Applied Computational Fluid Dynamics Project 2

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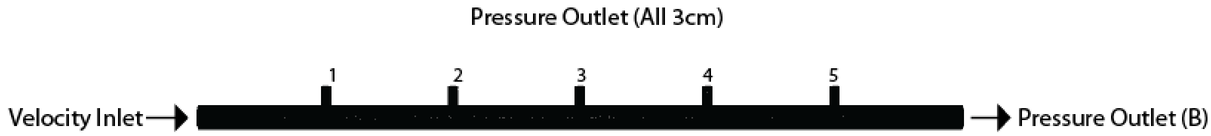
Statement of Collaboration:

Name of collaborator: None	
Task(s), specific detail:	Contribution to collaborative effort:
N/A	N/A

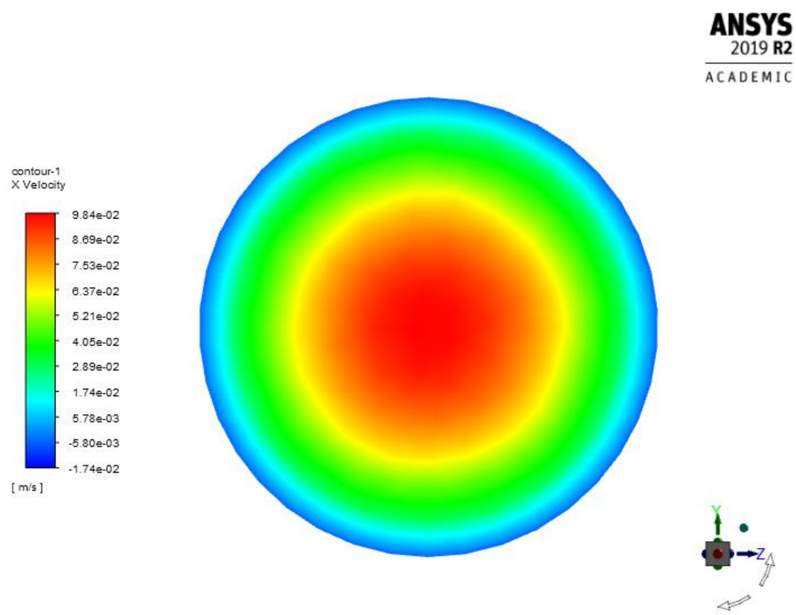
Task 1:



Turbulence:	k-epsilon
Continuity:	1e-6

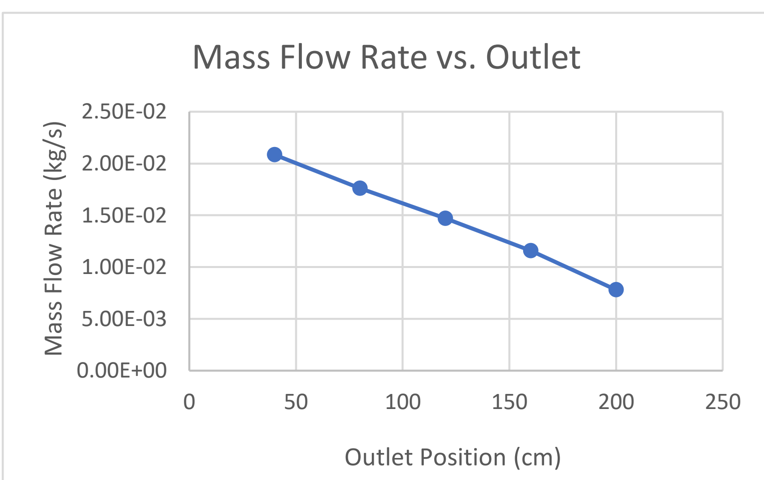
(i) X-Velocity Contour

Velocity Equation: (x-direction) =0.1[m s^-1] -(((y*y) *(0.1/0.0009[m s])) +((z*z) *(0.1/0.0009[m s])))

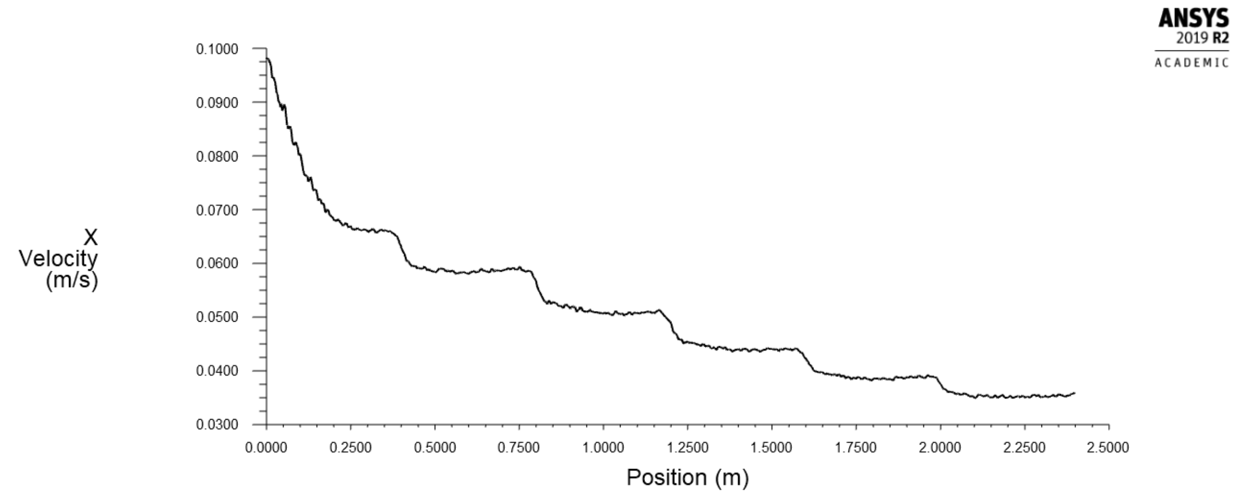


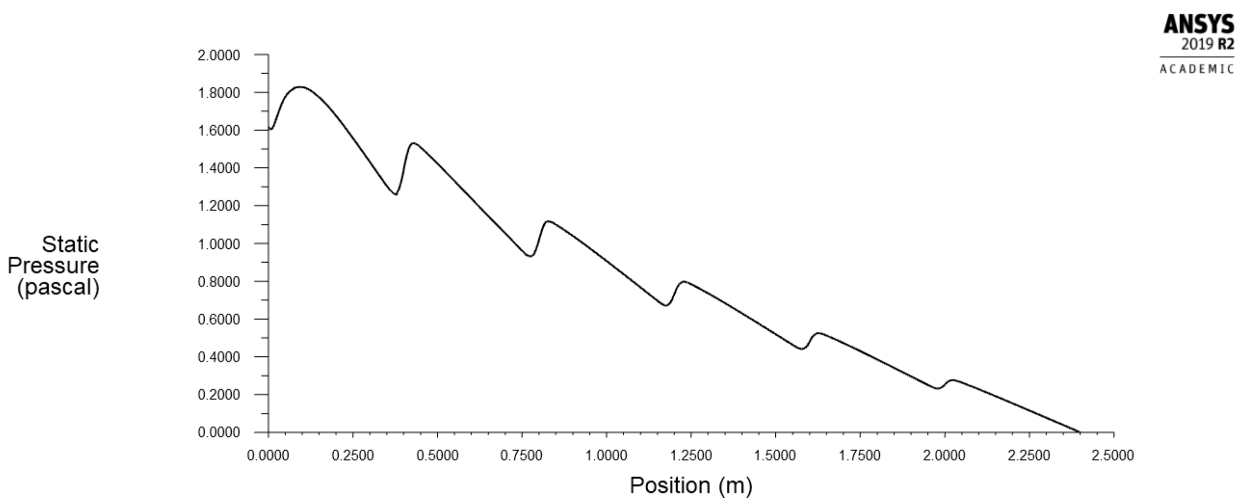
(ii) Plot of the mass flow rate of the five side pipes

Diameter	Mass Flow Rate
3cm	2.08E-02
3cm	1.76E-02
3cm	1.47E-02
3cm	0.01158239
3cm	0.007803476



(iii) Static Pressure & X-velocity graphs





Task 2:

(i)

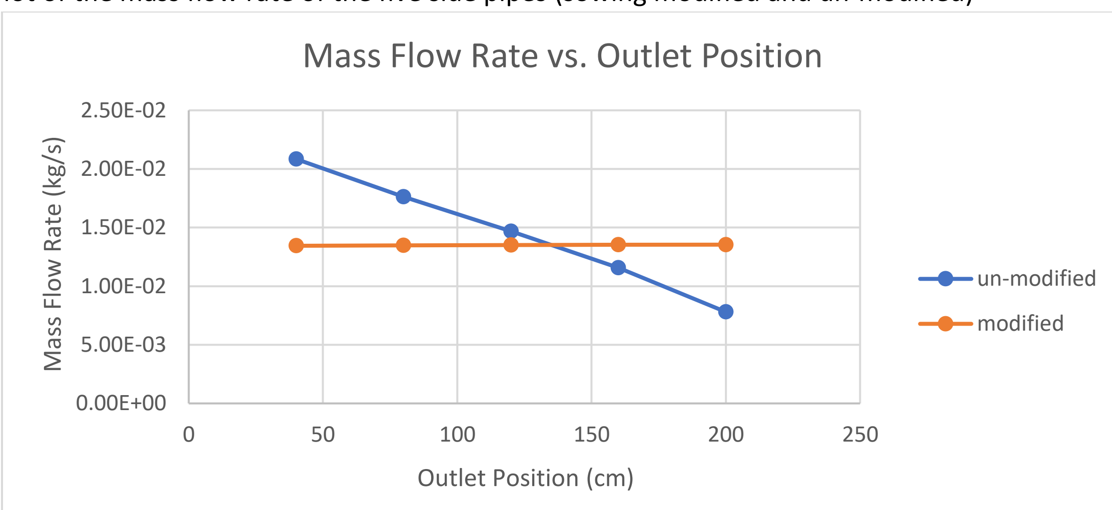
Turbulence:	k-epsilon
Continuity:	1e-6

1.) Values of the diameters at the 5 side pipes:

Outlet #	1	2	3	4	5
Diameter (cm):	2.260837066	2.521286216	2.834002391	3.391774824	4.44991939

See. Task 2 Section (ii) for description

2.) Plot of the mass flow rate of the five side pipes (sowing modified and un-modified)



See Task 1 Section (ii) for un-modified tabulated data

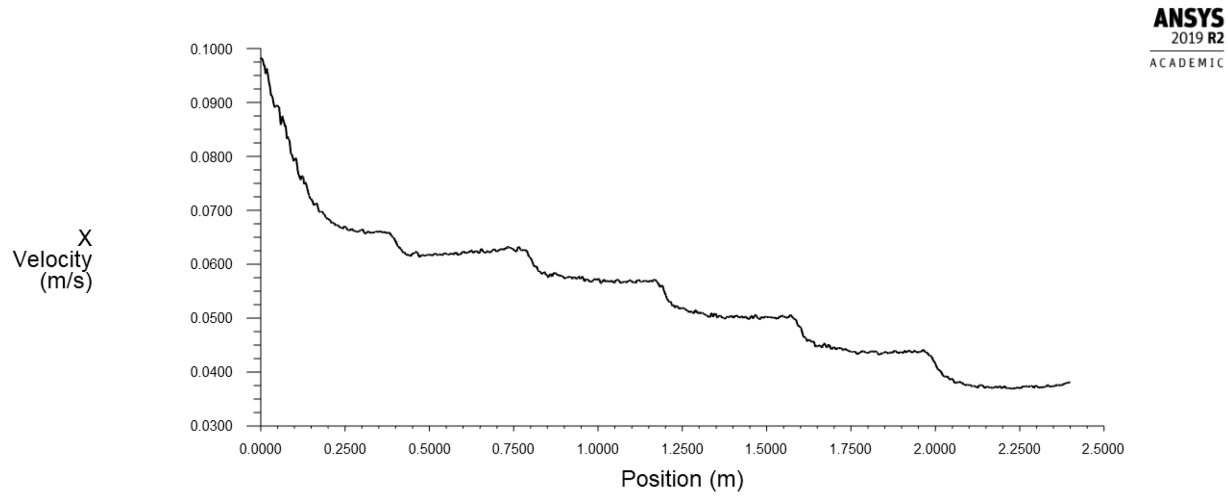
Modified Diameter(cm)	Mass Flow Rate
2.260837066	0.01344663
2.521286216	0.013475
2.834002391	0.01349784
3.391774824	0.0135316
4.44991939	0.01354252

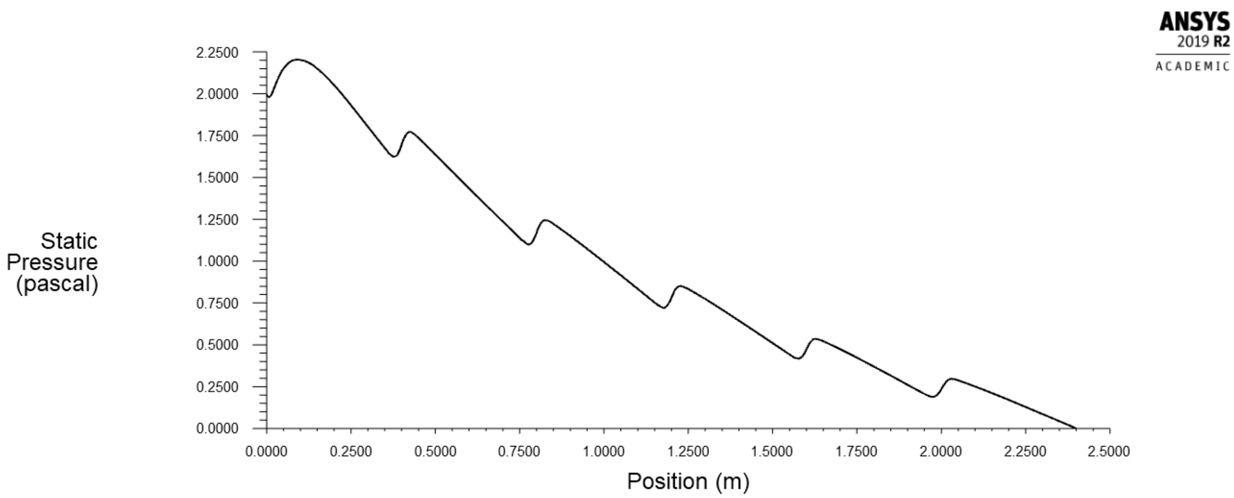
3.) Value of S at the best case:

S(modified)= 0.00262

S(un-modified) =0.313398248

4.) Static Pressure & X-velocity graphs





(ii)

Initial Approach:

In order to equalize mass flow rate of water through the side pipe outlets, modification to the outlet individual outlet diameters was required. My initial approach to this issue was to plot the results from a standardized diameter design (part 1). The resulting plots were then used to determine whether a simple numeric approach using data from the line of best fit, percentage change, or other trends could be used to interpolate on the best diameters to equalize the flow rate. Each of these methods failed due to the following criteria:

a.) Behavior of the mass flow rates were unpredictable and followed no general trend.
b.) S values did not seem to break lower than .1 despite adjusting multiple variables.

Final Approach:

The process that was used to equalize the flow rates was iterative and required velocity and mass flow rate information from each of the 5 outlet pipes. Using $\dot{M} = \rho V \pi r^2$, I assumed density to be constant and could calculate the average mass flow rate, and each outlet velocity, for any given experiment using the surface integral tool. With these known values I was able to rewrite the above mass flow rate equation as $r = \sqrt{\frac{\dot{M}}{\rho V \pi}}$, where r is an updated individual outlet radius, $\dot{M}$ is the average mass flow rate from the previous experiment, and V is the y-velocity at each respective outlet pipe. For each flow analysis an updated diameter for each of the five side outlets was calculated and implemented in for the next flow simulation. This process was repeated 5 times using excel to track the data and iteration results and shown in Appendix A. The resulting s values were tracked for each iteration and are shown in (figure 1).

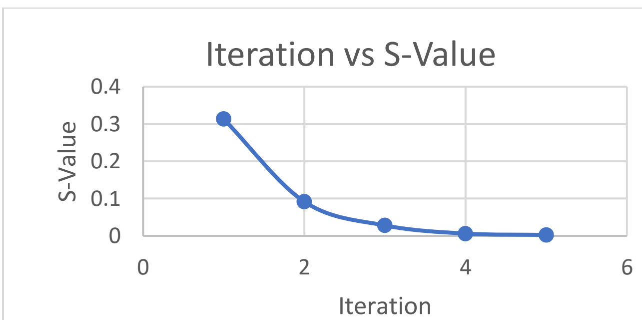


Figure 1

Process Logic and Thoughts:

It seemed logical to use the average mass flow rate as a desired result for each of the 5 side outlets. Additionally, although the velocities would change for each experiment, using velocities from the previous flow simulation would roughly estimate the velocities for the next flow simulation. As flow simulation converged to a more equal mass flow rate through the side pipes so would each respective velocity resulting in an increase in accuracy. <u>Unfortunately, this method resulted in irrational diameters which would not be useful in practice. Corrections could be made to account for this in future applications.</u>

Appendix A:

Sample Tables showing the final two iterations of Task 2.

Previous Velocity	radius(m)	Previous Avg. $\dot{M}$	diameter(cm)	Current $\dot{M}$
0.0336305	0.01141642	0.01374275	2.283284085	0.01368334
0.02708206	0.012722011	0.01374275	2.544402208	0.01366513
0.02134132	0.014331313	0.01374275	2.866262573	0.01372297
0.01511573	0.017028722	0.01374275	3.405744381	0.01353695
0.008841932	0.022265017	0.01374275	4.453003397	0.01350833
			% change	0.012790006
			Mean $\dot{M}$	1.36E-02
			S	6.23E-03

Previous Velocity	radius(m)	Previous Avg. $\dot{M}$	diameter(cm)	Current $\dot{M}$
0.03400359	0.011304185	0.013623344	2.260837066	0.01344663
0.02734129	0.012606431	0.013623344	2.521286216	0.013475
0.02164028	0.014170012	0.013623344	2.834002391	0.01349784
0.01510808	0.016958874	0.013623344	3.391774824	0.0135316
0.008777261	0.022249597	0.013623344	4.44991939	0.01354252
			% change	0.007131155
			Mean . $\dot{M}$	1.35E-02
			S	0.00262