Evaluation of Mechanical Seal Failures due to Lateral Vibrations

CONTINUATION PROPOSAL

Clay S. Norrbin, Research Assistant

Adolfo Delgado, Associate Professor

May 2019

Introduction

Mechanical seals are typically used as the end seal in pumps to contain working fluid within intended flow passages that have a moving boundary (rotor). These seals typically operate with small clearances (micrometers or less) to keep leakage down to drips. The first tests will be done on a Flexibly Mounted Rotor (FMR) mechanical seal. Figure 1 shows a representation of the FMR mechanical seal to be tested in the current test rig. The actual seal was designed and provided in collaboration with Flowserve.

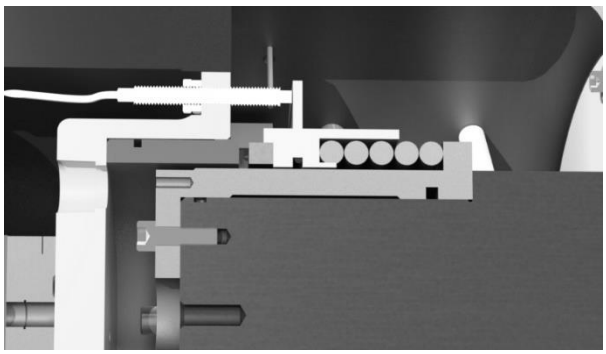

Figure 1: Model of FMR mechanical seal.

Mechanical seals are susceptible to shaft vibration and pressure fluctuations. Seal failures in some systems, like electric submersible pumps, can lead to motor and/or bearing failures. Failures in surface pumps can lead to spillage of the working fluid.

A previous test rig was developed by Green [1]. It examined the effects from a tilted offset tapered seals. The tests provided dynamic data of FMR mechanical seals for static misalignments of the stator. Another test rig of interest is one made by Doust in 1986 [2]. This test rig examined the thermal and pressure wedge generated in a mechanical seal. Since mechanical seals are axial seals, it is not clear why lateral vibration is causing them to fail. Currently, there does not exist test data that provides evidence to the reason vibration leads to failure. This program aims at investigating the reliability and performance of mechanical seals operating under controlled-motion excitations.

Proposed Work and Deliverables

The unique mechanical seal test rig was built during the second phase of this project and it is currently under commissioning. The plan is to utilize this new test rig to perform the first ever mechanical seal tests with simulated rotor and housing vibrations. It will provide data on how mechanical seals act with broadband vibration acting on the rotor and housing. Figure 2 shows the mechanical seal test rig. It comprises a 3600 RPM motor driving a rotor through a bellows coupling and test chamber housing the mechanical seal. The test rig features an overhung rotor design for facilitating access to the seal with minimal disassembly. The rotor is supported on rolling element bearings attached to pedestals through squirrel cages. This configuration allows to input controlled-motion excitations to the rotor. Hydraulic shakers will excite both the rotor and housing to simulate vibration transmitted through the pump shaft and casing, respectively. The test rig is capable of accommodating seals up to 3" in diameter, testing at 200 psi inlet pressure and delivering lateral excitations up to 10 mils pk-pk. The lubrication system resembles a Plan 54 where an external pump and oil cooler regulate the fluid temperature. The mechanical seals displacement and force are measured using 8 non-contacting displacement probes and a 6-axis silicone strain gauge force sensor.

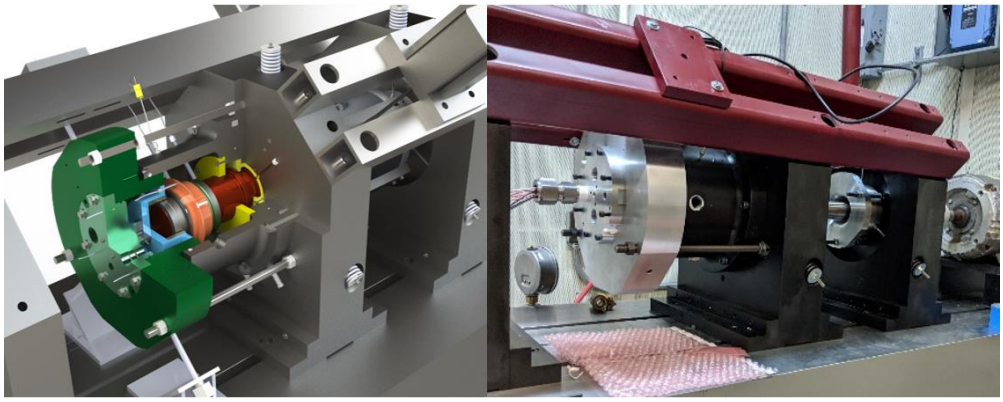

Figure 2: Left) Model of the mechanical seal test rig Right) Assembled view of the test rig.

Table 1 shows the currently proposed test matrix. The test program will include at least these tests. The tests parameters will include shaking location, temperature, pressure, and misalignment. For each test, select vibration waveforms at different frequency and amplitudes will be used to shake the rotor/stator and the relative vibration and force will be measured. Any contact will be documented and the seal faces will be lapped if needed.

Table 1: Proposed mechanical seal test matrix

Seal Type	Vibration Location	Vibration Type	Pressure (PSI)	Alignment (mil/")
FMR	Rotor Vibration	Rotor Lateral	30	0
				1
			60	0
				1
			100	0
				1
			200	0
				1
		Rotor Pitch	30	0
			100	0
			200	0
	Stator Vibration	Stator Pitch	30	0
			100	0
			200	0

Budget

Graduate Student Payroll, 12 months @ $2200/month	$ 26,400
Fringe Benefits	$ 5,755
Tuition and fees	$ 13,275
Test supplies (seal inspection, seal dynamic elements, misc. components)	$ 4,570
Total	$ 50,000

References

1. Lee, A. and Green, I. (1994) "Higher Harmonic Oscillations in a Non-contacting FMR Mechanical Face Seal Test Rig" ASME Journal of Vibrations and Acoustics Vol. 116 pp. 161-167
2. T. G. Doust & A. Parmar (1986) An Experimental and Theoretical Study of Pressure and Thermal Distortions in a Mechanical Seal, ASLE TRANSACTIONS, 29:2, 151-159.