Abstract

The mitigation of excessive vibrations is one of the essential design criteria in the turbomachinery applications. To meet this need, friction damping technologies introduce beneficial approaches such as the incorporation of secondary structures into main bodies via contact interfaces. Intentional implementation of friction into systems helps to reduce oscillatory responses; however, it also brings various challenging issues due to the complex physics of the problem accompanied by several uncertainties. In this thesis, one of these uncertainties, which is referred to as the non-uniqueness of contact forces, is addressed on the dynamics of frictionally constrained turbine bladed disks. More specifically, the fundamental mechanism of the nonlinear dynamic response variability is thoroughly elaborated in the context of non-unique static tangential friction forces. On the computational side of the current work, the non-repeatability of the nonlinear vibration behavior while keeping all user-controlled inputs same is first shown on an industrial turbine blade. Two novel approaches are then developed for the determination of nonlinear response boundaries of the variability range. The methods are demonstrated on an academic turbine bladed disk with contacts in the shrouds and blade-disk interfaces, and the results are validated with a test data previously recorded on under-platform dampers. In the experimental portion of the work, a novel test campaign, which aims to reveal the underlying kinematics of the non-unique friction force phenomenon, is designed for one another academic turbine blade coupled with mid-span dampers. It is shown that static force equilibrium achieved on the damper is non-unique, which leads to multiple dynamic response amplitudes, although all the user-controlled inputs are nominally same in the macro scale testing environment. Finally, the variability range measured in the experiments is computationally estimated by using the developed approach. The outcomes of this thesis contribute to the understanding of how non-unique contact forces affect the dynamic behavior of frictionally constrained turbine bladed disks.