Free surface flow of viscous fluids in technical apparatus

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ABSTRACT

In many technical apparatus the fluid flow of liquids with free surfaces plays a decisive role for the functionality of the desired process. For example, rotating screw extruders are not only used for feeding and melting of polymer melts but also for degassing of volatile components. This is necessary to enhance optical or mechanical properties of the polymer product or to fulfill safety requirements. Such devolatilization processes are integrated in modern screw extruders through special degassing zone where the apparatus is partially filled. Here the highly viscous fluid flows with a free surface in order to realize the degassing process.

The morphology of the free surface in such technical apparatus depends on the material parameters of the fluid, the geometry of the apparatus and the operation parameters. In this paper we use an efficient numerical method based on the volume of fluid method in order to calculate the continuity and momentum equations only for the liquid phase. At the unknown free surface we set suitable boundary conditions. The flow of the gas phase is not of interest for our applications. In our model we assume incompressible highly viscous liquids under isothermal conditions. The flow is laminar and the surface tension can be neglected because the gravity forces are much greater than the capillary forces.

We present the theoretical basis of the model and the numerical approach. For the integration of the approach the open source library OpenFoam® is used. First we apply the method to a two dimensional benchmark geometry. A horizontal concentric cylinder system is partially filled with a viscous fluid. The inner cylinder rotates with given angular velocities. The calculated results for the free surface morphology are compared with experimental and numerical results from literature [1]. It is shown that the numerical results are in a very good agreement with experimental data.

Next the flow in an unwounded extruder channel is numerical investigated with a two-dimensional flat plate model [2]. The results discuss the influence of the degree of filling and of the material parameter to the position of the free surface. Finally the performance of the approach is shown for the three dimensional flow in a rotating, partially filled single screw extruder.

REFERENCES

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