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# Four-Way Coupled CFD-Dem Simulation of Concrete Pipe Flow Using a Non-Newtonian Rheological Model: Investigating the Simulation of Lubrication Layer Formation and Plug Flow Zones

**Authors :** Tooran Tavangar, Masoud Hosseinpoor, Jeffrey S. Marshall, Ammar Yahia, Kamal Henri Khayat

**Abstract :** In this study, a four-way coupled CFD-DEM methodology was used to simulate the behavior of concrete pipe flow. Fresh concrete, characterized as a biphasic suspension, features aggregates comprising the solid-suspended phase with diverse particle-size distributions (PSD) within a non-Newtonian cement paste/mortar matrix forming the liquid phase. The fluid phase was simulated using CFD, while the aggregates were modeled using DEM. Interaction forces between the fluid and solid particles were considered through CFD-DEM computations. To capture the viscoelastic characteristics of the suspending fluid, a bi-viscous approach was adopted, incorporating a critical shear rate proportional to the yield stress of the mortar. In total, three diphasic suspensions were simulated, each featuring distinct particle size distributions and a concentration of 10% for five subclasses of spherical particles ranging from 1 to 17 mm in a suspending fluid. The adopted bi-viscous approach successfully simulated both un-sheared (plug flow) and sheared zones. Furthermore, shear-induced particle migration (SIPM) was assessed by examining coefficients of variation in particle concentration across the pipe. These SIPM values were then compared with results obtained using CFD-DEM under the Newtonian assumption. The study highlighted the crucial role of yield stress in the mortar phase, revealing that lower yield stress values can lead to increased flow rates and higher SIPM across the pipe.

**Keywords :** computational fluid dynamics, concrete pumping, coupled CFD-DEM, discrete element method, plug flow, shear-induced particle migration.

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