Two-Phase Flow and Displacement in Eccentric Annuli

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Brief description: Non-Newtonian fluid flow in eccentric annuli is encountered in the drilling of oil/gas wells and is of particular interest in polymer and food processing. The annular eccentricity makes the fluid to flow at a higher velocity in the wide part than in the narrow part of the annulus. In annular displacement of one fluid by another, this can lead to the displacing fluid channelling through the wide side, leaving behind a layer of the fluid to be displaced in the narrow side. An example is in the completion of oil/gas wells where the drilling mud, which initially fills the annulus between the steel casing and the wellbore, is displaced by a cementing fluid. Good bonding between casing/cement and cement/formation is essential for hydraulic isolation of the well. In addition to eccentricity, displacement efficiency is dependent on the flow rate, fluid rheology, interfacial mixing and deviation of the annulus from vertical.

This project is a fundamental study of the flow and displacement involving miscible fluids flowing through an eccentric annulus using a unique helical flow apparatus with adjustable annular eccentricity, angle of inclination and inner pipe rotation. The profile and velocity of the interface are determined by flow visualization. Displacement efficiency is measured using the conductivity method. Displacement experiments are to be conducted with a variety of non-Newtonian fluids, representing drilling and cementing fluids, in various annular geometries and flow conditions to quantify the factors that affect the displacement efficiency. The experimental data will be compared with, and used to validate, numerical simulations produced in this project.

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