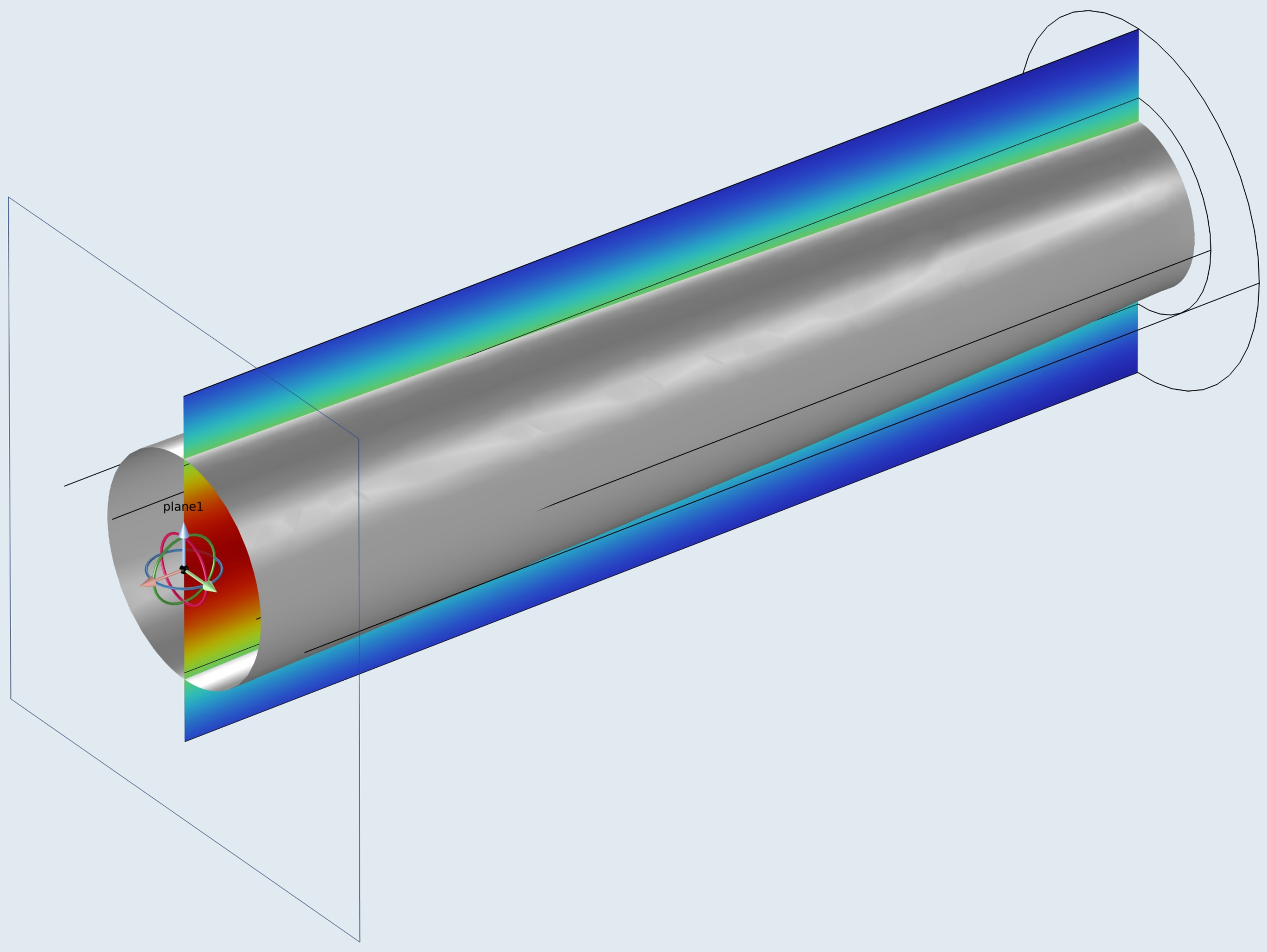

Hydrodynamic Performance and Stability Characteristics of Heavy Oil-Water Annular Flow

Understanding the behavior of heavy oil-water core annular flow for different inlet and boundary conditions, including oil and water superficial velocities, oil properties, and oil core geometric parameters.

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Introduction & Goals

The transportation of highly viscous oil surrounded by water annulus can be a practical option in terms of low-energy consumption and high efficiency. The stability of maintaining this type of flow can be an issue, especially with highly viscous oil.

The effects of inlet water fraction, liquid holdup, superficial velocities of oil and water, oil properties (density and viscosity), and oil core related parameters (size and position) on the hydrodynamic performance and stability characteristics were explored.

The results could provide a reference for optimized operation parameters and flow assurance in pipe structures.

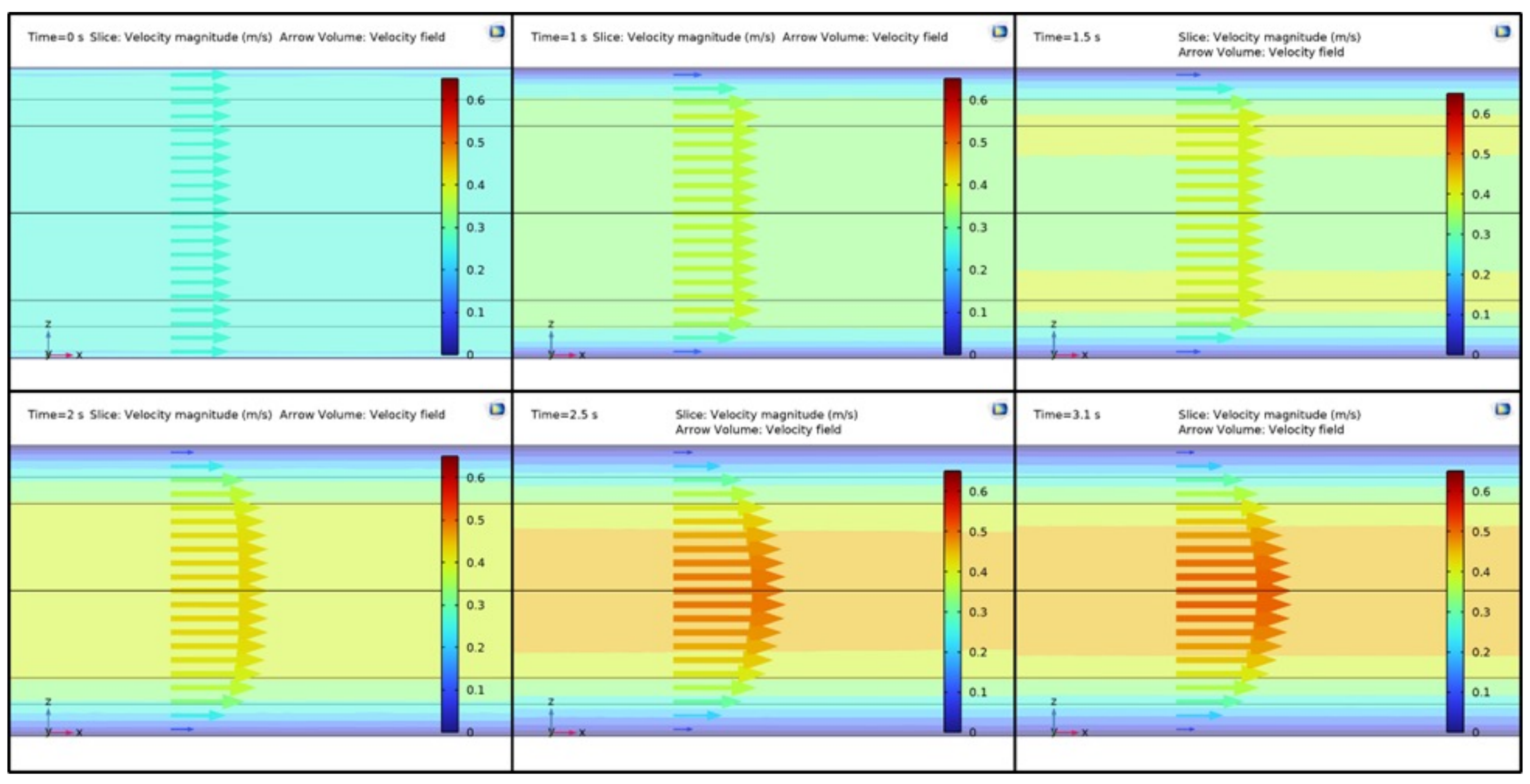

FIGURE 1. Transient development of core annular flow at x = 0.8 m.

Methodology

3D numerical simulations for heavy oil-water (Oil viscosity range = 1 – 10 Pa·s) core annular flow (CAF) through 1” diameter and 1 m long horizontal pipe were performed based on the two-phase level set method (LSM).

Both fluids enter the domain from the same surface with oil in the core surrounded by water. The results will be compared based on the water holdup percentage and the time it takes for the water holdup percentage to level-up at 0.8 m from the inlet.

Results

From figure 1, the high velocity oil gradually drives and replaces the water in the core until CAF is fully developed. The no slip condition can be seen where water velocity is nil at the walls. Also, at the interface between the phases, the smaller momentum phase is being dragged with an increase in velocity by the higher momentum fluid, and vice versa.

As shown in figure 2, while keeping the inlet water superficial velocity constant, increasing the inlet oil superficial velocity allows faster flow in the core. Furthermore, when maintaining constant inlet oil superficial velocity, increasing the inlet water superficial velocity similarly contributes to an increase of core flow.

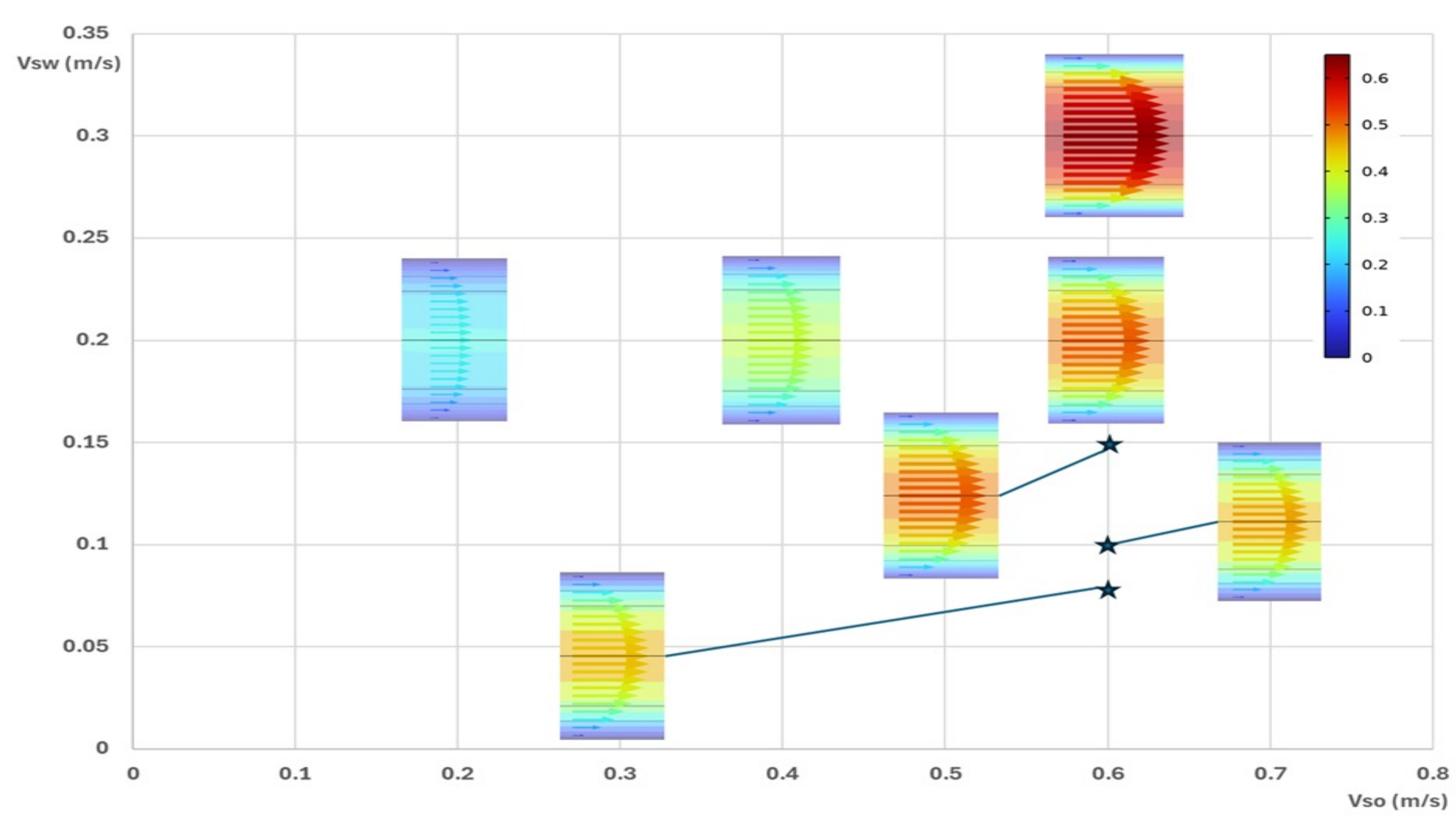

FIGURE 2. Velocity profile for different superficial velocities of water and oil.

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