The Effects of Different Incremental Rates of External Magnetic Fields on the Labyrinthine Instabilities of Miscible ...

梁梓奎、溫志湧 ; 葉俊良

E-mail: 9609686@mail.dyu.edu.tw

ABSTRACT

In this study, extensive experiments have been conducted to explore the rich labyrinthine- instability phenomena induced by external magnetic fields of different incremental rates at the miscible interface between a magnetic drop and a surrounding diesel oil. Three light mineral oil based ferrofluids (Ferrotech Corp. EMG 905, EMG 909 and EMG 911) were used in the experiment. The liquids were confined in a Hele-Shaw cell and the magnetic fluid drop maintained a circular geometry initially. To investigate the behavior of the miscible interface under external magnetic fields, the Hele-Shaw cell was inserted into a pair of solenoids, which provided a perpendicular magnetic field. The desired magnetic field strength was achieved by using a fixed incremental rate to increase the field from zero to the desired strength H linearly. The images of the evolution of the interfacial labyrinthine instability were taken with a CCD. As can be seen in all images, extremely fine labyrinthine fingering structures are triggered by the magnetic dipolar forces. While these labyrinthine fingers keep developing as time proceeds, there are several visible waves, referred as primary waves, evolved in the interfacial region for the cases of high incremental rates (dH/dt = ∞ and 5.7 Oe/s). The primary waves are not clearly seen for the cases of low incremental rates (dH/dt = 2.8 and 1.4 Oe/s). Lack of constrain of the surface tensions, mass diffusion comes into play. The pronounced labyrinthine fingers are weakened by the natural diffusive mixing. The local concentration of the magnetic fluids decays continuously and can be identified by the lighter color zone adjacent to individual fingers. As the sweet rate decreases, the magnetic fluids have more time to diffuse into the surrounding miscible fluids and smear the primary waves. The miscible interface is stabilized by the mass diffusion.

Keywords : incremental rates ; Magnetic fluids ; Miscible interface ; Labyrinthine instability ; diffusion

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