Non-Isothermal Displacement Flow of Buoyant Fluids

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Introduction

- This research studies non-isothermal displacement flow of two miscible fluids in an inclined (tilt angle ranging from 0° to 90°) duct.
- This phenomena is frequently referred to as “lock-exchange” problem. [1,2]
- The novelty of our research is that we experimentally investigate the influence of temperature gradient on the fingering characteristics and comparing the results with those we get from isothermal case.
- Both density stable and density unstable displacements are studied.
- We control dimensionless parameters of the fluid such as Atwood (At) and Peclet (Pe) number to study density stable and density unstable flows.

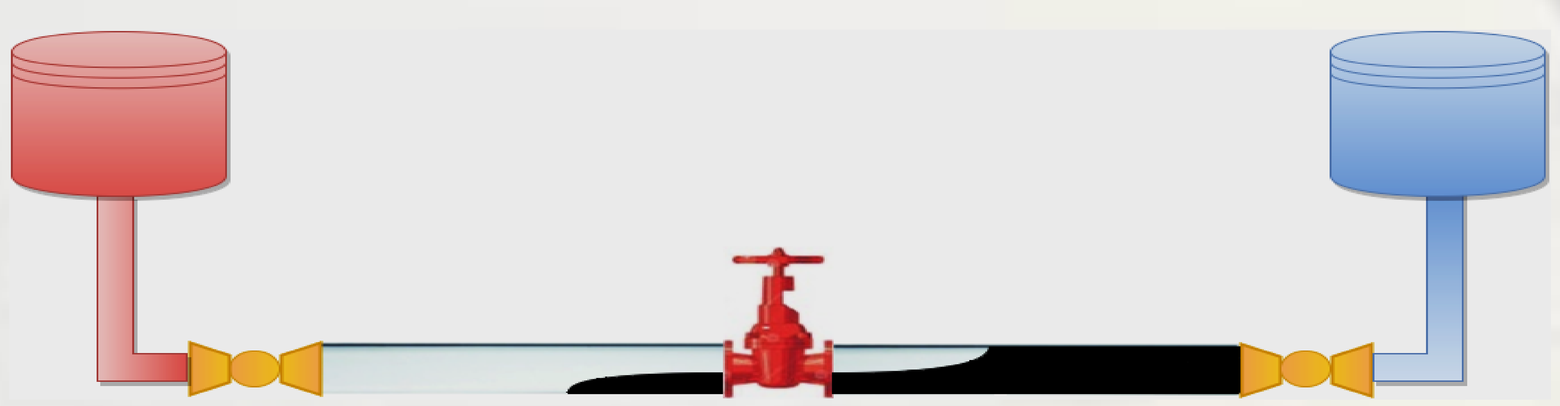


Figure 1. Schematic of Experimental Setup

specifications	
Length of Pipe	$L = 30\ cm$
Gate Valve	$L = 6\ cm$
Light fluid	$Distilled\ water$
Heavy fluid	$dyed\ water\ with\ NaCl$
Atwood number	$0.0035 \le At \le 0.01$
Viscosity	$445.56 \le \mu \le 992.88\ uPa.S$

Motivations

- Oil and gas industry [3,4]
  - Plug cementing
  - Drilling
  - Mud removal
  - Primary cementing in HTHP wells
- Biomedical applications
  - Mucus
  - Biofilms
- Food industries
  - Equipment cleaning
  - Food processing
- Natural systems
  - Oceanography
  - Atmospheric sciences
- Hydraulic fracturing

Results

- High speed and infrared cameras have been applied simultaneously and image processing results indicated below were conducted through a MATLAB code.

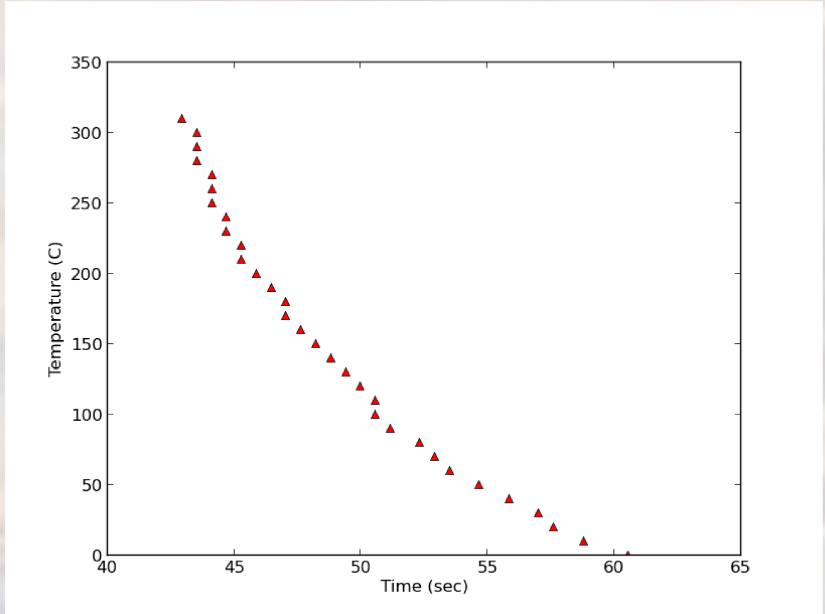
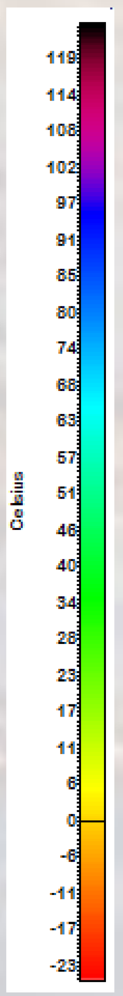


Figure 2. Temperature Distribution of Hot Finger



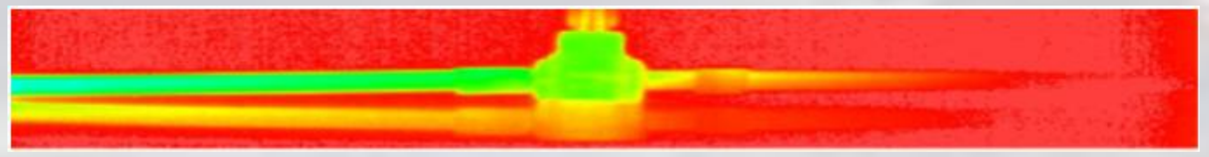


Figure 3. Temperature Distribution in Infrared Camera

Results

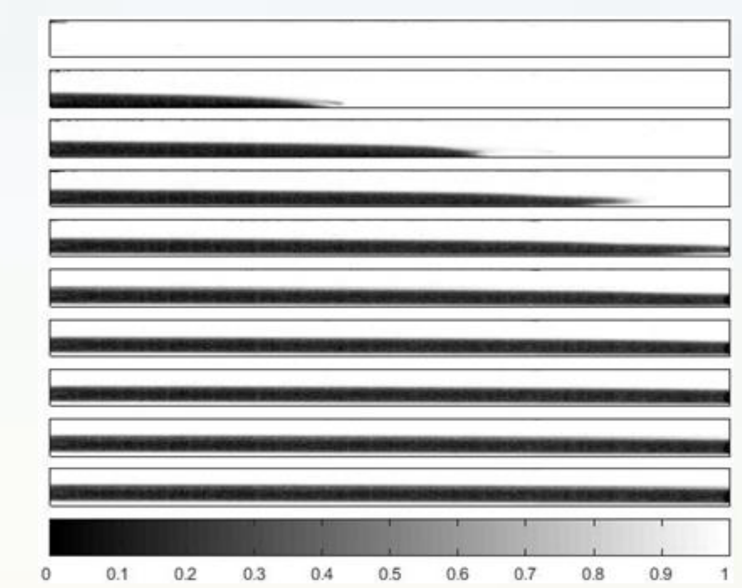


Figure 4. Fingering of Light Fluid, $At = 0.007$

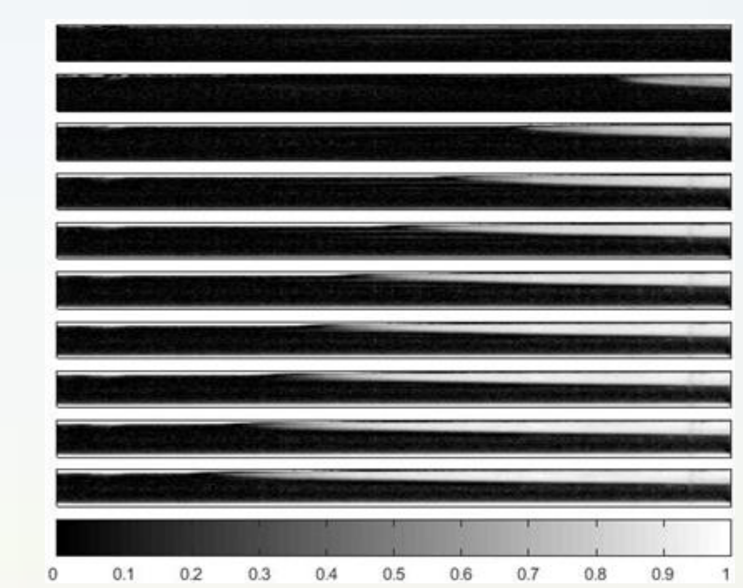


Figure 5. Fingering of Heavy Fluid, $At = 0.007$

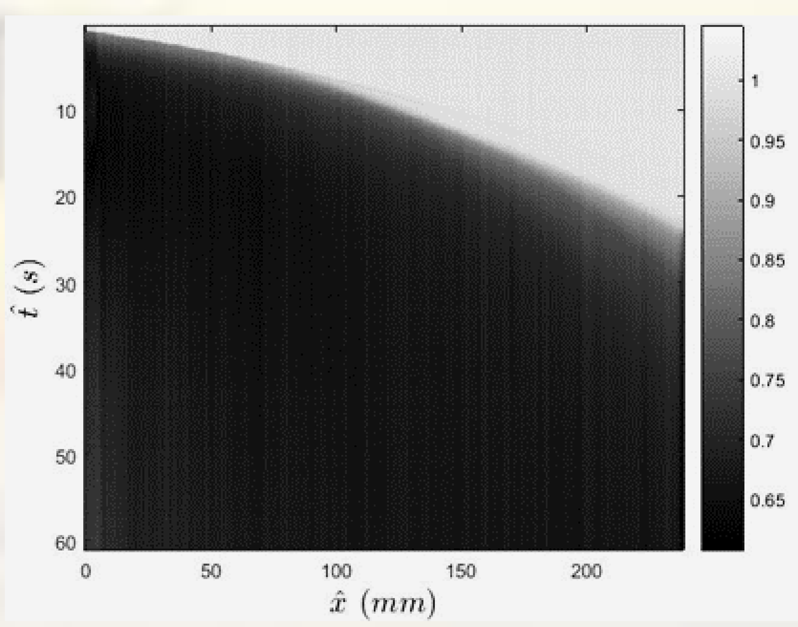


Figure 6. Fingering of Light Fluid, $At = 0.007$

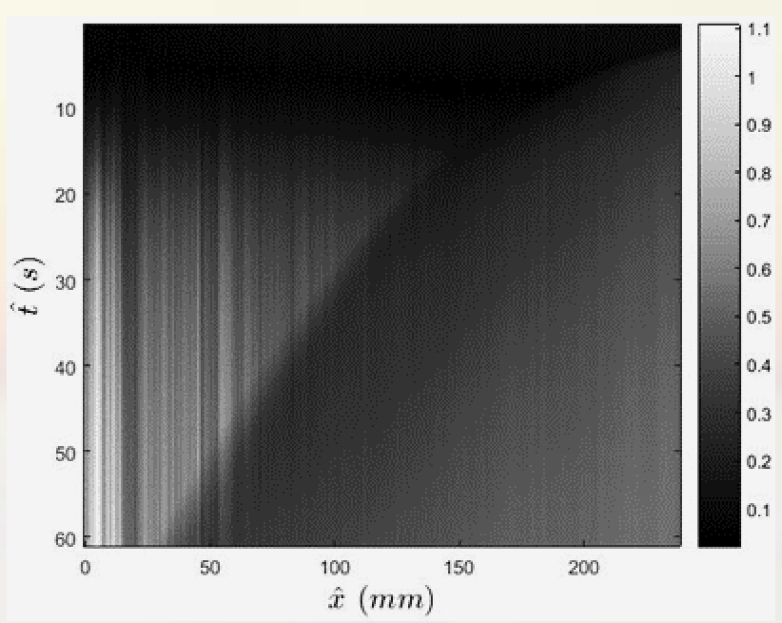


Figure 7. Fingering of Heavy Fluid, $At = 0.007$

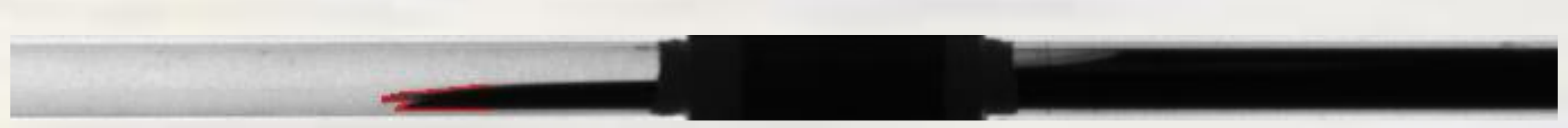


Figure 8. Multi-Layered Fingering of Heavy Fluid, $At = 0.007$

References

[1] A. Wakale, K. Venkatasubbaiah, K. C. Sahu, Computers and Fluids (2015) 54-61.

[2] T. Seon, J. Znaien, D. Salin, J. P. Hulin, Physics of Fluids (2007) 19-123603.

[3] K. Alba, S. M. Taghavi, I. A. Frigaard, Physics of Fluids (2012) 24, 123102-11.

[4] K. C. Sahu, S. P. Vanka, Computers and Fluids (2011) 199-215.