Project 2

Solution

MAE598 – Applied Computational Fluid Dynamics

Shashank Kunjibettu

General Procedure for Model Setup

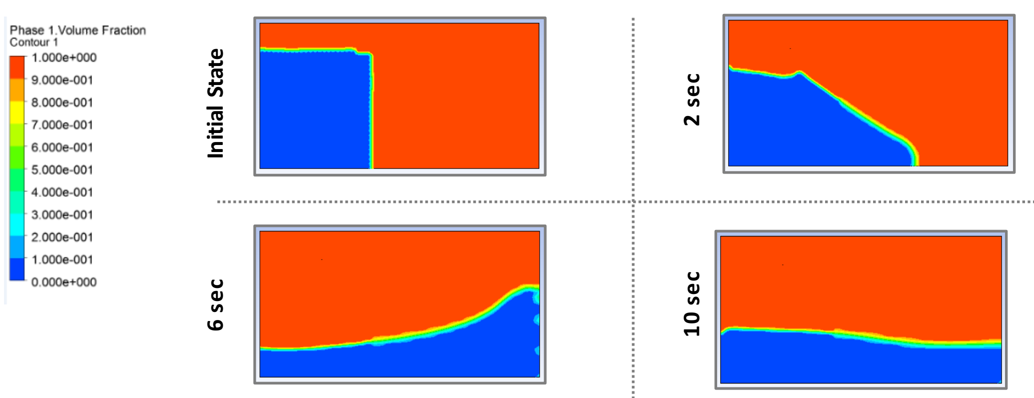
- **Step 1:** Model the given component using design modeler
- **Step 2:** Meshing is done for the designed model. Here for all the cases **fine mesh** is chosen in mesh sizing.
- **Step 3:** Fluent setup is opened and the respective boundary conditions and fluid phases are defined. The detailed procedure for Fluent setup will be discussed before each task.
- **Step 4:** The solution is initialized and patched to define initial phases inside the geometry.
- **Step 5:** Calculations are run using appropriate number of time steps. This can be correctly selected using the concept of Courant number.

Task 1 – Fluent Model Setup

- The Fluent database is setup considering the below options. Once these are selected, the program is run to obtain the final solution.
  - Mesh : Fine mesh
  - Solver : Pressure based solver, Transient time state
  - Models : Multiphase (Volume of fluid), k epsilon model, inviscid model (for c)
  - Materials: Engine Oil (Phase 1), Liquid Water (Phase 2)
  - B.C. : N/A
  - Soln. Method : PISO Scheme
  - Soln. Initializatin: Standard Initialization with patch on the adapted field
  - Calculation : 100 steps of 0.1 s considering 40 iterations/ step.

Task 1 (a) - Results

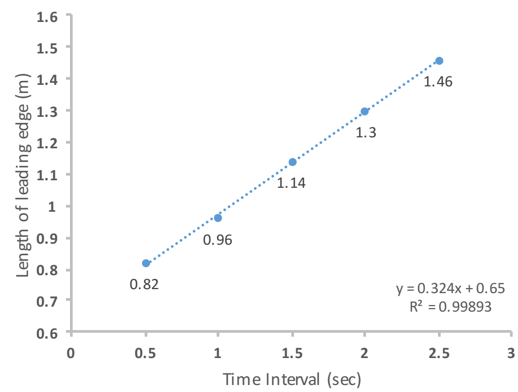
- Below are the contour plots of the phase mixing at various time intervals



Task 1 (b) - Results

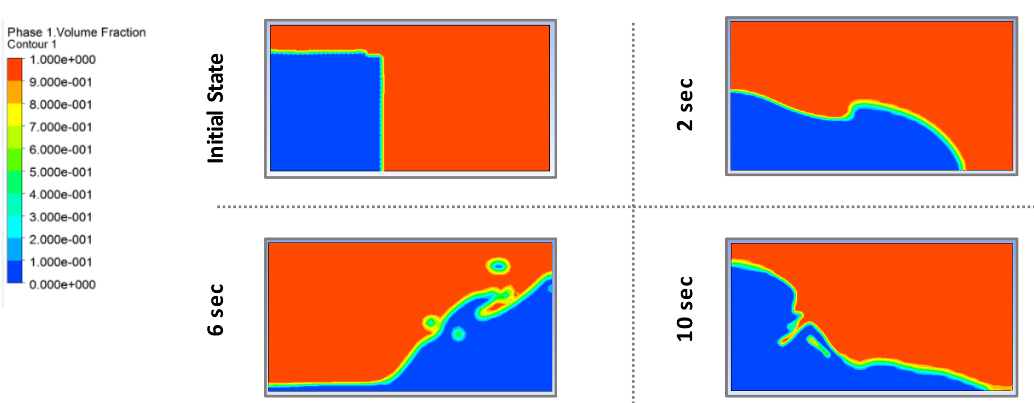
- Length of the cell, Δx = 0.03m
- Time step, $\Delta t = \frac{\Delta x}{\sqrt{gh}} = \frac{0.03}{1.98} \cong 15.14 \times 10^{-3}$
- Average Velocity, U = 0.324 m/s
- Courant Number, C = $\frac{U.\Delta t}{\Delta x} = 0.16$

- From the above analysis we observe that the Courant Number is <<1
- This implies that the solution obtained is numerically stable.



Task 1 (c) - Results

- Below are the contour plots of the phase mixing at various time intervals



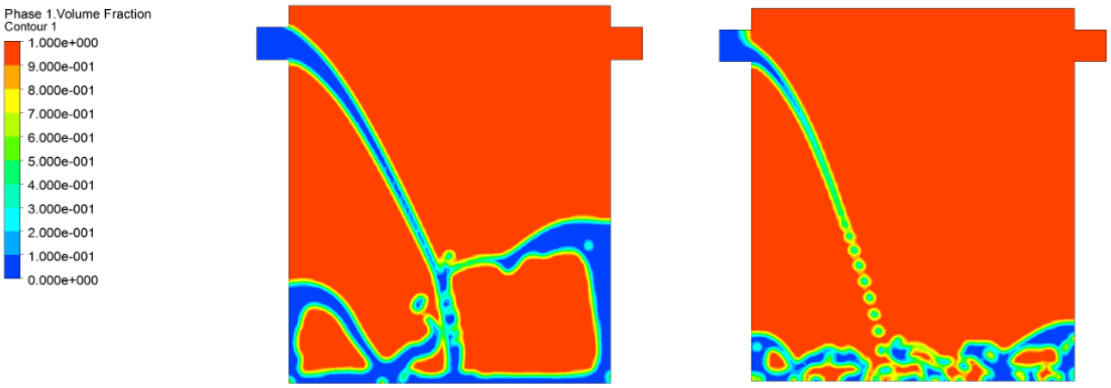
Task 1 - Inference

- From the results we observe that the first model (viscous) takes less time to settle down in the vessel when compared to the second model (non-viscous).
- This is because the first analysis was performed considering effects of viscosity and the second was performed without considering it.
- Due to the consideration of viscosity, the frictional effects between the fluid and the vessel are assumed during calculations as a result of which it takes less time to settle down.

Task 2 – Fluent Model Setup

- The Fluent database is setup considering the below options. Once these are selected, the program is run to obtain the final solution.
  - Mesh : Fine mesh and further mesh refinement with mesh adaption
  - Solver : Pressure based solver, Transient time state
  - Models : Multiphase (2 phases) (Volume of fluid), k epsilon model
  - Materials: Air(Phase 1), Liquid Water (Phase 2)
  - B.C. : Vol Fraction = 1 for phase 2 at inlet. I/L and O/L
  - Soln. Method : PISO Scheme
  - Soln. Initializatin: Standard Initialization
  - Calculation : 200 steps of 0.005 s considering 40 iterations/ step. (0.5 m/s)
    : 500 steps of 0.002 s considering 40 iterations/ step. (0.25 m/s)

Task 2 - Results

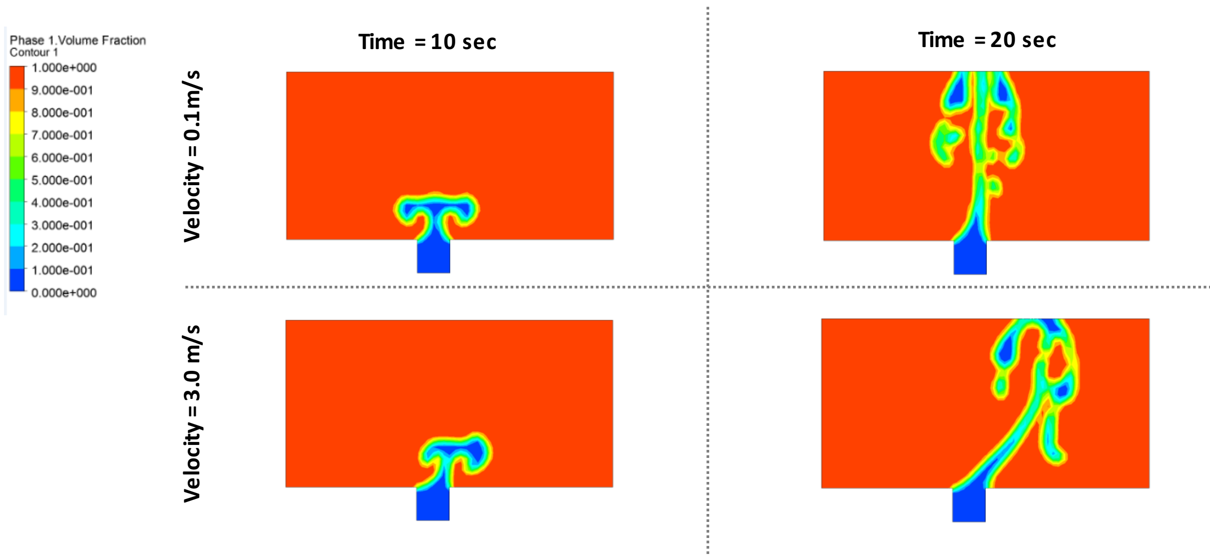


Velocity = 0.5m/s **Velocity = 0.25m/s**

Task 3 – Fluent Model Setup

- The Fluent database is setup considering the below options. Once these are selected, the program is run to obtain the final solution.
  - Mesh : Fine mesh
  - Solver : Pressure based solver, Transient time state
  - Models : Multiphase (2 phases)(Volume of fluid), k epsilon model
  - Materials: Air (Phase 1), Liquid Water (Phase 2)
  - B.C. : As mentioned in the problem
  - Soln. Method : PISO Scheme
  - Soln. Initializatin: Standard Initialization
  - Calculation : 200 steps of 0.1 s considering 40 iterations/ step.

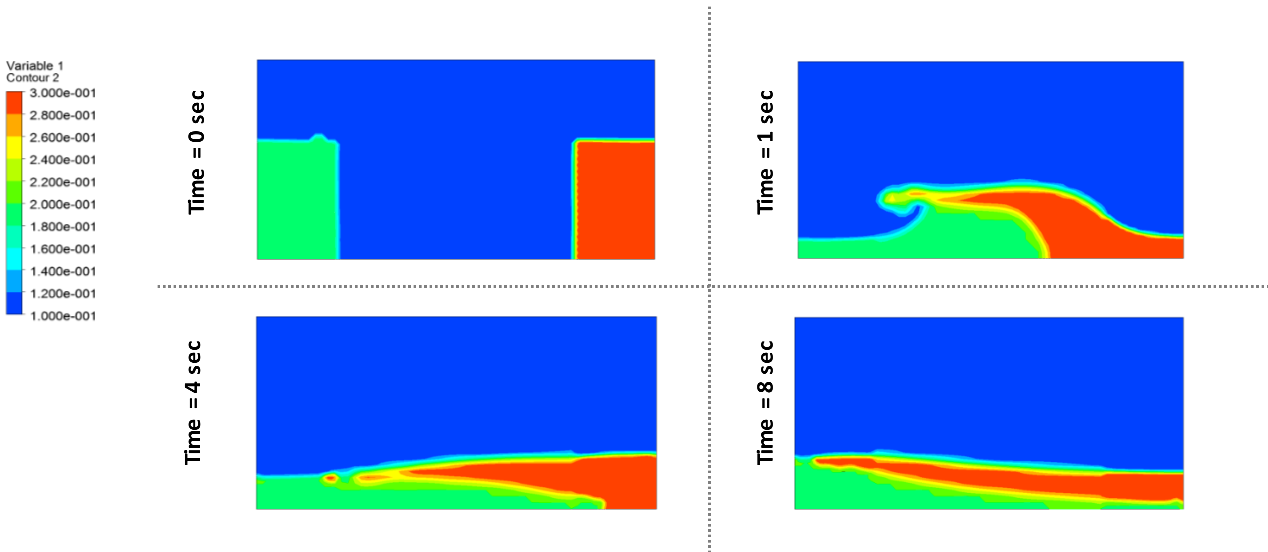
Task 3 - Results



Task 4 – Fluent Model Setup

- The Fluent database is setup considering the below options. Once these are selected, the program is run to obtain the final solution.
  - Mesh : Fine mesh
  - Solver : Pressure based solver, Transient time state
  - Models : Multiphase (3 phases) (Volume of fluid), k epsilon model
  - Materials: Air(Phase 1), Engine Oil (Phase 3), Liquid Water (Phase 2)
  - B.C. : N/A
  - Soln. Method : PISO Scheme
  - Soln. Initializatin: Standard Initialization at velocity inlet 1 with 4 patches on the adapted field of water and engine oil.
  - Calculation : 1600 steps of 0.005 s considering 20 iterations/ step.

Task 4 - Results



Task 4 - Inference

- The density's of the three fluids being analyzed can be summarized as below -

$$\rho_{Air} < \rho_{Engine\ oil} < \rho_{Water}$$

- Thus it is seen when the mixing is initiated air is at the top followed by engine oil with water at the bottom most portion of the container.
- Also with passage of time the fluid mixes completely and agitation slowly stops in the vessel.