Numerical and experimental investigations of the oscillatory motion of thin plates in a still viscous fluid.

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ABSTRACT

In the present study the problem of interaction of oscillating plates with a viscous fluid is considered in the context of determination of the aerodynamic drag of the elongated cantilever beams of rectangular cross-section undergoing free bending oscillations in the air. Assuming that the length of the beam substantially exceeds its width and thickness, the interaction of beams with the air can be considered under the hypothesis planar sections, according to which the aerodynamic forces acting on the each cross section of the beam can be determined by examining the plane motion of gas caused by harmonic vibrations of a thin rigid plate. Numerical and experimental investigations of the the problem are carried out.

Numerical part of the work is based on two-dimensional simulation of flow around oscillating thin plates, where fluid motion is governed by the full system of Navier-Stokes equations. Problem discretization is based on the finite-volume approach. The numerical scheme is realized in the OpenFOAM software package. Simulation is carried out in the low- Reynolds- number range that corresponds to the following values of the dimensionless frequency and amplitude of oscillations: $50<\beta<130$, $0.1<KC<10$, where β is a Stokes number, KC is a Keulegan-Carpenter number.

In the experimental study the methodology proposed in [1] is developed. The estimation of the aerodynamic drag of plates is carried out on the basis of the study of damping bending vibrations of cantilever duralumin test samples. For experiments rectangular cross section samples are used with the following characteristics: 0.15-0.6 m. length, 0.025 - 0.03 m. width, 0.001 – 0.003 m. thickness. The natural frequency of oscillation of the beams varies in the range 3-90 Hz. Registration of vibrations is performed by the MEMS gyroscope mounted on the end of the beams. The experiments cover the next range of dimensionless parameters of the problem: $120 < \beta < 2000$, $0.1 < KC < 15$.

The results of the work contain a detailed analysis of the development of flow regimes around the oscillating plates and estimates of their impact on the hydrodynamic forces and moments acting on the plates. The correctness of the obtained results is proved by the comparison of the experimental and numerical data, and the result of previous studies [1-3].

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