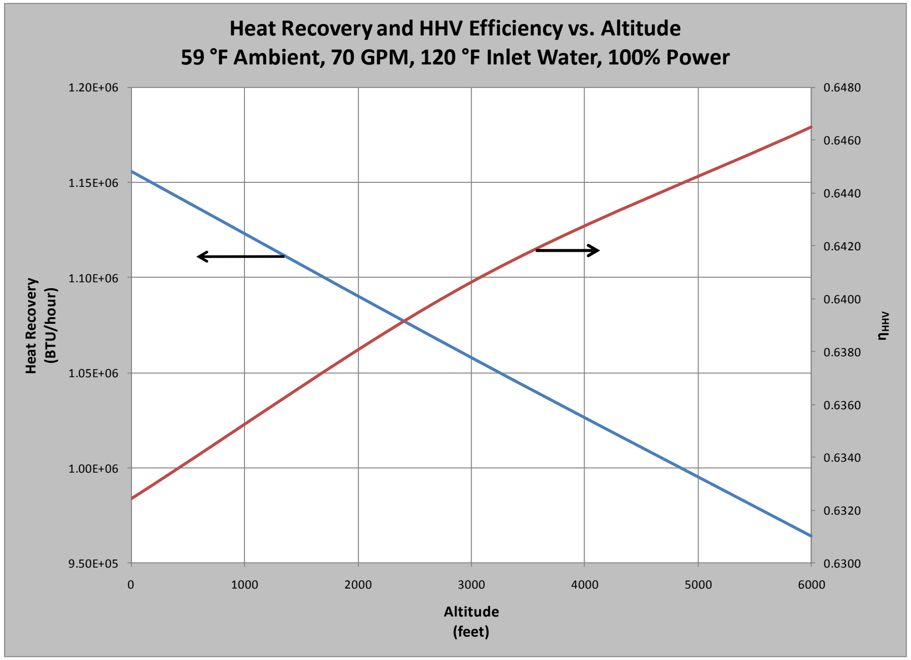
Parametric Studies





Test	Gas Type	q_calc	η_HHV
#		BTU/hour	
1	Natural	1.16E+06	0.6324
2	Anaerobic	1.17E+06	0.6333
3	Landfill	1.19E+06	0.6340

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