可互溶磁性流體複雜指狀化不穩定現象之實驗研究

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摘 要

本研究首次以實驗完整探討可互溶磁性流體(miscible magnetic fluid)界面部穩定性問題。在Hele-Shaw 流場中，起始 為一個圓形的磁性流體液滴，外層緊鄰可互溶環境流體-柴油， 再施以一個均勻向上的垂直磁場，所形成的磁力會造成液滴周圍產生微小的指狀物，稱為複雜指狀化的不穩定現象，因此本研究 將針對Hele-Shaw 流場中，可互溶磁性流體在垂直磁場強度、 液滴直徑和Hele-Shaw 平板間隔厚度之影響下做一定性和定量 上的比較。而研究結果中顯示〈Ⅰ〉外加磁場和Hele-Shaw 平板 間隔厚度的增加，皆會促使磁性流體複雜指狀化不穩定現象更加 的劇烈：〈Ⅱ〉沿著液滴周圍產生有別於微小指狀物的大波，其 寬度λ是受到第三維效應的影響。微小指狀物個數受到無因次磁 場控制參數Peclet number 和平板間隔控制參數δ的影響，當指狀 物個數越多代表液滴呈現越不穩定的狀態。此外根據先前文獻記 載，黏滯流指狀化不穩定現象受到第三維平板間隔厚度的影響 下，會產生不同的指狀物寬度。而本研究中觀察出大波的寬度大 約為λ～(7±1)Hele-Shaw cell 間距。

關鍵詞 : Hele-Shaw 流場，複雜指狀化不穩定現象，可互溶磁性流體介面

目錄

參考文獻

1 下飯阪達, “ 粉體液相中凝集分散 ” 粉體粉末冶金, 12, 6, 263, 1966 2 下飯阪達, 中鉢良治, 中塚勝人和左藤惟陽 “ 磁流體製造性 質 ” 粉體粉末冶金, 22, 1, 22, 1975 3 G.W. Reimers, S.E. Khalafalla “ Production of Magnetic Fluids by Peptization Techniques ” Bureau of Mines TPR 59, 13, 1972 4 黃忠良 “ 磁流體理論應X ” 復漢出版社, 1988 5 S.Hill, “ Channelling in Packed Colums. ” Chem. Eng. Sci.1:247,1952. 6 P. Saffman and G. Taylor, “ The Penetration of a Fluid Into a Porous Medium or Hele-Shaw Cell Containing a More Viscous Liquid. ” Proc. R. Soc. London. Ser. A, 245, 312,1958. 7 C. Flament, G. Pacitto, J. Bacri, I. Drikis, and A. Cebers, “ Viscous Fingering in a Magnetic Fluid. I. Radial Hele-Shaw Flow ” Phys. Fluids, 10, 10, 1998. 8 G. Pacitto, C. Flament, and J. Bacri, “ Viscous Fingering in a Magnetic Fluid. II. Linear Hele-Shaw Flow ” Phys. Fluids, 13, 11, 2001. 9 A. Cebers, and I. Drikis, “ A Numerical Study of the Evolution of Quasi-Two-Dimensional Magnetic Fluid Shapes ” T.32, 1, 1996. 10 C.Y. Wen, C.Y. Chen, C.H. Tsai, and D.C. Kuan, “ Labyrinthine Instabilities of a Magnetic Droplet in a Hele-Shaw Cell ” Magnetohydrodynamics, 41, 3, 215, 2005 11 A. Cebers and M. M. Maiorov, “ Structures of the Interface of a Bubble and a Magnetic Fluid in a Field ” Magnitnaya Gidrodinamika, 15, 3, 1980 12 D. Korteweg, “ Sur La Forme Que Prennent Les Equations Du Mouvement Des Fluids Si L ’ on Tient Compte Des Forces Capillaries Causes Par Des Variations De Densite. ” Arch. Neel. Sci. Ex. Nat. （II） 6, 1901. 13 D. Joseph, “ Fluid Dynamics of Two Miscible Liquids With Diffusion and Gradient Stresses ” Eur.J. Mech., B／Fluids 9,565, 1990. 14 陳慶耀, “ 國科會報告 Nsc 90-2212-E-212-013 ” 2000. 15 C.Y. Chen, “ Numerical Simulation of Fingering Instabilities In Miscible Magnetic Fluids in Hele-Shaw Cell and The Effects of Korteweg Stresses ” Physics of Fluids, 15, 4, 2003. 16 H. Hu, and D. Joseph, “ Miscible Displacement in a Hele-Shaw cell ” Z. Angew. Math. Phys. 43. 626, 1992. 17 I. Drikis, and A. Cebers, “ Free Boundary Problems: Theory and Applications ” Chapman and Hall／CRC , 1999. 18 Govind Menon and Felix Otto, “ Dynamic Scaling in Miscible Viscous Fingering ” 2004. 19 D. Jackson, R. Goldstein, A. Cebers, “ Hydrodynamics of Fingering Instablilities in Droplet Fluids ” Physical Rev E, 50, 298, 1994. 20 C.Y. Chen, and E. Meiburg, “ Miscible Displacements in Capillary Tubes. Part 2: Numerical Simulations. ” J. Fluid Mech., 326, 57, 1996. 21 M. Maiorov, and A. Cebers, “ Magnetic Microconvection on the Diffusion Front of Ferroparticles. ” Magnitnaya Gidrodinamika N4, 36, 1983. 22 A. Cebers, “ Stabilities of Diffusion Fronts of Magnetic Particles in Porous Media (Hele-Shaw cell)Under the Action of External Magnetic Filed.

” Magnetohydrodynamics. 33, 1, 67, 1997. 23 C.Y. Chen, and C.Y. Wen, “ Numerical Simulations of Miscible Magnetic Flows in a Hele-Shaw Cell, Part I. Radial Flows. ” Journal of Magnetism and Magnetic Matericals, Vol. 252C, 296, Nov., 2002 24 L. Paterson, “ Fingering with Miscible Fluids in a Hele-Shaw cell. ” Phys. Fluids, 28, 1, 26, 1985. 25 E. Lajeunesse, J. martin, N. Rakotomalala and D. Salin, “ 3D Instabilities of Miscible Displacements in a Hele-Shaw cell. ” Phys. Rev. Lett., 79, 26, 5254, 1997. 26 J.Fernandez, P.kurowski, L.Limat, and P.Petitjeans, “ Wavelength Selection of Fingering Instability inside Hele-Shaw cell. ” Phys. Fluids, 13,11,3120, 2001. 27 D. Jackson, R. Goldstein, and A. Cebers, “ Hydrodynamics of Fingering Instablilities in Droplet Fluids. ” Physical Review E 50, 1, 298, 1994. 28 C. Flament, G. Pacitto, J. Bacri, I. Drikis, and A. Cebers, “ Viscous Fingering in a Magnetic Fluid. I. Radial Hele-Shaw Flow. ” Phys. Fluids 10 2464, 1998. 29 M. Lgonin, and A. Cebers, “ Labyrinthine Instability of Miscible Magnetic Fluids ” Phys. Fluids, 15, 6, 2003. 30 蔡長豪, “ 磁性流體複雜指狀化現象之實驗研究 ” 大葉大學 碩士論文, 2004. 31 楊紹甫, “ 磁流體在Hele-Shaw cell 流場中的自然對流得實驗 研究 ” 大葉大學碩士論文, 2002.