Verification and validation in highly viscous fluid simulation using a fully implicit SPH method

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ABSTRACT

Catastrophes involving mass movements has always been a great threat to civilizations. In special, these events are becoming more recurrent due to climate change, such as the landslides caused by Hiroshima heavy rains in July 2018, revealing the importance of numerical studies of mass movements. One way to simulate it is to simplify the behavior of the mass movement material as a highly viscous fluid, possibly non-Newtonian. In this context, this study describes the application of two improvements in highly viscous fluid simulations using the smoothed particle hydrodynamics (SPH) method: an implicit time integration scheme to overcome the problem of impractically small time-step restriction, and the introduction of air ghost particles to fix problems regarding the free-surface treatment. The application of a fully implicit time integration method implies an adaptation of the wall boundary condition, which is also covered in this study. Furthermore, the proposed wall boundary condition allows for different slip conditions, which is usually difficult to adopt in SPH. To solve a persistent problem on the SPH method of unstable pressure distributions, we adopted the incompressible SPH [1] as a basis for the implementation of these improvements, which guarantees stable and accurate pressure distribution. We verified the proposed implicit time integration scheme with simulations of both Newtonian and non-Newtonian pipe flow and the free-surface treatment with a simple hydrostatic problem. As a result, the free-surface of the hydrostatic problem became very smooth and stable. In addition, we conducted a variety of dam-break simulations to validate this proposed SPH method. Finally, we demonstrate the potential of this method with the highly viscous vertical jet flow over a horizontal plate test, which features a complex viscous coiling behavior. More details of this study can be found in [2].

REFERENCES

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