Integrated Digital Platform for Aircraft Engine's Parts Life Cycle Management

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Abstract

The aim of this work is to support aircraft engine parts life cycle management from airfoil design to in-service tracking through an integrated digital approach. The study focuses on a practical use case involving fan and inlet guide vane (IGV) airfoils, selected as representative components for combining simulation, durability assessment, and operational analytics. Rather than treating these activities separately, the work connects them within a common framework to improve engineering decision-making across development and service phases.

The proposed methodology consists of three interconnected modules within an integrated digital workflow. Module A, which constitutes the focus of this study, addresses fluid-structure interaction (FSI) problems involving mechanical nonlinearities. To analyze components with poorly defined dynamic mechanical boundaries, the method employs the Hybrid Frequency-Time Domain Method (HFT). In the present application, this module is used to evaluate fan and inlet guide vane (IGV) airfoils, enabling efficient numerical assessment of their structural response during the development phase. The remaining modules provide complementary life-cycle support. Module B addresses operating cost forecasting and Module C addresses operational durability assessment using the Flight-by-Flight (FbF) approach.

The FSI results obtained for fan and inlet guide vane (IGV) airfoils show good agreement with experimental data, indicating that the proposed methodology is suitable for efficient numerical assessment of parts under development. Moreover, the iterative coupling process was found to converge rapidly when an appropriate under-relaxation treatment is applied, highlighting the importance of this parameter in achieving stable and computationally efficient solutions for nonlinear coupled analyses.

Keywords

FSI, airfoil design, fleet monitoring, fleet forecasting.