EXECUTIVE SUMMARY

ROUSH® CleanTech is a manufacturer of liquid propane fuel systems for commercial fleet vehicles. Their mission is to develop reliable products that will produce fewer emissions and reduce vehicle operation costs. Their propane conversion kits for trucks and buses replace the existing fuel tank and fuel pump system with a combined tank and pump system. The in-tank fuel pump system utilizes a jet pump to maintain fuel flow to the engine during low fuel, graded, and accelerated conditions. Currently, the internal geometry of the jet pump is not optimized for maximum efficiency while maintaining reservoir fluid level. Our task is to optimize the jet pump component of the liquid propane fuel injection system.

Our design needs to maximize fuel flow to the engine while ensuring that the fuel pumps are not starved. By varying the dimensions of the jet pump, we can minimize the losses caused by friction and mixing inside the jet pumps, ultimately reducing the amount of flow that can go to the engine. The maximum engine fuel demand possible is 62 gallons per hour, so our jet pump design needs to be able to meet this demand.

We brainstormed many concepts that could meet the above design specifications. We created criteria to evaluate our designs by understanding the components of a jet pump, which are the nozzle, throat entry, throat, and diffuser. The design also had to meet the efficiency and performance guidelines of the sponsor. From doing a thorough literature review, we were able to target four changes to the current design dimensions, which were nozzle to throat spacing, mixing chamber length, area ratio, and inlet pressure.

After creation of an alpha concept and test procedure to be performed at our University, we discovered our alpha concept cannot be used due to the current manifold setup in which fuel is diverted to the engine prior to entering the jet pump inlet. This setup did not allow any flow to the engine component; however, the larger orifice was able to maintain a fluid height in the reservoir ensuring the fuel pumps aren't starved.

In addition to testing the alpha design, we characterized the performance of the plastic and prototyped versions of the original design provided by Roush. From the results of our testing, we determined the efficiency of the plastic, in-production jet pump to be 10-11 percent and the efficiency of the prototyped original design to be between 7.1-9.8 percent. As we expected, the material has a large effect on the efficiency of the jet pump, in addition to the manufacturing process, since the nozzle outlet must have sharp, defined edges which allow for a single, high velocity stream.

The results of these two tests led us to a beta design round of testing. We increased and decreased the area ratio of the original design by 25%. In addition, we tested each of these three orifice sizes, .762, 1 mm, mm, and 1.27 mm orifices at three mixing chamber lengths of 10.33mm, 13.7mm, and 17.22 mm. This creates a design matrix of nine. Due to fragility of the material used in the testing, we broke two of the jet pumps. However, we were able to conclude from our test that the larger orifice of 1.27mm had the best efficiency of 10.7-12.5 percent. The mixing chamber length that created this efficiency for the larger orifice size was 13.7mm. Therefore, by increasing or decreasing the mixing chamber length, the efficiency decreased. This shows us that mixing chamber length does in fact have an effect on efficiency.

We recommend that ROUSH® CleanTech tests larger orifice sizes than 1.27mm because efficiency will increase with orifice size. Once the constraint of meeting the engine demand is placed on the jet pump design, the orifice cannot be increased further since increasing orifice size reduces flow to the engine. We also recommend that ROUSH® CleanTech tests the jet pumps with the plastic injection manufacturing process, since material has a large impact on the ability to optimize the jet pump.