Flow Visualization Water Tunnel

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Description

Initial description

The purpose of the flow visualization water tunnel automation and instrumentation was to create a working Water tunnel to be used at Gran Canyon University for the engineering program. The initial scope given to the team was to first design, test, and verify a new tank, pump, and filter system. Next, was to integrate and improve the automation and instrumentation features of the water tunnel. Once the water tunnel was functioning the different flow types (laminar, transitional, and turbulent) would need to be identified and recorded. Then finally, the water tunnel and instrumentation would need to be able to demonstrate and acquire images of flow trajectories around a submerged object.

Justification

The purpose behind this project is to allow GCU engineering students to have another opportunity to have hands on experience with a common piece of engineering technology. The water tunnel will allow for the students to get firsthand experience with visualizing flow around an object as well as how different flow types look around an object. Not only will the water tunnel be able to be utilized by current classes that are running at GCU but also current clubs. It can also be utilized for any future classes and clubs that are created at GCU that can benefit from the water tunnel and the information the instrumentation can provide.

Requirements of design

Table 1.1 Functional requirements from customer feedback

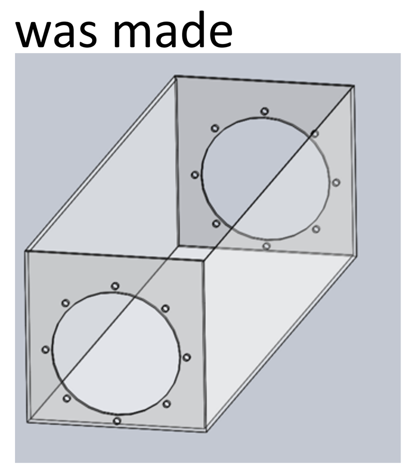
Functional Requirement	Customer Reasoning for Requirement	Design Implementation
Portable	Needs to be able to be moved from one room to another and easy to store	Removable piping to reduce width
Limited Dye Use	To prevent the water from becoming cloudy, making it difficult to visualize the flow	Use a viscous dye in small quantities to prevent dye from dispersing into the water
Variable Flow	Needs to be able to represent different types of flow	Adjustable rate pump
Easily Drainable/Fillable	Needs to be able to be drained and filled quickly between experiments	Dual drains on the bottom of the tank and an open top for easy filling
Digital Readout for Velocity	To provide numbers for students to perform Reynolds number calculations	Pitot tubes in the tank connected to NI USB-6001 DAQ board for use with LabVIEW
Safe to Operate	Cannot run the risk of electrical fire	Drains will be positioned so that water can not be near any electrical components
Quiet	Will be used for teaching purposes and must be quiet enough to speak over	Smaller pump to allow for quieter operation of the whole system.
OSHA1926.451, 1910.212	Wheels must lock exist for large erected tanks, moving components must be guarded or shielded if exposed.	No moving components will be exposed, but wheel locks will be installed.

The first step of the design process was correctly determining what our customers wanted. Defined the problem and began on potential solutions

First hand-drawn design, basic idea of how flow will work in the system.

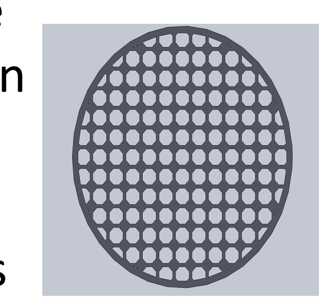
2nd round of customer feedback

Decision to continue with square design was made



Data collection-quantification of customer's needs

Custom flanges and a regulator were designed to improve on the flow control in the system. Additionally, the ink injection system was changed following customer feedback and expert consultation.

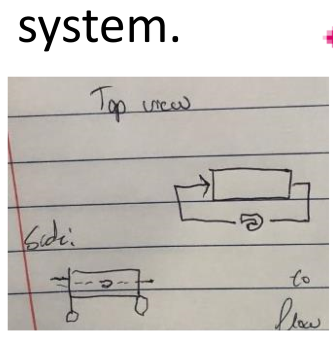


Regulator printed and tested at low PSI

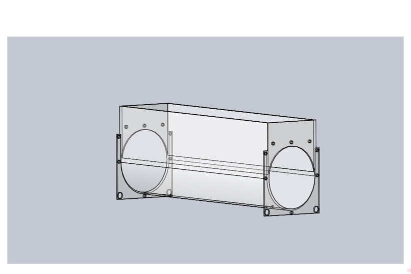
Define — Measure — Analyze — Modify — Analyze — Modify — Measure — Modify — Improve

Design Process

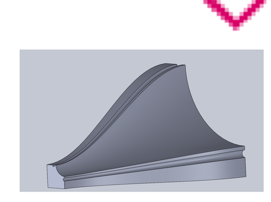
First hand-drawn design, basic idea of how flow will work in the system.



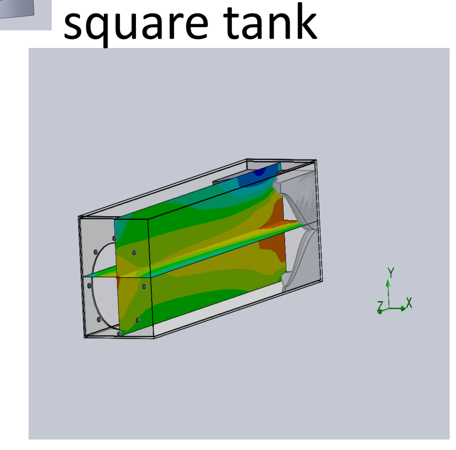
Initial designs in Solidworks for two different tanks.



Design choices were analyzed, and outcomes for both were critically considered. Due to light bending the square tank was determined

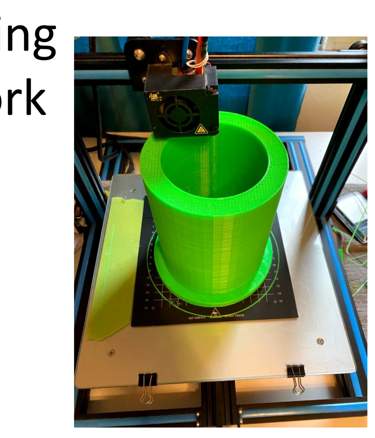


Square tank was analyzed further, inserts were designed to overcome the difficulty of flow control in a square tank



Network and pumping assembled to determine possible improvements

Flanges printed out, and fitted to piping network



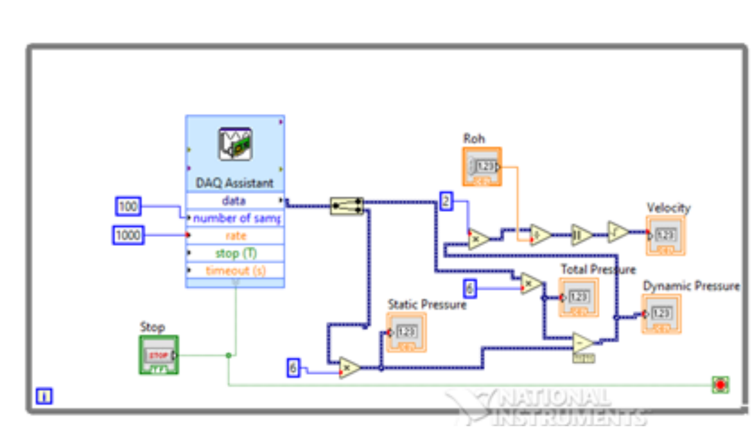
The general design process followed the DMAIC model, essentially defining the problem, quantifying it, analyzing solutions, implementing changes, reevaluating, improving design decisions, and controlling the future changes in the design.

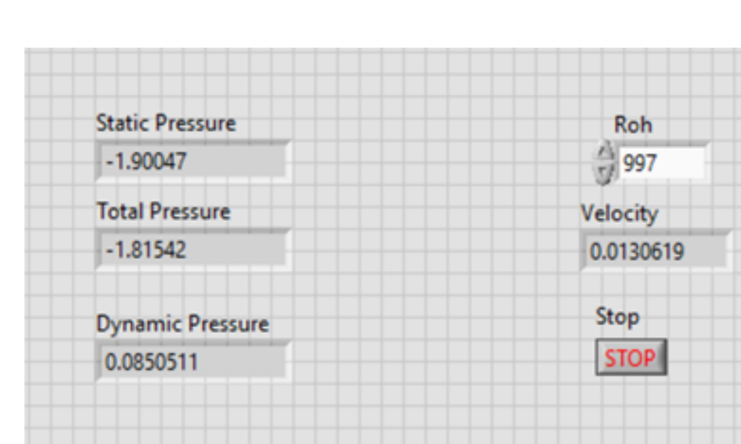
Data collection and evaluation

Data Using LabVIEW

The lab view program will take voltage differential inputs that are created as a result of the pressure differential in the pitot tubes. There are two transducers, and one differential pressure pitot tube that is placed inline with the flow stream. The readout will take this information and convert it into a Reynolds number that the user can view to determine the flow type.

In addition, the ink dye is injected from either the object or a tube that is inline with the fluid, and data can be visually collected by the user. This is the reasoning for the square tank, which prevents light bending.





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