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STUDY OF OIL-WATER FLOW WITH DRAG-REDUCING POLYMER IN DIFFERENT PIPE INCLINATIONS AND DIAMETERS

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Abstract

In this work, the study of oil-water flow with drag-reducing polymer (DRP) was carried out in different pipe inclinations and diameters. Three acrylic pipes with internal diameters of 30.6, 55.7 and 74.7 mm were used in the study. The investigations were conducted in the smallest pipe (30.6-mm ID) at horizontal (0^o), upward ($+5^o$ and $+10^o$) and downward (-5^o) inclinations, and in the larger pipes (55.7-mm and 74.7-mm ID) only at horizontal position. The working fluids were tap water and mineral-based hydraulic oil (Shell Tellus S2 V 15), with medium viscosity and density of 24 cP and 872 kgm^{-3} respectively while the interfacial tension between the water and the oil was 12.9 mN/m at 25 ^oC. The oil-water flow conditions of 0.1 – 1.6 m/s mixture velocities and 0.05 – 0.9 input oil volume fractions were used, and 2000 ppm master solution of the water-soluble DRP, which is a high-molecular-weight anionic copolymer of polyacrylamide and 2-Acrylamido-2-Methylpropane Sulfonic acid, was prepared and injected at controlled flow rates to provide 40 ppm of the DRP in the water phase at the test section. Overall, six flow patterns were identified and grouped into four as stratified, dual continuous, dispersion of oil in water and dispersion of water in oil flows. However, not all of them were observed in all the pipe inclinations and diameters. The presence of the DRP increased the separated water-dominated flow regions to higher mixture velocities while the oil-dominated flow regions were not affected by the DRP. Also, the pipe inclination increased the dispersed flow regions while the reverse was the case with increase in the pipe diameter. Significant drag reductions, which increased with the increase in the mixture velocity but with the decrease in the input oil volume fraction, were also achieved particularly in the water-dominated flow regions. The magnitudes of these variations of the drag reductions against the flow conditions were different in all the pipe inclinations and diameters. Similarly, the water holdups and velocity ratios in the water-dominated flow regions increased with increase in the mixture velocity and after the addition of the DRP to different extents in all the pipe inclinations and diameters. Empirical correlation in terms of friction factor of the oil-water flow at maximum drag reduction as a function of mixture Reynolds number was developed using power law concept. The developed correlation when tested against previously published experimental data showed a very good performance. In addition, the accuracy of the pressure gradient prediction by the developed correlation was better than the accuracies of similar correlation in the literature and homogeneous model. Finally, energy analysis of the oil-water flow with DRP in terms of the head loss, pumping energy consumption and increase in the flow rate was conducted. The results showed that there were drastic reductions in the head losses, huge

savings in the pumping energy consumptions and significant increases in the flow rates by the DRP.