

Dynamics of aerosols at nonlinear oscillations in tubes. The theory and experiment

D.A. Gubaidullin, R.G. Zaripov, A.L. Tukmakov and L.A. Tkachenko

Institute of Mechanics and Engineering, Kazan Science Center, Russian Academy of Sciences,
2/31, Lobachevsky str., 420111, Kazan, Russia

Keywords: aerosol, coagulation, deposition, experiment, oscillations.

In the present work, nonlinear oscillations of an aerosol of different initial concentration and dynamics of particles is considered in closed and open tubes of different length near to sub-harmonic resonances.

Experimental investigations were carried out for length of tubes $L_0 = 2,7; 3,7; 4,7; 6,7$ m in a range of oscillation frequency of an aerosol from 0 to 18 Hz. For making an aerosol the fluid Di-ethyl-hexyl-sebacate $C_{26}H_{50}O_4$ (DEHS) was used. On the average geometrical diameter of droplets DEHS aerosol in undisturbed state is $0,8 \mu\text{m}$. Dependences of concentration of droplets of an aerosol on time for various frequencies of excitation, times of an enlightenment (coagulation) of an aerosol from frequency and intensity of oscillations have been received.

Concentration of drops for all experiments monotonously decreases in due course and with growth of frequency of excitation. In case of the closed tube this process is caused by coagulation of an aerosol and deposition of drops on walls of a tube and it is well approximated by a Boltzmann distribution law. In an open tube alongside with coagulation of an aerosol and deposition of drops on walls of a tube emission of an aerosol in environmental space takes place also. In this case, dependences of concentration of drops of an aerosol on time is approximated by an exponential distribution. Dependences of time of enlightenment (coagulation) of an aerosol on frequency of excitation also have non-monotonic character with a minimum and a maximum at transition through a resonance. Thus time of an enlightenment of an aerosol in an open tube decreases in two and more times in comparison in due course coagulations in the closed tube. Nonlinear association of time of enlightenment (coagulation) of drops is established at nonlinear oscillations of an aerosol in a tube from initial concentration of an aerosol. It is revealed, that reduction of length of a tube also increase in intensity of piston oscillation results in decreases of an enlightenment (coagulation) time of an aerosol. The ordered existential structures (alternation of the condensed and rarefied sites of an aerosol) in visual area about the middle of the closed tube are found out.

The numerical modeling of a drift of the solid spherical particles were in a suspension in a nonlinear wave field of the closed tube and open flat

channel at excitation of oscillations of a gas column on three first fundamental frequencies is executed. It is obtained, that easy particles drift under an operation of acoustical current, and heavy are displaced under an action of wave pressure. In result easy and heavy particles concentrate in different areas of the resonator: easy are displaced to antinodes of a standing wave of velocity, heavy - to nodes. Depending on a steepness of a wave front of compression, the same particles can behave as easy at small nonlinearity, or as heavy at steep enough fast-head wave front. Drift of heavy particles in the open channel proceeds in two stages. The first quickly proceeding stage is connected to the mechanism of drift due to asymmetry of a wave, and the second with drift under action of developed acoustic stream.

Dynamics of a single particle with various physical and geometrical parameters is experimentally investigated at the longitudinal oscillations of gas generated by the flat piston, in a tube with various conditions on the ends. It is revealed, that a particle, both from closed, and from the open end of a tube moves to the piston, near to a wall of the closed pipe - to the return side, making longitudinal oscillations with increase in the oscillations swing that is caused by acoustic streaming. In a radial direction, the oscillating particle goes from an axis to a wall of the closed tube up to a boundary point. It is revealed, that the increase in lengths of a tube and frequency of excitation of gas in up to - resonant modes gives in growth of an oscillations swing of a particle and increase of its medial velocity. Nonmonotonic character of dependence of medial velocity of a motion of a spherical particle from frequency of excitation of gas is detected. At approach to a resonance medial velocity is incremented and attains the peak value on a resonant frequency. Behind a resonance medial velocity decreases. Effect of a weight and diameter of a particle on its oscillations swing and medial velocity is investigated. Shift of a maximum of a curve of dependence of medial velocity of a motion of a particle from an oscillation frequency aside magnifications of frequency is shown at increase of a weight or diameter of a particle.

The work was supported by the Russian Fund of Foundation Investigation under grant 07-01-00339.