SIMULATING THE SEDIMENTATION OF A DILUTE MONO-DISPERSE SOLID-LIQUID SUSPENSION

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Sedimentation describes a process whereby solid particles are separated from a fluid, usually under the action of gravitational forces. Sedimentation is observed in a wide variety of industrial and environmental settings. In industrial processes sedimentation is often performed in Inclined Settlers, tall slender vessels which are orientated with their longest dimension slightly away from vertical.

For the past eight or so decades the performance of Inclined Settlers has been described using the Ponder-Nakamura-Kuroda (PNK) theory (see [1]). This theory is a kinematic theory which gives the rate of production of clear fluid per unit depth of a vessel as a function the vessel's geometry, angle of inclination and the hindered settling velocity of a single particle. In practice the PNK theory often overestimates the efficiency of an inclined settler because it does not account for instabilities that can arise at the interface between the suspension and clarified fluid regions. These instabilities have the potential to harm the efficiency of the settler as they can grow as they ascend the vessel, developing into waves that can 'break', entraining suspension into regions of previously clarified fluid.

In this study we employ a finite volume Computational Fluid Dynamics (CFD) method to examine the behaviour of a continuous inclined sedimentation process, and in particular, the stability of the suspension/clarified fluid interface described above. A set of 'multi-fluid' equations (two continuity equations and two momentum equations) is used to describe the fluid system. These equations are based on those presented by Zhang and Prosperetti [2] for a dilute suspension of mono-disperse spheres, but here include a hindered settling function and solid packing pressure to account for the small but finite volume fractions present in the test cases.

The simulation cases are based on experiments performed by Acrivos and Herbolzheimer [3] and Herbolzheimer [4]. These cases include tests where the sedimentation regime is stable through to tests where large scale instabilities cause significant re-mixing of the suspension and clarified fluid regions. The simulations capture the process well, in particular the behaviour of the interface as the fluid viscosity is decreased and the process moves from one regime to the other. Further, the distance from the settler base that waves on the interface appear as measured by Herbolzheimer [4] compares favourably with simulation predictions.

References

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