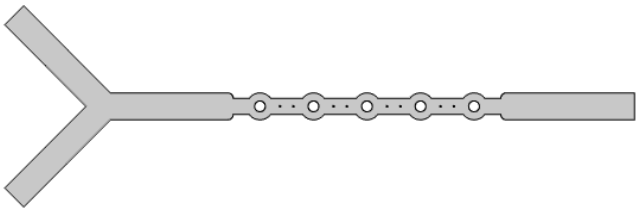
Luciana Castro

ECH 3854

Proposal of Microfluidic Device

This project consisted of building a high efficiency microfluidic device. These devices consist of small geometric features and strategic positions within the device features that allow a high mixing quality. In this occasion, our goal was to build a device that is effective enough to mix two substances at 100% but it is also very small in size for its purposes. This device is meant to mix blood and molecules that trace COVID-19 antibodies specifically. It also has to comply with certain specifications such as maximum velocity of 0.5 meters per second, maximum pressure of 7000 Pascals and minimum size of geometric figures.

My design consists in a narrow channel with an array of 5 circles that overstep the width of the channel, which they also have a hollow radio inside of them. For an optimum mixing performance, I added 8 more hollow very small circles in between the bigger circles. To simplify the convergence of my model, I used fillets for the sharp ends of some channels. My goal was to make my model as symmetric and evenly distributed as possible, for which I used arrays to implement the circles. My final model was a product of all of my previous trial models since using the error and trial approach, I understood what lead to better mixing.



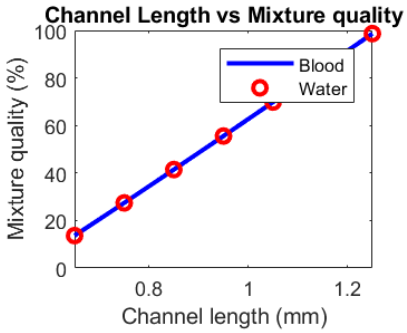
[Microfluidic Design]

[Zoomed channel]

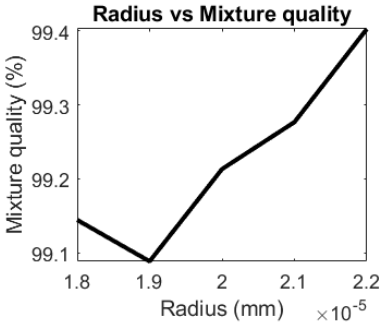
This device satisfies the conditions because of the many circles it has and also because of the narrow channel the connects all circles. When first doing my models, I could observe from the concentration graphic that a higher mixing quality is achieved when the fluid goes through curved shapes and narrow spaces. However, the most challenging part was to have a high mixing quality while complying with the velocity specification. These two properties are affected directly proportional one to each other. Whenever I reached a high concentration, I also got a high velocity that did not fulfill the requirements. I opted for a wider channel than I initially had to lower down my velocity, nevertheless, it was still narrower than the rest of the channel to keep a high mixing quality. Also, a factor that increased mixing quality it is to decrease the thickness of my bigger circles to improve high concentration. My precise symmetry, location of figures and even distributed circles gives my best quality mixture: 99.213%

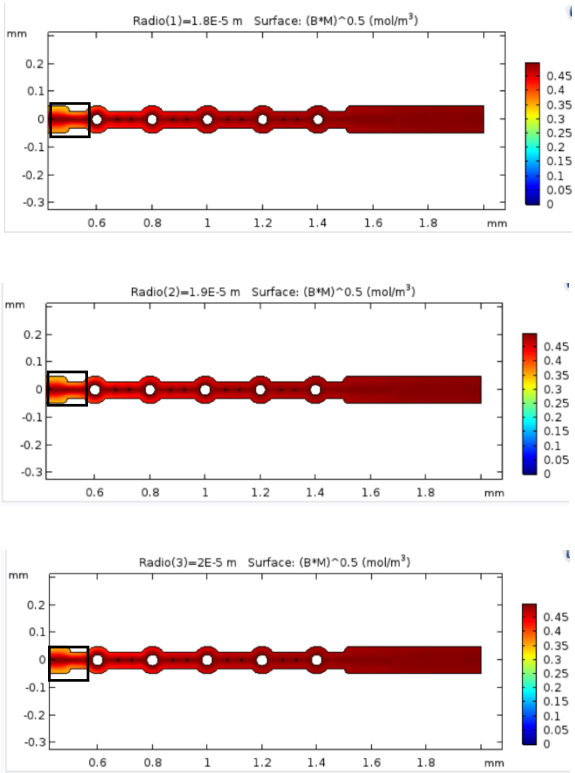
Key Results		
Average Fluid Velocity [m/s]	Maximum Fluid Velocity[m/s]	Total pressure drop [kPa]
0.19843	0.51	3.72

The first plot graphs the mixture quality percentage vs the channel length with water and blood. To do this graph. I located seven different cut lines around my channel. The separation between each cutline was of 0.1mm and they were located before and after each circle. This graph is linear since the fluids keep getting past circles as they go through the channel, so the mixing keeps getting better. Even though blood has different properties from water, viscosity of 2.7e-3 Pascal per second and a density of 1.06e3 kilogram per cubic meter (Al-Atabi, Espino, Hukins)[1] ,they are so similar that my results did not have a significant change.



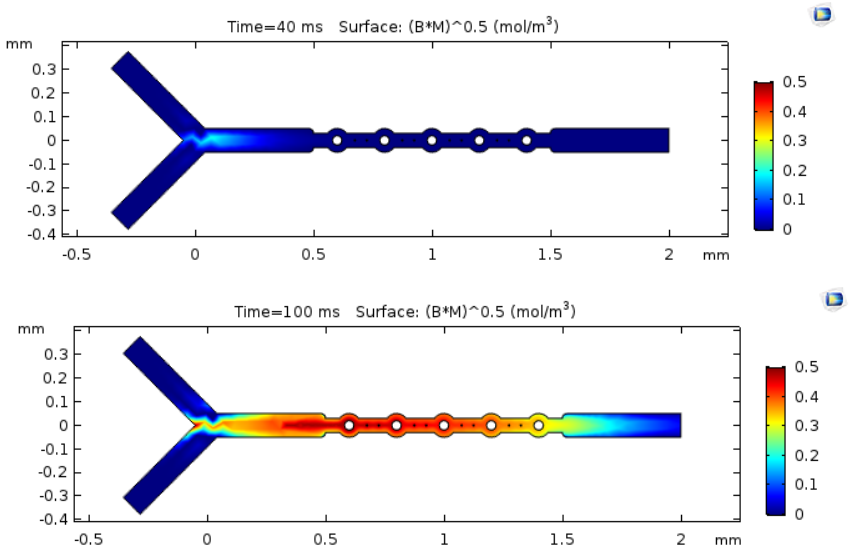
For the second graph, I had 5 parametric sweeps regarding the change of inner radius of the circles. My original value was 0.002mm and my changes in an interval of 0.0001mm. I decided to do two values higher and lower than the original one. What I expected is a linear graph since if the inner radius increased, there would be a thinner area for the fluid to pass across the circles, leading to a higher mixture quality. When I obtained this graph with the exported data, I analyzed the concentration graphics on COMSOL to understand this result. The graph in the middle (0.0019mm) is slightly more orange than red in the boxed area, compared to the graphs above (0.002mm) and below (0.0018mm). This explains the result of the plot.





[1] Al-Atabi, Mushtak, et al. "Computer and Experimental Modelling of Blood Flow through the Mitral Valve of the Heart." *Journal of Biomechanical Sciense and Engineering*, vol. 5, no. 1, ser. 2010, 1 Aug. 2009. *2010*.

The time dependent study showed that the fluid mixture was present in the begginging of the channel at 40 miliseconds and in the end of the channel at 100ms. The total time to go through the channel is 60ms. It is fast because my design was a straight channel without deviations.



This microfluidic device satisfies the conditions required because the channel is narrow enough so it can increase quality mixture but not so narrow that it will give a higher velocity than stated. Since the channel was contributing to the quality mixture but had a limit to do so, the circles increase quality mixture. Also, the separation between the circles is precise so the area is big enough to not have a high velocity at those point. Overall, it has a good performance and it meets the conditions because of key elements such as spacing, size and many circles.