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Original
Identification of Blade-root Joint Dynamics in Turbine Disks / Saeed, Zeeshan. - (2021 Sep 28), pp. 1-214.

Availability:
This version is available at: 11583/2928612 since: 2021-10-01T14:52:00Z

Publisher:
Politecnico di Torino

Published
DOI:

Identification of Blade-root Joint Dynamics in Turbine Disks

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Bladed-disks are fundamental bricks of the rotating parts of a turbomachine. They are operated in harsh operating conditions of elevated temperatures and pressures at high speeds. This can lead to high structural vibration and high cycle fatigue failures. Thus, it is strongly desired to dampen the vibration and also to predict the vibratory response accurately. The connections at blade-root and shroud, among other sources, can be utilized to dampen the vibration. However, predicting the connection or joint dynamics is extremely challenging, mainly due to complex vibratory characteristics of the blades and disk, their small and unreachable interface Degrees-of-Freedom (DoF), and uncertainty of the contact conditions.

This work aims to identify dynamics of blade-root connections through experimental measurements in the dynamic substructuring framework. The inability to acquire an adequate set of the interface DoF measurements compels one to use hybrid modelling and expansion techniques in order to describe the substructure dynamic behaviour. Thereafter, the joint in the assembled blade-disk system is identified through the inverse approach or substructure decoupling methods. The inherent sensitivity of the inverse methods to small errors are also investigated and they are reduced by introducing a new correlation approach in the original expansion method. The joint identification applications, in practice, have been limited to most simple test cases and configurations. In this work, these methods have been reviewed mathematically to better understand their limitations and to provide links with the general dynamic substructuring framework. A substructure decoupling based on the expansion strategy is demonstrated on a bladed-disk system with a dove-tail type connection. The test-case is academic yet the joint is realistic and more complex compared to other test-cases in the literature. The research findings may enable to better predict the response of built-up bladed-disk systems at the design and testing stages.