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Fluid-structure interaction problem of two coaxial vibrating flexible cylinders separated by a thin layer of fluid

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This work deals with the three-dimensional hydrodynamic interaction of two-coaxial cylinders immersed in a viscous stagnant fluid. A displacement corresponding to a bending mode of vibration of an Euler-Bernoulli beam is imposed on the inner cylinder. The external cylinder is rigid.

We present a new theoretical formulation based on the assumption of a narrow fluid annulus [1], leading to a complete analytical expression for the coefficients of the added-mass matrix of the vibrating cylinder. This formulation does not rely on the slender-body approximation so that it is applicable to cylinders with a small aspect ratio. We show that the added-mass coefficient depends on the radius ratio of the configuration, acting like a confinement parameter, but also on the aspect ratio of the vibrating cylinder. The diagonal terms of the added-mass matrix are positive and always increase with the confinement and the aspect ratio. More importantly, we also show that the finite length of the vibrating cylinder generates off-diagonal terms. The variations of these terms depend on both the boundary conditions and the wave number of the vibration modes.

In addition to this new theoretical work and to assess the validity of its predictions, we have performed numerical simulations with the open source code TrioCFD [2]. We have carried out an indepth comparison, considering different values of the aspect ratio, radius ratio, and all classical types of boundary conditions. In all cases tested, the numerical simulations successfully corroborate the theoretical predictions.

REFERENCES

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