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FLOW ONSET FOR A SINGLE BUBBLE IN A YIELD-STRESS FLUID

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ABSTRACT

We use computational methods to determine the minimal yield-stress required to hold static a buoyant bubble in a yield-stress liquid. Static bubbles in viscoplastic fluids occur in many industrial settings. In the oil sands industry, the by-products of the extraction of bitumen from oil sands are stored in tailings ponds over many decades. Pond slurries, known as Fluid Fine Tailings and Mature Fine Tailings (FFT/MFT) are complex suspensions rheologically characterized as thixotropic yield-stress fluids. Anaerobic micro-organisms within the fluid form both carbon dioxide and methane. The objectives of this research are to understand how bubbles may be trapped in the different layers (FFT, MFT) within the pond. Trapping happens due to the yield-stress of the pond fluids. The underlying research motivation is environmental, i.e. emissions estimation and control.

Computations have been conducted using both Augmented Lagrangian and FISTA (fast iterative shrinkage-thresholding algorithm) methods, both of which are able to capture zero strain rates reliably in unyielded regions. Coupled with the adaptive meshing methods, these capture the yield surfaces well. The static limit is governed by the bubble shape, surface tension, buoyancy and yield-stress. For a given bubble geometry, bubbles are static if the fluid yield-stress is above a critical limit. We study families of bubble shapes to understand the characteristic effects of aspect ratio and curvature in both 2D planar and axisymmetric settings. For these families we explore the relative effects of surface tension and buoyancy on the flow onset. These results help us obtain new insight into understanding bubble stoppage criteria in viscoplastic fluids.

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