Sand-layer evolution in a partially filled-pipe

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In petrolium engineering, the extraction of oil in ducts is commonly associated with the presence of solid particles, coming directly from the source and/or from the abrasion of the pipe during propagation. The extraction procedure can require the initiation and stop of the flow which entails the sedimentation of particles such as a roughly flat sediment layer accumulates progressively at the base. This bed can develop different patterns whose morphology is principally governed by the bottom shear-stress exerted by the overlying fluid. The amplitude of these perturbations can disturb the flow (by increasing the pressure drop) and lead ultimately to the flow blockage. Therefore, petroleum companies require predictions of the temporal evolution of the fluid-solid interface in order to improve the sand management for operational decisions.

The physical model developed in this study presents a 1D model for the sand transport in pipes under laminar and turbulent regimes in which equations are integrated over the wet section. The novelty here is to propose consistent Saint-Venant equations able to describe non-equilibrium situations. Following this target, the fluid phase modeling is represented by an elongated flow (i.e. characterized by a small aspect ratio) and confined between a slowly varying bottom (associated with long-wave perturbations) and an upper rigid wall. The flow is considered as fully developed, such as the vertical momentum diffusion is made instantaneously at each location. Following these assumptions, we used the boundary-layer equations of Prandl, assuming a no slip-condition at the two extremities. Theoretical predictions are thus compared with direct numerical simulations and highlight a very statifying agreement between the theoretical predictions of the bottom shear-stress, which govern the net deposition rate, and numerical simulations. On the other side, the modeling of the solid-phase considers non-equilibrium sand-transport laws, including relaxation effects.