Project 1

MAE 494 – Applied Computational Fluid Dynamics

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I, Hunter Halversen, had no collaboration with anyone for this project.

Figure 1. Isometric view of geometry and mesh generation of the half-cylinder water tank.

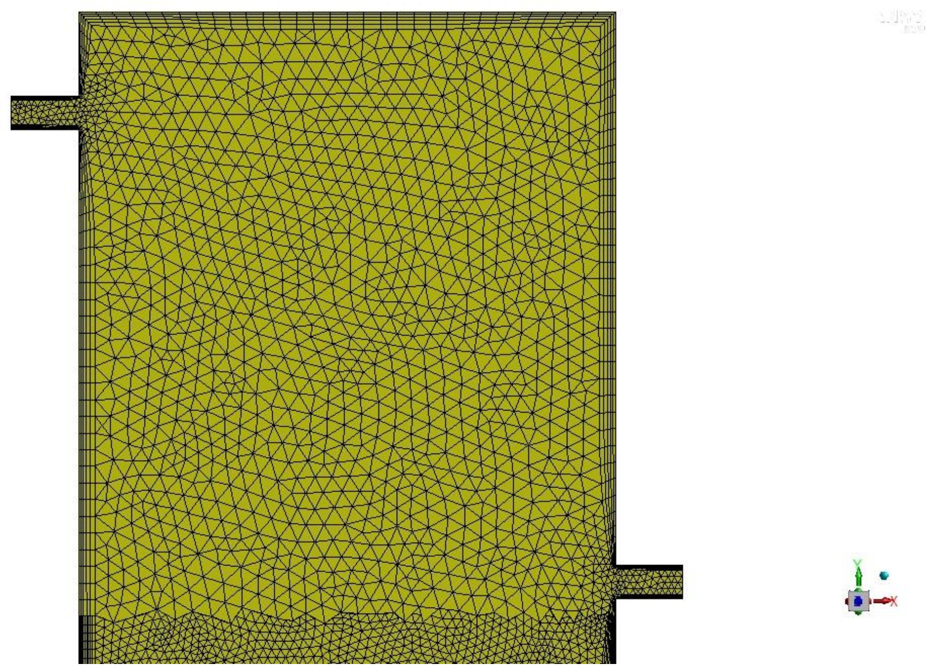

Figure 2. Plane of symmetry with mesh view on for the water tank.

Task 1:
i) Outlet temperature of the steady state:

Simulation # 1

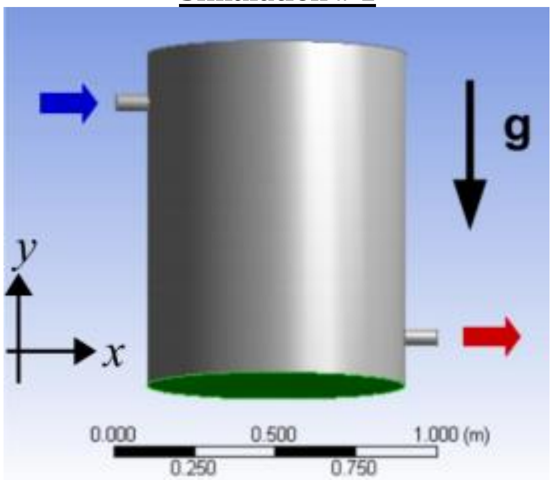

Figure 3.
Area-Weighted Average
Static Temperature (k)
------------------------------ --------------------
Outflow: 298.96723

Simulation # 2

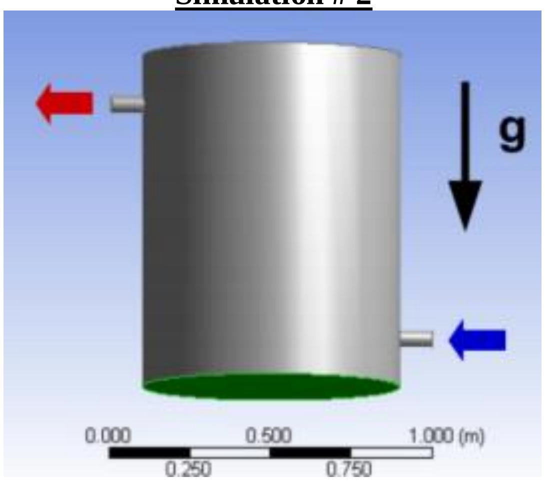

Figure 4.
Area-Weighted Average
Static Temperature (k)
------------------------------ --------------------
Outflow: 298.15782

For simulation #1, the area-averaged surface integral calculated outflow temperature was **298.97 Kelvin** to a respective **298.16 Kelvin** in simulation #2, in which the inlet and outlet pipe conditions were swapped. One observation is that changing the location of inlet and outlet had little effect on the final steady state outlet temperature. Changing boundary condition magnitudes would presumably have a greater effect than changing location.

ii) A contour plot of temperature in the plane of symmetry:

Figure 5. Temperature contours for simulation #1

Figure 6. Temperature contours for simulation #2

iii) A contour plot of the y-velocity in the plane of symmetry:

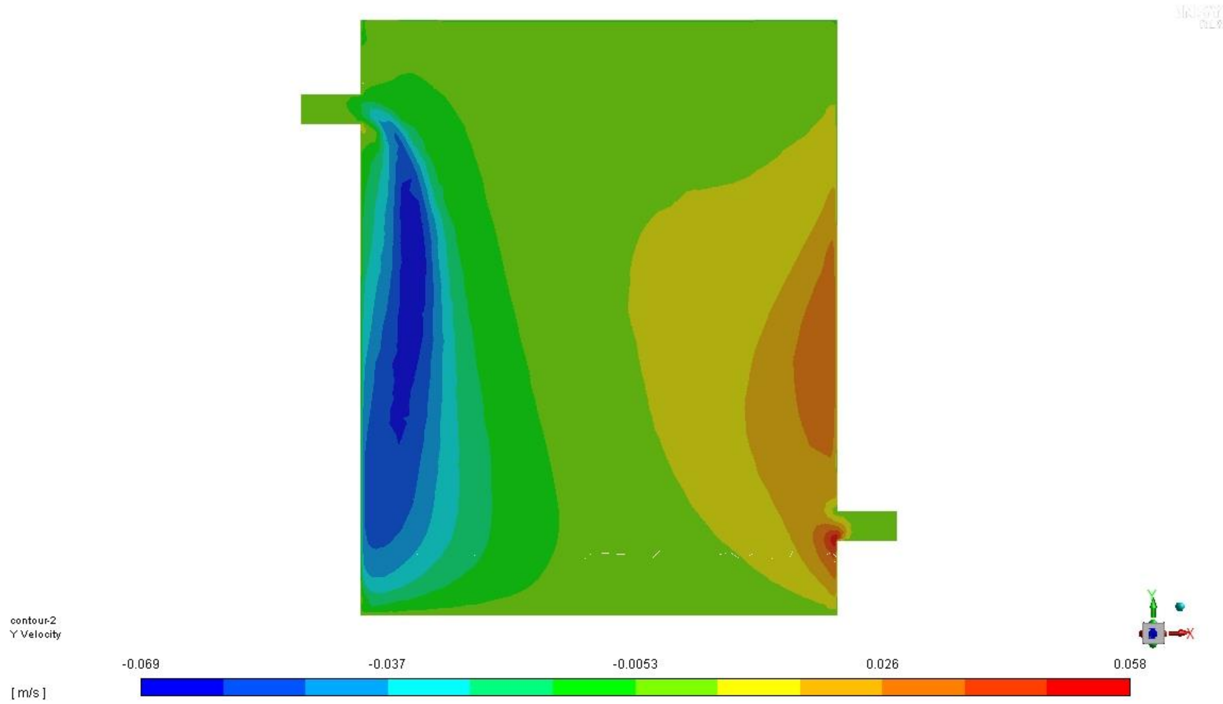

Figure 7. Y-Velocity contours for simulation #1

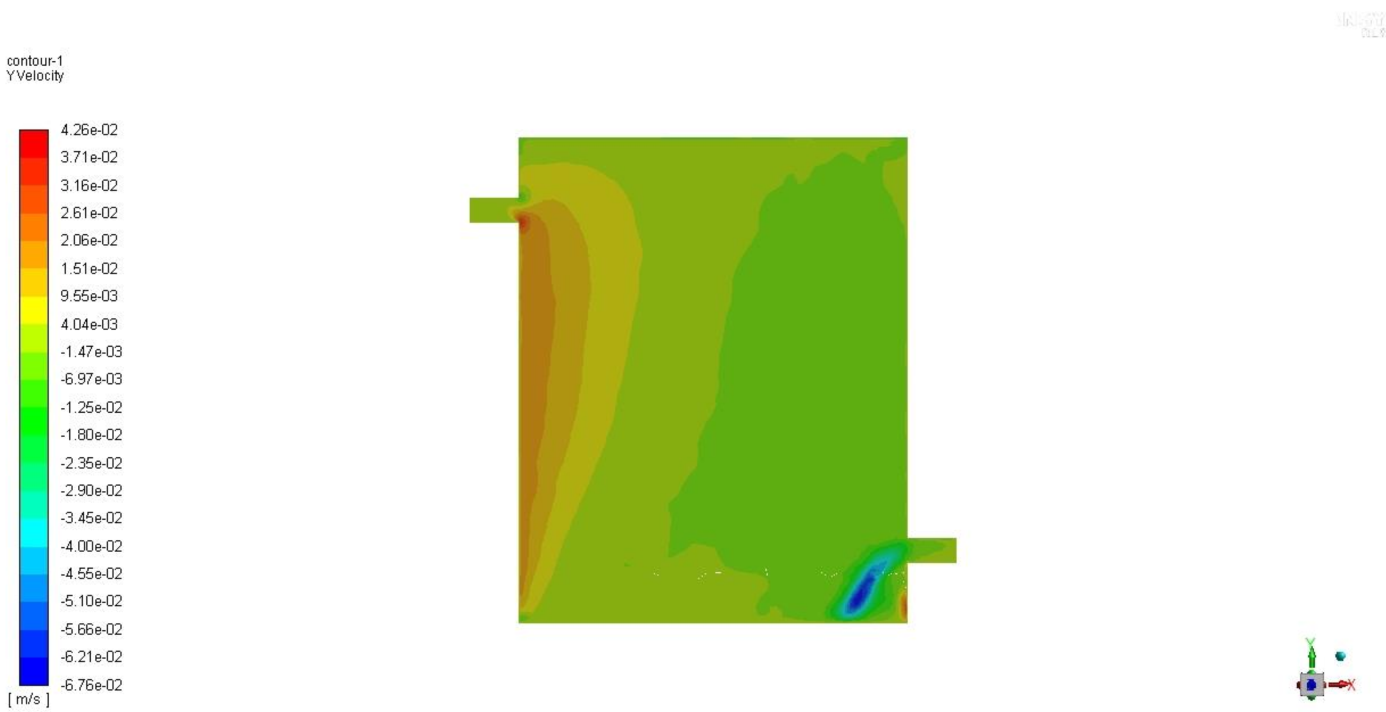

Figure 8. Y-Velocity contours for simulation #2

<u>Task 2:</u>

Setting density to constant instead of boussinesq, and intlet/outlet setup as in simulation #1 in task 1, disable gravity.

i) Outlet temperature of the steady state:

Area-Weighted Average
Static Temperature (k)
------------------------------- --------------------
Outflow: 292.75104

Using area-average surface integral function, the static temperature at the outflow was found to be **292.75 Kelvin.** This is a much greater difference in outlet temperature than the swapping of inlet/outlet location in task #1. Apparently gravity and whether or not density is constant play a crucial role in modeling a system.

ii) A contour plot of the y-velocity in the plane of symmetry:

Figure 9. Y-Velocity contour plot for task # 2

iii) A contour plot of the x-velocity in the plane of symmetry:

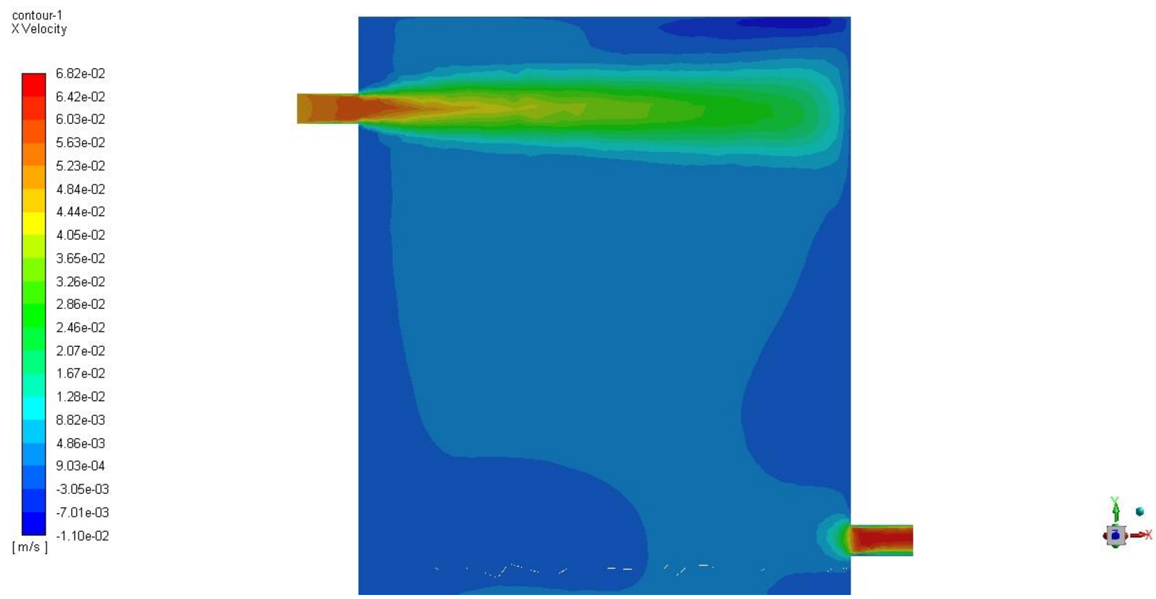

Figure 10. X-Velocity contour plot for task # 2

As seen in the results above, the effects of gravity and boussinesq density play a large role in fluid X and Y velocities, as well as the outlet steady state temperature. A difference in about 6° was present for steady state solution of temperature at the outflow. There are nearly no regions of high Y-velocities except around the corner of the outflow pipe. The X-velocities are also more centralized around the inlet and exit pipes.

<u>Task 3:</u>

Seek a transient solution instead of steady-state. At t=0 all water in the tank is at 15 degrees Celsius, with velocity (u, v, w) = (0.05, 0, 0) m/s.

Key transient parameters:

- ***Time step size – 50 seconds***
- ***Maximum iterations per time step - 5***

i) A contour plot of y-velocity in the plane of symmetry at the end time of the transient simulation:

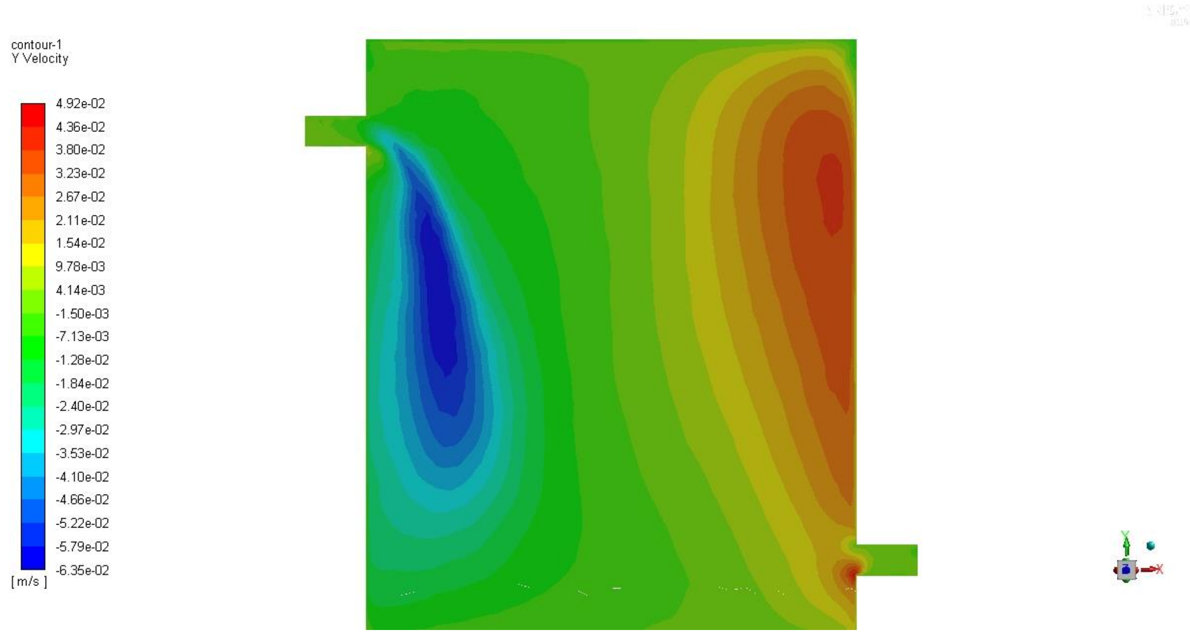

Figure 11. Y-Velocity contour in the plane of symmetry for transient solution

ii) A plot of $T_{out}(t)$ as a function of time, over the entire range of time for the transient simulation:

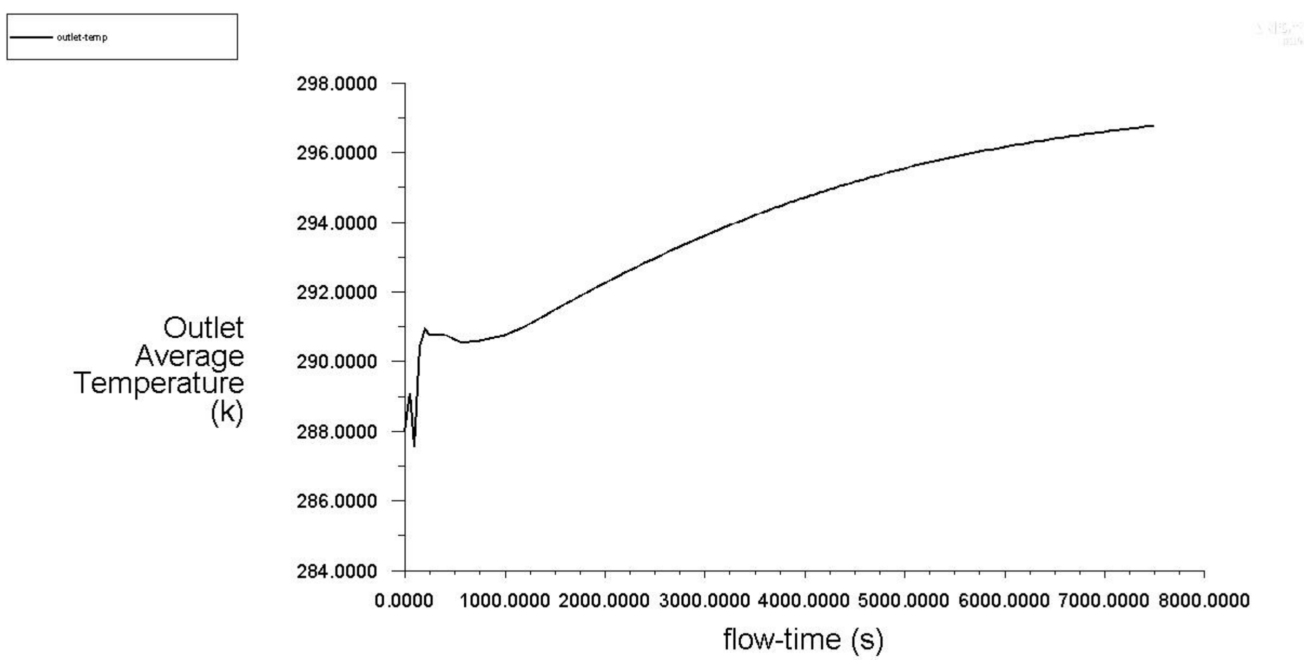

Figure 12. Outflow temperature versus flow-time. Note that steady state outlet temperature value is about 299 Kelvin.

iii) A plot of another quantity, S(t) as a function of time over the entire range of time for the transient simulation.

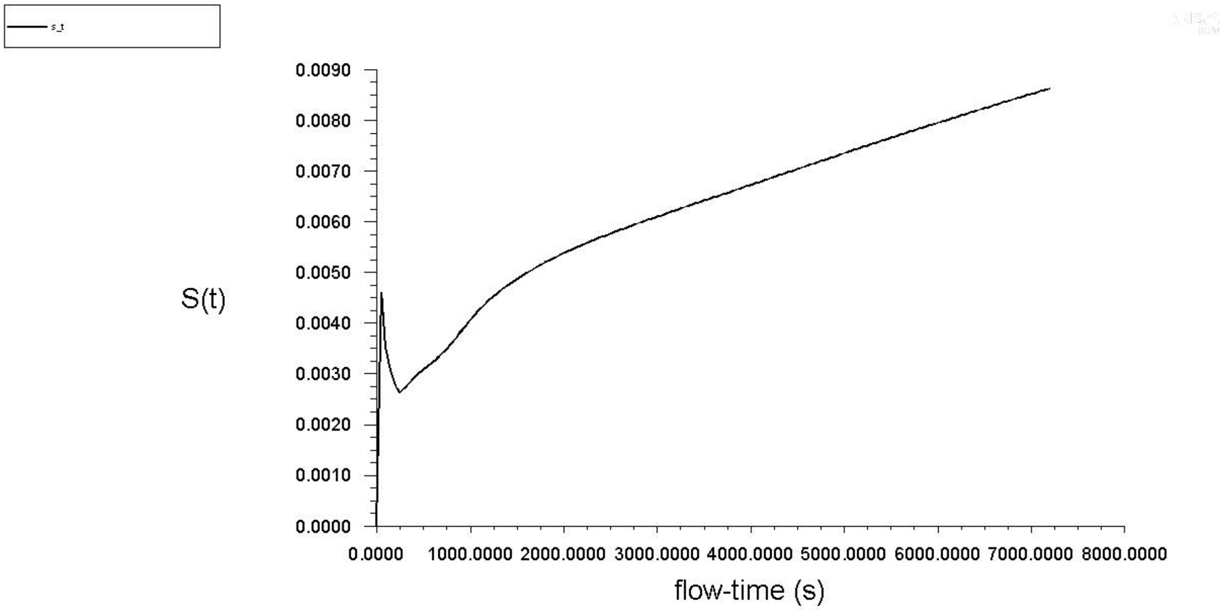

Figure 13. User defined function *S(t)* vs flow-time

$$S(t) = \frac{1}{A}\iint \frac{(|V|-V)}{2}\,dA \qquad \textbf{(1)}$$

The convergence criterion was set to stop calculating the transient solution when the transient outlet temperature is within 2° of the steady state outlet temperature. Because of this, exact convergence is not witnessed in figure 12, but the trend is visible towards 299 Kelvin.