IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Technology (3) (10)

Author: Dr. Pascal Jolly
France, pascal.jolly@univ-poitiers.fr

Prof. Olivier Bonneau
France, olivier.bonneau@univ-poitiers.fr
Prof. Mihaï Arghir
CNRS, France, mihai.arghir@univ-poitiers.fr

A TEST RIG FOR MEASURING ROTORDYNAMIC FORCE COEFFICIENTS OF SEALS, HYDROSTATIC BEARINGS AND IMPELLERS: SUMMARY OF A DECADE OF TESTS

Abstract

Starting with 2007, a dedicated test rig was used to measure rotordynamic force coefficients of thin fluid film components as used in rocket engine turbopumps, namely seals, hydrostatic bearings and impellers. The test rig was designed to use water as working fluid. Two centrifugal pumps supply $120m^3/h$ of hot water (up to 50C) at 50bar (electrical power: 400kW). The tested components can have diameters up to 350mm and can be tested with a pressure difference of 45bar. This leads to axial Reynolds numbers up to 10^5. The tested component is overhung mounted at one end of a rotating shaft, supported by a double conical hybrid bearing (fed with water at 150bar) and driven by a 180kW electric motor up to 6000rpm. The housing of the conical thrust bearing is linked to the frame of the test rig via 8 piezoelectric actuators (mounted 4 by 4 in 2 planes) allowing cylindrical and conical dynamic displacements with amplitudes up to $\pm 100\mu m$ and within a frequency range of 20 to 200Hz. Dynamic loads of 20kN per direction can be applied. The housing of the tested component is equipped with many sensors for measuring dynamic forces, displacements and accelerations, in order to identify rotordynamic force coefficients. Fluid film thickness, pressures and temperatures are also measured. The following components had been tested in the last decade:

- Annular seals, smooth or textured, Brush seals,
- A straight labyrinth seal,
- Hydrostatic bearings, smooth or textured, with radial or angled injection,
- Impellers, open or shrouded.

A summary of the experimental results will be given for one of the tested components (sealing, supporting, pressure increase) together with a comparison with numerical prediction. The difficulties encountered during experiments will be discussed as well as the solutions that were found to override them. In 2018, the test rig was moved to another location. This allowed a retrofit of the test rig, as explained below:

- A stiffer conical thrust bearing, equipped with more sensors, needed to secure the test rig, was designed and manufactured,
- A 500kW heat exchanger was added for performing longer tests with a regulated water temperature,
- The geographical proximity with compressors and tanks able to furnish a large quantity of compressed air offers the possibility of testing air fed components. The design of the test rig was therefore adapted in consequence