Acoustic waves in vapour-gas mixtures with polydispersed particles and droplets

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The propagation of small disturbances in two-component gas-vapour mixtures with polydispersed particles and drops in the presence of phase transitions is studied. A mathematical model is proposed, the dispersion relation is obtained. The effect of the droplet and particle polydispersity on the dispersion and dissipation of small disturbances is analysed.

Fig. 1 illustrate the effect of polydispersity of droplets and particles on the form of the decrement of attenuation on the wavelength on the nondimensional oscillation frequency $\Omega_{5,3} = \omega\tau_{va}^{(5,3)}$, where $\tau_{va}^{(5,3)}$ is the velocity relaxation time, $a_{5,3}$ is average radii Gubaidullin and Nigmatulin (2000). The calculations were performed using the dispersion equation Gubaidullin and Fedorov (2012) and the dispersion relation for the case of monodispersed droplets and particles Gubaidullin *et al* (2011). A mixture of ait with water vapour, water droplets and particles of ash was considered. The relative mass contents of droplets of water m_a and ash particles m_b we will take equal to 0.3. The pressure of the carrier phase $p_1 = 0.1$ MPa, temperature $T_0 = 271$ K. The radii of the droplets and particles were set as follows: curve *1* - $a = 10^{-4}$, $b = 10^{-6}$ m, curve *2* - $a = 10^{-5}$, $b = 10^{-7}$ m, curve *3* - $a \in [10^{-5}, 10^{-4}]$, $b \in [10^{-7}, 10^{-6}]$ m. Curve *1* is built on the monodispersed theory with maximum radii from the range, curve *2* is calculated on the monodispersed theory with minimum radii from the range, curve *3* – on polydispersed theory. Distribution functions of droplets and particles sizes: $N_0(a) = a^{-3}$, $N_0(b) = b^{-3}$.

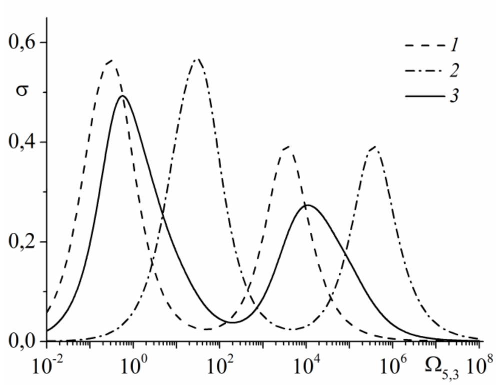

Figure 1. Dependences of the attenuation decrement on dimensionless oscillation frequency

The presence of the two fractions in the mixture leads to the occurrence of two local maxima in the dependences the attenuation decrement per wavelength. Since in real fogs droplets and particles are mainly polydispersed, then, as it seen from fig. 1, the attenuation is not so strong comparably with calculations with monodispersed droplets and particles. It should be noted that the polydispersity, as well as the distribution functions of dispersed phases of sizes, substantially affect the dynamics of wave propagation.

There are experimental data Cole and Dobbins (1971) on the attenuation decrement in the wavelength in the particular case “vapour-gas-droplet” mixture without particles ($m_b = 0$). The radius of the droplets ranged from 10^{-6} up to 10^{-5} m. Three groups of the experimental points correspond to the three experiments carried out at different mass content of drops, and different temperatures (different concentration of vapour in the gas phase):

1 - $T_0 = 281$ K, $m_a = 0.0076$, $k_V = 0.012$

2 - $T_0 = 276$ K, $m_a = 0.0039$, $k_V = 0.008$

3 - $T_0 = 271$ K, $m_a = 0.0038$, $k_V = 0.006$

Note that because of the complexity of the experiment there is a large spread of experimental data 10-15%. In fig. 2 $\omega\tau$ - the dimensionless oscillation frequency, where $\tau = 3\tau_{va}^{(3,1)} / (2m_a)$.

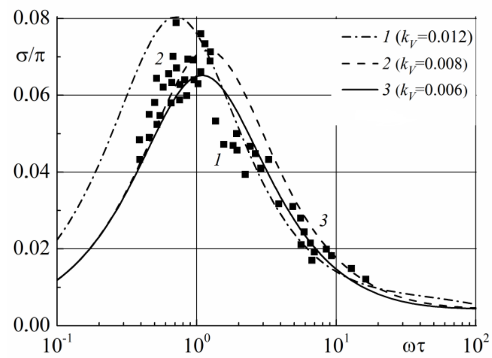

Figure 2. This is a comparison between theory and experimental data.

Overall, there is good agreement between theory and experiment.

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