VIBRATION PHENOMENA IN IMPERFECT BLADED DISK STRUCTURES

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Abstract

Vibration localization occurs in spatially repetitive structures whose ideal periodicity is broken by small imperfections, or disorder. Local irregularities can alter drastically the global dynamics, by localizing vibration modes to small geometric regions and inhibiting the propagation of incident waves. Remarkably, this is achieved without dissipation. Localization is particularly acute for bladed disk structures, which are fundamental components of numerous turbomachines such as those in powerplants and jet, rotorcraft, and rocket engines. Their free and forced responses can be highly sensitive to unavoidable blade mistuning, resulting in large stresses and high cycle fatigue.

In this presentation, the physical mechanism for localization is first examined, after which the implications for bladed disk structures are explored. A key attendant issue is the generation of reduced-order models (ROM), which are required to compute the statistics of the vibratory response of bladed disks with random mistuning. A ROM based on a component mode mistuning approach is developed, and the resulting design tool can be used to mitigate the deleterious effects of mistuning. The ROM successfully handles large mistuning situations, including rogue and fractured blades, intentional and geometric mistuning, and design changes. Finally, recent research on non-smooth unilateral contact rotor-stator interactions and dry frictions dampers is presented, motivated by the advent of technologies that seek to minimize operating clearances and reduce blade response, respectively. Computational tools are developed to predict critical structural interactions such as abradable material removal at blade-casing interfaces, and a promising approach is introduced for the periodic solutions of friction damped systems based on an exact formulation of the non-smooth governing equations as equalities.