A CFD-DEM EULERIAN-LAGRANGIAN SOLVER FOR PARTICLE-LADEN VISCOELASTIC FLOWS (FOR ORAL PRESENTATION)

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The ability to simulate the behavior of dense suspensions using computationally-efficient Eulerian-Lagrangian techniques requires accurate particulate-phase drag models that are valid for a wide range of material parameters. The present work aims at developing appropriate drag models for moderately-dense suspensions, in which the continuous phase also has viscoelastic characteristics. To this end, we parametrize the suspension properties through the Deborah number and the particle volume fraction, and compute the evolution in the drag coefficient of spheres translating through a viscoelastic fluid that is described by the Oldroyd-B model. To calculate the drag coefficient, we resort to 3D direct numerical simulations (DNS) of unconfined viscoelastic creeping flows ($Re < 0.1$) past random arrays of stationary spheres, over a wide range of Deborah numbers ($De < 5$), volume fractions ($\phi < 20\%$) and particle configurations. From these calculations we obtain a closure law $F(De, \phi)$ for the drag force in the viscoelastic fluid (with fixed retardation ratio $\beta = 0.5$), which is on average within 4.7% of the DNS results. Subsequently, this closure law was incorporated into a CFD-DEM Eulerian-Lagrangian solver to handle particle-laden viscoelastic flow calculations, and two case studies were simulated to assess the accuracy and robustness of our numerical approach. These tests consisted of simulating the settling process in Newtonian and viscoelastic fluids within eccentric annular pipes and rectangular channels; configurations commonly employed in hydraulic fracturing operations. The numerical results obtained were found to be in good agreement with experimental data available for suspensions in Newtonian matrix fluids. For the case of viscoelastic fluids, the resulting particle distribution is presented for different elasticity numbers (i.e., $El = De/Re$) and particle volume fractions, and the results provide insight into the pronounced effects of viscoelastic matrix fluids in hydraulic fracturing operations.

ACKNOWLEDGEMENTS

This work is funded by FEDER funds through the COMPETE 2020 Programme and National Funds through FCT (Portuguese Foundation for Science and Technology) under the projects UID-B/05256/2020, UID-P/05256/2020 and MIT-EXPL/TDI/0038/2019 – APROVA – Aprendizagem PROfunda na modelação de escoamentos com fluidos de matriz Viscoelástica Aditivados com partículas (POCI-01-0145-FEDER-016665). The authors would like to acknowledge the Minho University cluster under the project NORTE-07-0162-FEDER-000086 (URL: http://search6.di.uminho.pt), the Minho Advanced Computing Center (MACC) (URL: https:// macc.fccn.pt), the Texas Advanced Computing Center (TACC) at The University of Texas at Austin (URL:http://www.tacc .utexas.edu), the Gompute HPC Cloud Platform (URL: https://www.gompute.com) for providing HPC resources that have contributed to the research results reported within this work.