Mathematical problems arising in chemical enhance oil recovery

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Abstract

In this talk we will describe several applied problems arising from modeling of enhanced oil recovery. Design of efficient chemical enhanced oil recovery processes often requires injection of fluids with different properties, some laden with chemical such as polymer, surfactant etc, in succession. The appropriate choice of displacing fluids based on their properties and the sequence in which these should be injected are often dictated by several needs and one of them is that the front sweeping the oil be as stable as possible to interfacial disturbances. Motivated by this industrial problem, we review some of the author's and his collaborator's recent and ongoing works on the extension of two-layer Saffman-Taylor formula to N-layer case. The Saffman-Taylor formula gives the growth rate of interfacial disturbances in a Hele-Shaw cell when the displacing fluid is less viscous than the displaced one. In this talk, we will present our results on the generalization of this formula to multi-layer flows involving many interfaces. The generalization is in the form of upper bounds on the growth rates of interfacial disturbances. This will be discussed for the case of constant viscosity layers. The upper bound provides a way to assess cumulative effects of many layers and many interfaces on the growth rates of unstable waves. As an application of the generalized Saffman-Taylor formula, we will derive an infinite family of necessary conditions for suppressing instability of two-layer flows by introducing arbitrary number of constant viscosity fluid layers in between. The weakest and strongest necessary conditions from this infinite family will be identified. The important role that this condition plays in stabilization of hydrodynamic instabilities and enhanced oil recovery will be discussed. We will also present results for the variable viscosity case. We show that the linear

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viscous profile of the middle layer for three-layer flows is the most optimal profile among monotonic viscous profiles. We will present numerical results for some non-monotonic viscous profiles as well. This will be based on some unpublished ongoing results and recent publications listed in the bibliography. Some of the research to be presented has been accomplished with the help of Gelu Pasa and Xueru Ding.

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