6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Modelling three-phase dispersed flows using a projection scheme within a finite element framework

Giovanni Cozzuto[1], Christopher E. Kees[2], Aggelos S. Dimakopoulos[1], Tristan de Lataillade[1,3]

[1]HR Wallingford, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, UK
e-mail: G.Cozzuto@hrwallingford.com
[2]Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180, USA, e-mail: Christopher.E.Kees@erdc.usace.army.mil
[3]IDCORE, Graduate School of Engineering, The University of Edinburgh, The King's Buildings, Edinburgh, EH9 3FB, Scotland, e-mail: T.Delataillade@hrwallingford.com

Key Words: *Multi-phase flows, sediment transport, finite element analysis, granular dispersed phase modelling, projection-based schemes*

Recent advances in numerical methods, computational techniques and computing technology have made possible the rise of numerical models that are capable of simulating truly complex flows that comprise multiple phases and different material states, such as e.g. sedimentation in a marine environment. The current work steps on an existing computational toolkit based on the finite element method for modelling two-phase flows [1] and further extends its capability to include modelling of two-phase (e.g. air / water) mixtures that include a granular dispersed phase. The flow equations are discretized using finite element approximation. The mass momentum equations equation for the two-phase fluid mixture are numerically solved using a coupled level-set / VOF approach that has been successfully tested in modelling marine engineering applications [2]. The equations of the granular phase are formulated according [3] to include complex processes related to the granular phase, such as interface momentum exchange, collision and contact stresses. The approach is used to model unsteady flows by implementing a projection method for variable density flow mixtures [4] further adapted to ensure the solenoidality of the phase-averaged velocity field. A set of simple benchmarks is presented comprising various case studies of sedimentation in quiescent and steady flow conditions with the aim to verify the implementation of various modes of fluid / sediment interaction and momentum exchange, showing that the method is promising for modelling complex flow processes pertaining to coastal and marine engineering applications.

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