Liquid layer characteristics in gas-liquid upflow in slightly inclined pipes: Effect of surfactant additives

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Abstract

The co-current gas-liquid upflow in slightly inclined pipes is extensively encountered in the transportation of hydrocarbons. Furthermore it is well known that the presence of small amounts of surfactant additives in flowing liquids largely affects a wide range of phenomena (e.g. stability of laminar flow, transition to turbulence)[1,2,3,4]. Thus, the objective of this study is to experimentally investigate the effect of the addition of such substances on the gas-liquid upflow characteristics in slightly inclined pipes.

Experiments are conducted for various gas-liquid flow rates in a 24 mm i.d. pipe and for two pipe inclination angles (β=1 & 3^o from the horizontal position). Apart of tap water, three dilute aqueous solutions of the non-ionic surfactant *Tween*®-80 are also employed, in order to study the effect of the surfactant on the flow pattern and the liquid layer characteristics (i.e. mean layer thickness, amplitude and celerity of the interfacial waves). New experimental data, based on liquid layer thickness measurements, are used to examine whether the addition of small amounts of a non-ionic surfactant additive during co-current gas-liquid upflow influences the interfacial characteristics. From the findings of the present study it is verified that the mean liquid layer thickness, the wave celerity as well as the transition to different flow regimes (***Figure 1***) are not strongly affected by the presence of surfactant additives. However, the wave amplitude seems to be influenced by the presence of the surfactant additives especially at higher liquid flow rates. Moreover, it has been verified that the wave amplitude decreases as the surfactant concentration increases regardless of the flow regime (***Figure 2***). This behaviour may be attributed to the fact that the surfactant molecules concentrate at a region near the interface, increase the interfacial shear viscosity and create a protective layer which damps the gas-induced waves [4].

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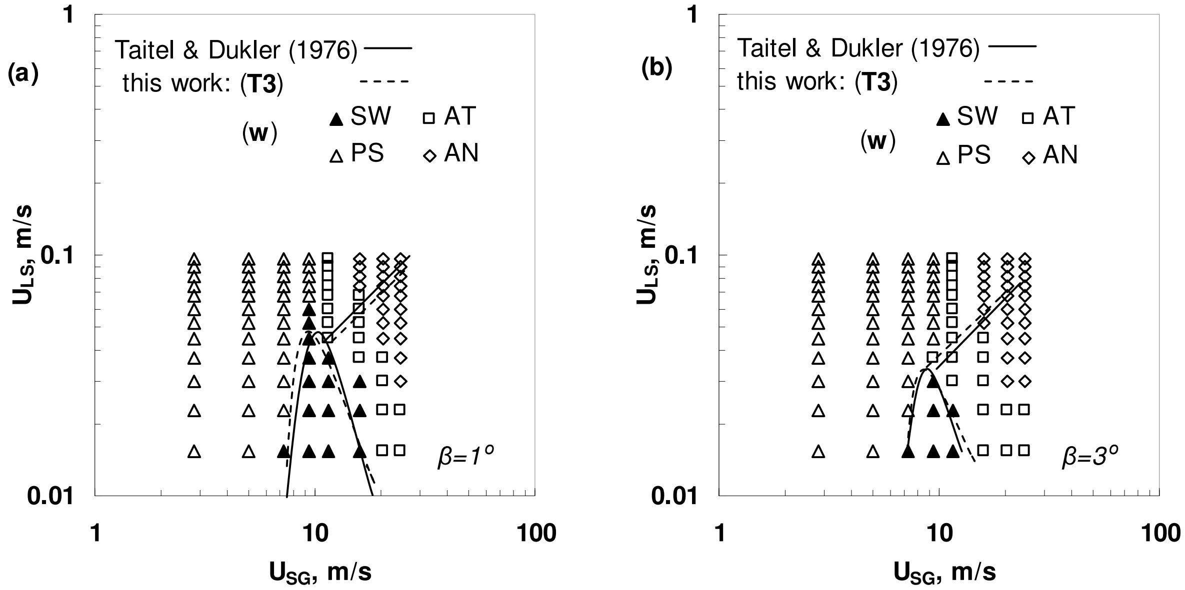

Figure 1. Flow pattern map for water and T3; (a) β=1°; (b) β=3°. Comparison with model [5].

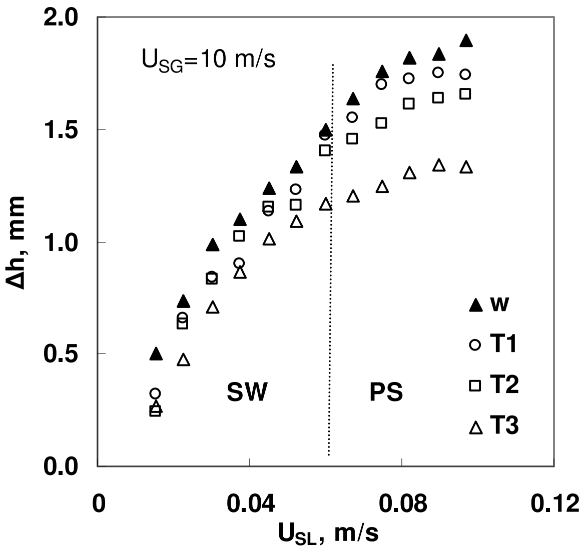

Figure 2. Effect of liquid physical properties on Δh values for a range of liquid flow rates and a typical gas flow rate (U_{SG}=10 m/s); β=1°.