TEXAS A&M ENGINEERING EXPERIMENT STATION

Turbomachinery Laboratory
Turbomachinery Research Consortium

TEST A PLAIN ANNULAR SEAL OVER A RANGE OF GVF RATIOS FROM ALL AIR TO ALL LIQUID WITH IMPOSED AND MEASURED PRESWIRL

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Two-phase flow is increasingly a factor in compressors (wet-gas compression) and pumps that must handle gas-liquid mixtures. Annular seals dramatically influence the rotordynamics of centrifugal compressors and pumps. Figures 1a and 1b illustrate, respectively, straight-through and back-to-back compressor designs. The "X" in figure 1a denotes the *balance-piston seal* of a straight-through compressor; it denotes the *division-wall* or *center seal* for a back-to-back machine in figure 1b. These seals tend to dominate the rotordynamic stability characteristics of high-pressure compressors. For a straight-through compressor, leakage flow from the last impeller goes down the impeller's back face and out through the balance piston seal, and it is then returned to the compressor inlet. The balance-piston seal absorbs the full head rise of a straight-through compressor. A similar situation holds for the last stage of the back-to-back compressor with leakage flow going down the back side of the last impeller, then through a center seal to proceed radially outwards along the back side of the last impeller of the opposing-flow stages. The center seal absorbs about one half of the compressor's head rise. A similar story holds for balance-piston and center seals of multi-stage centrifugal pumps.

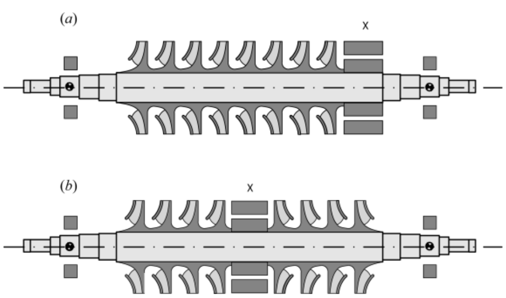

Fig.1 (a) Straight-through and (b) back-to-back compressors

The Turbomachinery Laboratory has produced a very considerable volume of test data for gas annular seals using air as the test medium with supply pressures up to 70 bars and speeds out to 25 krpm. The seal's that have been tested have diameters of 4.5 inches (114 mm). Test results have been presented for pressures ratios on the order of 0.4~0.6 over a range of imposed and measured pre-swirl ratios. The following configurations were tested: (1) smooth-rotor/smooth stator, (2) smooth-rotor/honeycomb stator (varying hole depths), (3) smooth-rotor/hole-pattern stator (varying hole depths), (3) smooth-rotor/tooth-on-stator (TOS) labyrinth, (4) smooth-stator/tooth-on-rotor (TOR) labyrinth. Tests have been conducted with and without swirl brakes.

Over the past 3 years, the test rig has been modified to test with a 2-phase mixture of silicone oil and air. The development was funded by a Joint Industrial Partnership (JIP). Tests have been carried out with GVF ratios from 100 to 80% (mainly air) and zero to 12% (mainly oil).

Work Statement

The following test program will be carried out: Test a smooth (3.5 inch diameter, L/D = 0.75) seal at speeds to 15k rpm with supply pressures to 82 bars for the GVF ranges [0-12%], [90-100%] *for three imposed and measure pre-swirl conditions* (*none, medium, high*).

- Test at 3 speeds (up to 15 krpm) and 4 ΔPs, pressure ratios on the order of 0.5 for mainly-air conditions. The pressure **ratio is not a factor for mainly-oil conditions, only ΔPs.**

- Obtain leakage and rotordynamic coefficients for motion about the centered position.

- Compare the results to predictions from San Andrés' code [1].

[1] San Andrés, L. (2011), "Rotordynamic Force Coefficients for Bubbly Mixture Annular Pressure Seals," ASME Paper GT2011-45264, ASME-IGTI Turbo Expo.

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