

Abstract

Bladed disks can be found in engines used to power aircrafts and power plants. Due to their high modal density and the broad frequency range of the aerodynamic excitation forces, resonance-crossings on Campbell diagram are very likely during the design phase. High cycle fatigue (HCF) failure of turbine/compressor blades due to high vibration amplitudes in resonance frequency is one of the main concerns in their design stage. To suppress excessive vibrations in the blades and prevent HCF, dry friction damping has been widely incorporated into the design of bladed disks. However, due to the nonlinear nature of friction contacts, analysis of such systems becomes complicated. In addition to that, the inevitable presence of small variations between blades and consequently the loss of cyclic symmetry properties, known as mistuning, could considerably affect the dynamic behavior of bladed disks. Compared with that of a tuned bladed disk, which is a bladed disk with identical blades/sectors, the vibration response levels of a mistuned system can be much higher, that can ultimately result in premature HCF of blades.

Motivated by the turbomachinery community's need for practical design tools that can account for realistic operating conditions, one main focus of this dissertation is to develop models for nonlinear forced response analysis of bladed disks with friction interfaces. The developed models can be constructed by minimal computational effort (sector-level) and are suitable for statistical analyses, tailored for industrial applications. In addition, this dissertation faces the inherent complexity of experimental investigations of nonlinear dynamics of mistuned bladed disks. To this end, a detailed experimental campaign is conducted to evaluate the effects of mistuning on nonlinear forced response levels of an integrally bladed disk. The provided experimental benchmark can be used to validate the tools developed for nonlinear forced response of mistuned bladed disks.