DEVELOPMENT OF A FULLY VARIABLE BEARING ACTIVE PRELOAD SYSTEM WITH NOISE REDUCTION FEATURES

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BACKGROUND

This paper presents the findings of the development of a new variable Bearing Active Preload System (BAPS) device offering fully adjustable preload via a redundant stepper motor actuator.

BAPS devices allow spacecraft mechanisms to perform optimally during a severe launch environment whilst maintaining a well defined low friction/torque characteristic when in-orbit. This is achieved by the introduction of a high preload in the mechanism's bearings during the launch phase and thereafter reduction of this high preload to a lower level for the mechanism's on-orbit life. Previously this lower preload level has been fixed, however the variable BAPS device offers a fully tuneable system which provides benefits in a number of different areas and applications.

The original driver for such a technology was the requirement to increase the life of solid lubricants by reducing the contact stress once on orbit, however a number of additional benefits and desirable characteristics of the system have been identified. The target application in this case is a liquid lubricated reaction wheel which uses a BAPS-enabled noise reduction system.

CONTENTS

This paper includes a brief overview of the novel design, including the evolution of the BAPS design, as well as the intended benefits which include significantly enhanced lubricant life, torque performance and micro-vibration performance. Predicted system performance as well as the results of the test program will then be presented. This has an emphasis towards the micro-vibration performance of the device with and without the noise reduction system and also with a gravity offload system (required to achieve the low operational preload levels during 1g testing).

Although BAPS devices have been produced previously for flight applications this is the first variant to offer variable setting of the preload on orbit. The target application, for which an Engineering Model has been built, also extends the scope of the device to include noise reduction features, which are desirable for the intended application as well

as a number of alternative applications. The benefits are particularly significant for small satellites with low inertia or sensitive instruments.

The variable stiffness afforded by the system allows the use of an isolating shaft design which reduces the exported forces and torques from the system in two ways:

- Isolation of the inbalance loads
- Reduction of ball-raceway forces

The extent to which we succeed in each of these areas will be evident from the micro-vibration data presented and through analysis of the vibration signatures obtained by the different models at varying preloads. These will consist of comparative waterfall plots of the hardware in the different configurations to give an indication of how and where benefits have been obtained.

The paper also includes any lessons learned in the manufacture and testing of the hardware particularly in the area of micro-vibration measurement, but also including thermal vacuum and vibration testing.

STATUS

This development project is currently at the Engineering Model stage and funded by ESA. The hardware is currently undergoing characterisation testing and pre-qualification testing, essentially equivalent to the qualification levels for the target application, which will be completed in the coming weeks. No work has previously been published or presented on the fully variable BAPS device or its low noise variant, although the original BAPS engineering model was presented at AMS in 2006.

Figure 1 – Rendered image of complete device

Figure 2 – Major sub-assemblies undergoing characterisation tests

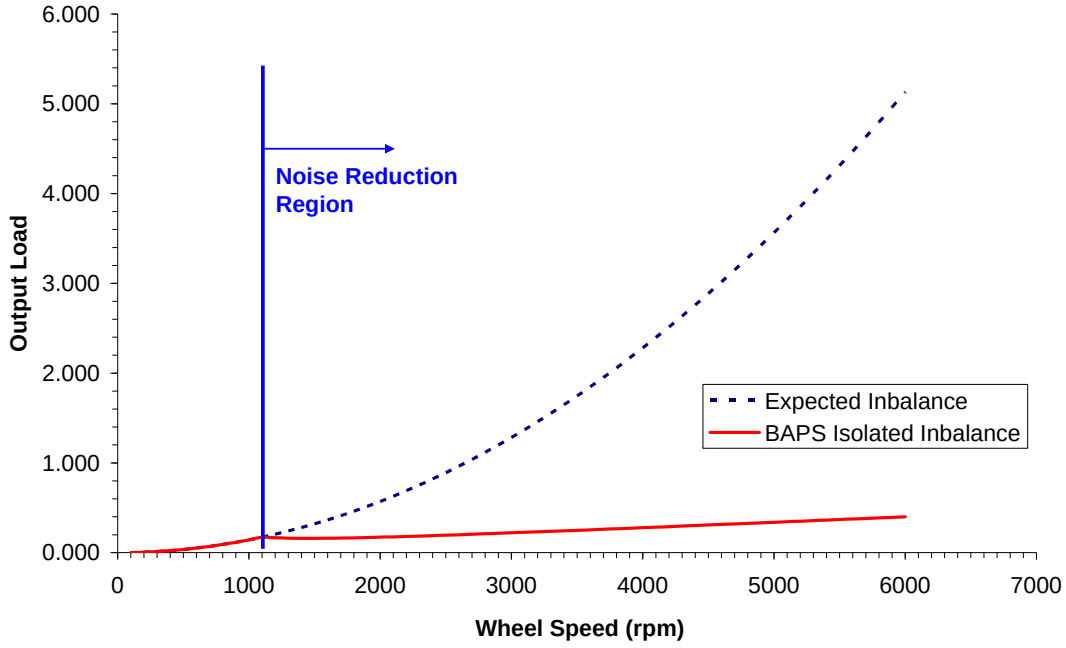

Figure 3 – Predicted inbalance reduction