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MAE 494
November 10 2016

Project # 2: Transient Simulation using VOF Methods

INITIAL SET UP

The initial set-up for all the geometries varied with respect to each tasks. The common similarities between these tasks were the following: Added mesh refinement (fig1a), used VOF methods (fig1b), turned on gravity (fig1c), and followed Tutorial 3 guidelines for Solution Methods and Solution Controls. All pictures have phase 2 (testing material) colored in red.

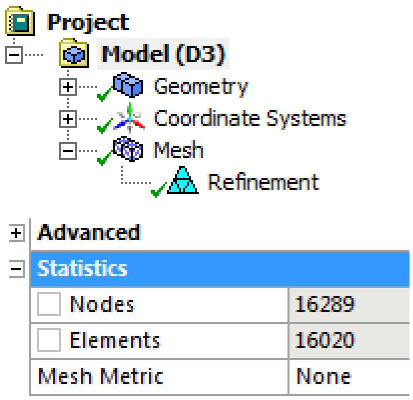

Figure 1a: Added Refinement

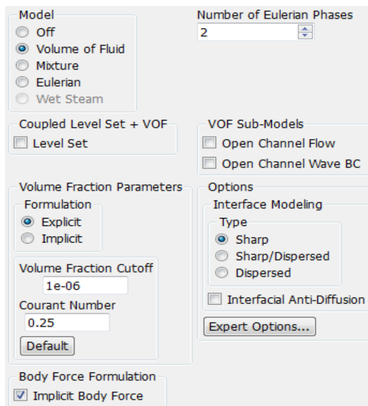

Figure 1b: VOF Model

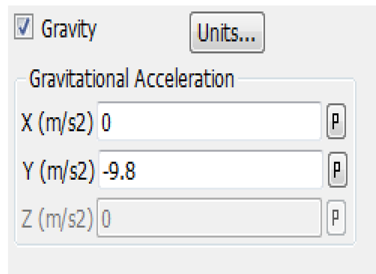

Figure 1c: Operating Conditions

TASK 1

CASE A

Task 1 involved setting the viscosity to the *viscous-laminar* or *inviscid* conditions and tracking changes in the contour plot at different time steps. Figure 2 illustrates the change in shape of the engine-oil due to kerosene at 0, 1, 5 and 10 seconds.

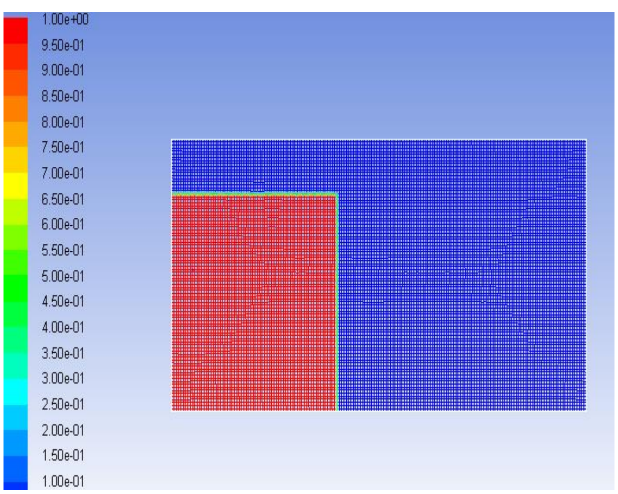

Figure 2a: t = 0

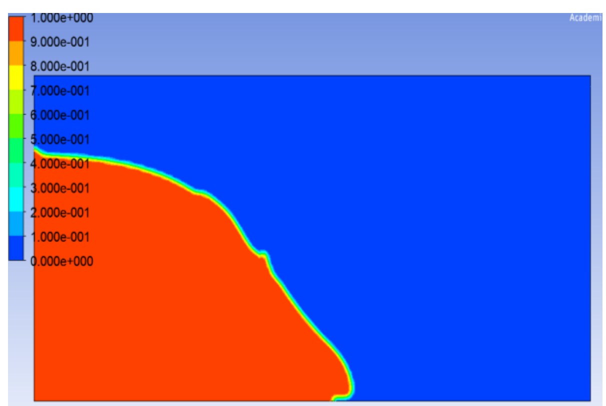

Figure 2b: Setup t = 1s

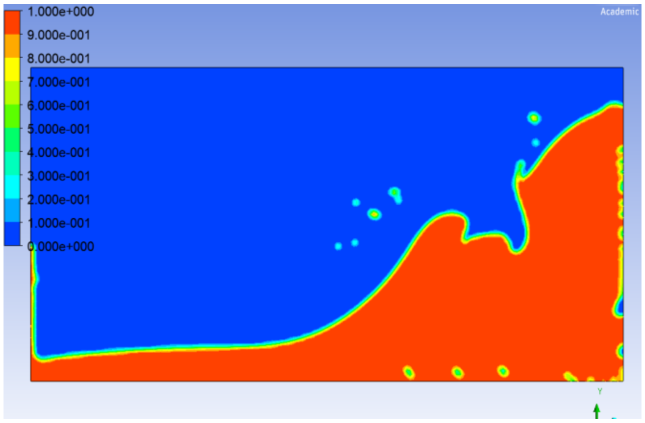

Figure 2c: t = 5sec

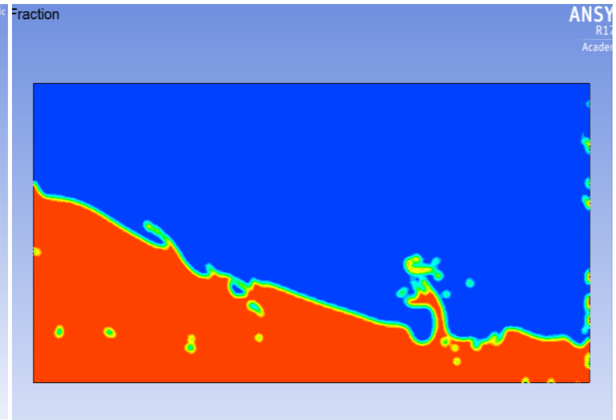

Figure 2d: t = 10 sec

CASE B

Case B started with the same initial setup while changing the viscosity to the *inviscid* conditions. The same time steps were chosen.

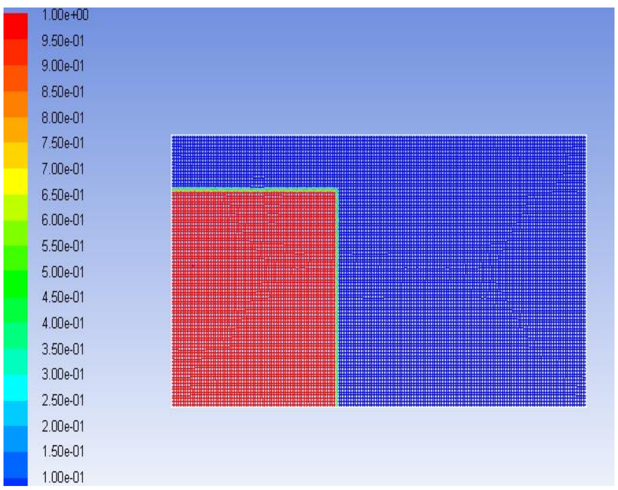

Figure 3a: t = 0

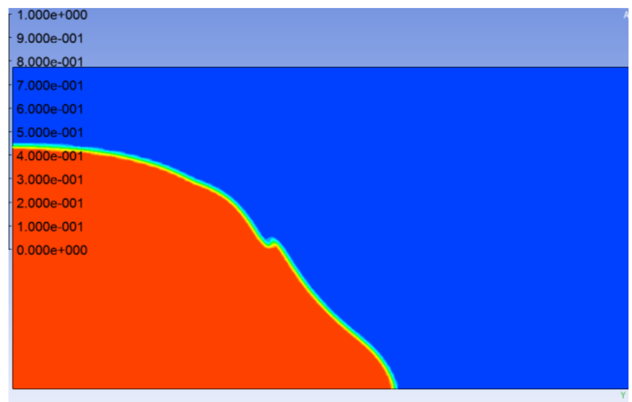

Figure 3b: Setup t = 1s

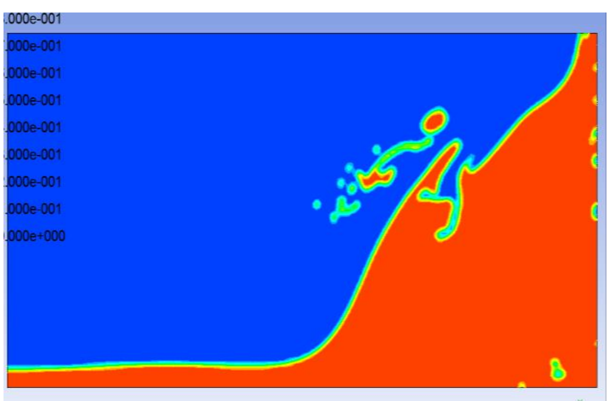

Figure 3c: t = 5sec

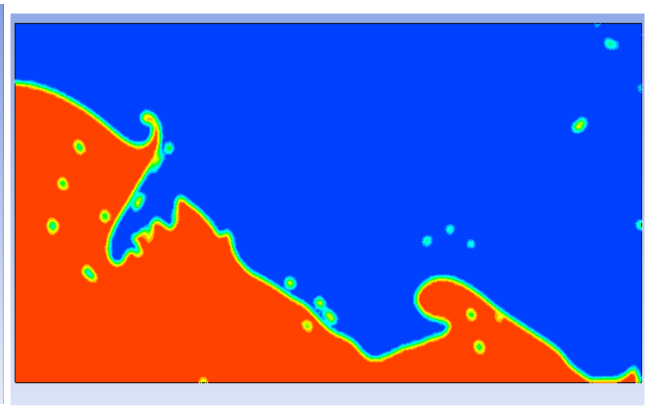

Figure 3d: t = 10 sec

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CASE C

Equations 1 and 2 found the *Kinetic Energy* and *Potential Energy* for the system. The following functions were used to graph the Available, Kinetic and Total Potential energies within the system.

$$PE = \int\int \rho \; g \; y \; dx \; dy \quad , \qquad \text{Eq. (1)}$$

$$KE = \int\int \frac{1}{2}\rho\,(\,u^2 + v^2\,)\; dx \; dy \quad , \qquad \text{Eq. (2)}$$

The first step was to find the *baseline potential energy* (PE_0) for this system, which represents the energy at the final state. This value was found by integrating along the steady state condition when both fluids stopped moving within the

$$PE_0 = PE_{Steadystate\ Engine\ oil} + PE_{Steadystate\ Kerosene}$$

$$9.8 \times \left(889 \cdot \int_0^{0.32}\int_0^2 ydxdy + 780 \cdot \int_{0.32}^{1}\int_0^2 ydxdy\right)$$

$$9.8 \times \left(889 \cdot \int_0^{0.32} 2ydy + 780 \cdot \int_{0.32}^{1} 2ydy\right)$$

$$9.8 \times (91.0336 + 700.128)$$

$$\underline{PE_0 = 7753.38}$$

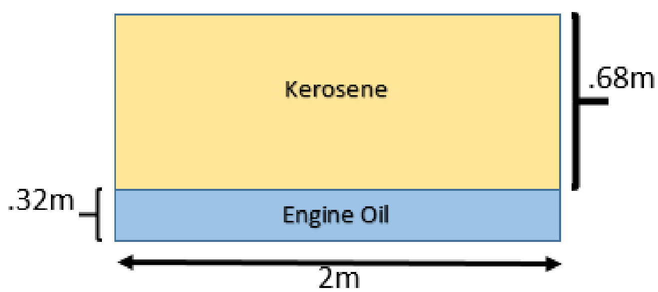

Figure 4: $t = \infty$

The Available Potential Energy (APE) was equal to the potential energy in the system minus the baseline energy (APE = PE – PE_0). Figure 5 represents the Custom Functions created for this task. The APE function had to use a factor of a half for the PE_0 since computation of the integral would inadvertently multiply a factor of 2. To cancel this factor out, the APE function had to be modified as seen in fig. 5a.

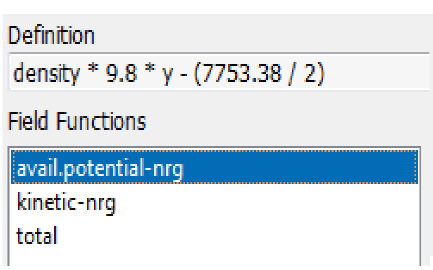

Figure 5a: APE

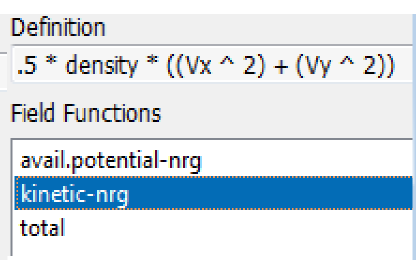

Figure 5b: KE

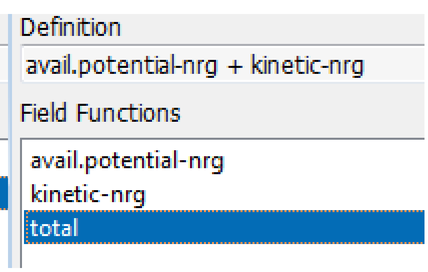

Figure 5c: Total

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Using the *Volume Monitors*, on Fluent's *Solution tab*, I was able to monitor the changes in energy, in real time, as the solution approached 25 seconds. *Figure 6* shows how these monitors were set up. The volume integral option was used since the energy equations were related to the double integral where z was held constant. Figure 7 shows the results for the two viscous models.

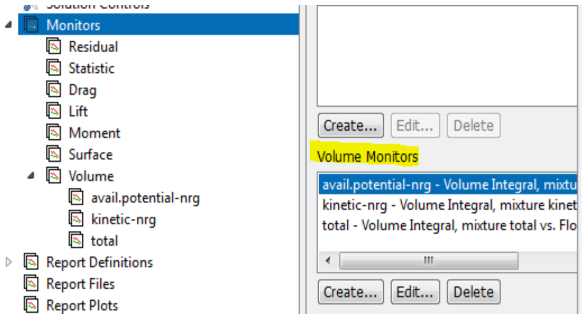

Figure 6a: Monitor

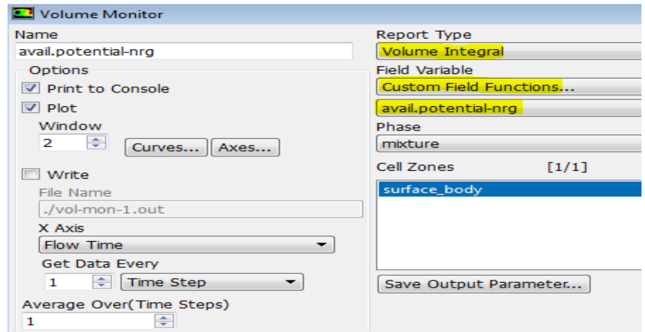

Figure 6b: Volume Monitor

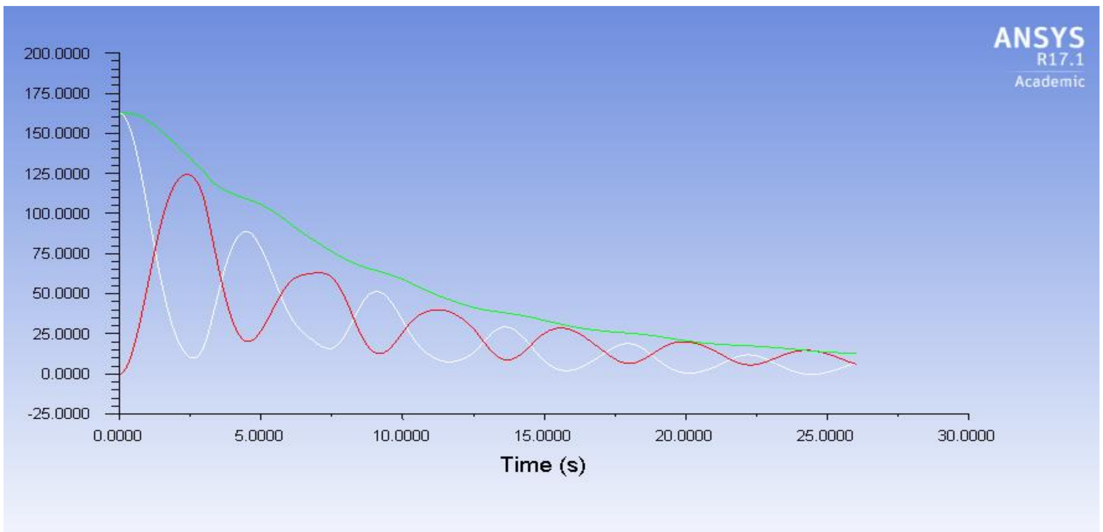

Figure 7a: Laminar

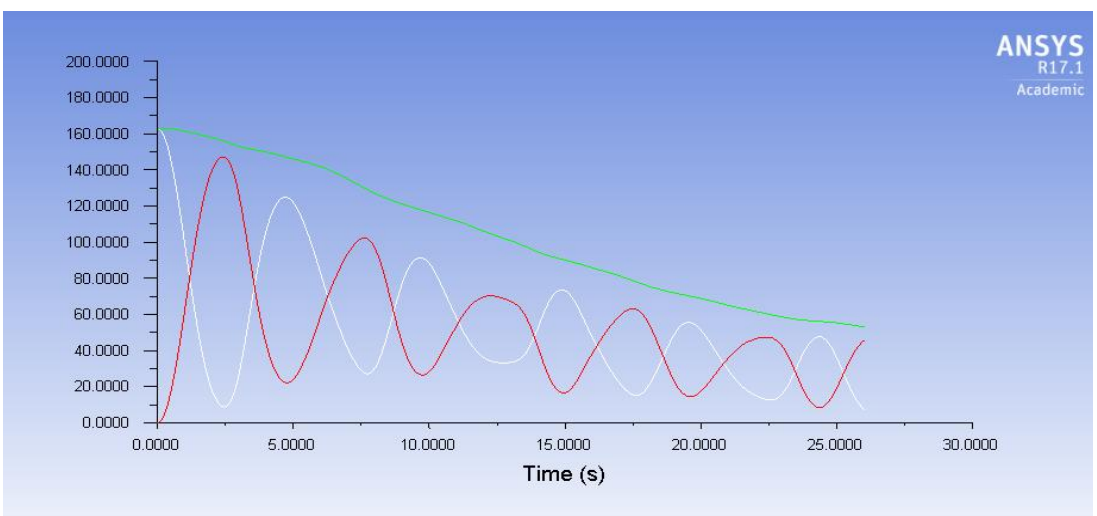

Figure 7b: Invicid

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The two graphs above relate the effects of viscosity on the energy within the system. Initial observations shows that the inviscid model (lack of viscosity) has a rate of change in total energy, that is much smaller than the laminar viscosity model. This makes logical sense since viscosity adds internal friction within the interacting fluids. This causes usable energy in the laminar model, to dissipate quicker than the inviscid model.

TASK 2

CASE A

Task 2 involved a new geometry, where water is injected through an inlet that produces a jet gradually filling a container with air.

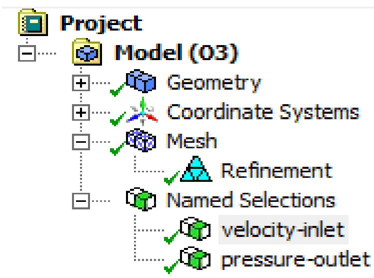

Figure 8a: Mesh

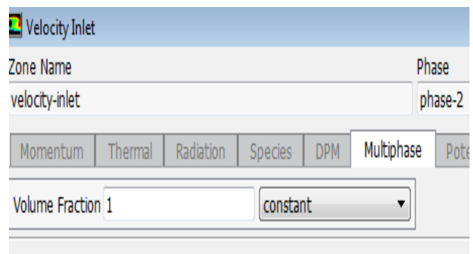

Figure 8b: Volume Fraction

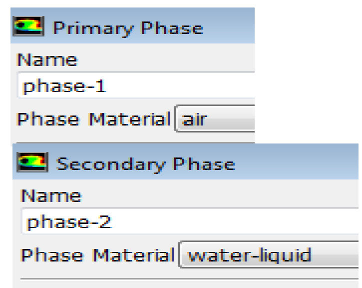

Figure 8c: Phases

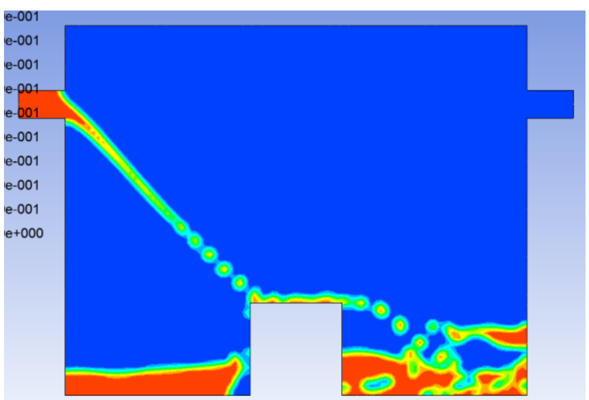

Figure 9a: t = 2sec

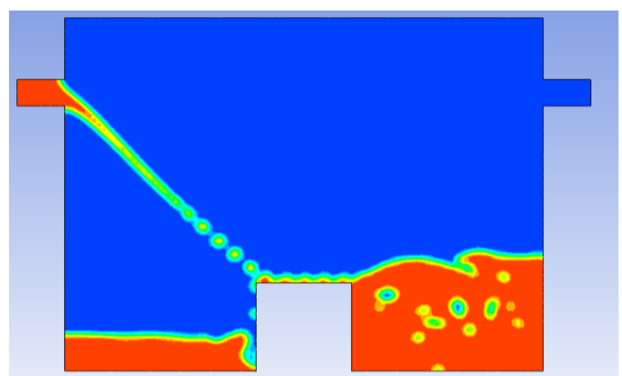

Figure 9b: t = 4sec

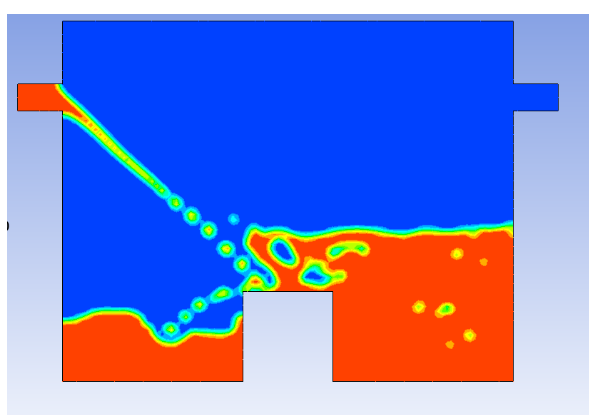

Figure 9c: t = 6sec

CASE B

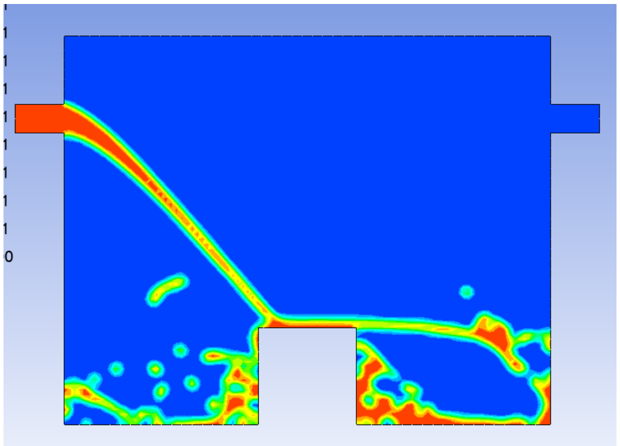

Figure 10a: t = 1sec

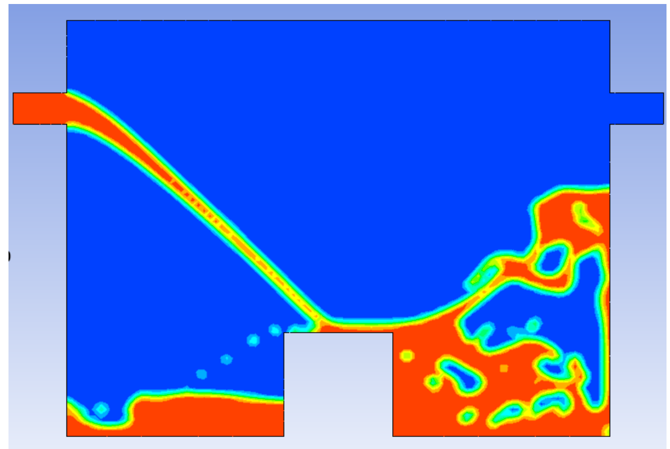

Figure 10b: t = 2sec

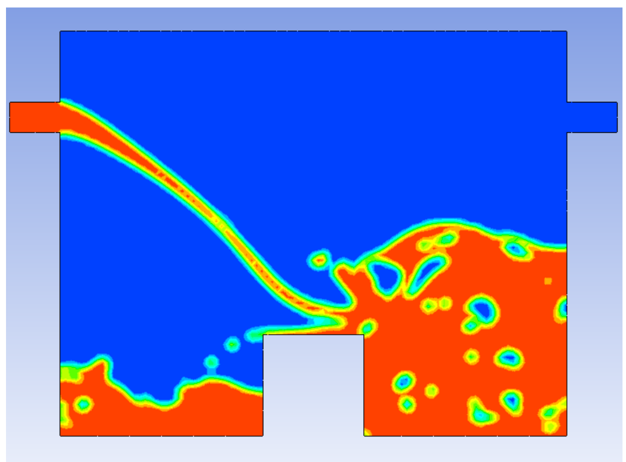

Figure 10c: t = 3sec

Case A and Case B only differ in inlet velocity condition. This was seen in the y direction of the fluid as it fills the container. When one compares *Figure 9b* and *10b*, one can see that the y-direction that the water travels as it hits the wall surface is much greater due to the increase velocity of the water filling the container.

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TASK 3

CASE A

Task 3 used similar setups as Task 2, except with more selected areas to define velocity inlets and volume fractions. Figure 11 depicts inlet velocity of 0.2 m/s whereas figure 12 has 2m/s at inlet.

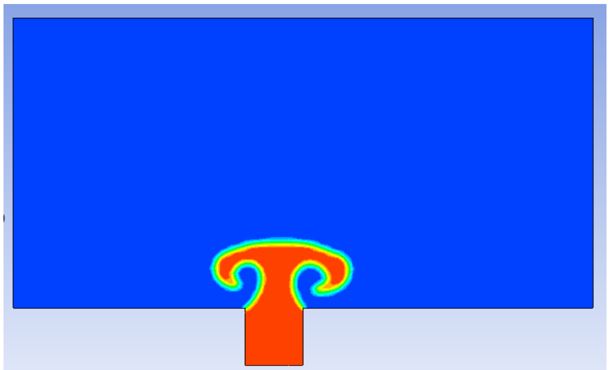

Figure 11a: 5sec @ V =0.2m/s

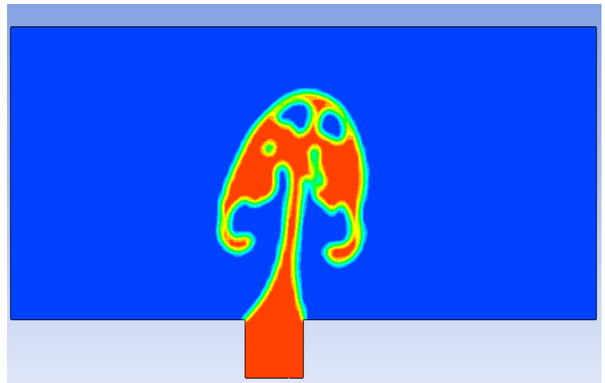

Figure 11b: 10sec @ V =0.2m/s

CASE B

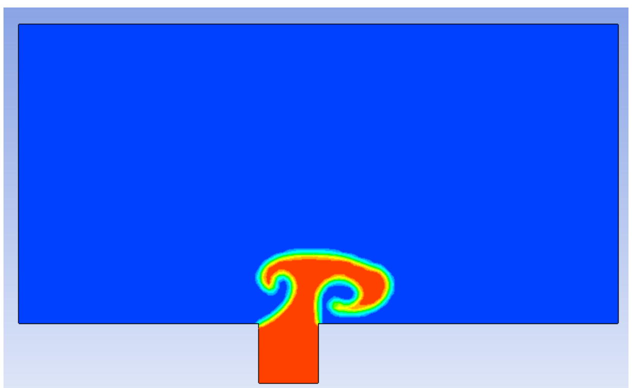

Figure 12a: 5sec @ V =5.0m/s

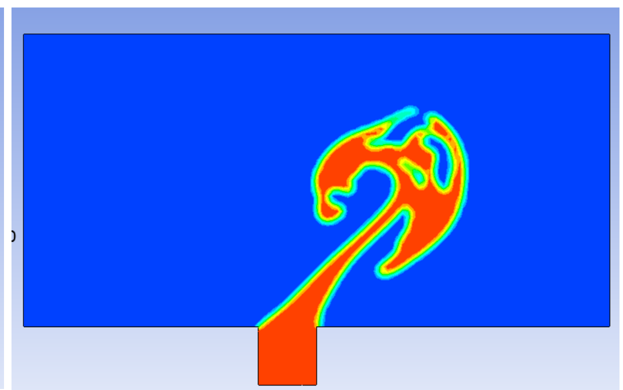

Figure 12b: 10sec @ V =5.0m/s