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Transient Buoyant Convection of A Highly Thermodependant Viscous Fluid in A 3D Cylindrical Drum

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Abstract

The study of the thermal behaviour of highly thermodependant fluids is primordial in the management of radioactive bituminous waste products (BWP) contained in drums. Bitumen has indeed a large thermodependancy: more than 6 decades in viscosity ratio between the hot and cold parts. To do so, a transient 3D convective system with the configuration of a constant temperature stress on the vertical boundary is considered. To estimate the key features of the physics involved, an analytical study is undertaken to draw a first general understanding of the system behaviour. Numerical simulations on a 3D Finite Element solver with the Boussinesq approximation are then carried out for various parameters to confirm the analytical results. Four phases are enhanced: a diffusive thermal choc, a vertical boundary layer convection, a global convection lead by the collapse of the cold inner core, and finally the heating of the remaining cold area by diffusion. Additional simulations with non-newtonian rheological laws (such as Hershel-Bulkley model) were also tested. The addition of a yield stress reduces the convection and thus the intensity of the second and third phases.