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Improvement of damage detection methods based on experimental modal parameters

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ABSTRACT

The objective of this paper is to introduce a new method for structural damage detection based on experimentally obtained modal parameters. The new method is suitable for detection of fatigue damage occurring in an aluminium cantilever beam. The damage has been practically realised as saw cuts of different sizes and at different locations. The first step of analysis included an attempt of damage identification with the most often used damage indicators based on measured modal parameters. For that purpose special signal processing technique has been proposed improving the effectiveness of indicators tested. However the results obtained have not been satisfactory. That was the motivation for defining new damage indicators (frequency change based damage indicator, Hybrid Damage Detection method), utilising the change of natural frequencies and any mode shape (measured or modelled) as the measurement of frequencies is much less time consuming in comparison to total mode shape measurement. It has been shown that the proposed technique is suitable for damage localisation in beam-like structures.

1. Introduction

According to the definition, the structural health monitoring is a scientific procedure comprising of several non-destructive processes including identification of operational and environmental loads acting on the component, recognition of the mechanical damage caused by that loading, and observation of damage growth as the component operates. Finally, the health monitoring deals with assessing the future performance of the component as damage develops.

The health monitoring techniques should be non-destructive and ideally implemented online in an automated manner with embedded hardware/software, as a system operates [1]. The modern health monitoring techniques utilise such parameters as the electromechanical and high frequency impedance changes, the strain, stress or temperature fields, and the vibration changes. So as to measure these responses different transducers have been used. The most frequently used are eddy current/electromagnetic sensors, fibre optic based sensors, piezoelectric and piezoceramic sensors, thermal imaging sensors, conductive polymers, MEMS (Micro Electro-Mechanical Systems), and optical lasers.

An integral part of damage identification algorithm is adequate signal processing and the feature extraction techniques. The signal processing methods are applied to raw data that is acquired from the sensors in order to produce significant information for diagnostics. One of the main challenges faced in signal processing is the variability of symptoms caused by operational conditions and the resulting changes in the quantities used for diagnostics. Such variations may cause false positive or negative indications of damage, which should be excluded according to the end user's health monitoring

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