FORCED GAS-STRUCTURE VIBRATIONS IN A RECTANGULAR TANK

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1. Introduction

Rectangular thin elastic plates are often used as structural components closing or covering parallelepiped cavities filled with compressible fluid (gas) and subjected to dynamic loads. Such mechanical systems are applicable in the glass-skin technology of tall buildings, as outside skin plates of supersonic air crafts, as covers of different tanks in chemical industry, etc. In [1] the method of Bubnov-Galerkin together with the method of the crossed strips of G. Warburton is used and it is elaborated in the form of an easy scheme for application to the dynamic problem about the stationary vibrations of a special fluid-structure interaction system. It consists of a thin elastic plate, inserted into a rectangular orifice of an arbitrary wall of a parallelepiped tank, filled with an acoustic fluid.

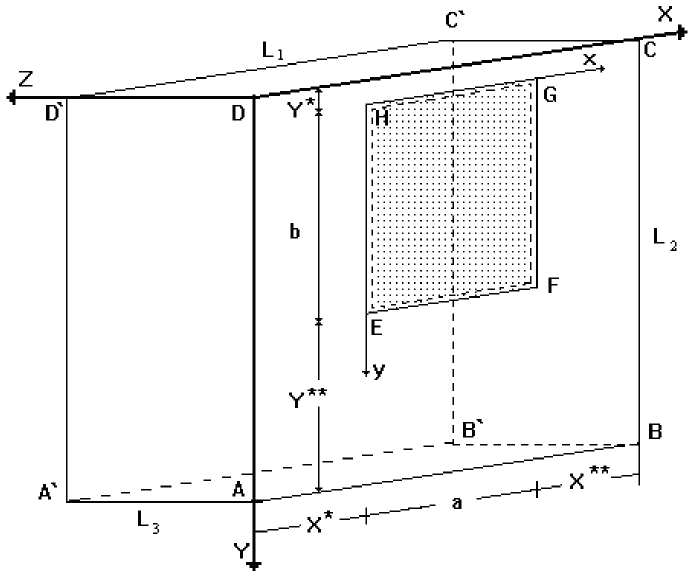

Figure 1. The geometry of the gas-structure interaction system under consideration

2. Formulation of the problem

Thin linearly elastic rectangular plate EFGH with sizes a and b and surface S is inserted into an orifice of the absolutely rigid wall ABCD of a rectangular parallelepiped tank, all its other walls are absolutely rigid (Figure 1). The tank volume is filled with gas with given sound velocity and mass density. The mass density per unit area of the plate, the flexural rigidity, the thickness, Young's modulus of elasticity and Poisson's ratio of the elastic plate material are given. Two rectangular co-ordinate systems DXYZ and Hxyz are used (see Figure 1). The problem about the stationary forced vibrations of the gas and the elastic plate under the action of a source, being situated in the gas tank, is under consideration. Let the source have a range of sizes which are small

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in comparison with the lengths of the excited waves: then it is possible to be accepted as a point source. It is supposed that the productivity and the frequency of the source are given and are not influenced by the earlier excited waves. The problem is considered in a linear approximation without giving an account of the dissipating forces. Then the velocity potential function of the gas motion and the function, describing the middle surface vibrations of the plate, satisfy corresponding partial differential equations with boundary conditions which describe the way of supporting of the elastic plate as well as some compatibility condition [1].

3. Analytical solution

The point source is presented by the Dirac delta function. The velocity potential function of the gas motion and the function, describing the middle surface vibrations of the elastic plate, are separated into space-dependent modes and time-dependent terms, where the trial functions as well as the wave numbers or the dispersion equations are chosen correspondingly to the supporting conditions along the four plate edges [1]. After satisfying the compatibility condition and using the Bubnov-Galerkin method, some infinite system of nonhomogeneous algebraic equations about the unknown coefficients is obtained. Taking the determinant of the homogeneous system equal to zero, the equation about the determination of the natural frequencies of the considered gas-structure interaction system is obtained.

4. Numerical calculations

The theoretical solution is very complicated - that is why an approximate solution is made at based on ignoring diffraction by the elastic plate waves. The approximate solution can be used when the frequencies of the source are not close to the resonance frequencies of the gas-structure interaction system and when the cavity is filled with air.

Some numerical examples are made and they are represented graphically. If the frequency of the source tends to zero, very strong increase of the amplitudes appears except at the resonance points. The approximate formula cannot be used if there is a heavy liquid in the rectangular tank.

5. Conclusions

In this paper a closed rigid rectangular parallelepiped tank is filled with gas as a part of one of its walls is a thin linearly elastic rectangular plate. The problem about the stationary forced vibrations of the gas and the elastic plate under the action of a source, being situated in the gas tank, is under consideration. A combination of the use of the method of the crossed strips of G. Warburton and the method of Bubnov-Galerkin is made to investigate the dynamic behavior of this gas-structure interaction system in the cases of arbitrary supporting conditions of the plate. Some numerical examples are given which demonstrate the necessity of taking into account which part of the spectrum of the natural frequencies of the elastic plate the forced frequency is located in.

6. References

[1] E.G. Gavrilova (1994). *Hydroelasticity of Thin-walled Prismatic Structures with Elastic Inclusions. PhD Thesis,* BAS IM, Sofia.

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