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FORCED LONGITUDINAL OSCILLATIONS OF A GAS IN AN OPEN PIPE NEAR THE RESONANCE EXCITATION FREQUENCY

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Results of theoretical and experimental investigations of forced longitudinal oscillations of a homogeneous gas in an open pipe near the first natural frequency are presented. It has been established that at the resonance frequency the shape of the gas pressure wave changes with time by a law different from the harmonic one. The amplitude–frequency characteristics of the indicated oscillations have been derived. Satisfactory agreement of the theoretical calculation of the gas pressure oscillation range with experimental data has been obtained.

Keywords: *forced longitudinal oscillations, open pipe, resonance frequency of excitation.*

Introduction. Development of the theory of nonlinear oscillations of homogeneous and multiphase media in pipes is of current interest in view of the increased connection of this theory with various branches of science and technology, for example, with mechanics, machine building, engine manufacturing, turbine construction, and ecology. In the case of such oscillations in pipes at a frequency close to the resonance one, periodic shock waves and secondary flows appear, thermoacoustic effects originate, a pulsating jet is formed in the external wave field near the open end of the pipe, as well as coagulation of the suspended phase in a multiphase medium and its deposition on the pipe walls take place. A detailed analysis of the works on nonlinear oscillations in pipes and on the accompanying effects was made in reviews [1–3]. Mention can also be made of the experimental works [4, 5] dealing with the study of flow in an open pipe in the external wave field in the vicinity of the pipe end face. Nonlinear gas oscillations in an open pipe near linear and nonlinear resonances have been studied theoretically and experimentally in [6–18]. In works [6–12], the appearance of periodic shock waves has been revealed whose amplitudes near nonlinear resonances attain the amplitude of waves at linear resonances. The acoustic approximation for the first three harmonics near the piston and the distribution of the amplitudes of these harmonics along the pipe length are given in [13]. In works [14, 15], resonance oscillations in an open pipe at small Strouhal numbers are considered. The calculations of the first and second approximations of nonharmonic oscillations at the first natural frequency and at the frequency twice as small are given in [16]. Work [17] theoretically investigated resonant oscillations of a gas in pipes with open end faces of different geometries. Resonance oscillations of a gas in an open pipe in a shock-free–wave regime are investigated in [18]. Thus, nonlinear oscillations of a gas excited in open pipes in the mode of shock wave formation at large amplitudes of pressure variation (0.1–0.4 bar) and gas oscillations excited in a narrow open pipe in a shock-free–wave regime at small amplitudes of pressure variation (up to 0.01 bar) have been studied.

The aim of the present work is a theoretical and experimental investigation of nonlinear oscillations of a gas in the mode of transition to shock waves at small amplitudes of excitation (up to 0.02 bar) in an open pipe near the first natural frequency.

Experimental. The present work is the continuation of work [18]. Experimental investigations were carried out on a new setup (Fig. 1) based on an oscillator 1 of TIRAvib S 5220/LS type (Denmark) with a BAA 100-ET power amplifier and a cooling fan. On the oscillator fitting, a rod was fixed that brought into motion a plane piston 3 of diameter 0.1 m. The piston executed oscillations in the cylinder, which was connected with a quartz pipe 5 of length $L_0 = 0.918$ m and of inner diameter $2R = 0.1$ m. The passive end of the pipe with a flange, which was at a right angle to the place of connection with the pipe, was in communication with the surrounding medium. Sinusoidal oscillations were measured and controlled with the use of a special software VibrationVIEW, installed in a computer 8, by means of a piezoelectric IEPE type 4513-001 accelerometer 2

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