# Simulation of Yield-Stress Fluid in a Rotational Rheometer: The Effect of Vane Geometry on the Accuracy of Measured Properties

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## Abstract

We studied the flow behaviors of self-consolidating concrete (SCC: a new type of cement which does not require energy for consolidation due to its high flowability [1]) in a rotational rheometer. The fluid of SCC was simulated as a single phase yield-stress fluid using an expression by Bercovier and Engelman [2] (through a user-defined viscosity model in the COMSOL Multiphysics® software). The rheometer in this study, which consists of rotating outer cylinder and a vane at the axis, was simulated as a 2D rotational flow using the model provided by CFD Module.

Different types of SCC were simulated by varying rheological parameters (plastic viscosity and yield stress) in the yield stress formula. Different vane geometries (number of blades, shape of blades, etc.) were also tested. Simulations were performed for chosen types of SCC and vane geometry with varying rotational speeds. Double Dogleg method was chosen as a solver to resolve typical convergence issue in numerical simulation of yield stress fluids [3]. The results of flow pattern, required torque, and unyielded zone were investigated to enhance the reliability of rheometer, to understand the flow behaviors, and to optimize the vane geometry. The effect of the regularization parameter, which is a numerical parameter to prevent the singularity at near-zero shear rate in the yield-stress expression, was also discussed.

In conclusion, the COMSOL Multiphysics® simulation was used to identify the flow pattern and to calculate the rheological properties of cement flow in a rotational rheometer. The COMSOL simulation can provide the information for optimization of vane geometry, the relation between the rheological properties, and operation condition of the rheometer.

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## Reference


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[2] M. Bercovier and M. Engelman, “A finite-element method for incompressible non-newtonian flows,” J. Comput. Phys. 36 (1980) 36: 313-326.

[3] M. M. Denn and D. Bonn “Issues in the flow of yield-stress liquids,” Rheol. Acta (2011) 50: 307–315.


## Figures used in the abstract

**Figure 1**

**Figure 2**

**Figure 3**

**Figure 4**