Study of the interfacial waves in stratified oil-water flow

Noureddine Latrache[a], Blaise Nsom[a], Lucius Ramifidisoa[b]

a. Université de Bretagne Occidentale. IRDL/UBO UMR CNRS 6027. Rue de Kergoat. 29238 BREST
noureddine.latrache@univ-brest.fr
b. Université d'Antsiranana. ENSET. Laboratoire de Mathématiques et d'Informatique. ANTSIRANANA (Madagascar)

Abstract:

To facilitate the transport of viscous fluid in the pipe (ex. oil) , a low viscosity fluid (usually water) can be injected in the pipe in order to reduce the pressure gradient [1]. Following the minimum energy principle, the water migrates close to the wall where high shear rates exist while the viscous crude oil locates in the region of reduced shear rate, i.e. the central part of the pipe. Different flow patterns of the oil-water system can be observed. The perfect core annular flow (PCAF) is usually unstable and can undergo three kinds of instability: capillarity instability, instability caused by interfacial friction and instability due to Reynolds stresses [2]. In reality the density of viscous oil being less than that of the water, the buoyancy force on the (lighter) oil is counterbalanced by the viscous and pressure forces [3]. Thus a secondary flow appears to counterbalance the buoyancy and it is manifested by the presence of the wavy oil-water interface [4]. The CAF is stratified in the direction of the gravity force, and it presents two different interfaces. The first is situated close the up wall, and it relatively stable, while the second one is close the down wall and it is instable. This second interface can present a strong undulations. The apparition of this undulations of the interface is the results of the interactions of many forces: gravity (density difference between oil and water), inertia (velocities of water and oil), shear rate (viscosity difference between water and oil), and interfacial tension oil-water. The mechanism of the interface formation between oil and water is not well understood until now. The goal of this work is to characterize the interface in the stratified flow by fixing the flow rate, interfacial tension, viscosity and density ratios, and by varying the flow rate of water. By the help of the spatiotemporal diagram technique of stratified flow, we have measured the spatiotemporal properties of the wave interface (amplitude, wavelength, frequency, phase velocity) as function flow rate of water. We have observed that in our experiments the pump energy of the pressure gradient decreases with the flow rate of water when the interface presents an undulations.

References

[1] Bensakhria A, Peysson Y, Antoninig (2004), Oil Gas Sci Technol Rev. IFP 59(5), 523–533.
[2] Ooms G. and Beckers H. L., Appl. Sci. Res. 26, 321 (1972).
[3] Huang, A., Christodoulou, C. and Joseph, D.D. (1994), Int. J. Multiphase Flow, 20, 3, 481-491
[4] G. Ooms, M. J. B. M Pourquie and J. C. Beerens, (2013), Physics of Fluids 25, 032102.