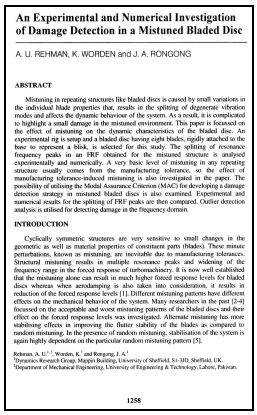
An Experimental and Numerical Investigation of Damage Detection in a Mistuned Bladed Disc

A. U. REHMAN, K. WORDEN and J. A. RONGONG

ABSTRACT

Mistuning in repeating structures like bladed discs is caused by small variations in the individual blade properties that, results in the splitting of degenerate vibration modes and affects the dynamic behaviour of the system. As a result, it is complicated to highlight a small damage in the mistuned environment. This paper is focussed on the effect of mistuning on the dynamic characteristics of the bladed disc. An experimental rig is setup and a bladed disc having eight blades, rigidly attached to the base to represent a blisk, is selected for this study. The splitting of resonance frequency peaks in an FRF obtained for the mistuned structure is analysed experimentally and numerically. A very basic level of mistuning in any repeating structure usually comes from the manufacturing tolerance, so the effect of manufacturing tolerance-induced mistuning is also investigated in the paper. The possibility of utilising the Modal Assurance Criterion (MAC) for developing a damage detection strategy in mistuned bladed discs is also examined. Experimental and numerical results for the splitting of FRF peaks are then compared. Outlier detection analysis is utilised for detecting damage in the frequency domain.

INTRODUCTION

Cyclically symmetric structures are very sensitive to small changes in the geometric as well as material properties of constituent parts (blades). These minute perturbations, known as mistuning, are inevitable due to manufacturing tolerances. Structural mistuning results in multiple resonance peaks and widening of the frequency range in the forced response of turbomachinery. It is now well established that the mistuning alone can result in much higher forced response levels for bladed discs whereas when aerodamping is also taken into consideration, it results in reduction of the forced response levels [1]. Different mistuning patterns have different effects on the mechanical behavior of the system. Many researchers in the past [2-4] focussed on the acceptable and worst mistuning patterns of the bladed discs and their effect on the forced response levels was investigated. Alternate mistuning has more stabilising effects in improving the flutter stability of the blades as compared to random mistuning. In the presence of random mistuning, stabilisation of the system is again highly dependent on the particular random mistuning pattern [5].

Rehman, A. U.[1,2], Worden, K.[1] and Rongong, J. A.[1]
[1]Dynamics Research Group, Mappin Building, University of Sheffield, S1 3JD, Sheffield, UK.
[2]Department of Mechanical Engineering, University of Engineering & Technology, Lahore, Pakistan.

1258

Код: 10392

A.U. Rehman, K. Worden, J.A. Rongong

An Experimental and Numerical Investigation of Damage Detection in a Mistuned Bladed Disc

Издательство DEStech Publications, Lancaster, 2011 год

8 стр; формат: 23,5 x 16 см; библиографический список: 11 единиц
ISBN: 978-1-60595-053-2

Mistuning in repeating structures like bladed discs is caused by small variations in the individual blade properties that, results in the splitting of degenerate vibration modes and affects the dynamic behaviour of the system. As a result, it is complicated to highlight a small damage in the mistuned environment. This paper is focussed on the effect of mistuning on the dynamic characteristics of the bladed disc. An experimental rig is setup and a bladed disc having eight blades, rigidly attached to the base to represent a blisk, is selected for this study. The splitting of resonance frequency peaks in an FRF obtained for the mistuned structure is analysed experimentally and numerically. A very basic level of mistuning in any repeating structure usually comes from the manufacturing tolerance, so the effect of manufacturing tolerance-induced mistuning is also investigated in the paper. The possibility of utilising the Modal Assurance Criterion (MAC) for developing a damage detection strategy in mistuned bladed discs is also examined. Experimental and numerical results for the splitting of FRF peaks are then compared. Outlier detection analysis is utilised for detecting damage in the frequency domain.

Ключевые слова:

Содержание.