Dynamic Characterization of Fully Partitioned Damper Seals

NEW PROPOSAL

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Introduction

Balance piston seals are subjected to large pressure differential and can generate large forces directly impacting the stability of centrifugal compressors. The most common designs are textured seals such as honeycomb, hole-pattern seals, and pocketed seals including pocket damper seals (PDS) and fully partition damper seals (FPDS), shown in Fig. 1. The dynamic performance of textured seals have been extensively characterized and compared to each other under similar operating conditions [1,2]. PDS and FPDS have also been tested in multiple test facilities and conditions, but the amount of data is limited and there is still missing a complete data set that can be used for direct comparison of stiffness and effective damping to textured seals.

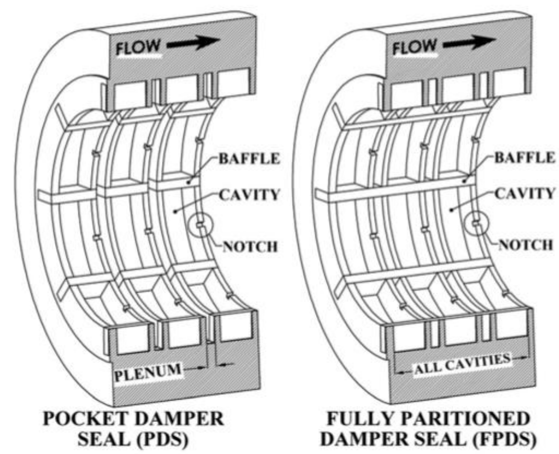

Figure 1. Pocket damper and fully-partitioned damper seal [4].

Ertas [3] tested pocket damper seals for multiple clearance ratios, rotor surface speeds and pressure differentials but only for zero inlet preswirl. Ertas et al. [4] also tested a fully-partitioned pocket damper seal (FPDS- shown in Fig. 1) with multiple preswirls but only for small exit-to-inlet pressure ratios (10% - rig lacked back-pressure capability). This was the first attempt to compare crossover frequency values between FPDS and honeycomb seals. The results shown in Fig 2. Indicate the FPDS has a lower crossover frequency that honeycomb seals. However, it is not certain if those results are also valid for higher exit-to-inlet pressure ratios and higher supply pressures. Vannini et al. [5] tested FPDS and laby seals, and reported force coefficients only for a single pressure ratio and preswirl.

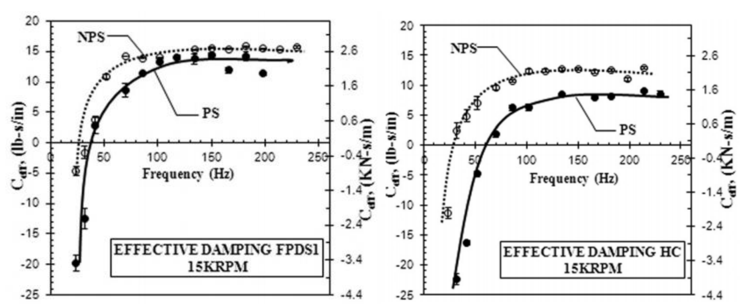

Figure 2. Effective damping for the FPDS and honeycomb seals tested by Ertas et. al. [4].

Proposed work 2017-2018

The proposed experiments will aim at characterizing the dynamic performance of fully-partitioned damper seals (FPDS) under multiple inlet preswirl conditions and pressure ratios. The PDS will be tested in the same rig [6] and test conditions used to evaluate textured seals. The dynamic identification procedure will follow that used by Rouvas and Childs [7]. Force coefficients will be reported as a function of excitation frequency and compared to other damper seals. Table 1 displays the proposed seal diameter and the range of test variables.

Table 1. Seal Diameter and proposed test conditions

Parameter	Value
Diameter	4.5"
Rotor speed	5000,10000,15000 RPM
Inlet pressure	70 bar
Pressure ratio	15, 35, 50%
Inlet preswirl	zero, medium, high

The budget below includes a test seal donation from the TRC members.

Budget

Graduate Student Payroll, 12 months @ $2200/month	$ 26,400
Fringe Benefits	$ 5,000
Tuition and fees	$ 9,000
FPDS pair	$ 7,500
High pressure air	$ 4,600
Hardware donation from TRC member	-$ 7,500
Total	$ 45,000

References

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[4] Ertas, B., Delgado, A., and Vannini, G., 2012, "Rotordynamic Force Coefficients for Three Types of Annular Gas Seals with Inlet Preswirl and High Differential Pressure Ratio," ASME J. Eng. Gas Turbines Power, 134(4), p.042503

[5] Vannini, G., Cioncolini, S, Del Vescovo, G., Rovini, M., 2013, "Labyrinth Seal and Pocket Damper Seal High Pressure Rotordynamic Test Data," J. Eng. Gas Turbines Power. 2013; 136(2):022501-022501-9.

[6] Childs, D., and Hale, K., 1994, "A Test Apparatus and Facility to Identify the Rotordynamic Coefficients of High-Speed Hydrostatic Bearings," J. Tribol., 116, pp. 337–334.

[7] Rouvas, C., and Childs, D., 1993, "A Parameter Identification Method for the Rotordynamic

Coefficients of a High Reynolds Number Hydrostatic Bearing," ASME J. Vib. Acoust., 115(3), pp. 264–27