Diagrams for drift acceleration of inclusion in acoustic field.

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Inclusion (elastic or rigid particle, bubble) in acoustic field is subject to the action of various forces: Stokes, Oseen type forces, Archimedes, added mass, Basset and other less studied forces. Oscillations of fluid may cause a drift of inclusion. This effect is widely used in wave technologies of separation and coagulation. Inclusion drift acceleration in standing wave with fluid velocity $v_1 = U_0 \sin kx \; \sin \omega t$ depends on the wave number k, frequency ω, amplitude U_0, density of fluid ρ_1, elasticity of fluid, as well as on inclusion density ρ_2, elasticity, location, relaxation time τ_v, surface tension between inclusion and fluid.

Numerous investigations on inclusion drift problem have been done in the last three decades. Various formulas for drift acceleration were obtained. Recently a new approach to the drift problem was developed in (1. Gubaidullin D.A., Ossipov P.P. 2011). The model of drift of compressible inclusion in compressible fluid at low Reynolds number taking into account Stokes force, added mass and Archimedes forces and surface tension was investigated analytically. Method of small parameter and Van-der-Pole was used. This approach is based on decomposition of inclusion motion into slow and fast parts (evolution and oscillation). Obtained in this work formula for drift acceleration and coordinates ρ_1 / ρ_2, $(\omega\tau_v)^2$ were laid to the base of diagram for drift direction. This diagram covers all possible frequencies of standing wave, and all relative inclusion densities. Diagram shows existence of threshold curves, dividing the drift regimes into several groups. In each group the drift of inclusion is directed to the nodes or antinodes of standing wave. The further step in better understanding and systematizing the inclusion drift problem in standing wave was done in (2. Gubaidullin D.A., Ossipov P.P. 2013). The drift of incompressible inclusion at different Reynolds and Strouhal numbers under influence of viscosity, added mass and Archimedes forces was investigated numerically. The diagram of drift direction with coordinates $D = 3\rho_1 / (\rho_1 + 2\rho_2)$-density parameter, $\mu_p^2 = \{1 + [\omega\tau_v(1 + 0.5\,\rho_1 / \rho_2)]^2\}^{-1}$ - squared entrainment coefficient, was introduced. The existence of threshold curves in diagram, dividing all drift regimes into several groups was revealed. The threshold curves for different Reynolds and Strouhal numbers were computed. It was shown that with increasing Reynolds and Strouhal numbers the threshold value of squared entrainment coefficient decreases significantly. In (3. Gubaidullin D.A., Ossipov P.P. 2013) the direction of drift of incompressible particle in acoustic resonator with periodic weak shock wave was studied numerically. The impact of main hydrodynamic forces on drift direction was investigated. Simulations revealed the existence of threshold value of particle radius which divides drift regimes in two groups with opposite drift directions.

The main result of above mentioned articles was development of diagrams for drift direction. The further step in better understanding of drift problem is introduction of diagrams for drift acceleration instead of thosefor drift direction. They are mush more informative, because depict the level curves for dimensionless drift acceleration. The 0-level curves correspond to the threshold curves in diagrams for drift direction. In Figure 1 the diagram for drift acceleration of incompressible inclusion in compressible fluid is presented. There are two threshold curves, dividing all regimes into three regions. Numbers depict the drift acceleration. The grayed regions correspond to drift towards the nodes, white-corresponds to drift towards the antinodes.

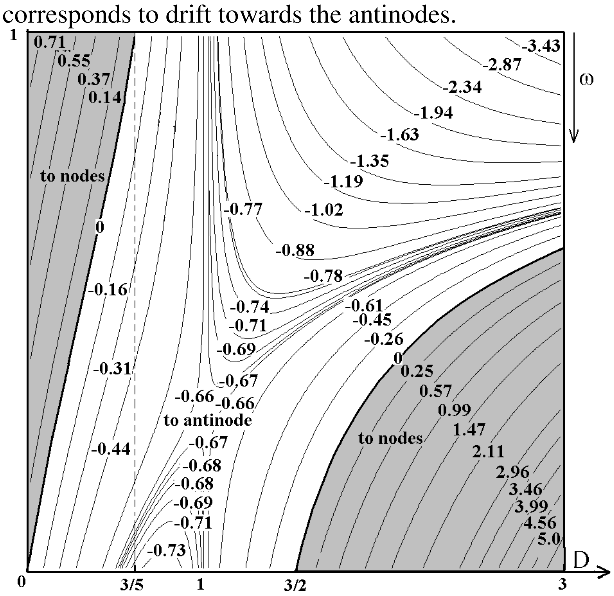

Figure 1. Diagram for drift acceleration.

In present work different models of inclusion drift and corresponding diagrams of acceleration are presented and analysed.

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1. Gubaidullin D.A., Ossipov P.P. (2011) J. Eng. Phys. Thermophysics. 84 (2), 270–283.
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