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Vibroacoustic analysis for a uniform beam using composite Green function method

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Abstract

This paper presents the vibroacoustic analysis of a uniform beam submerged in the compressible fluid. The sound radiated from the beam is formulated by means of the composite Green function method. In this approach, the sound pressures on the beam surface and the velocities of the beam are modeled by using two integral equations of which the kernel functions are the composite Green functions symmetrical to each other. Furthermore, the near field and far field sound radiation of the beam could be predicted based on the free space Green function. An eigenequation of the coupled system is also derived. Numerical results of the vibroacoustic system are given and verified by the power flow method, and the good agreements show that the study work in the paper is correct.

Keywords: Beam; Sound radiation; Composite Green function

1. Introduction

The vibroacoustic analysis is always of great interest for the elastic body submerged in the compressible fluid. This coupled system can be found in several engineering fields practically, such as the automobile industry. Especially, the sound radiation of underwater vessels is quite an important subject to be studied for the purpose of improving their performance on hiding themselves. Due to the complexity of this kind of coupled system,

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conducting the research theoretically is mainly aimed at some simple models like the beam, plate and cylindrical shell. As the simplified model of a submerged cylindrical shell, a uniform beam submerged in fluid is studied in the work so as to gain some characteristics of sound radiation from the coupled system. Understanding this problem clearly is rather valuable for the further investigation on more complicated models.

This kind of problem and the similar subjects have been studied by many researchers in the past and several effective methods have been developed. Junger and Feit [1] have carried out much fruitful research on the topics of sound and vibration. Moreover, Junger [2] and Feit [3] have studied the sound radiation of a free-free beam and point excited elastic plate, respectively. The resonant oscillations of a cantilever under an incident pressure in a fluid environment were described in terms of a Fourier integral solution by Crighton [4]. The forced vibration of a simply supported submerged beam was analyzed by Achenbach and Qu [6] based on two methods. Song et al. [5] studied the acoustic radiation of submerged strings and beams under the local excitation. Further, the extended models were also under consideration. The sound radiation from periodically supported beams was investigated by Cheng and Chui [7]. Sun [8] presented an analytical method to study the vibration and acoustic radiation for non-uniform beams. The method to reduce the vibration level and total acoustic radiation power of a submerged beam was developed by Cheng and Wang [9] based on optimization techniques. In the previous work, many valuable conclusions have been achieved and the theoretical models under investigation were more complicated gradually. On the other hand, the simpler models are still interesting and informative.

In the study, a new approach is presented to analyze the coupled system of a uniform beam submerged in the compressible fluid for the prediction of sound radiation based on the composite Green function method. In Section 2, the theoretical model of this kind of problem is developed. Section 3 depicts the power flow method which is used to verify the method in the work independently. In Section 4, the numerical method of integral equations is introduced at first, then the numerical examples of the coupled system are presented. The conclusion remarks and future work are discussed in Section 5.

2. Formulation of the problem

The problem under consideration is schematically depicted in Fig. 1: a simply supported uniform beam is submerged in the compressible fluid. A system of Cartesian

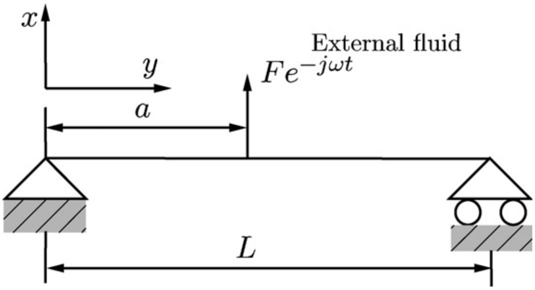

Fig. 1. The vibroacoustic system under consideration.