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An artificial compressibility CBS method for modelling heat transfer and fluid flow in heterogeneous porous materials

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ABSTRACT

This work is concerned with the development of an artificial compressibility version of the characteristicbased split (CBS) method proposed by Zienkiewicz and Codina (Int. J. Numer. Meth. Fluids 1995; 20:869–885). The technique is applied to modelling both forced convection as well as heat transfer and fluid flow through heterogeneous saturated porous materials via an edge-based finite volume discretization scheme. A volume-averaged set of local thermal disequilibrium governing equations is employed to describe the general case which allows for the modelling of effects such as wall channelling and wall-bed radiative heat transfer. The resulting set of coupled non-linear partial differential equations is solved in a matrix-free manner with spatial discretization being effected with a compact vertex-centred finite volume edge-based discretization scheme. The latter was done in the interest of efficiency and accuracy. The developed scheme is validated via application to problems ranging from forced convection to natural convection in heterogeneous materials, and shown to be stable, robust and accurate.