# Secondary Flow of Liquid-liquid Two-Phase Fluids in a Pipe Bend

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## Abstract

The world is progressively requiring more energy with the main one coming from petroleum. The difficulties in the whole process of its production are enormous, from the exploration to its transport through pipelines. In the oil industry, its production often involves the presence of water (brine), sand and other types of solid particles. These particles can be harmful to pipeline and equipment's life cycle as they can erode their walls, which increments companies cost of maintenance due to necessary pipe (or equipment) replacement. The highest erosion rate is most commonly found in bends, as particles are dragged towards the wall due to the streamwise and secondary flows. When brine is present in the oil the fluid is considered a Liquid-liquid two-phase fluid and it could affect the secondary flow development. A better understanding of the secondary flows in a liquid-liquid two-phase flow is required to gage their impact in the particle trajectories.

Two-phase flow in bends is a complicated phenomenon that has been extensively studied for liquid-gas two-phase flows (e.g., Yadav et al., 2014). To the best of our knowledge, liquid-liquid two-phase flow has only been addressed by Zhu et al. (2011). However, the density difference between the two fluids they considered was only about 4%, which makes the gravitational forces effect almost negligible. In this research, we propose to study the secondary flows in elbows of liquid-liquid two-phase fluids with marked density differences.

A study of oil and brine in a bend was carried with COMSOL® software using the Multiphase Flow interface with an Euler-Euler model. We investigate how the secondary flow develops along bends for: different Reynolds numbers for laminar and turbulent regimes, bend radius of curvature, and sweep angles (45 and 90 degrees), brine NaCl composition (that affects brine density and viscosity), bend orientation with respect to gravity, and phase volume fractions. Close attention was given to the mesh and the straight pipes (connected to the bend) lengths in order to minimize the numerical error in the domain of interest. For all of the cases in this study, we visualized the secondary flow streamlines, velocity contours, and velocity vectors, and looked at the axial and transverse velocities, vorticity magnitude (maximum, minimum, and their locations), swirl intensity, and pressure field for different cut planes along the bends.

## Reference

1. Zhu et. al., Numerical Simulation of the Oil-Water Two-Phase Flow in Horizontal Bend Pipes, Communications in Computer and Information Science, 158, 75-82 (2011).

2. Yadav et al, Experiments on Geometric Effects of 90-degress vertical-upwards Elbow in Air Water Two-phase Flow, 65, 98-107 (2014).

## Figures used in the abstract

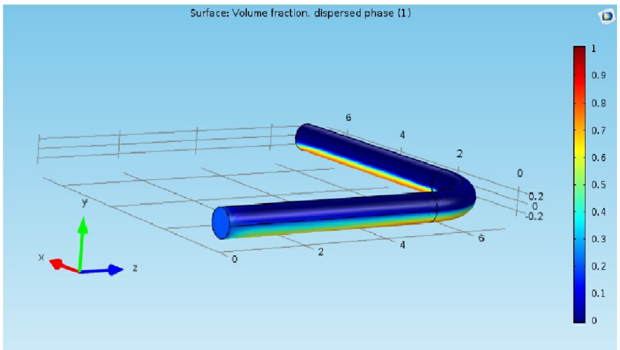


**Figure 1**: A bend configuration showing the volume fraction of the brine phase.