Internal Flow
MAE560
Caleb Redshaw

Statement of Collaboration:

Name of Collaborator: Caleb Redshaw	
Task(s), Specific Detail	Contribution to Collaborative Effort
All Tasks	**No Collaboration**

I. Internal Flow with Thermal Convection

Ia: Vertically Oriented Tank

D1.

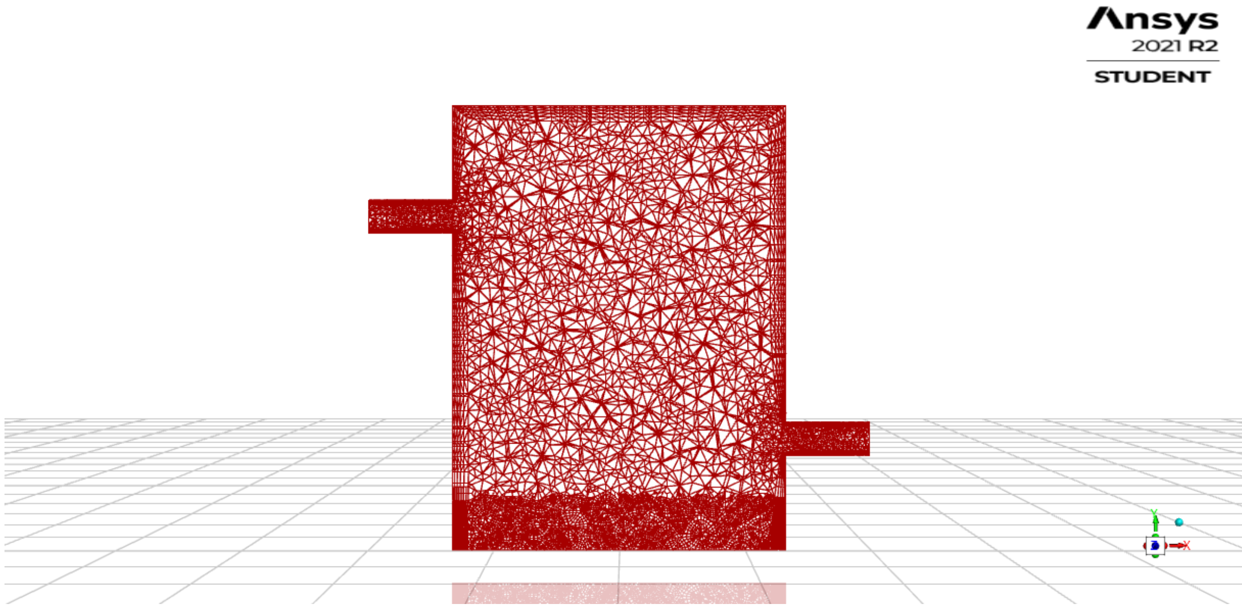

Figure D1. Plot of Mesh along plane of symmetry

Operating Temperature: $T_o = 25°C$

Operating Density: $\rho_o = 997.0420256\ kg/m^3$

Thermal Expansion Coefficient: $\beta = \frac{-1}{\rho_o}(\frac{d\rho}{dT})|_{T_o} = 2.573799 * 10^{-4} K^{-1}$

D2.

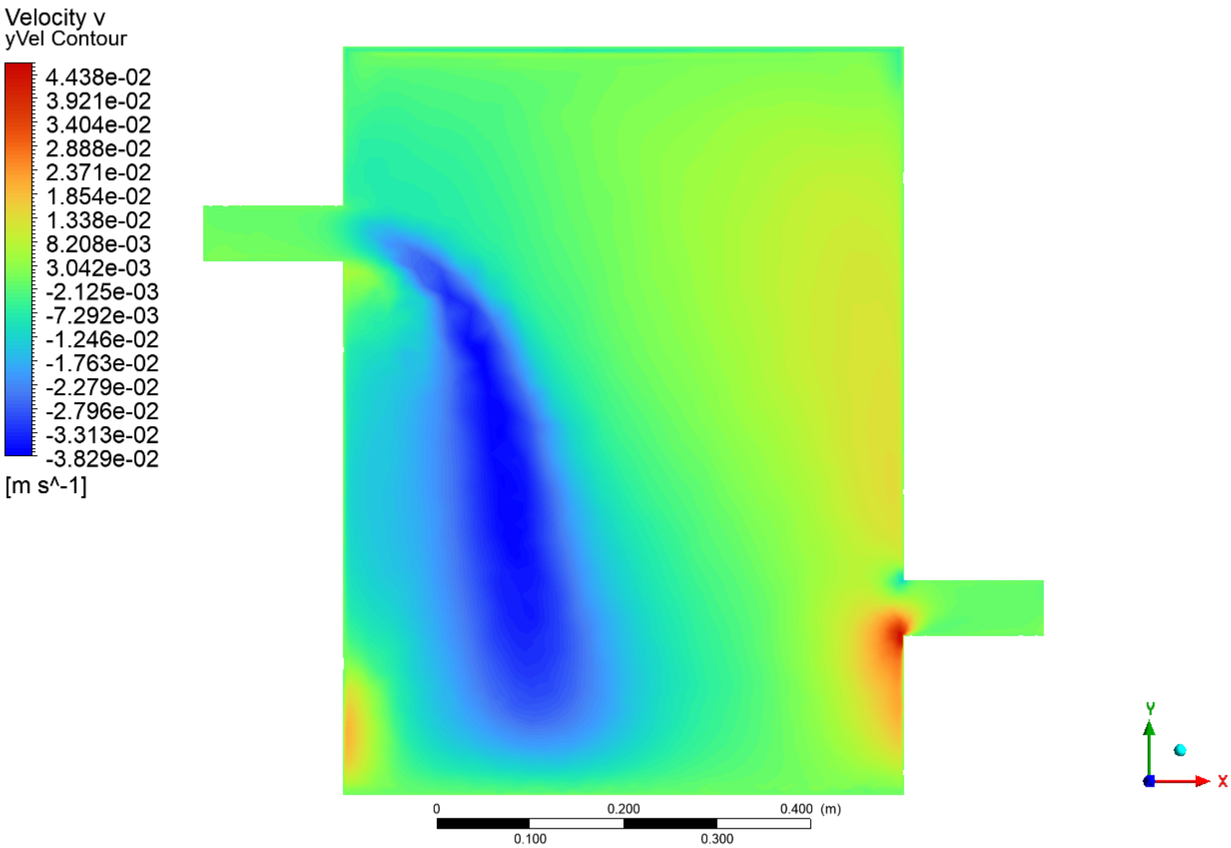

Figure D2. y-Velocity Contour along Plane of Symmetry for Vertically Oriented Tank.

D3.

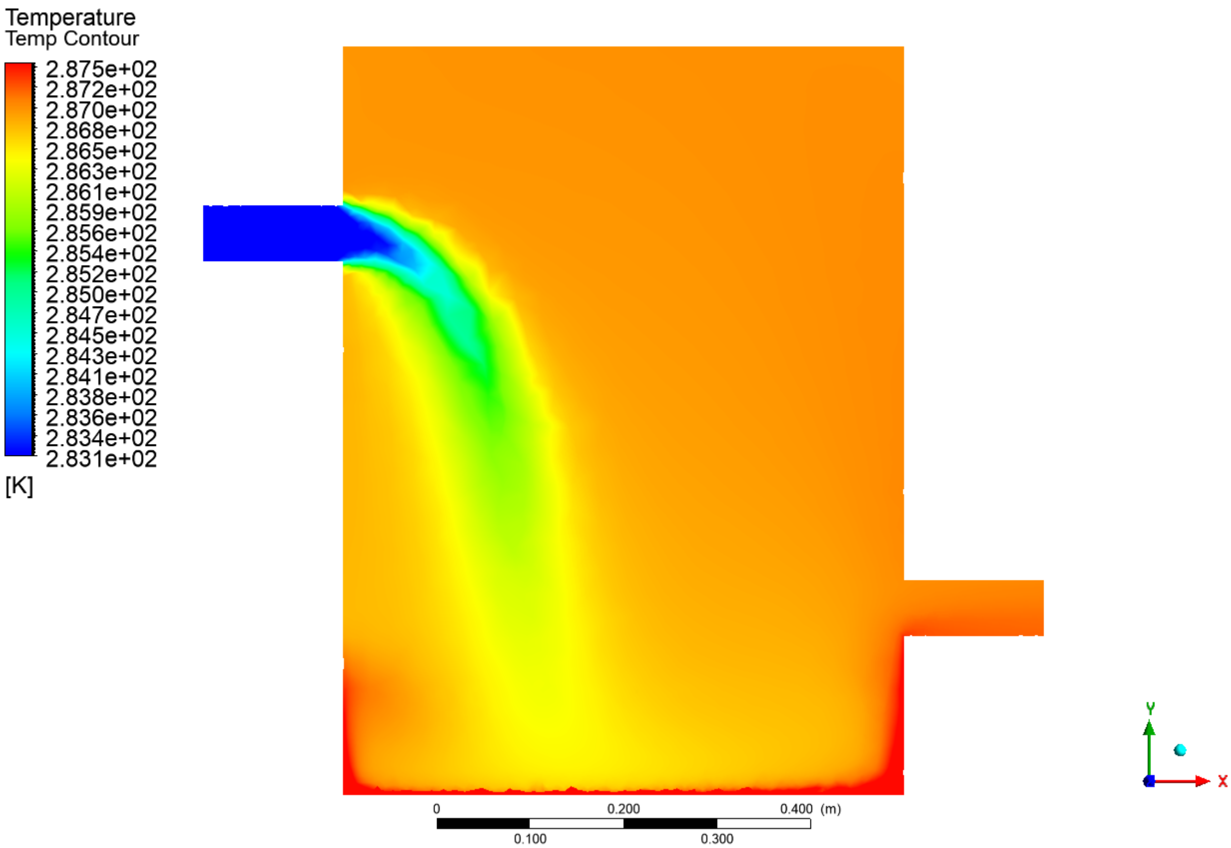

Figure D3. Temperature Contour along Plane of Symmetry for Vertically Oriented Tank.

D4. **T_{out} = 287.07K** at steady state (after 1400 iterations).

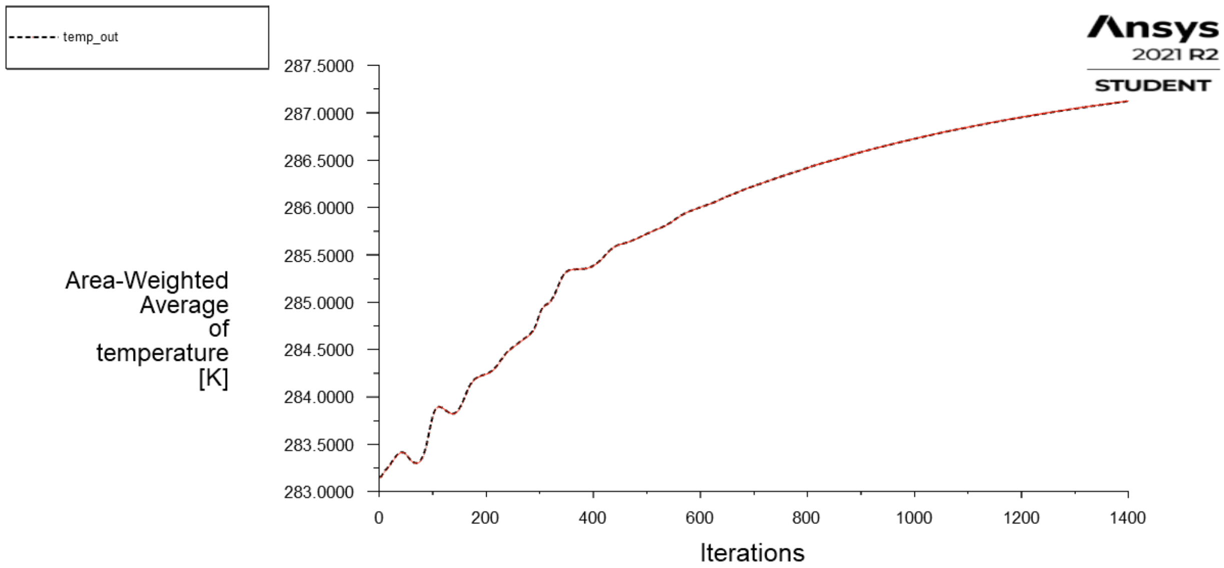

Figure D4. Line plot of T_{out} vs # of Iterations, up to 1400.

Ib:

D5.

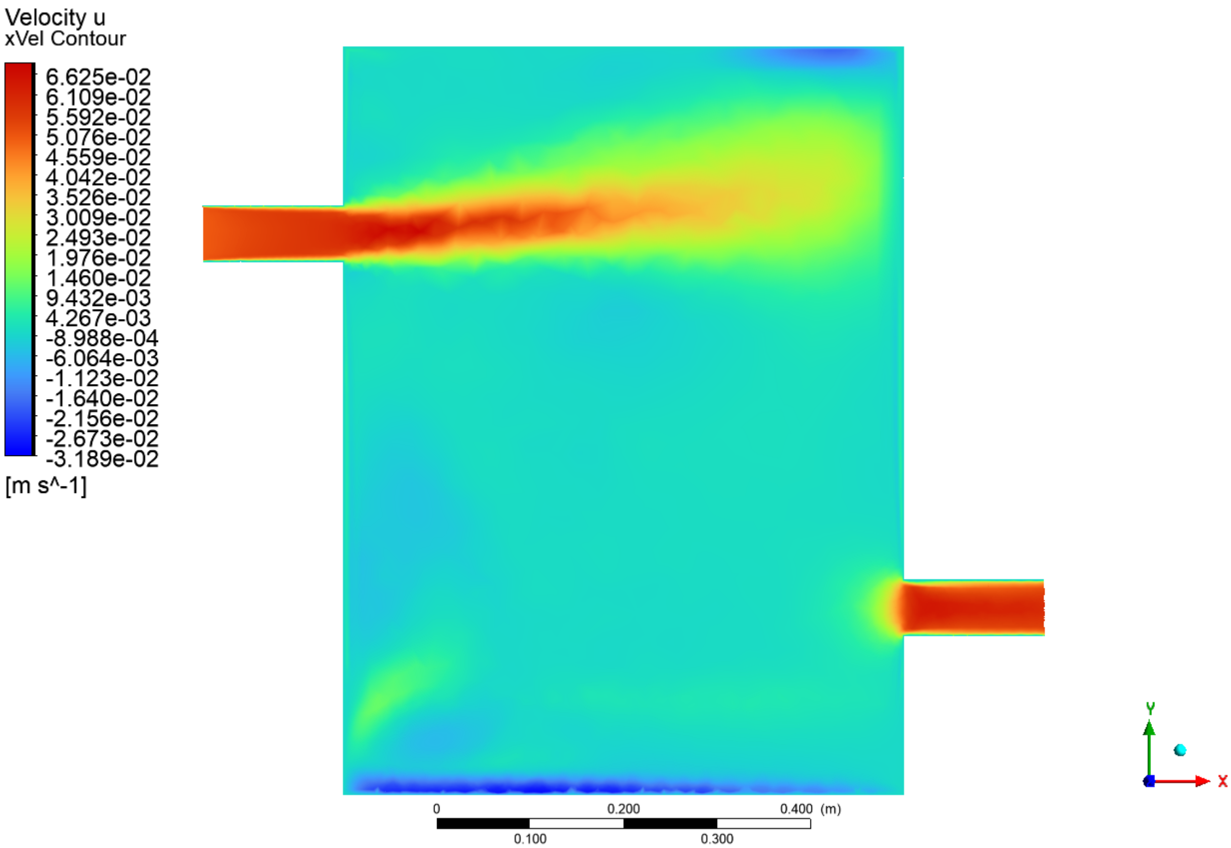

Figure D5. Velocity Contour along Plane of Symmetry for Horizontally Oriented Tank.

D6.

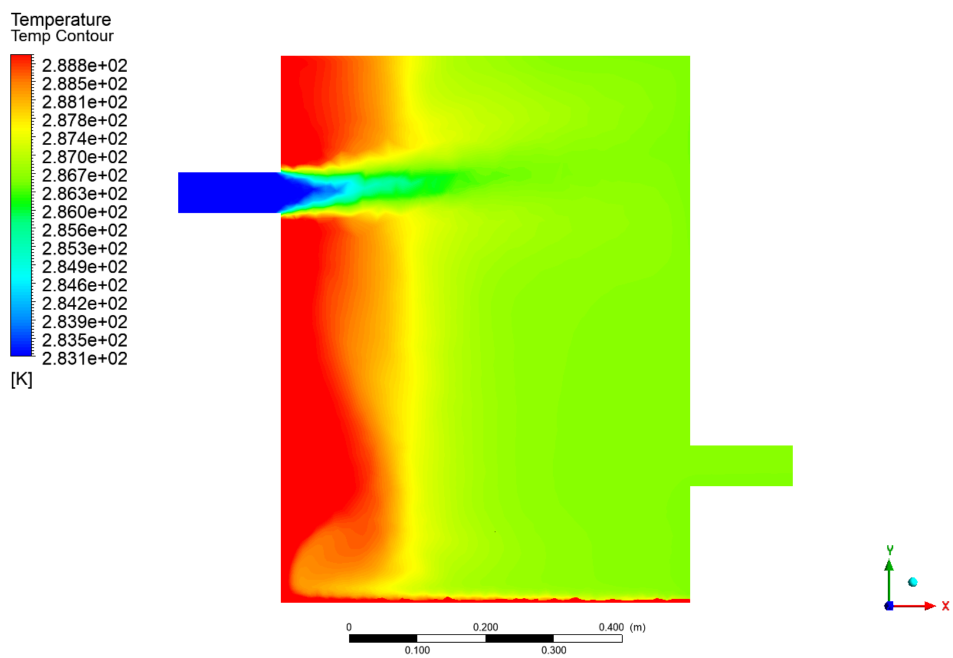

Figure D6. Temperature Contour along Plane of Symmetry for Horizontally Oriented Tank.

D7. T_{out} = 286.58K at steady state (after 1500 iterations).

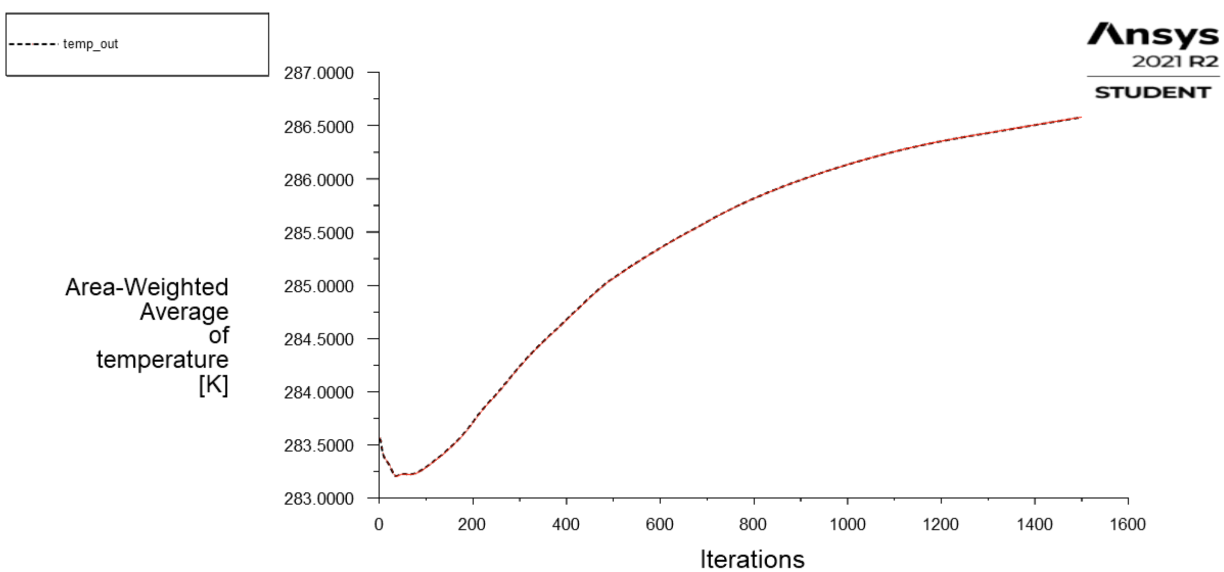

Figure D7. T_{out} vs # of Iterations, up to 1500.

II. Internal Flow with Heat Transfer

2a:

D8.

Table D8. Values of ΔT for four inlet velocity cases.

Inlet Velocity (m/s)	ΔT (K)
.005	28.8
.01	14.62
.02	7.45
.04	3.79

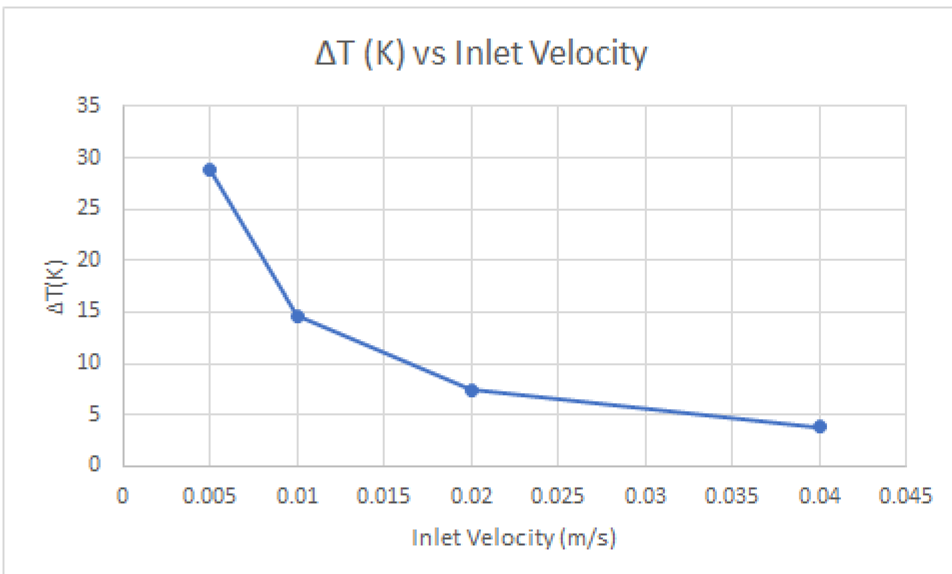

Fig. D8. Plot of ΔT vs Inlet Velocity

ΔT seems to decrease roughly inversely proportionally to greater inlet velocity. This makes sense because greater inlet velocity, with constant inlet area and fluid density, means that the mass flow rate is increasing. Since the heat input remains constant regardless of input velocity, when there is more mass to receive that energy per unit time the temperature will not increase as much (as per the equation $Q = \dot{m} c_p \Delta T$, with a constant Q and c_p).

D9.

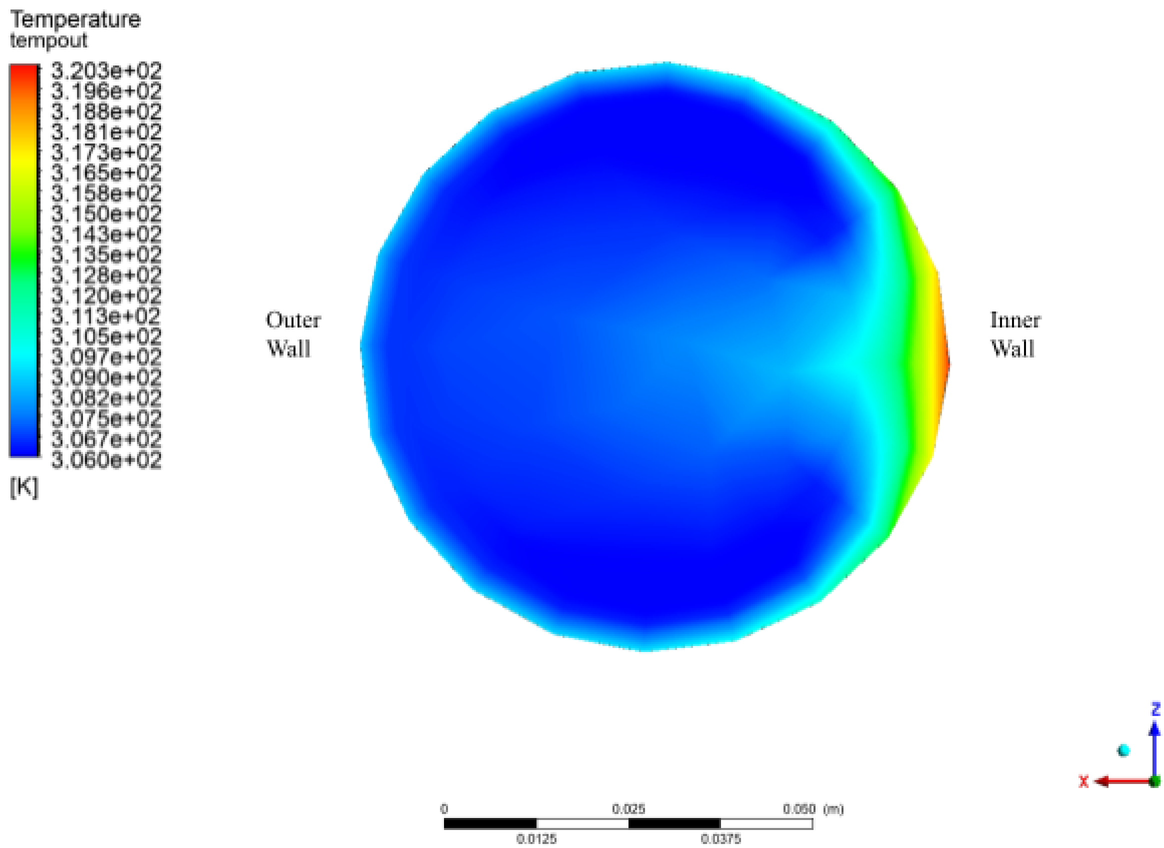

Fig. D9.1. Contour of Temperature over Outlet at V = .02 m/s.

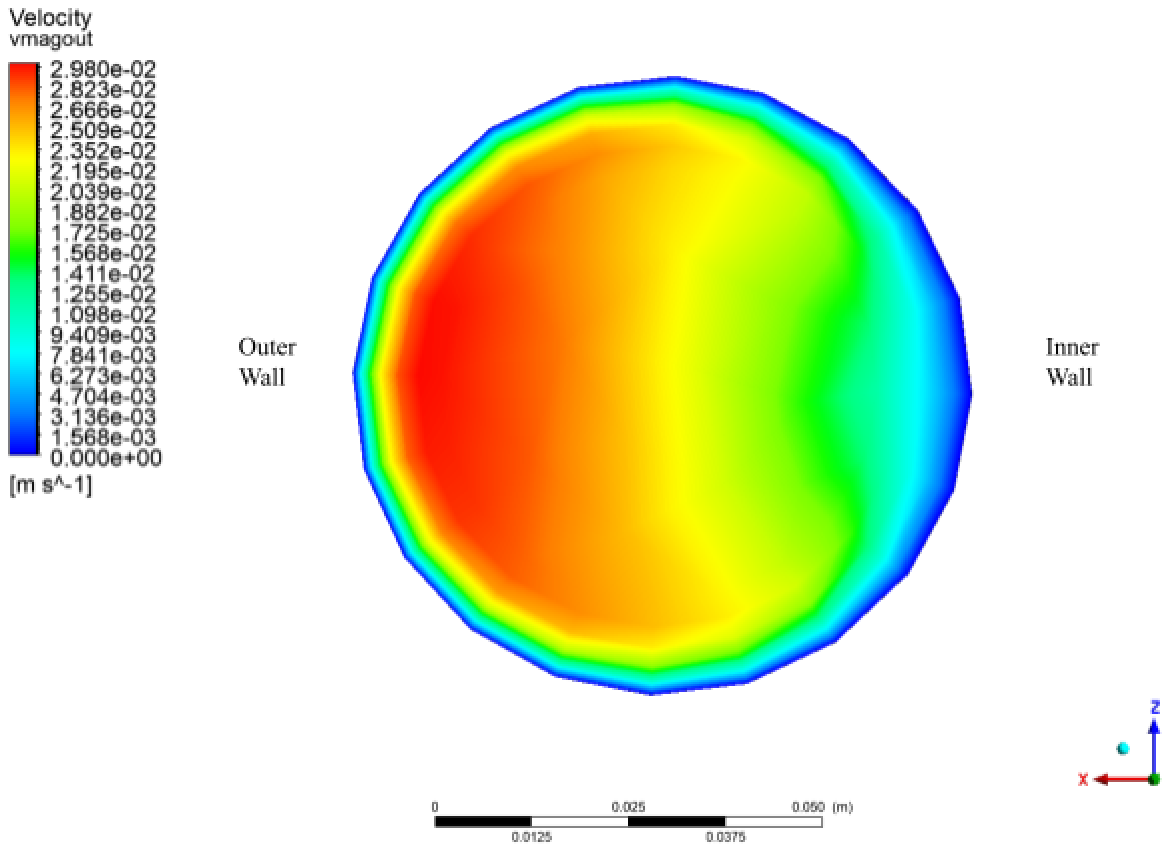

Fig. D9.2. Contour of Velocity Magnitude over Outlet at V = .02 m/s.

2b:

D10.

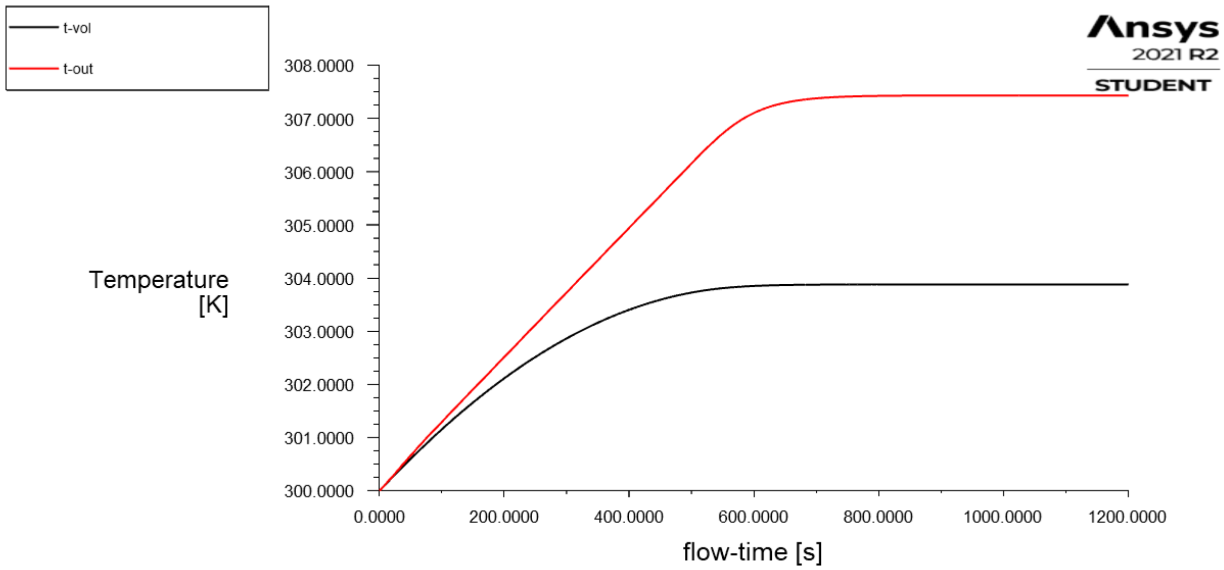

Fig. D10. Volume-Averaged Temperature and Outlet Temperature Vs Time.

D11. For the transient simulation, I used a **step size of 0.5s**, with **10 iterations per time step** (for a total of 24000 iterations).

III. Compressible Flow

3a:

D12.

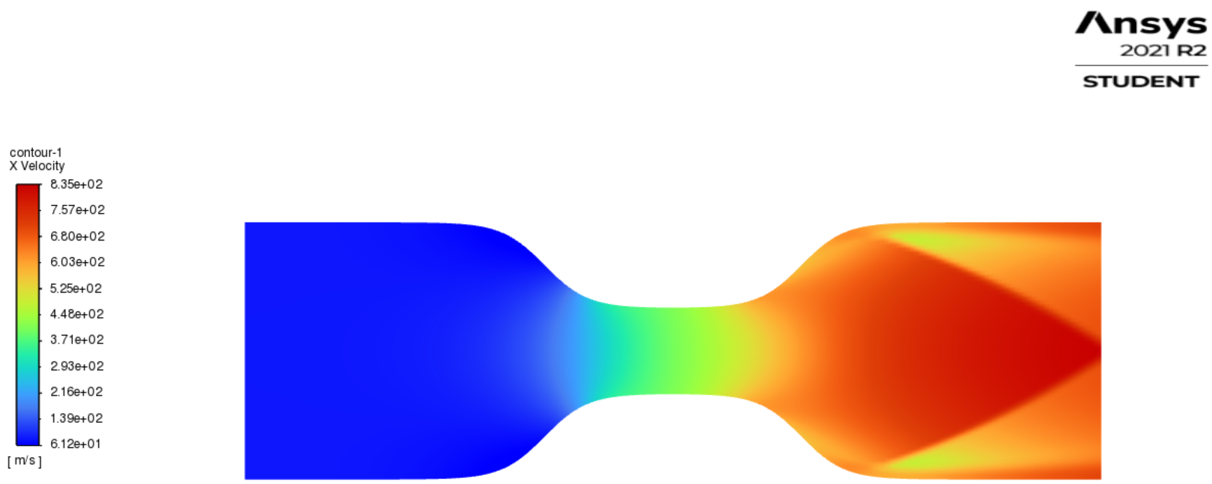

Fig. D12.1. Contour Plot of X-Velocity

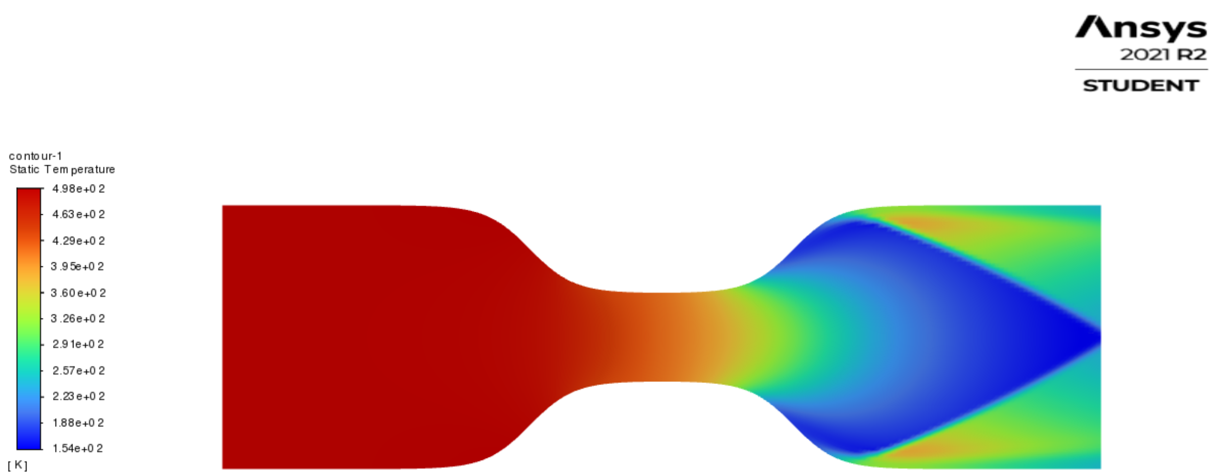

Fig. D12.2. Contour Plot of Static Temperature

D13.

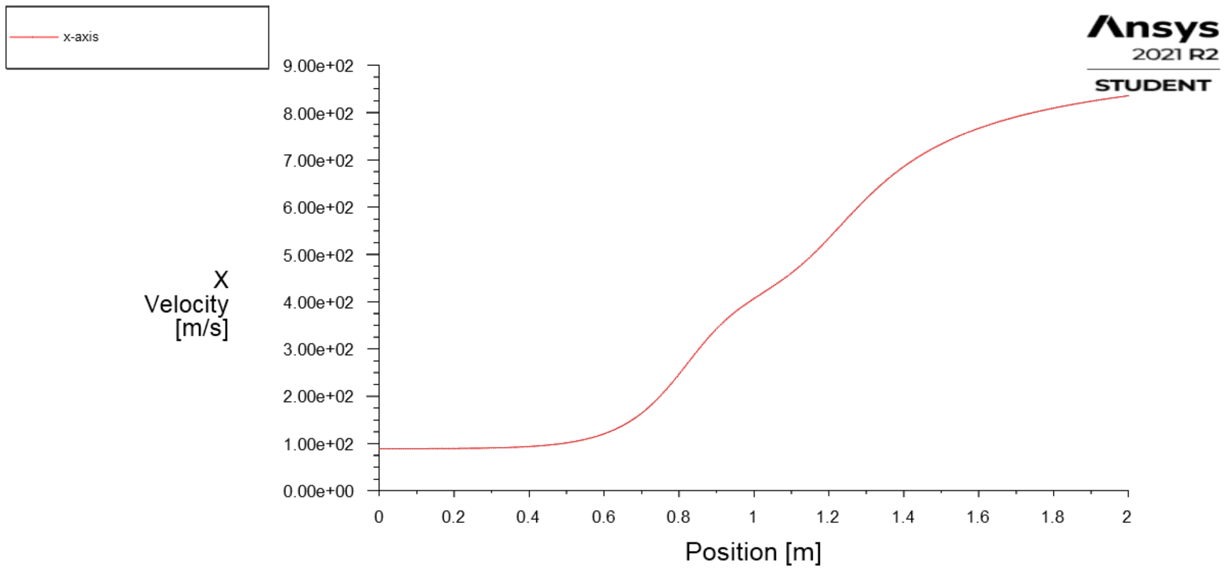

Fig. D13.1. Line Plot of X-Velocity along Axis of Symmetry.

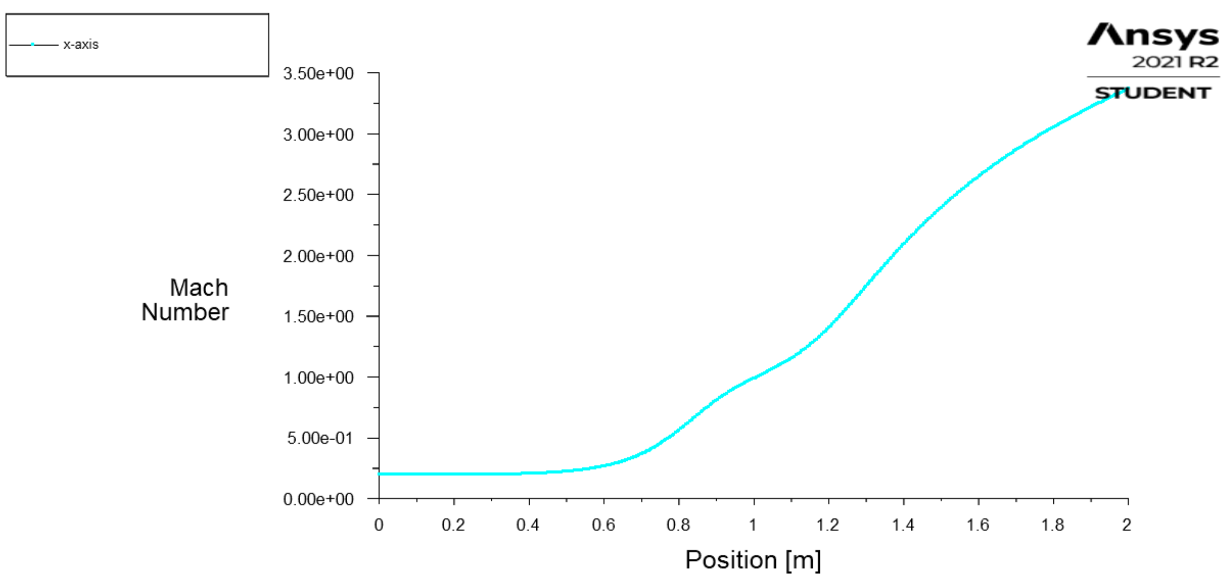

Fig. D13.2. Line Plot of Mach Number along Axis of Symmetry.

3b:

D14.

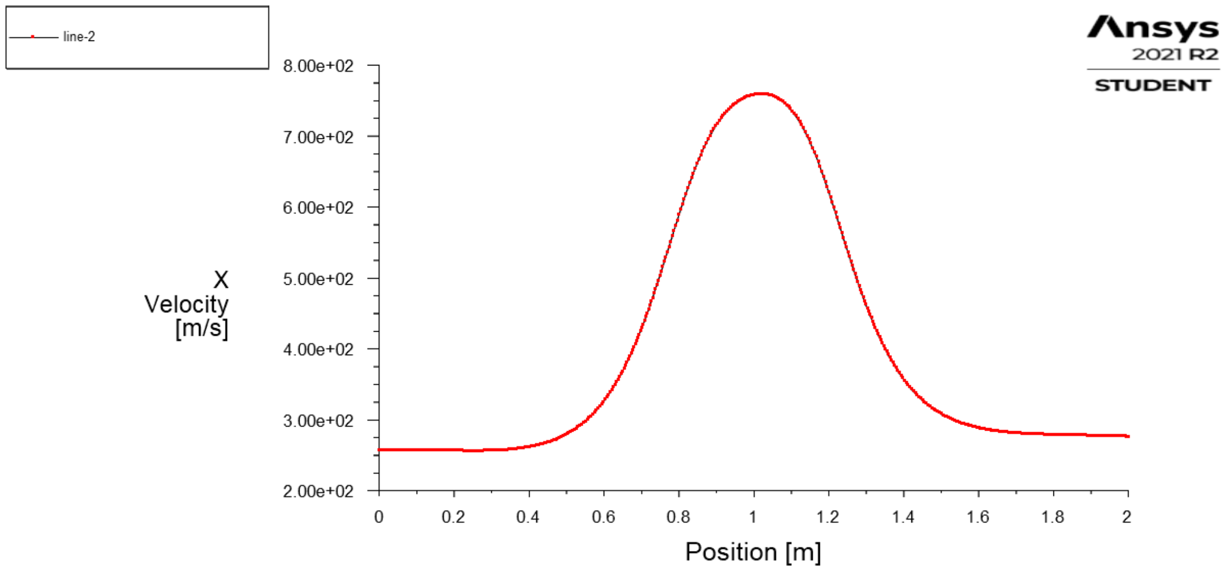

Fig. D14. Line Plot of X-Velocity along Axis of Symmetry.

In D13, with the density set to ideal gas, the x velocity consistently increases along the axis of symmetry, though it increases most in the region where the nozzle's height is minimum. In D14, the x velocity increases only in that region, and then returns to a value close to its initial velocity. By suppressing the effects of compressibility, the air's density remains constant - therefore, to maintain conservation of mass, it should exit at the same average velocity that it entered with. In the compressible case, the decrease in pressure along the nozzle means that the air also decreases in density, which results in greater exit velocities to maintain the same mass flow rate. The compressible case is the more realistic simulation.