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Detection of Damage in Aerospace Structures Using Optimization Techniques on Impact Tests Results

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1 Abstract

The present work has the objective of analyzing the spectrum of vibration of a cantilever beam with non-homogeneous mass distribution and, by comparing its response to a numerical model, create an error function between both responses that, as it is shown, allow us to determine if there is - and where to find - a failure over the real structures surface, based only on its vibrational characteristics. The methodology created consists of registering the energy of impact tests using an accelerometer sensor applied to a hammer that hits the beam and another accelerometer that is attached to the beam itself, with a known failure. The data collected, registered and sent to a computer, is used to create an equation for the beam movement in time domain, which feeds an optimization algorithm that creates a virtual non-homogenous beam that represents the best the real one, making it possible to find the failure's position.

2 Introduction

Consider $\lambda^{1,real}$, the 1^{st} eigenvalue of the structural system from an impact test obtained from the accelerometer, correlated to the the firts frequency of resonance by $\lambda = \omega^2$. This value, along with the free-end movement amplitude, $\mathbf{u}^{1,real}(t)$, give us the time response of the real system, which is known for fitting the general equation (1) [1], where $\mathbf{K}$ and $\mathbf{M}$ are the stiffness and mass matrices, respectively. Nevertheless, the energy applied in the system, necessary to the determine the expected movement amplitude, is known from the impulse registered with the hammer's accelerometer.

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$$\mathbf{u}^{1,real}(t) = \mathbf{A}e^{\omega t^{1,real}} sin(\zeta\omega_n^{1,real} t + \theta_0) \tag{1}$$

The FEM model have its frequencies and amplitudes obtained from equation (2) [2], which allow us to construct a numerical version of expression (1). This expression will be modified by the optimization algorithm in order to minimize the objective function, represented in (3) .

$$abs(\frac{\mathbf{K}}{\mathbf{M}} - \mathbf{I}(\omega^2)^{fem}) = 0 \tag{2}$$

The objetive function, shown in (3), in which "x"represents the position and "m", the extra-mass' magnitude, is subjeted to (4).

$$f(x,m) = \left(\frac{1}{2}\right)\sum_{k=1}^{N}\left(\int_0^{\tau} \mathbf{e}^{\omega t^{k,real}} sin(\zeta\omega_n^{k,real} t + \theta_0)dt - \int_0^{\tau} \mathbf{u}(t)^{fem} dt\right)^2 \tag{3}$$

$$\frac{x}{L} < 1 \quad \text{and} \quad \frac{m}{M} < 1 \tag{4}$$

In expression (4), L and M are the length and total mass of the real beam, respectively, restricting the failure to have feasible characteristics. What is important to notice in equation (3) is the fact that the objective is minimizing the area described by the graphic of amplitude vs. time for the difference between real and numeric model. For correctly comparing the two expressions, the algorithm may be able to choose a proper value for θ_0 in order to put both signals in phase.

Referências

[1] B. P. Lathi, *Sinais e Sistemas Lineares*, 2. ed., Porto Alegre: Bookman, 2007.

[2] Jan R. Wright, Jonathan E. Copper. *Introduction to Aircraft Aeroelasticity and Loads*, John Wiley and Sons, Ltd, 2007.