TRIBOLAB. A Space Tribometer (POSTER)

J. Serrano (serranotj@inta.es), J. Gómez-Elvira, , R. Santiago, J. Pazos
Instituto Nacional de Técnica Aeroespacial (INTA)
Crtra. Ajalvir Km 4. 28850 Torrejón De Ardoz. Spain (Phone: 34 91 5201629, Fax:34 91 5201369)

J. I. Oñate, I. Garmendia, A. Rodríguez
Fundación INASMET
Mikeletegi Pasealekua, 2
20009 San Sebastian, Spain

ABSTRACT

TRIBOLAB is one of the instruments selected by ESA as part of the European Technological Facility (EuTEF) with the objective to perform basic and component level tribological tests on flight . Three types of tests have been selected to be place in the International Space Station (ISS): pin-on-disk (POD) tests to evaluate the behaviour of solid films and coatings developed by INASMET and INTA, ball bearing (BB) tests to characterise new solid lubricant films, and a set of passive tests to measure oil losses through labyrinth shapes designed by ESTL.

1. INTRODUCTION

INTA, INASMET and ESTL (European Space Tribology Laboratory) proposed to ESA a test facility called TRIBOLAB to carry out lubricant characterisation tests in the ISS. The facility proposed here should be able to evaluate a variety of tribological phenomena under the combined effects of the ISS environment (i.e. vacuum, radiation, zero gravity, micro-vibrations, etc.).

2. TRIBOLAB DESCRIPTION

2.1 General

The TRIBOLAB baseline design is shown in Figure 1 to Figure 3. The instrument contains six piled up experiments cells; each cell includes one pin-on-disk (POD) test and one ball bearing (BB) test both totally independent.

Disks and bearings are attached to different shafts supported by a preloaded bearings pair at one end and a groove bearing at the other end. DC actuators rotate the shafts.

A parallel mechanism is used to select and exchange experiments.

The instrument is joined to the EuTEF panel by a four legs main support structure.

2.2 Experiments Description

The pin-on-disk is a basic tribological experiment recommended in the development of any lubricant, with the purpose of modelling lubrication, friction or wear behaviour under a set of variable conditions.

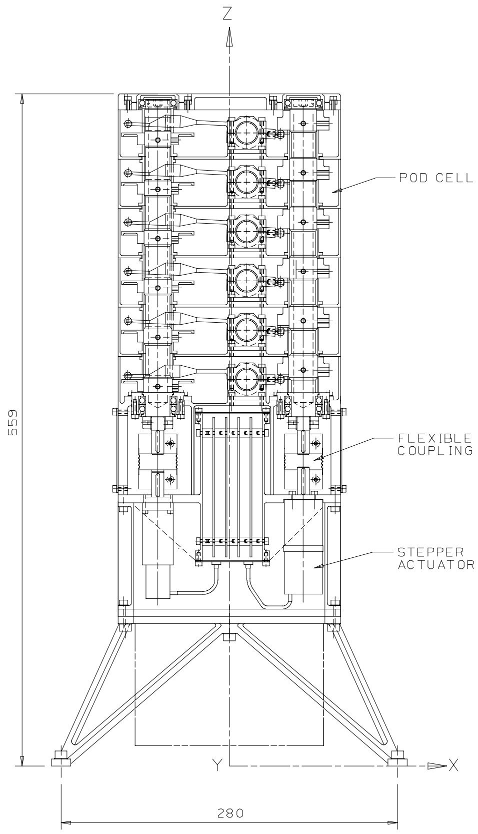

Figure 1: TRIBOLAB. POD Experiment section

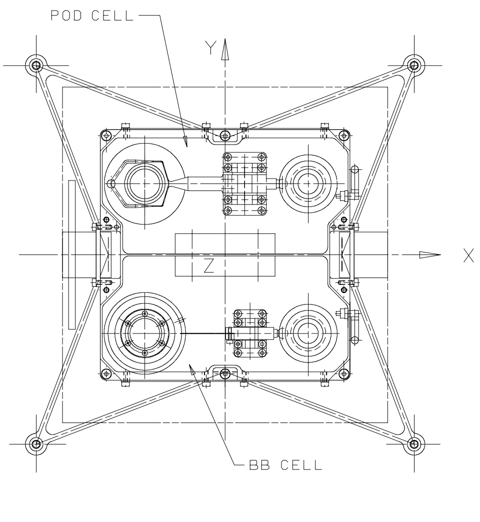

Figure 2: TRIBOLAB. Cell top section

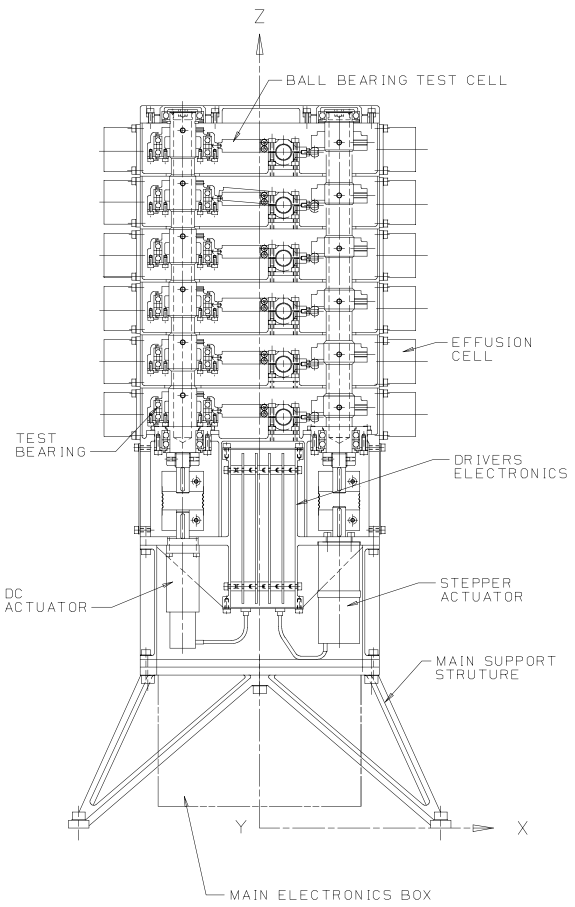

Figure 3: TRIBOLAB. BB Experiments Section

The instrument has a column of pin-on-disks in such way that different coatings can be tested independently. Cross contamination by generated debris is avoided by using labyrinth seals between shaft and cases.

A second column for the testing of bearings is included in the TRIBOLAB. With a pin-on-disk test, it is possible to highlight the main characteristics of a solid lubricant, but with the data drawn from it is not sufficient to foresee its behaviour in a more complex element like a bearing. This is the reason for including a dedicated bearing test; moreover with this device it is possible to test not only lubricants, either liquid or solid, but bearing cages or sealing labyrinths as well, which are key elements in a space environment.

2.3 Experiment Cells

Each experiment cell is divided in two compartments for POD (POD cell) and BB (BB cell) tests. The complete experiment cell is shown in Figure 4.

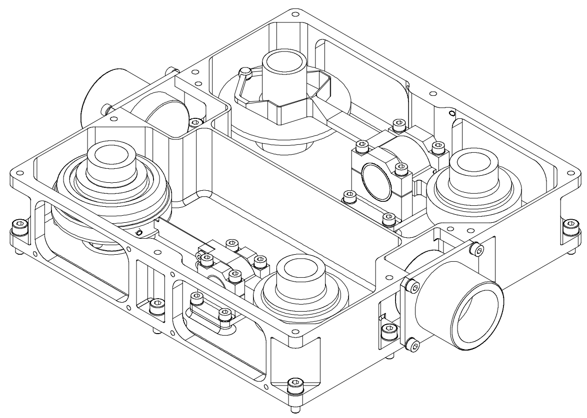

Figure 4: Experiment Cell

The POD design is a classical one based on a spring loaded flexible cantilever arm with a ball at one extreme as shown in Figure 5.

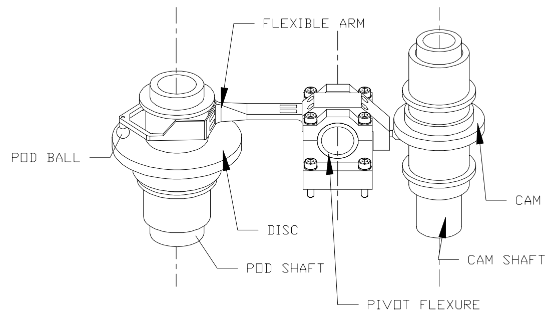

Figure 5: POD experiment configuration

The BB torque sensor consists in a flexible cantilever plate which avoid the rotation of the bearing outer case by contacting with an external pin as shown in Figure 6.

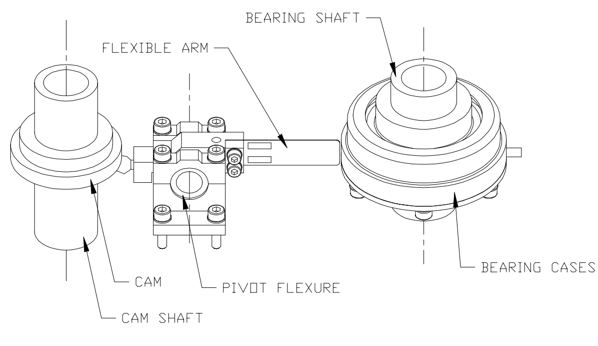

Figure 6: BB experiment configuration

Finally, in two TRIBOLAB sides some effusion cells are allocated to evaluate the behaviour of liquid lubricants in a range of labyrinth seals (static tests). Each cell is a cylinder with an oil reservoir at its bottom, and a small gap between the cylinder wall. By measurements of the oil losses during the operational life (3 years) in the ISS, it is possible to estimate the efficiency of the labyrinth designs.

2.4 Electronics

A data acquisition system, four motor drivers, an onboard computer based on a Motorola 68302 microprocessor, and a specific board to handle the MIL-1553 bus compose the electronics.

2.5 Measuring system

Friction and normal forces are both monitored during POD tests. Two complete wheatstone bridges of semiconductor strain gauges are bonded on the plates of a flexible arm to measure the forces. The arm design is a compromise between signal level produced by deformation and strength and stiffness requirements. The arm with the gauges already implemented is shown in Figure 7.

Figure 7: POD arm with bonded gauges

The sensors used to measure friction torques in BB tests are also based on a wheatstone bridge of semiconductor strain gauges; the gauges are bonded in a flexible sheet which is in contact with the bearing outer case and clamped at the other end.
The sensor sensitivities to load are as follows:

Experiment – LOAD	Sensitivity
POD – friction force	100 mV/N
POD – normal force	25 mV/N
BB – friction torque	15.5 mV/mNm

2.6 Exchange Mechanism

An additional mechanism is designed with the following purpose:

- To exchange experiments
- To remove an experiment in case of test end or malfunction
- To maintain balls and disks with no contact during launch to avoid cold welding

The mechanism is similar for POD and BB and consists in a single shaft that contains a set of cams. The system allows to test sequentially the POD coatings and to set different bearings configurations to test.
Stepper actuators rotate the shafts.

2.7 POD Loading system

The POD arm is supported on a pivot flexure spring; the arm release produced by the rotation of the exchange mechanism puts the arm ball in contact with the disk applying a normal force according to on-ground calibrations.

3. INSTRUMENT FUNCTIONALITY

The main characteristics of the experiments are below shown.

3.1 Pin-On-Disk Experiments

- Number of tests: 6
- Disk diameter: ϕ60 mm
- Radius track: 25 mm
- Ball diameter: ϕ6 mm
- Load range: 0.5-2.3 GPa (fixed for each experiment)
- Frictional forces range: 0.05 to 2 N
- Rotation Speed: 10 – 50 rpm
- Measuring errors:
    - 20% for low friction measurements
    - 10% for high friction measurements
- Automatic switch-off either up to selected number of revolutions or pre-selected value of friction coefficient (max. 0.4)

3.2 Ball Bearings Experiments

- Bearing type (nominal): Preloaded angular contact ball bearings
- Number of tests: 6
- Test combinations: 16
- Ball Bearing Size (nominal):ϕ44.5 mm (outer) - ϕ33.3 mm (inner)- 12.7 mm (thickness)
- Friction torque range: 1.0E-3 to 0.1 Nm
- Rotation Speed: 50 – 300 rpm
- Measuring errors: ± 8%
- Automatic switch-off either up to selected number of revolutions or pre-selected value of friction torque

4. TRIBOLAB PROGRAM STATUS

Presently, and after some changes in the EuTEF location that have required a revision of the design, a prototype of the flight module will be manufactured this year to prove the instrument performance.