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Influence of Elastic Characteristics of Regular System on the Vibrodiagnostic Parameter Due to the Presence of a Breathing Crack

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Abstract: The paper presents the results of computational experiments on determination of the influence of the coefficient of elastic coupling between the discrete model elements (rods) of regular system on the value of vibrodiagnostic parameter due to the presence of a breathing crack. It is shown that due to elastic coupling between the elements the chosen parameter is evident not only within the damaged subsystem, but also within the undamaged one.

Introduction

During operation many structural elements of machines, in particular turbine rotor blades, are subjected to a wide spectrum of mechanical and temperature loads resulting in the occurrence of closing or the so-called "breathing" fatigue cracks. They give rise to a significant change in the elastic characteristics during the cycle of deformation being the cause of the nonlinearity of vibrations of the object under investigation.

Recently, a great attention has been paid to studying vibrations of the objects of engineering with a crack in question and search for reliable vibrodiagnostic criteria of its presence.

In view of the presence of various constraints between components of machine assemblies, which is typical of them, separate consideration of a structural element does not allow one to describe its dynamic state with sufficient accuracy. This is only possible by taking into consideration its interaction with other elements of the system under investigation. Therefore, in the theory of vibrations, increasingly greater attention is being paid to studying complex mechanical systems, among which regular systems involving series of parallel connection of equitype elements (subsystems) occupy a special place. Among such systems are primarily the set of blades and blade assembly as a special type of regular systems with rotation symmetry.

Considering the above-said, the purpose of the present paper is the calculated determination of the influence of the coefficient of elastic coupling between subsystems $\gamma = k_s/k$ on the value of vibrodiagnostic parameter due to the presence of a breathing crack of a discrete model of the simplest regular system presented in Fig. 1.

Computational experiments on determination of the vibrodiagnostic parameter at the subharmonic mode of vibrations of order ½ have been performed using the method presented in [1]. The ratio of the amplitudes $æ_1 = A^{(1)}/A^{(2)}$ of the first $A^{(1)}$ and second $A^{(2)}$ harmonics of vibrations is chosen as a specified parameter.

From the results of computational experiments the dependences of the vibrodiagnostic parameter on the damage parameter $\alpha = (k - k_o)/k$ have been obtained for damaged and undamaged subsystems of discrete model of regular system as well as for damaged subsystem in an isolated state ($\gamma = 0$).

Their analysis shows that the value of vibrodiagnostic parameter for damaged subsystem in an isolated state is higher than that one for subsystems of the model of regular system, which makes its use for the diagnostics of damage under investigation as a fatigue crack for such systems more difficult. Moreover, with an increase of the coefficient of elastic coupling γ of the model of regular

system the value of vibrodiagnostic parameter decreases for damaged subsystem, whereas it increases for undamaged subsystem.

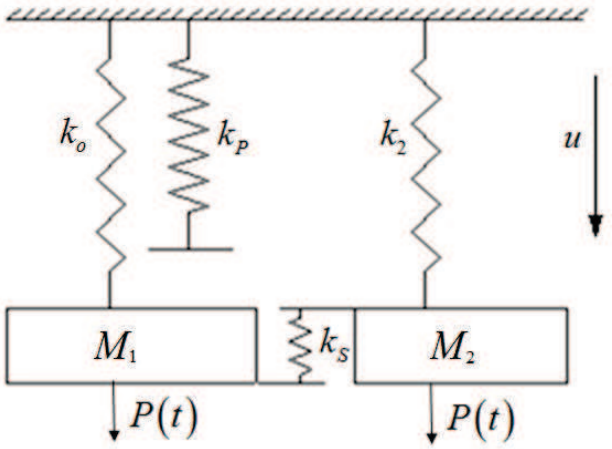

Fig. 1: Discrete model of the simplest regular system with a closing crack

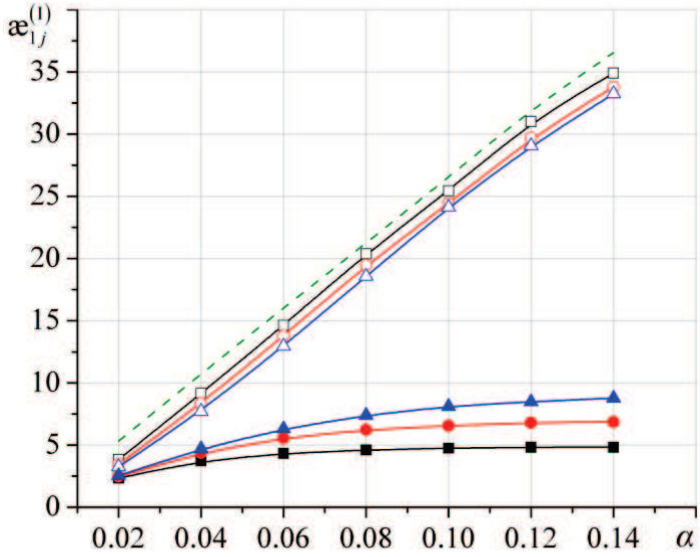

Fig. 2: Dependence of the vibrodiagnostic parameter on the damage parameter for damaged (open symbols) and undamaged (filled symbols) subsystems at the subharmonic resonance for h = 0.0008 sec^{-1} and the coefficient of elastic coupling γ equals to 0.01 (■,□), 0.015 (●,○), 0.02 (▲,Δ). Dashed line is the damaged subsystem in an isolated state.

References

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