Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract
Preferred Topics: TURBO / PROPHY / STUDENT
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Type: Oral
Status of corresponding author: Student
For student corresponding author: student member of one of the following:
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Title
Identification of degradation profiles for turbopump bearings in reusable liquid propellant rocket engines

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Abstract

The turbopump bearings in a reusable Liquid Propellant Rocket Engine (LPRE) are one of the most critical components, directly affecting the engine performance and lifetime. At the state of the art, several studies on bearing degradation, State of Health (SoH) estimation and prediction, and Remaining Useful Life (RUL) estimation have been conducted in the field of Prognosis and Health Monitoring (PHM).
The objective of the present work consists in researching a degradation profile that could be integrated in a bearing dynamic model to generate synthetic non-stationary data for PHM applications. Indeed, to simulate such kind of vibration signal, the dynamic model must be provided with a degradation model. This latter consists in a mathematical relation that contains two major pieces of information: the moment at which the degradation starts and how its shape evolves.
To understand the degradation dynamic, a public data-base of vibration signals [1] was deeply analysed with two techniques: Short Time Fourier Transform (STFF) and the Wavelets Multiresolution Analysis (MRA). Different statistical features were computed with respect to time and they were used as Health Indicators (HI). The comparison of all the obtained HIs allowed the identification of a recurrent degradation trend. After careful analysis, the identified profile was divided into four phases: nominal phase, gradual degradation, degraded equilibrium and failure. This empirical degradation profile provides interesting information about the degradation evolution. In particular, by looking at the HI curve it is possible to define the time $t_1$when the degradation first appeared. In order to validate the obtained values, the same quantity was computed using crack initiation fatigue criteria with the CNES bearing computation tool RMS5.
The work presented, concerning this parameter, is a first step towards the generation of synthetic non-stationary bearing vibration data. It also plays a key role in the formulation of a theoretical degradation profile which describes the bearing degradation evolution according to its material and operating condition. Eventually, the generated data will be of great help for the training of PHM data-driven algorithms like the one presented in [2].

References

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[2] F. Galli, V. Sircoulomb, G. Hoblos, P. Weber, and M. Galeotta, 'Remaining useful life estimation based on wavelet decomposition: Application to bearings in reusable liquid propellant rocket engines', presented at the 16th European Workshop on Advanced Control and Diagnosis, ACD 2022, Nov. 2022.