Effective acoustic properties of suspensions containing poroelastic inclusions.

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Abstract

We have obtained the solution to the problem of the scattering of an elastic compressional wave on a porous inclusion located in a fluid (the one-particle problem). The solution of this problem is of technical interest in connection with the development of acoustic insulators. Such insulators can be used, for example, in geophysics, when creating measuring devices for boreholes or in shipbuilding, when designing the hulls of underwater vessels.

We have calculated the amplitude of the scattered wave by using the assumption that the characteristic inclusion size is much bigger than the pore diameter. To describe the elastic wave propagation in the inclusion, we have used the equations of the theory of poroelasticity (the Biot theory). The calculations have been performed for different hydrodynamic conditions at the boundary between the inclusion and the host (fluid): for the case of an ideal hydrodynamic contact ("open" interface) and for the case of closed for hydrodynamic flow pore channels ("closed" interface). We have considered two models: an ideal fluid and a viscous Newtonian fluid containing the inclusion. The wave field in the inclusion consists of the fast and slow compressional and shear waves. Outside the inclusion, the scattered spherical compressional and shear waves are generated. The solution for an isolated inclusion is obtained in terms of series of spherical Bessel functions and Legendre polynomials.

The solution of the one-particle problem is used for the calculation of effective wave number of the compressional wave propagating in the fluid containing a set of poroelastic inclusions (suspension). The effective wave number is calculated using the single scattering theory.

The results obtained have shown that the generation of the fast-attenuating compressional wave of the second kind at the inclusion boundary leads to a considerable attenuation of the compressional wave in the fluid host. The parameters of the effective compressional wave propagating in the suspension of porous inclusions depend considerably on the hydrodynamic permeability of inclusions and fluid properties in the inclusion pore space.