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[Extended Abstract]

Geometric Optimization of Dry Friction Ring Dampers for Maximized Reduction in Forced Responses

Weihan Tang, Department of Mechanical Engineering, University of Michigan, Ann Arbor
Bogdan I. Epureanu, Department of Mechanical Engineering, University of Michigan, Ann Arbor

Introduction

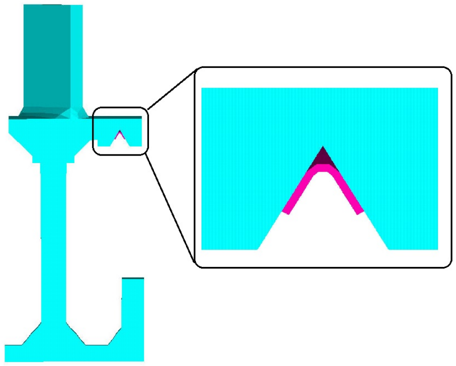
In operation, bladed disks are subject to high levels of dynamic loading, which result in large response amplitudes at resonance. To reduce the response level and prevent damages caused by high cycle fatigue, friction damping sources are introduced to dissipate vibration energy. The common types of friction dampers include underplatform wedge dampers, frictional shroud contacts, and ring dampers. Ring dampers have gained increasing popularity. These dampers, located underneath the rim, are held in contact with the blisk by centrifugal loading. Energy dissipation by friction damping takes place when relative motions occur between the damper and the blisk.

The effectiveness of friction dampers depends on a variety of design parameters, including the contact properties, external forcing, and damper geometries. To determine the optimal design parameters that lead to maximized energy dissipation, conventional methods involve repetitive forced respone analysis on a large amount of pre-selected sets of parameters. Such approaches are computationally expensive, and the pre-selected parameter sets are often not guaranteed to provide adequate information that leads to an optimal solution. To address this issue, sensitivity analyses have been adopted to facilitate in tracing the optimal design parameters, with significantly reduced amount of computations [1, 2, 3, 4, 5]. Unfortunately, existing work based on sensitivity analyses heavily focuses on determining optimal contact parameters, and forcing conditions. Limited work has been done to explore the effect of damper geometry on its effectiveness in energy dissipation.

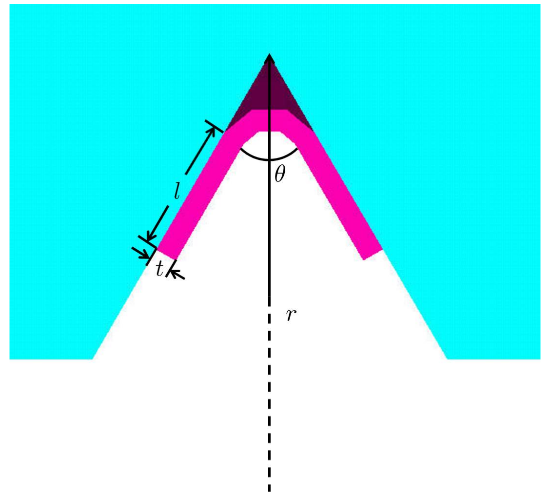
Methods

The effectiveness of the damper is determined by evaluating the reduction in forced responses due to friction damping. To compute the non-linear forced responses of a blisk-damper system, a reduced-order model is constructed with the method of coherent ring dampers (CoRiD). The small-sized equation of motion in the reduced-order domain is efficiently solved by the harmonic balance method.

Figure 1a shows an academic blisk model in contact with a V-shaped ring damper. In this study, the geometry of the V-shaped damper is first parametrized as shown in Fig. 1b. Small variations in damper geometric parameters are applied following a volume constraint by varying two of the parameters simultaneously. Forced responses are computed for 28 blisk-damper systems with distinct damper geometry variations to study the trade-offs among different damper dimensions. Moreover, a series of sensitivity analyses are performed to reveal the optimal damper dimensions associated with maximized response reduction. Results suggest an optimal damper geometry that leads to a large reduction in forced response amplitude (63%). Based on the analyses conducted in this work, a set of



(a) UM validation blisk-damper system



(b) A parametrized V-shaped damper

Figure 1. A typical blisk-damper system: UM validation blisk (blue) in contact with a V-shaped ring damper (purple). The damper is parametrized into four geometric parameters.

damper design rules are also proposed.

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