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

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Introduction: In the **OIL INDUSTRY**, its production often involves the presence of oil and water (brine) particles which is considered a Liquid-liquid two phase fluid. These particles can be harmful to pipeline and equipment's life cycle as they can cause **EROSION**, which cost **BILLIONS OF DOLLARS** of maintenance due to necessary replacement. The highest erosion rate is most commonly found in bends. 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). In this research, we propose to study the **SECONDARY FLOWS** in elbows of liquid-liquid two-phase fluids with marked density differences.

Computational Methods:

Three orientations were proposed by varying the bend direction

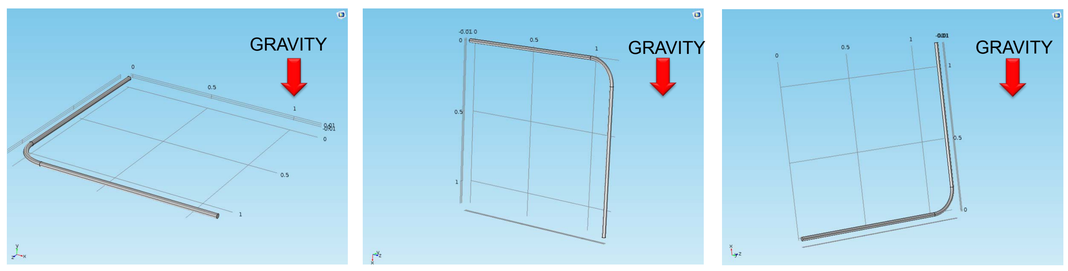
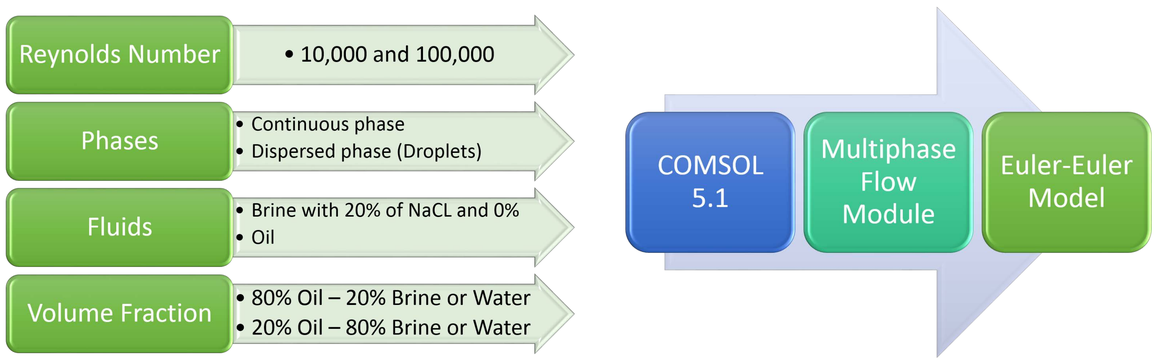


Figure 1. Bend configurations (Horizontal-Horizontal, Horizontal-Vertical Down, Horizontal-Vertical Up), Fluid flows in the +Z direction. Sweep angle 90 degrees



At the inlet, a predetermined velocity profile was imposed. A prescribed value of 0 Pa was set as the outlet condition and Wall function was set as wall condition. After performing a mesh sensitivity analysis, a “Normal” mesh was used.

Results: Reynolds 10,000 only

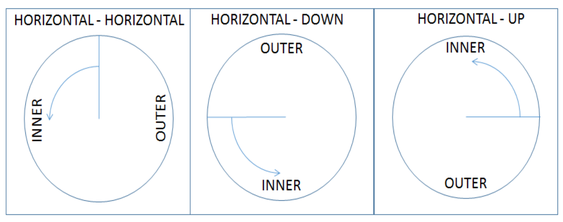


Figure 2 Inner and Outer position for all the plots

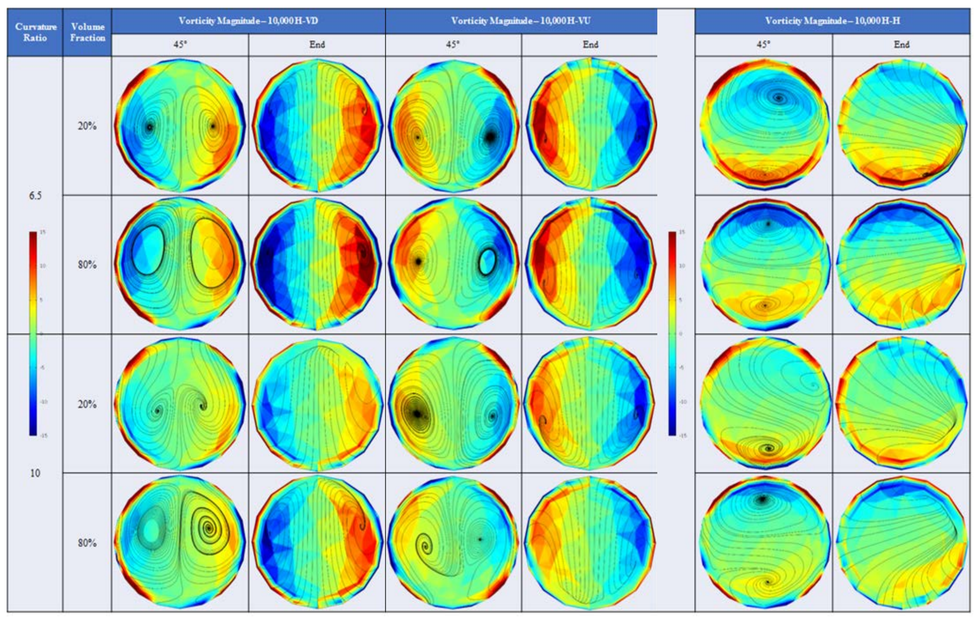


Figure 3: In plane vorticity for all gravity configurations for Reynolds 10,000

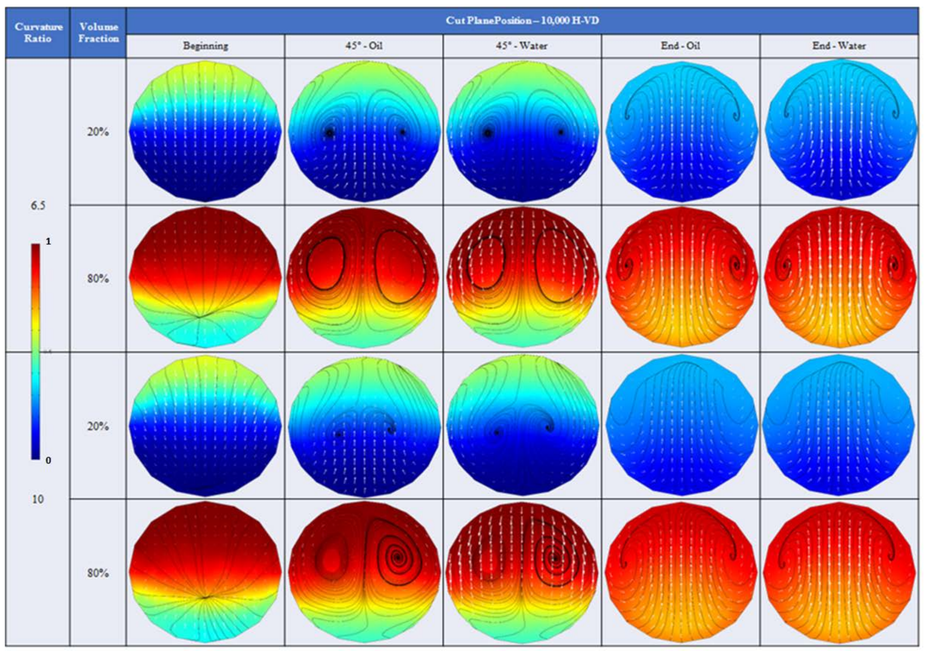


Figure 4. In plane velocities for gravity configuration Horizontal-Horizontal for Reynolds 10,000

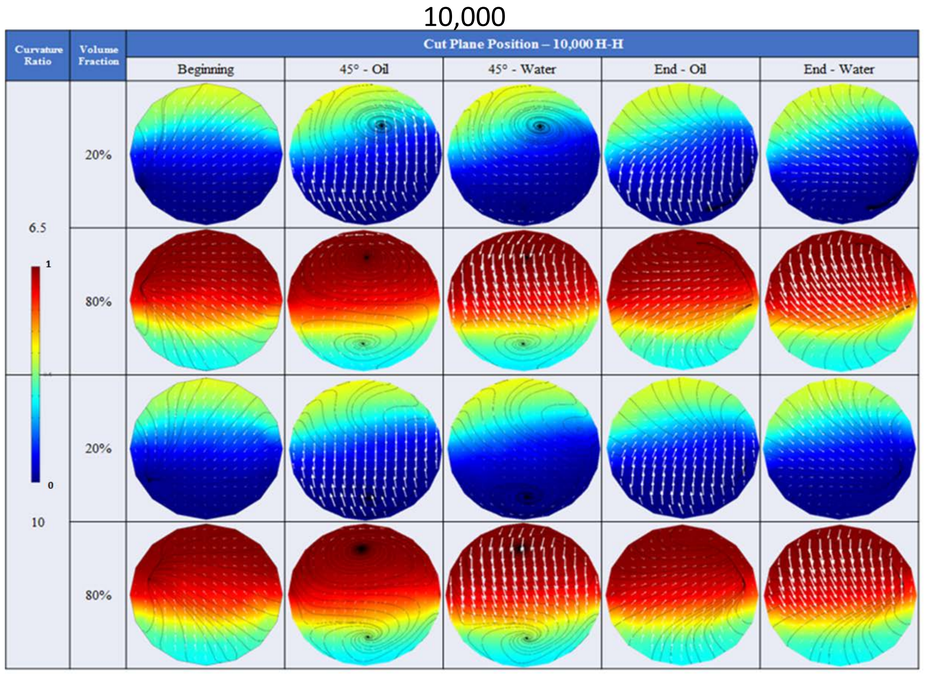


Figure 5. In plane velocities for gravity configuration Horizontal-Down for Reynolds 10,000

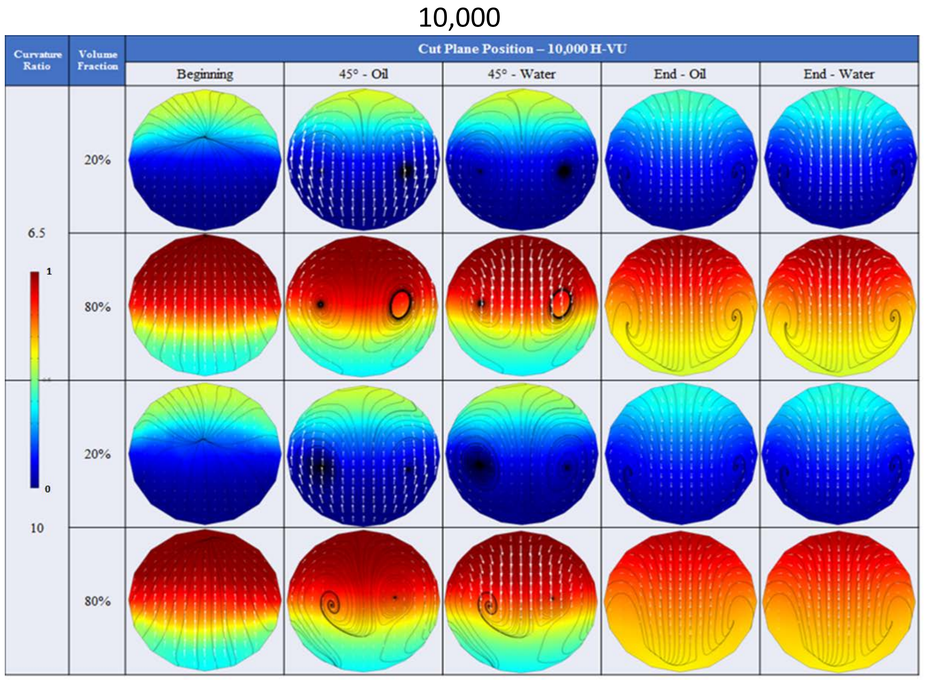


Figure 6. In plane velocities for gravity configuration Horizontal-Up for Reynolds 10,000

Conclusions:

- The flow behavior is strongly related to gravitational and centrifugal force ratio
- Secondary flow appears, in the form of vortical structures
- Salt concentration plays little or no role on the fluid behavior
- Future work is planned to undergo a study of a gravitational-to-centrifugal ratio of 1 and behavior of two-phase Laminar flow in pipe bends

References:

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).

Excerpt from the Proceedings of the 2016 COMSOL Conference in Boston