UTSR 2018 Gas Turbine Industrial Fellowship Program

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Fellow Background

- Hometown: Flowery Branch, GA
- Rising 4th year Aerospace Engineering Undergrad at Georgia Institute of Technology
- Undergraduate research assistant at the Ben T. Zinn Combustion Laboratory

Introduction

- Three main tasks performed during research fellowship
  - Axial Compressor Test Demo
    - Design and construction
  - High-Pressure Oxygen Safety Review
    - Literature review and risk identification
  - Original Gas Turbine Design Project Renewal
    - Assistance in preparing project for renewal

Axial Compressor Demo

- Axial compressor demo for turbomachinery design training course
  - Based on cordless leaf-blower with two-stage axial compressor

- Transparent compressor stage gives access to blade geometry for aerodynamics calculations

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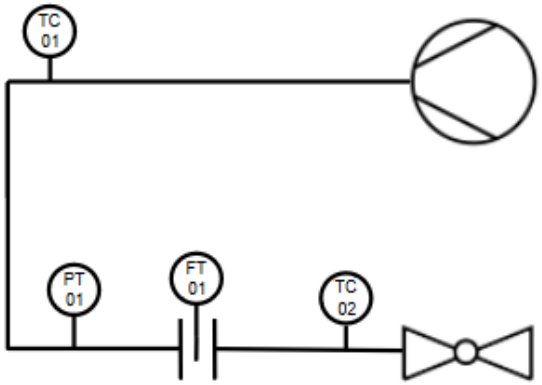
Axial Compressor Demo (cont.)

- Instrumentation: dP sensor, static pressure sensor, orifice plate, thermocouples, potentiometer throttling

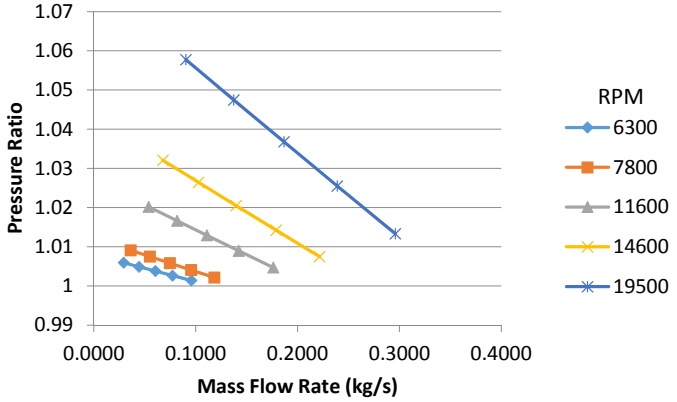


Test Demo P&ID

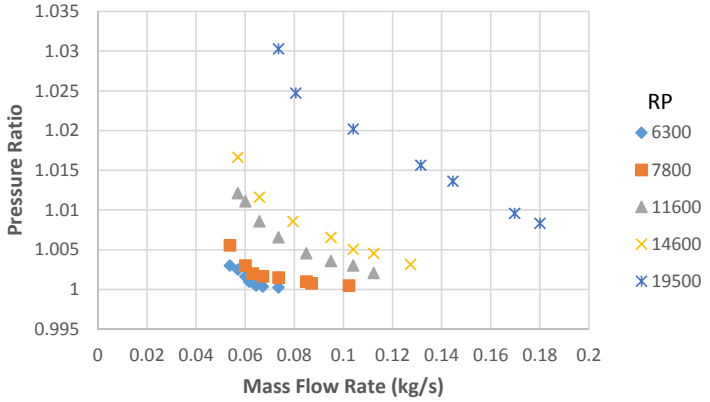
Completed Axial Compressor Test Demo

Axial Compressor Demo (cont.)

- Theoretical compressor map constructed using velocity triangles and isentropic compressor relationships
- Actual performance roughly half that of the theoretical model



Model Compressor Map



Experimental Compressor Map

Axial Compressor Demo (cont.)

- Future Work
  - Reduce vibrations at high speeds that might affect gauge accuracy
  - Consider replacing 0-50 in. H_2O dP gauge with 0-15 or 0-25 in. H_2O gauge
  - Performance is affected by battery charge, so an additional battery would prove useful if the demo needs to run for longer periods of time

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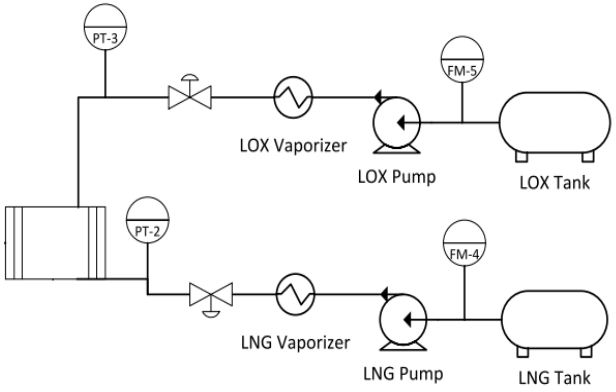
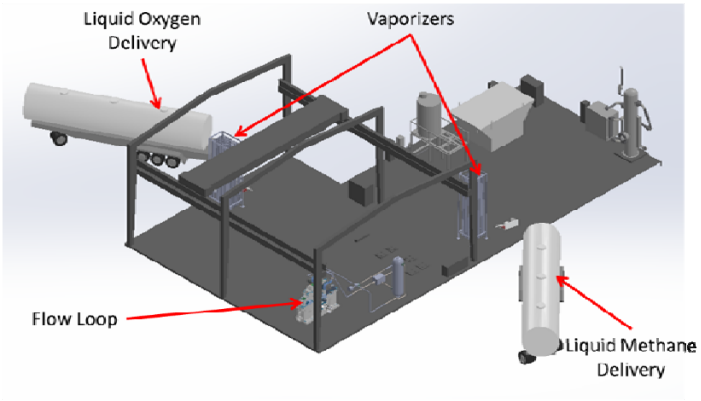
High Pressure Oxygen Safety Review

- Background
  - Oxy-fuel supercritical CO_2 gas turbine combustor
  - Reduced flow test loop
  - Oxygen supplied at pressures as high as 31.6 MPa
  - Components and materials reviewed for safe use and operation





High Pressure Oxygen Safety Review (cont.)

- At high pressures, gaseous and liquid oxygen is an incredibly potent oxidizer
  - At 100% oxygen concentration, most nonmetals are flammable
  - As pressure increases, metals will also become flammable

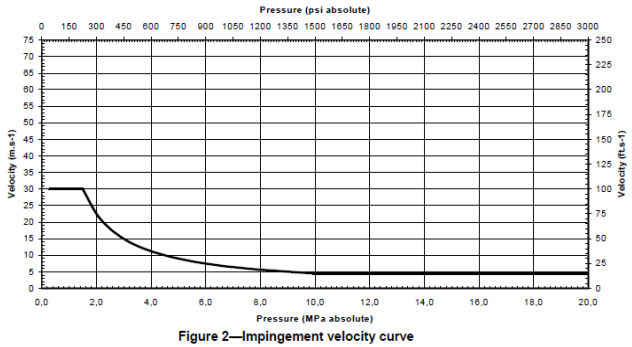


Figure 2—Impingement velocity curve

The curve shown in Figure 2 is valid for design temperatures up to 150 °C (302 °F) for carbon steel piping, and 200 °C (392 °F) for stainless steel and non-ferrous piping. The carbon steel temperature limitation may be increased to 200 °C (392 °F) provided a hazard analysis is performed that takes into account factors such as site conditions, operating experience, experimental data, etc. Pressures are limited to a maximum of 21 MPa (3000 psig).

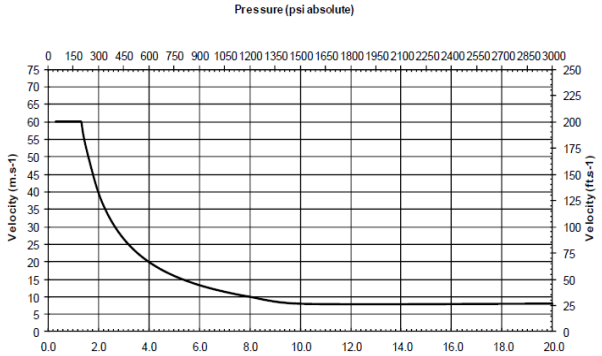


Figure 3—Non-impingement velocity curve

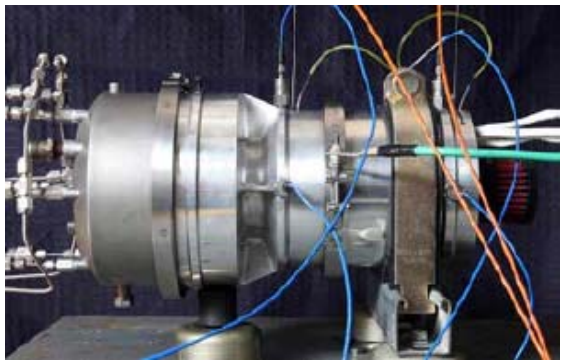
(IGC Doc 13/12/E)

High Pressure Oxygen Safety Review (cont.)

- Material Selection
  - Nickel, Monel, brass, and Inconel metals are more resistant to ignition than stainless steel, carbon steel, and aluminum
  - Carbon and stainless steels can be used at low pressures and velocities
  - All nonmetal components should be tested in before use
- Component Selection
  - High risk components include valves (globe, butterfly, ball, check, relief), regulators, filters, and fittings
- Particle impact ignition risk can be mitigated through thorough chemical and mechanical cleaning

Great Horned Owl (GHO)

- IARPA program focused on the development of systems that can be utilized in a small UAV
- SwRI developed a prototype small, lightweight gas turbine generator for use in an electric hybrid propulsion system
  - Features novel single disk radial flow design
  - Simple construction, lightweight, rugged design
  - Novel bearing lubrication system using two peristaltic pumps
- Photos and details are limited due to IARPA requirements



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GHO (cont.)

- Fellowship tasks
  - Experimental setup for project renewal
    - Computer installation for DAQ and controls
  - Repaired bearing lubrication system and visually inspected bearings to ensure proper delivery of lubrication oil
  - New fuel tank installed and connected to boost pump supply
  - Prepared GHO for rotor balancing process

Miscellanea

- Modal testing for tie bolt rotor
  - Ping testing and ANSYS analysis
- Literature Review
  - Relationship between axial preload and angular contact bearing stiffness
  - Strong disparity between experimental data and theoretical models

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