Doctoral Defense

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AMPLIFICATION OF BLADE RESPONSE DUE TO MISTUNING: PREDICATION AND ALLEVIATION

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Abstract

This research focuses on three aspects of the forced response of mistuned bladed disks: (i) the development of a novel perturbation technique for its accurate predication (ii) the formulation and validation of an expedient algorithm for the estimation the maximum blade amplitude can be induced by mistuning; and (iii) the development of a search strategy to find the intentional mistuning pattern that leads to the least sensitivity of bladed disk to additional random mistuning.

A novel perturbation approach based on the Sherman-Morrison-Woodbury formula is proposed in this research. The numerical validation of this method is first accomplished on a single degree freedom per blade model and it is demonstrated that this perturbation technique accurately predict the forced response of mistuned bladed disk through the entire range of blade to blade coupling stiffness. The accuracy of this perturbation technique is further confirmed on a multi degree of freedom per blade disk model. A comparison with other perturbation techniques has also been accomplished to demonstrate the value of this perturbation method.

In regards to the determination of the maximum amplitude of the forced response of mistuned bladed disks, a previous analytic solution is first generalized. Then, a new optimization approach is proposed in which the entire mode shape is the subject of the optimization and the corresponding results are in excellent agreement with those obtained previously with a much more time consuming method. This technique is shown to be equally applicable to damped and undamped systems and is validated on both single and multi degree of freedom per blade disk models.

Finally, the reduction of the sensitivity of the forced response of bladed disks due to random mistuning is addressed through the consideration of intentional mistuning, i.e. of disks in which the blades do not exhibit the same properties. Disks composed of two different blade types are more specially considered and a dedicated optimization strategy is proposed and validated to determine the arrangement of this two blade types (i.e. the intentional mistuning) that leads to the least sensitivity to random mistuning. Numerical validations with different models demonstrate the computational advantage of this strategy over several previously proposed approaches.