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EXPERIMENTAL VERIFICATION OF FLUTTER LIMITS FOR A MISTUNED SUPERSONIC TURBINE BLISK

Abstract

Turbine flutter is a critical failure mode for turbomachinery applications that needs to be well mastered in the product development process. This necessity is pronounced for modern space turbine applications where rotors most often are of blisk (blade integrated disk) type, sometimes enabled by additive manufacturing (AM) processes, and for which the functional requirements are requiring safe operation for more engine cycles and over a larger operating envelope than traditionally to enable engine throttleability on reusable launcher applications. This study concerns the possibility to inhibit flutter of a supersonic space turbine by introducing mistuning.

Turbines operating at high pressure in high velocity flow are susceptible to flutter. The flutter limits of a supersonic test turbine have previously been established in a turbine air test rig at GKN [1]. The blisk used in the test was tuned. The turbine was operated at running conditions over a large operating envelope to map out flutter limits. During the test, flutter was intentionally triggered at several different operating conditions.

In [2] the rotor blisk used in [1] was modified to inhibit flutter. The objective of the test was to show that the flutter boundary could be moved far enough to be able to clear the entire operational envelope of the application. The design strategy chosen was to introduce a mistuning concept. Based on aeroelastic analyses using a reduced order method a criterion for the level of mistuning was established to stabilise the lower system modes. Running the redesigned blisk at operating conditions deep in to the unstable region of the tuned blisk and to the limit of the test rig no occurrence of flutter could be detected.

In this work, the rotor blisk in [2] was modified again but now in order to reduce the mistuning level. Two different intermediate mistuning levels were tested in a turbine air test rig at GKN with the objective to obtain flutter within the operational envelope and to study how the mistuning level affects the flutter limits. The design choices were successful rendering that flutter occurred several times during the test campaign. This paper continues the experimental verification of the mistuning concept in [2] and the associated methods used for calculation of the aerodynamic damping for mistuned blisks.

References:

[1] Groth P, et.al. 2008, "Experimental and CFD based determination of flutter limits in supersonic space turbines", ASME paper GT2008-50675, ASME Turbo Expo 2008.

[2] Groth P, et.al. 2008, "Design and experimental verification of mistuning of a supersonic turbine blisk, ASME paper GT2008-50677", ASME Turbo Expo 2008.