The effect of surfactants on flow characteristics in. oil/water flows in large diameter horizontal pipelines

H SHI, J Y CAI, and W P JEPSON
Department of Chemical

1. INTRODUCTION

With the more and more sea water has been produced by maturing oil wells, oil-water flow is drawing much more attention in the petroleum industry. Most research on oil-water flows has focused on the pressure gradient. Ariachakaran et al. (1989) developed pressure gradient models for stratified and homogeneous flows. Sarica et al. (1997) studied the oil-water flows in vertical and deviated wells. The pressure drop and holdup were found to be strongly affected by oil-water flow patterns, water cut, and inclination angle.

However, corrosion is a serious problem in multiphase pipelines and the corrosion mechanisms are dependent on the phase in contact with the pipe wall. The presence of water layers at the pipe wall can cause extensive levels of corrosion. It is therefore extremely important to be able to predict oil-water flow patterns and the presence of free water.

Flow patterns change with increases in the input concentrations and the superficial velocities of the two phases. Figure 1 shows the oil-water flow patterns observed by Oglesby (1979). The

Addition of surfactants to the corrosion inhibitor formulations can increase th dispersibility of the inhibitor and help increase its effectiveness. It is also possible that th surfactant will change the surface and interfacial tensions of the fluids and enhance the oi watetmixing and maybe the formation of emulsions.

This work examines the effect of addition of surfactant on the flow characteristics.

2. EXPERIMENT SETUP AND PROCEDURE

The experimental layout of the flow loop is shown in Figure 2. The oil-water mixtUl with specified composition is placed in a 1.2 m^3 stainless storage tank (A). The tank . equipped with two 3kW heaters (B). The oil-water mixture is pumped into a 7.5 cm 10 PV' pipeline using a 5hp centrifugal pump (C). The flow rate is controlled using a by-pass systel (D), which also serves to agitate the oil-water mixture in the tank. An orifice plate is used 1 measure flow rate.

thicker and more and more well mixed with increase in surfactant concentration. This especially noticed at the mixture velocities of 1.6 and 2 *m/s.*

3.4 PRESSURE GRADIENT

The variation of pressure gradient at input water cut of20, 40 60 80% for three differel surfactant concentration are shown in Figure 17, 18 and 19. The experimental error is about 5%.

From these three figures, it is seen that for velocity of 1.0 mis, there are no laq changes in the pressure gradient with an increase in the input water cut.

In Figure 17, at a superficial mixture velocity of 1.4 *ml,* as the input concentration (water is increased to 20%, the pressure gradient increase from $136 N/m^3$ to 210 N/m^3. There a dramatic increase in the pressure gradient between the input water concentrations of 20 1 40%. The pressure gradient reaches 317 N/m^3 at 40% then drops down to 260 N/m^3 at 60%. then decreases to 220 N/m^3 when the water cut is increased to 80%. Further increase in tl water percentage to 100% results in a pressure gradient of 157 N/m^3 which is in agreement (the calculated value of 164 N/m^3 for water alone.

When 5 ppm surfactant is added Figure 18 indicates that there is little effect on tl pressure gradient. There are small differences at the higher mixture velocities of 1.8 and 2 mls. However, when 10 ppm surfactant was added, Figure 19 shows the pressure gradient affectedfTxv6tutLllfItutLdgrs6fxuptutLsu-jT.xptlTTuxp6tlfuxT.tLd16x2vtutLdptutLdadLjyf1xuptutLdoredLj

Segregated - no mixing at the interface

Semi-segregated - some mixing at the interface

Semi - mixed - segregated flow of a dispersion and "free" phase. Bubbly interface, Dispersion volume less than half of the total pipe volume.

Mixed - same as the above coding but with the dispersion occupying more than half the total pipe volume

Semi - dispersed - some vertical gradient of fluid concentration in the mixture

Fully dispersed homogenous flow

0.9

O.S

0.7

0.6

0.5

0.4

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

~20%we
-40%we
-60% we
-80% we

0 20 40 60 80 100

Insitu Water Percentage (%)

Figure 8 Variation of Water Percentage with Vertical Position
(1.4 *mis*, 5 **ppm)**

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2

0.2

0

0

2007 -5.30 9 Tf (<7)Tj 2 7 /23%50 Tz /Tj 0 -3.84 Td 100

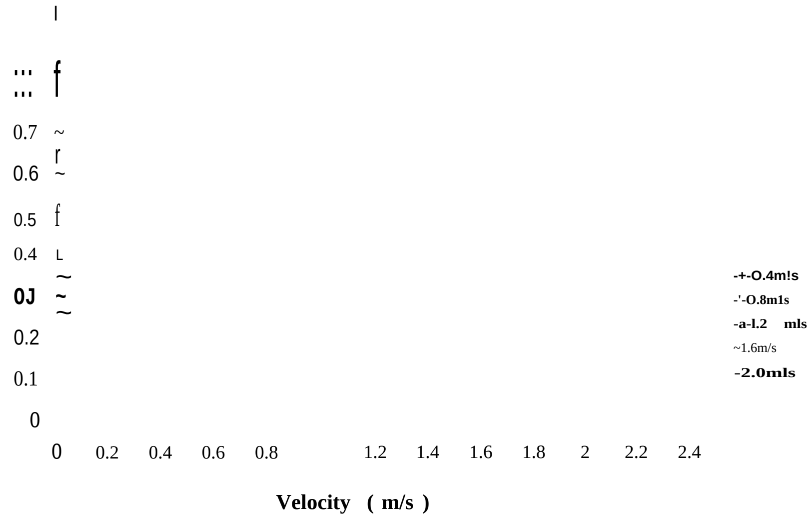

Figure 12 Insitu Velocity Profile for Different Mixture Velocities (40% water cut)

--0.4 m/s
•..•..0.8 m/s
--1.2 m/s
-1.6m/s
...•..2.0m/s

0.2 0.4 0.6 0.8 1.2 1.4 1.6 1.8 2 2.2 2.4

Velocity (m/s)

Figure 16 Insitu Velocity Profile for Different Input Mixture Velocities (40% water cut, 10 ppm)

800
700
600
500
400
300
200
100
0

--1.0 m/s
...•...1.4 m/s
--1.8 m/s
...•...2.2 inls

0 10 20 30 40 50 60 70 80 90 100

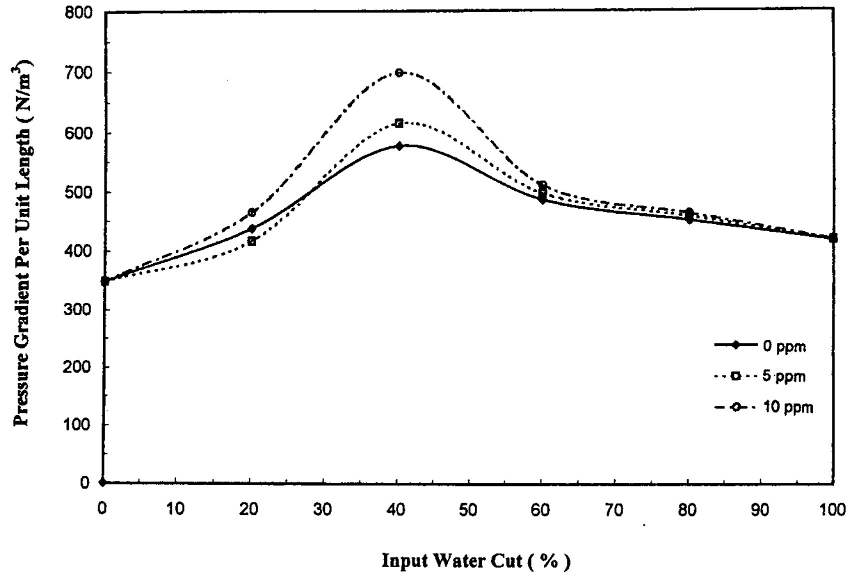

Figure 20 Effect of Surfactant Concentration on Pressure Gradient (2.2m/s)