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Structural dynamic modification of vibrating systems

M. Nad' [a, *]

[a] *Faculty of Materials Science and Technology, STU in Bratislava, Paulínska 16, 917 24 Trnava, Slovak Republic*

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Abstract

Vibration and acoustic requirements are becoming increasingly important in the design of mechanical structures. The need to vary the structural behaviour to solve noise and vibration problems occurs at design or prototype stage, giving rise to the so-called structural modification problem. Structural dynamic modification (SDM) as an application of modal analysis is a technique to study the effect of physical and geometrical parameter changes of a structural system on its dynamic properties which are mainly in the forms of natural frequencies and mode shapes. The fundamental approaches and formulations to SDM of vibrating systems are introduced. The changes of dynamical behaviour of a structure by modification of mass, damping and stiffness parameters of the structure are presented. The SDM of the real engineering structures is demonstrated. For these structures, it is more important to determine the structural modification in terms of physical and geometrical parameter changes related to mass, damping and stiffness parameters of vibrating structure. In this paper, the design and technological treatments are considered to achieve suitable vibration and acoustical properties of vibrating system. The modal properties of selected structures under physical parameters modification are studied.

Keywords: structural dynamic modification, modal analysis, damping, natural frequency, mode shape

1. Introduction

Structural modification within the frame of vibration analysis technology refers to a technique to modify physical properties of a structure in order to change or optimize its dynamic properties. Enhancement of the structural or acoustic response is one of the common goals of structural modification processes and can be related to any of the following elements: the source, the transmission path or the noise radiating component. This differs from structural modification for static analysis, where the changes are made to satisfy criteria of static design such as the reduction of stress concentration.

The dynamic characteristics of a structure usually referred to as its modal properties - natural frequencies and mode shapes, are determined by its mass, stiffness and damping distributions. The properties outlined by these distributions are called the spatial properties of the structure. The spatial properties are often quantified by a mathematical model of structure, such as a finite element (FE) model. This model translates the physical properties of the structure, such as its geometrical parameters and material properties, into distributed mass, stiffness and damping properties. For structural modification using an FE model, it is possible to determine the modification in terms of mass, stiffness and damping changes. However, for a real-life structure, it is more important to determine the structural modification in terms of geometrical parameter (such as thickness, length, diameter, etc.) changes or material property (such as damping coefficient, density, Young modulus, etc.) changes.

* Corresponding author. Tel.: +421918646035, e-mail: milan.nad@stuba.sk