Large Angle Flexure Pivot Development for Future Science Payloads

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An innovative large angle flexure pivot was developed that is capable of a performing an angular stroke of ±90° while maintaining a lateral shift error of less than 35 µm. The findings of the resulting prototype shall be the base for future optical space components operating in a cryogenic environment.

An innovative design of a Large Angle Flexure Pivot (LAFP) is described. Designed in the frame of an ESA activity, it combines the advantages of flexure mechanisms while surpassing one of their few flaws, small displacement strokes. The LAFP design exceeds these angular limitations to reach a deflection of 180° (±90°). The center shifts laterally by less than ±35 µm throughout the full rotation range. The LAFP is meant to be mounted in pairs, coaxially and with the payload between them. The intended application of the LAFP is to angularly guide an optical component in a space environment for future science missions operating in a cryogenic environment.

Pivot specifications

The high-level requirements for the pivot mounted in pairs with a mobile payload are:

- Angular range ±90° (±70° infinite lifetime)
- Central shift <±35 µm (@70°)
- Angular stiffness 0.33 Nm/rad (@90°)
- Payload mass 1.8 kg
- Number of cycles >3 million
- Pivot mass 440 g, Marval X12 stainless steel
- Temperature range -125° to +50°C
- Random vibration 12.2 grms (X, Y & Z)

Extensive FEM analysis was performed to validate the pivot design both at component level and as an assembly mounted on a test bench. Among the component tests performed, the pivot rotary stiffness was measured using a Kistler torque sensor and compared with the FEM values which showed a very good correlation (Figure 1).

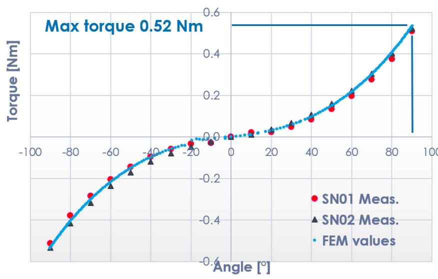

Figure 1: Pivot torque measurement curve.

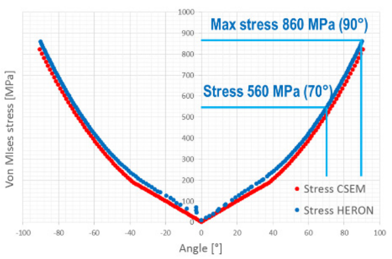

Figure 2: LAFP blade stress as a function of rotation.

Figure 3: LAFP Engineering Model.

A dedicated performance test bench (Figure 4) was developed and manufactured to test the pivot characteristics notably the lateral shift using Eddy current sensors. The test bench incorporates a representative dummy payload for mass and inertia, a custom rotary Voice-Coil Actuator (VCA) from Cedrat Technologies (FR) and a Renishaw Tonic angular encoder system for closed loop control. The test bench is operated using a MicroLabox controller from dSpace driving an amplifier on which a dedicated control algorithm was implemented.

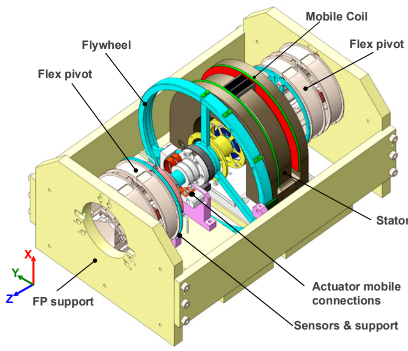

Figure 4: EM Test Bench.

Further FEM simulations were performed with the assembly which included a representative payload in an environment with random vibrations, shocks and thermal cycling. The vibration and shock test bench (Figure 5) incorporate a simplified launch locking device to offload the pivots from the payload.

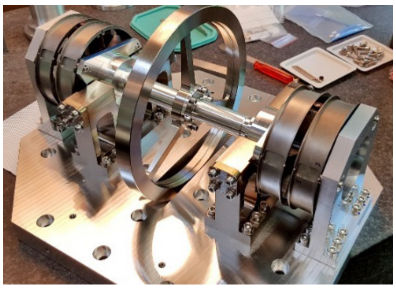

Figure 5: Vibration test bench with LAFP pivots assembled.

The pivots were successfully tested, and survived vibration loads for high level sine at 24 g and random vibration at 12 grms in all three directions. The performance tests have confirmed a lateral shift of less than ±35 µm over an angular stroke of ±70°.