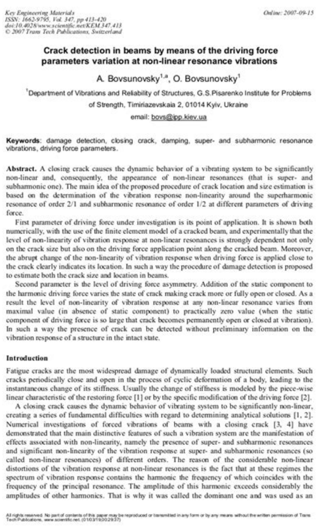

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Crack detection in beams by means of the driving force parameters variation at non-linear resonance vibrations

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Abstract. A closing crack causes the dynamic behavior of a vibrating system to be significantly non-linear and, consequently, the appearance of non-linear resonances (that is super- and subharmonic one). The main idea of the proposed procedure of crack location and size estimation is based on the determination of the vibration response non-linearity around the superharmonic resonance of order 2/1 and subharmonic resonance of order 1/2 at different parameters of driving force.

First parameter of driving force under investigation is its point of application. It is shown both numerically, with the use of the finite element model of a cracked beam, and experimentally that the level of non-linearity of vibration response at non-linear resonances is strongly dependent not only on the crack size but also on the driving force application point along the cracked beam. Moreover, the abrupt change of the non-linearity of vibration response when driving force is applied close to the crack clearly indicates its location. In such a way the procedure of damage detection is proposed to estimate both the crack size and location in beams.

Second parameter is the level of driving force asymmetry. Addition of the static component to the harmonic driving force varies the state of crack making crack more or fully open or closed. As a result the level of non-linearity of vibration response at any non-linear resonance varies from maximal value (in absence of static component) to practically zero value (when the static component of driving force is so large that crack becomes permanently open or closed at vibration). In such a way the presence of crack can be detected without preliminary information on the vibration response of a structure in the intact state.

Introduction

Fatigue cracks are the most widespread damage of dynamically loaded structural elements. Such cracks periodically close and open in the process of cyclic deformation of a body, leading to the instantaneous change of its stiffness. Usually the change of stiffness is modeled by the piece-wise linear characteristic of the restoring force [1] or by the specific modification of the driving force [2].

A closing crack causes the dynamic behavior of vibrating system to be significantly non-linear, creating a series of fundamental difficulties with regard to determining analytical solutions [1, 2]. Numerical investigations of forced vibrations of beams with a closing crack [3, 4] have demonstrated that the main distinctive features of such a vibration system are the manifestation of effects associated with non-linearity, namely the presence of super- and subharmonic resonances and significant non-linearity of the vibration response at super- and subharmonic resonances (so called non-linear resonances) of different orders. The reason of the considerable non-linear distortions of the vibration response at non-linear resonances is the fact that at these regimes the spectrum of vibration response contains the harmonic the frequency of which coincides with the frequency of the principal resonance. The amplitude of this harmonic exceeds considerably the amplitudes of other harmonics. That is why it was called the dominant one and was used as an

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