Magnetohydrodynamic Pump

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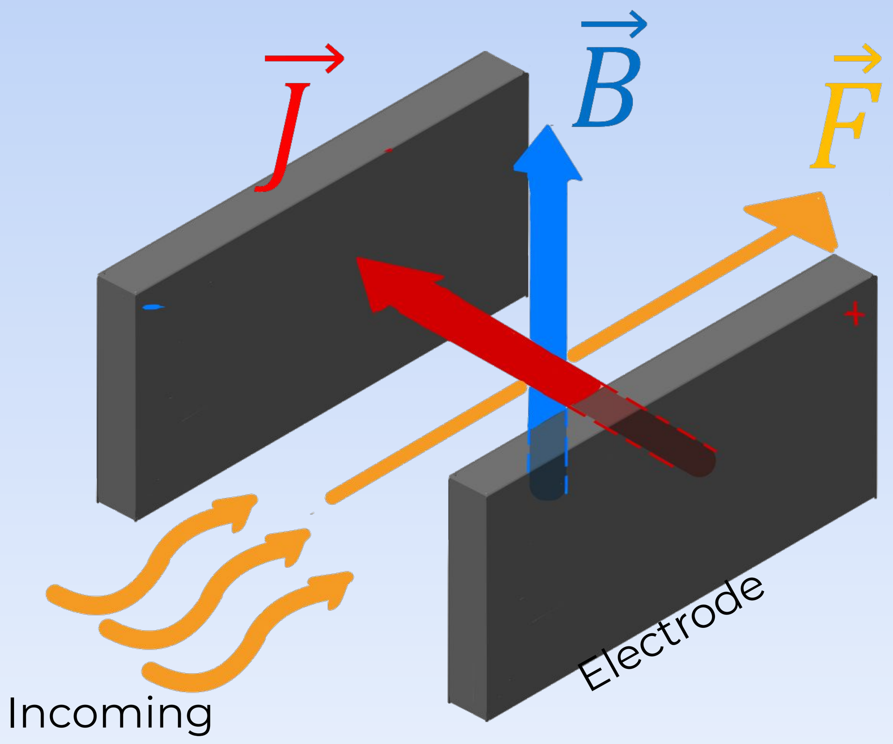
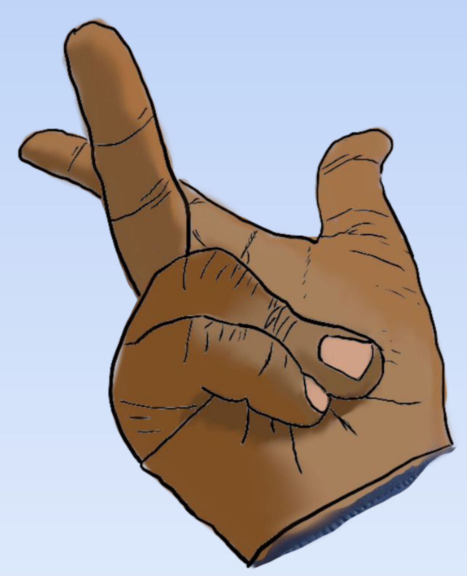
Project Description

L3Harris is interested in utilizing magnetohydrodynamic (MHD) pumping in liquid heat exchangers due to the increased reliability that such systems provide. The objective of this project is to assess the feasibility of MHD pumping. In depth research utilizing FEM models and physical experiments will aid in the completion of this objective. This will allow L3Harris to determine if MHD heat exchangers should be pursued.



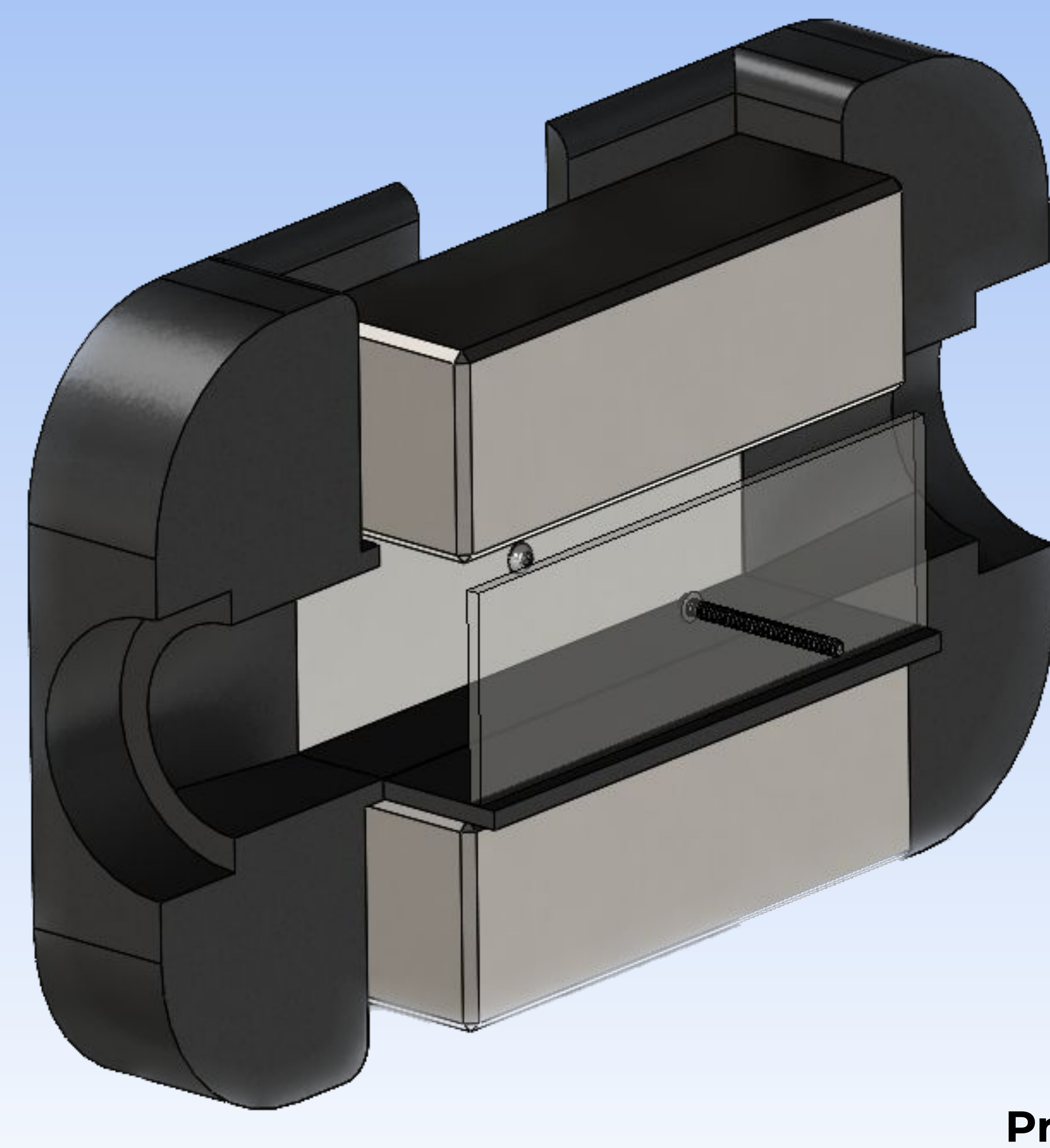


Right Hand Rule

$$\vec{J} \times \vec{B} = \vec{F}$$

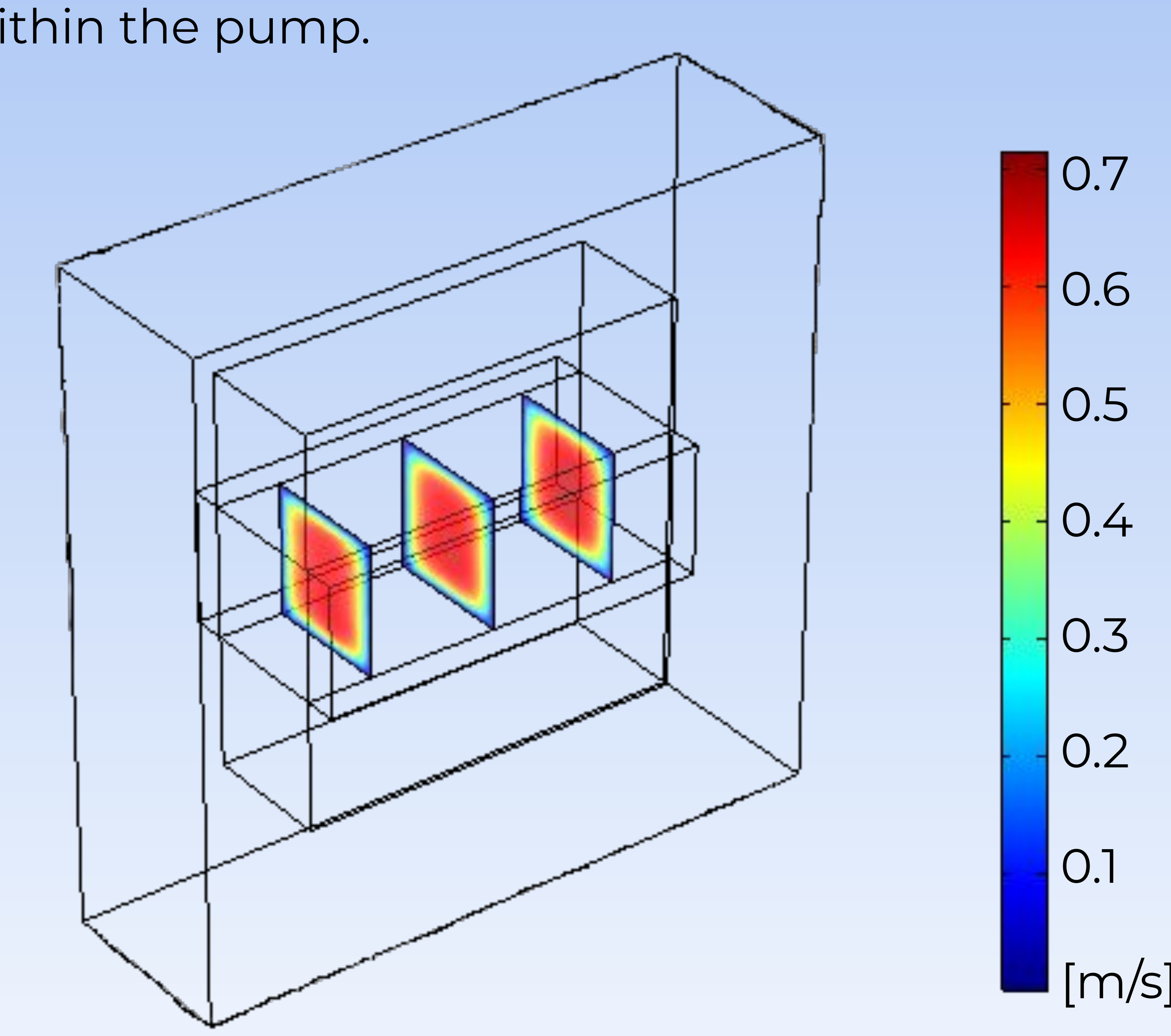
Cross-section view of 1" MHD Pump

Two 1" x 1" x 3" N48 magnets and two stainless steel electrodes encase a 1" x 1" channel.



COMSOL Model

An FEA model was developed so that fluid flow through the pump could be predicted. This allowed us to find important design parameters for MHD pumps as well as explore the impact of using liquid metals. The figure below is the COMSOL result showing fluid velocity profile within the pump.

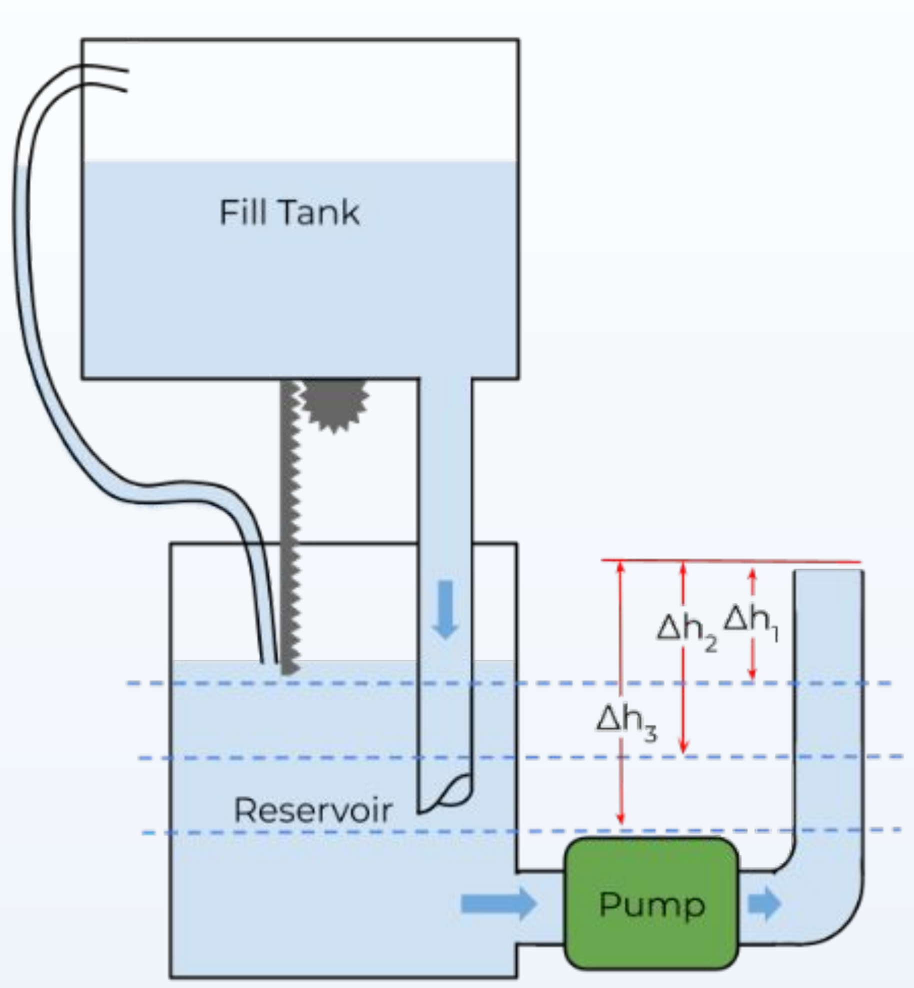


Testing Setup

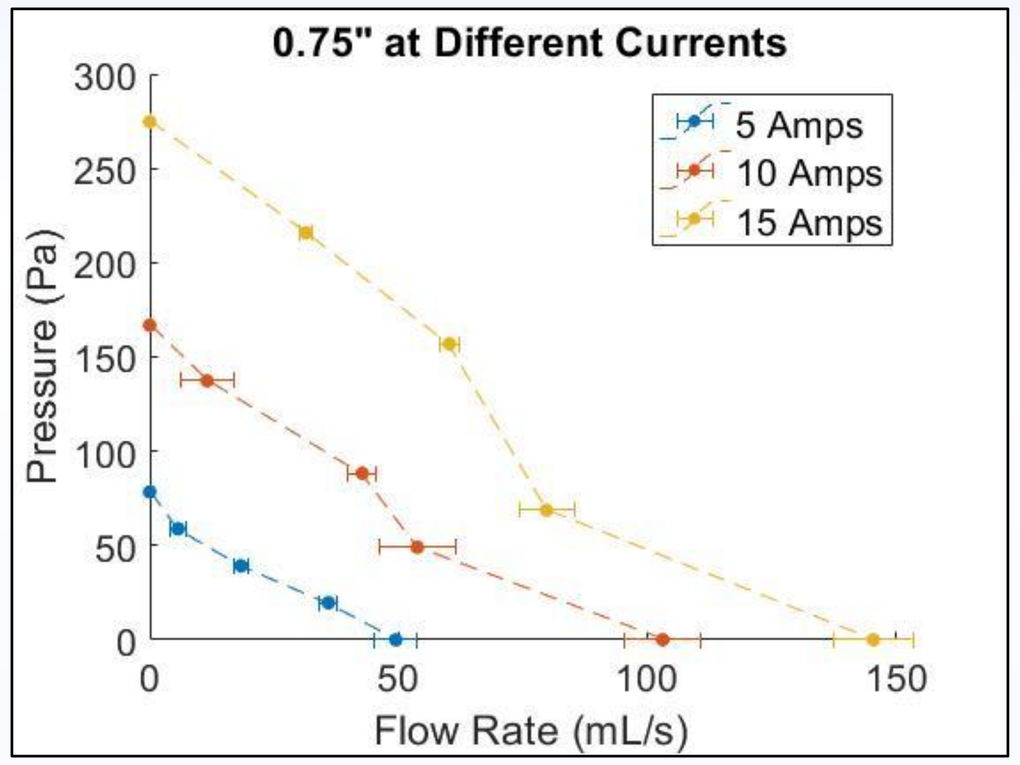
Pressure is calculated by measuring height difference between the reservoir and the top of the tube. This height difference is controlled by an arduino and auto leveling system, so that multiple points can be collected for the pump curve.

Auto Leveler

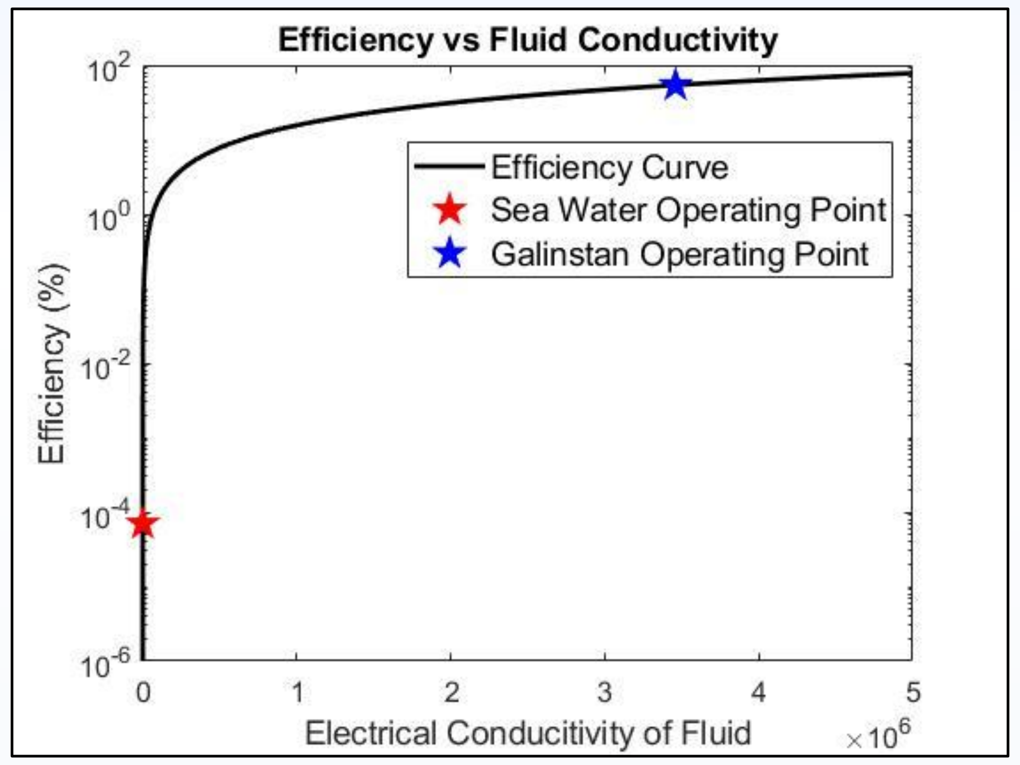
Water fills the reservoir from the fill tank through gravity as the pump is pumping it out. When the height of the water reaches the end of the tube, air can no longer enter the fill tank, and the water level does not rise.



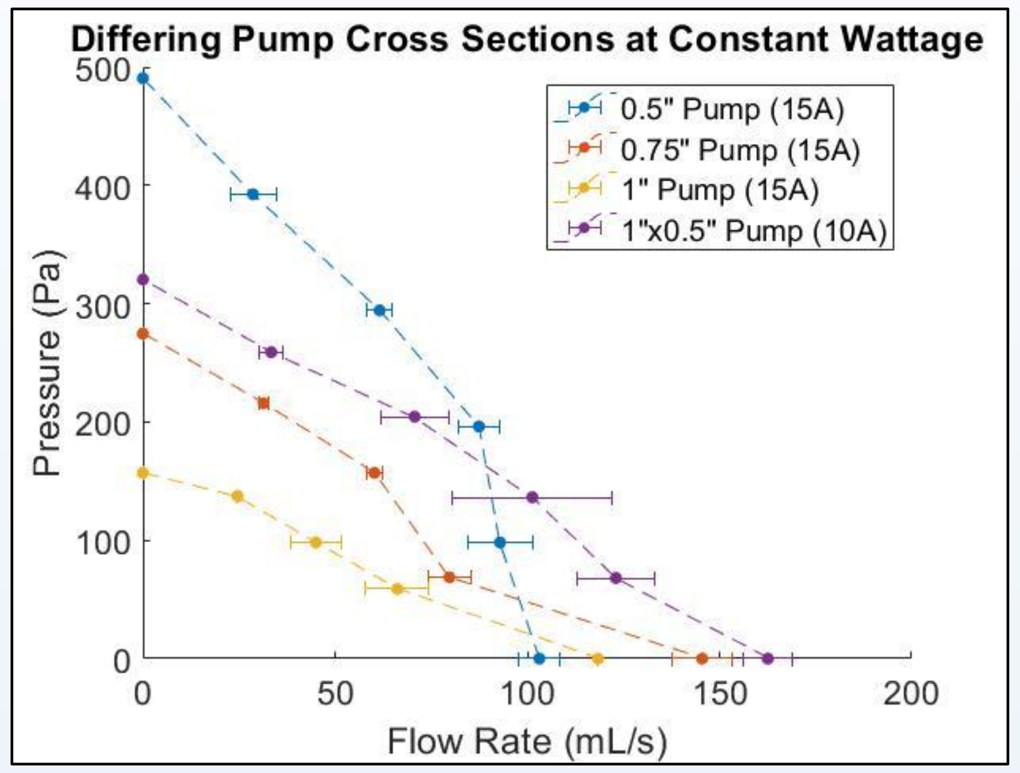
Project Results



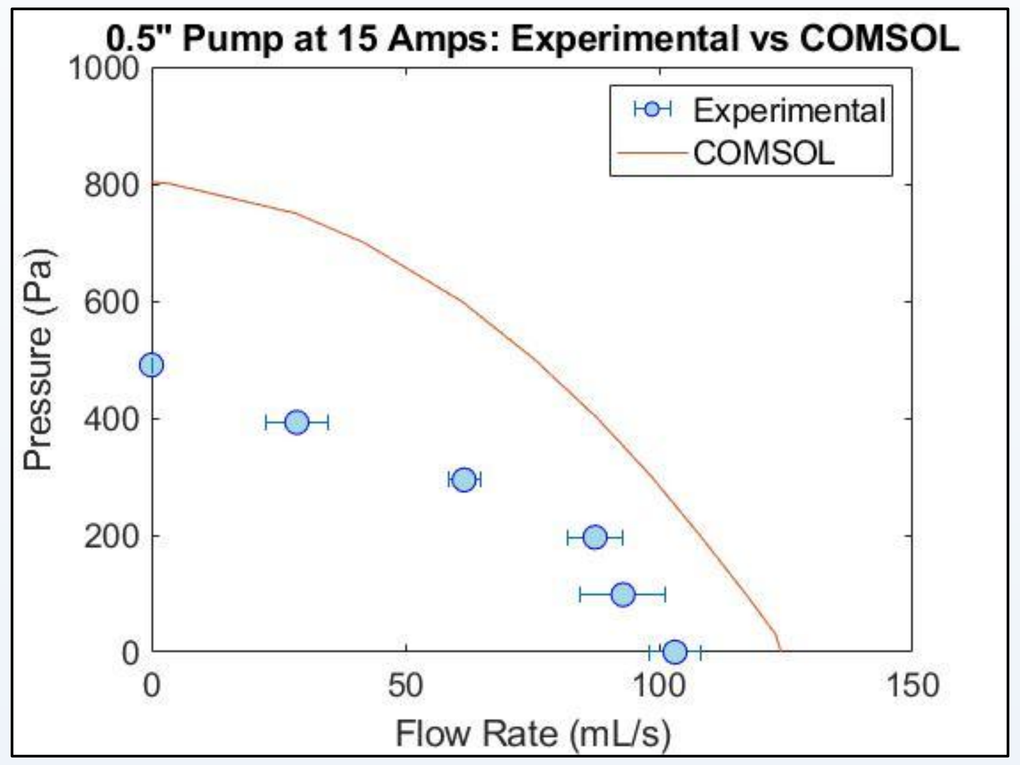
The figure on the left illustrates that current serves as the primary driving force for an MHD pump. As the applied amperage increases, the pump's performance increases. Consequently, the electrical conductivity of the fluid directly correlates with the efficiency of the pump.



An MHD pump using salt water is too inefficient for any practical uses. However, fluids with higher conductivity, such as galinstan (a liquid metal), holds far greater promise. The figure to the left shows this relationship.



The figure to the left shows how changing the pumps cross section, changes the performance. The 1" x 0.5" pump has a 1" distance between the electrodes, and a 0.5" distance between the two magnets. The rest of the pumps have square cross sections. Our 0.5" and 1" x 0.5" pumps were the most promising.



The figure on the left shows the experimental vs the theoretical pump curve for our 0.5" pump. The error bars represent one standard deviation. We tested 4 different pumps, at three amperages each.