the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Air-Riding Seal Technology for Advanced Gas Turbine Engines—Florida Turbine Technologies, Inc.

Background

Advanced gas turbine engines have many engineered gaps and clearances to permit relative movement between stationary and rotating parts, and relative thermal expansion between adjacent parts that operate at different temperatures. Reduction of the leakage flows associated with these critical hot gas path component interfaces—through the use of highly efficient sealing technologies—will result in a significant improvement in overall turbine performance, efficiency and power output.

Florida Turbine Technologies, Inc (FTT) is developing an innovative design approach to provide a highly durable contactless air-riding seal (ARS). This rotating-to-static sealing approach may permit dramatic improvement in steady-state clearance control and cooling air requirements. The reduced running clearance of the ARS as compared to a knife-edge seal increases efficiency and total power output.

This turbine project was competitively selected under the Small Business Innovative Research (SBIR) Program. It is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). NETL is researching advanced turbine technology with the goal of producing reliable, affordable, and environmentally friendly electric power in response to the nation's increasing energy challenges. With the Hydrogen Turbine Program, NETL is leading the research, development, and demonstration of these technologies to achieve power production from high hydrogen content fuels derived from coal that is clean, efficient, and cost-effective, minimizes carbon dioxide (CO_2) emissions, and will help maintain the nation's leadership in the export of gas turbine equipment.

Project Description

Many of the rotating-to-static sealing techniques applied commercially today have capabilities limited by the worst-case transient gap conditions. More specifically, gaps are set based on the pinch point within the transient response to prevent rubbing and or damage to the sealing device of the rotating and stationary components. This passive approach to clearance setting results in larger steady-state operating clearances and efficiency-robbing air leakage.

FTT is proposing an active sealing technique to allow for the tightest clearances at the steady-state operating condition. The contactless ARS technology utilizes a pressure balancing system, permitting the seal to "follow" the target surface through axial and radial transient excursions. This results in reduced running seal clearances with no degradation over time, as the seal does not rub at any point in the mission cycle.

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
06/28/2012	08/13/2015

COST

Total Project Value
$1,149,847

DOE/Non-DOE Share
$1,149,847 / $0

AWARD NUMBER

SC0008218

U.S. DEPARTMENT OF ENERGY

In this project, an ARS rig will be created at FTT will be modified to operate at similar speeds and pressure ratios as those expected in a gas turbine engine. Seal operating data will be recorded and used to calibrate a computational fluid dynamics (CFD) model. The CFD model will be used to predict seal performance at off-design points (e.g., start-up transient, shutdown). Test results will also be used to compare flow leakage against the current state-of-the-art static-to-rotating seal (the knife-edge seal).

Goals and Objectives

The goal of this SBIR project is to gain understanding and advance the development of the ARS concept with the ultimate goal of introducing this technology into a gas turbine engine. The Phase II project aims to build upon the technology feasibility demonstrated in Phase I by considering real world anomalies and testing the ARS in an engine like environment. Phase II objectives include the following:

- Design work for implementation of the ARS technology into industrial gas turbine engines.
- Creation of analytical models (one-dimensional [1D], CFD, and fluid structural interactive [FSI]) to predict seal performance of various design concepts.
- Creation of system model to address seal response characteristics.
- Generation of a rig design capable of testing the design concepts and evaluating their performance.
- Evaluate seal design concepts through testing.
- Correlate analysis predictions with test data.

Accomplishments

- Proved the ARS's functionality to operate with significantly reduced leakage rates over a range of pressures.
- Matched analytical results, 3D CFD and 1D hand calculations, to test data demonstrating understanding of the physical behavior of the technology.
- Developed technology maturation concepts based upon analytical models rooted to test data.
- Created engine performance models to illustrate the potential benefit of $7.2 million per year for a single utility scale engine with the ARS technology installed.
- Awarded Phase II SBIR to take the technology from technology readiness level (TRL) 2/3 to 5/6.

Benefits

This SBIR project supports DOE's Hydrogen Turbine Program, which is striving to show that gas turbines can operate on coal-based hydrogen fuels, increase combined cycle efficiency by three to five percentage points over baseline, and reduce emissions. The SBIR program is positioned to leverage the agility and innovative competencies of small businesses. Accordingly, FTT will advance the development of air-riding seals that will reduce leakage, improve durability, and ultimately, increase turbine efficiency.

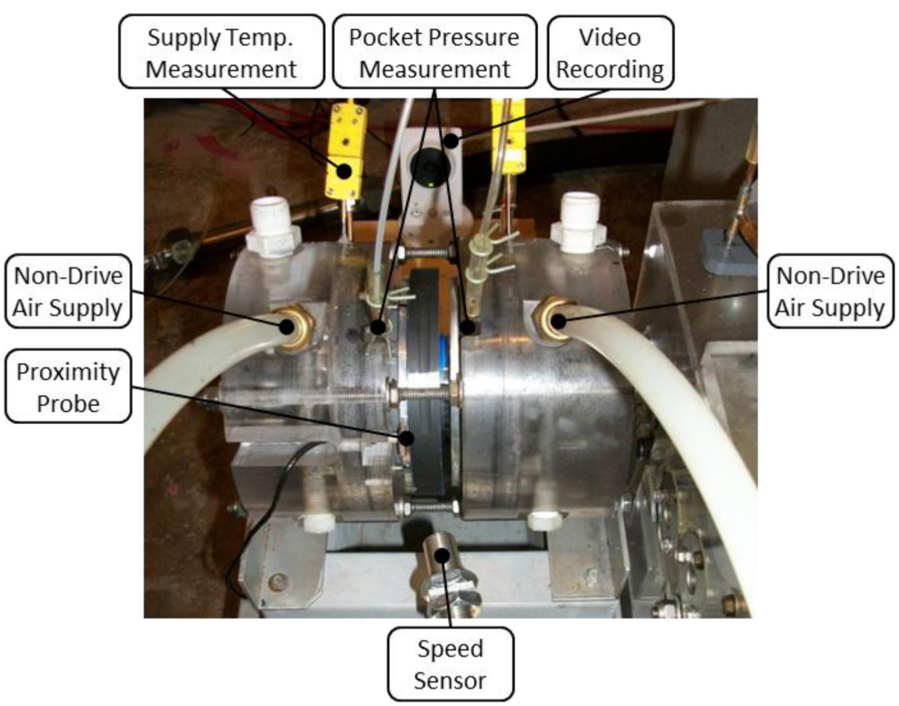

Figure 1. ARS Phase I Test Rig Showing Instrumentation Locations.

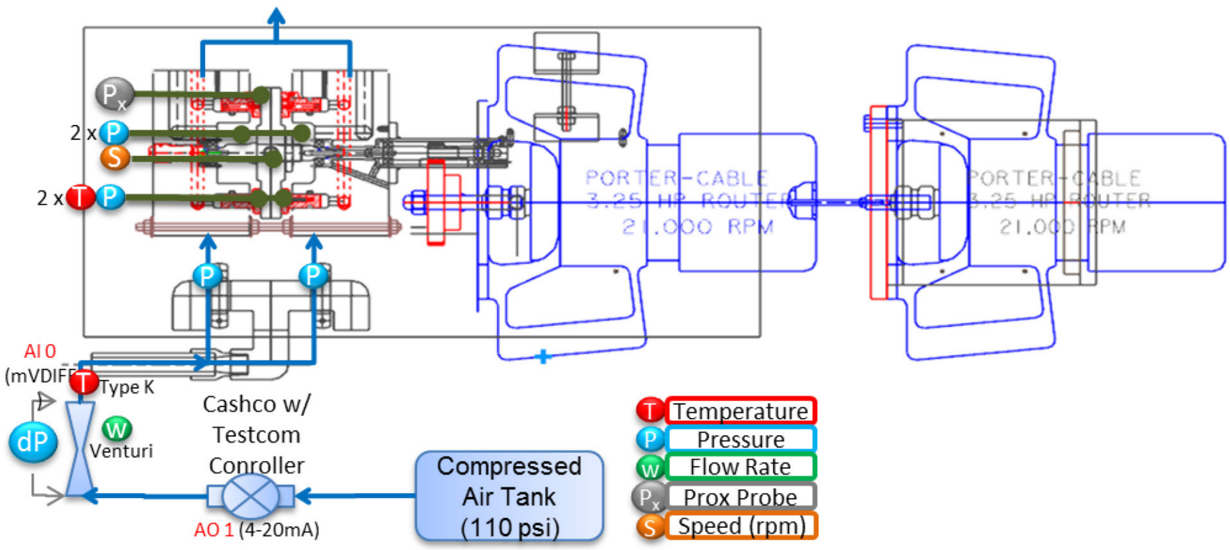

Figure 2. Facility Layout of the ARS Phase I Test Rig.

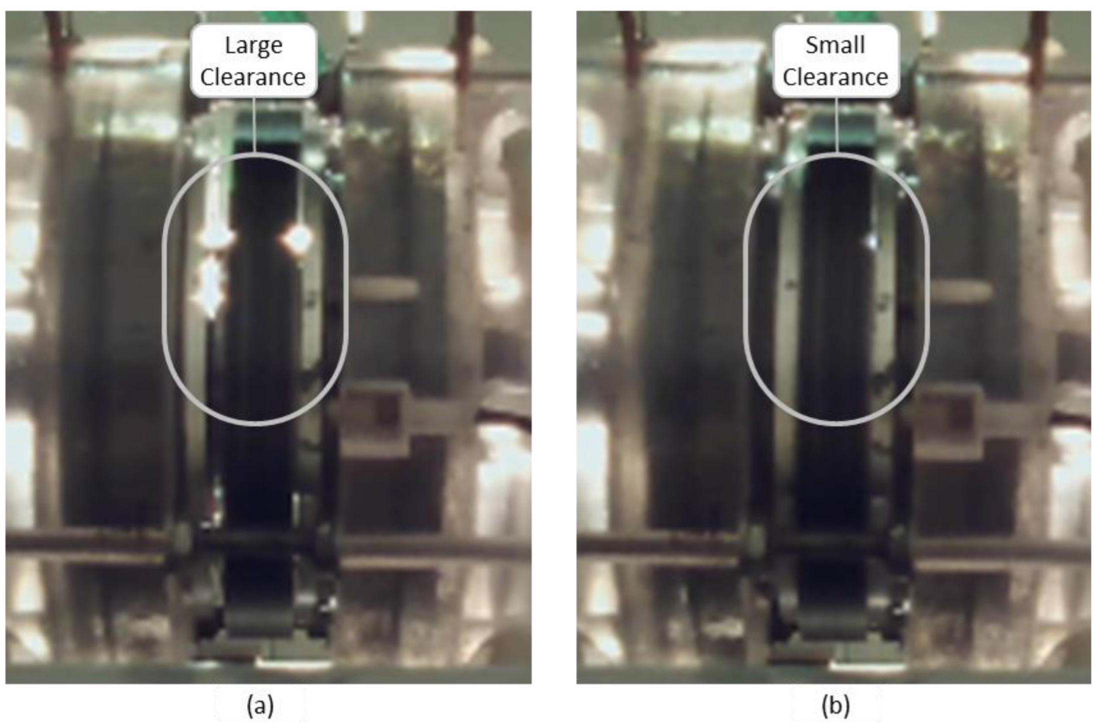

Figure 3 . Video Screen Captures of the Seal in the Unpressurized/Open State (a) and Pressurized/Closed State (b) During the Phase I Rig Operation.

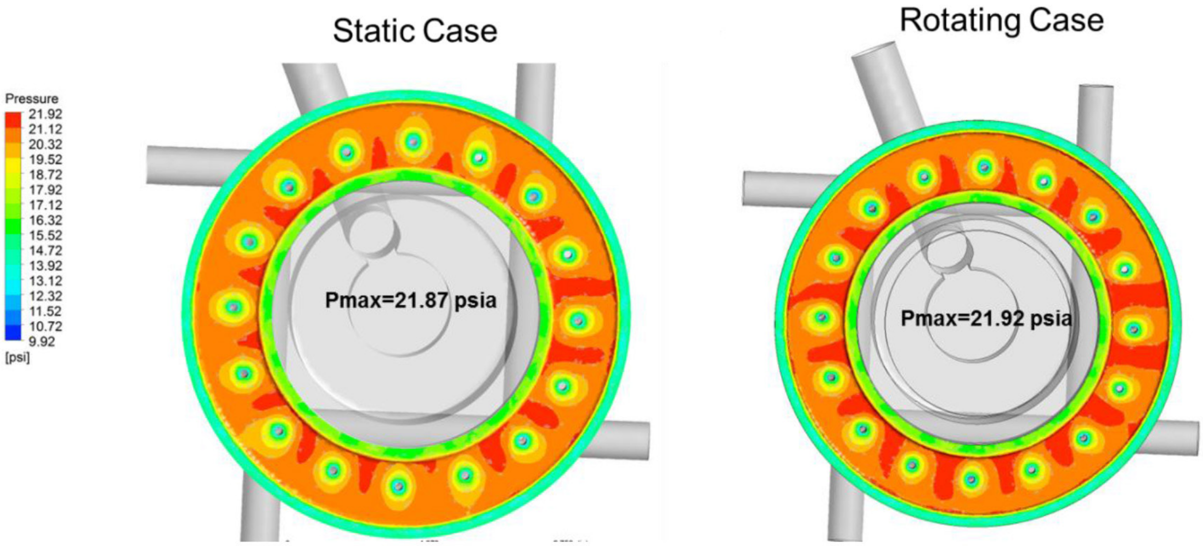

Figure 4. 3D CFD Results Detailing the Effects of Rotation at 80 psi Inlet Pressure.

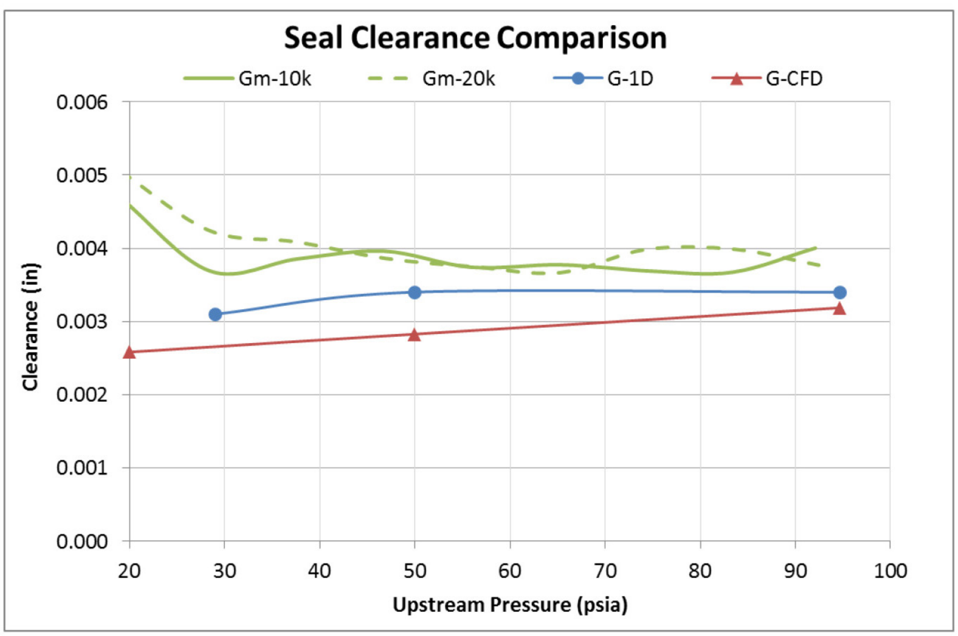

Figure 5. Seal Clearance Analytical Predictions Compared to Test Data.