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A linearised closure approach for averaged inertial and compressible flows

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An important challenge in up-scaling inertial and compressible flows is the treatment of the non-linear terms remaining in the closure problems [1]. As a consequence of these non-linearities, current approaches require to solve closure problems that are themselves dependent on the local averaged flow [2], thus limiting the benefits of the upscaling procedure.
Here, a methodology is proposed wherein the non-linear closure problems are linearized according to relevant dimensionless numbers using power series. Indeed, dimensional analysis of the closure problems arising in the volume averaging procedure of inertial and slightly compressible flows indicates that non-linear terms are controlled by dimensionless parameters such as the Reynolds number and the dimensionless compressibility coefficient [3]. For each order of the power series decomposition, linear and intrinsic closure problems are determined. Finally, the effective properties of the medium for small values of the dimensionless numbers are obtained by truncating the developments to the appropriate order. One of the main advantages of the proposed method is that it does not require to solve the full closure problems for each value of the local averaged flow.
After assessing the validity of this approach against numerical solution of the corresponding non-linear closure problems, the global permeability tensor, including contributions from inertia (Forchheimer term) and compressibility, is determined. Finally, generalization of this methodology to other types of non-linear flows such as flows with temperature-dependent properties is examined.

Participation

In-Person

References

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