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Development of Advanced Predictive Software for Optimizing Oil and Gas Well Cementing

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ABSTRACT

Primary cementing is a critical process in oil and gas well construction, involving the placement of a cement sheath in the annulus between the casing and the formation to ensure well integrity. Over the past two decades, the complex fluids research group at UBC has developed advanced mathematical and computational models to simulate this process, matched with extensive laboratory scale experiments. These models account for the complex displacement of Newtonian/non-Newtonian fluids in inclined, non-concentric, narrow annuli as well as in pipes, and have employed complex rheological fluid models in 1D, 2D and 3D simulations.

A current focus of the group is on translating these research-grade models into robust, user-friendly predictive software written in Python and Julia, primarily targeted at stakeholders in Western Canada, i.e. land-based wells. Some challenges faced include data transfer between components of simulation results, numerical precision, measurement system management, and versatility of well definition. Our ultimate goal is to provide Canadian energy stakeholders with a powerful tool to optimize primary cementing operations, improve wellbore integrity, and reduce environmental risks.

The computational core contains the numerical models, which are packaged and embedded. The physical models handle laminar, transitional, and turbulent flow regimes, significant buoyancy, geometric and dispersion effects, giving insights into observations from field data, laboratory experiments, and high-fidelity 3D simulations. Data input from surveys, previous casings and open hole caliper readings is combined with centralization computations to give unparalleled predictions of irregular hole and annuli along the flow path.

In this talk we will show the evolution of the model, highlighting the challenges of adapting the research codes into a friendly graphic user interface that can be adopted by engineers in the field.