Rig Building Report:

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Abstract

The goal of this project is to design and build a closed system rig to control the depth of water in a tank and the flow rate to the tank independently. First, to develop practical problem solving skills and manual dexterity. Second, to manage time and resources efficiently. Third, to become familiar with basic process equipment like pumps, valves and pipes. Finally, to learn standard documentation skills, standard operating procedures, and to create piping and instrumentation diagrams.

Introduction

This task is an engineering project combining hands-on skills and calculation skills. The project started by building a stand, then placing two boxes on top of each other, then connecting the pipes to the holes on the boxes, and finally measuring the flow rate in the pipes.

The project uses aluminum rods, nails and angle brackets, two 30 L Plastic Containers, one drip dray, acrylic tubes, flexible hoses, tape, brass connectors, a centrifugal pump, three gate valves, and one ball valve.

This machine's principle is that the pump is the main input for the container that has the controlled water level, and the output from that container acts as the provider of water for the pump. That way, it is a closed system, conserving water, and also serves its main purpose.

It works as a great machine to control the water level of a container and also refreshing the water inside. This machine can be found in many places in today's society. If enlarged, it can act as a swimming pool, keeping the water at a favorable level, and at the same time maintaining a circulating system. It can be found at bays, controlling the water height for ships to cross without dropping a great height or being flooded. This mechanism is the main control of water in this world.

Method

In this project, aluminum was the main material for the stand. The stand was built by connecting different aluminum rods with aluminum connectors and bolts. The overall stand was a grid shape that could hold two plastic tanks in place.

Before the tanks were placed in the aluminum structure, holes were drilled in various places in the tanks. The holes at the bottom of the tanks were more complicated, because there were inconsistent protrusions, around the hole, so they had to be made smooth using the drill.

After the tanks were placed in place, connecting pipes and connectors were the next step. They were connected by using different connectors made of zinc and copper, with plastic pipes in between. There were also gate valves and ball valves in necessary places, and these are the main factor of controlling the flow rate. Overall, the pump pumped water to the upper tank through a pipe, which had a gate valve. Then, two pipes, each having a gate valve, were marked with the responsibility of directing water back to the lower tank. The water from the lower tank was then pumped up, and so on.

Because the pump could only be connected with rubber pipe, the other end of the rubber pipe overlapped the hard pipe. The pump was connected to a power source to activate the pump.

After all that, the entire structure was then placed inside a large tray that would potentially catch any leaks or spills from the structure. The bottom tank was attached with another pipe structure with a ball valve, to release any unwanted water into the tray underneath. All of these steps were conducted by the cooperation of the entire team.

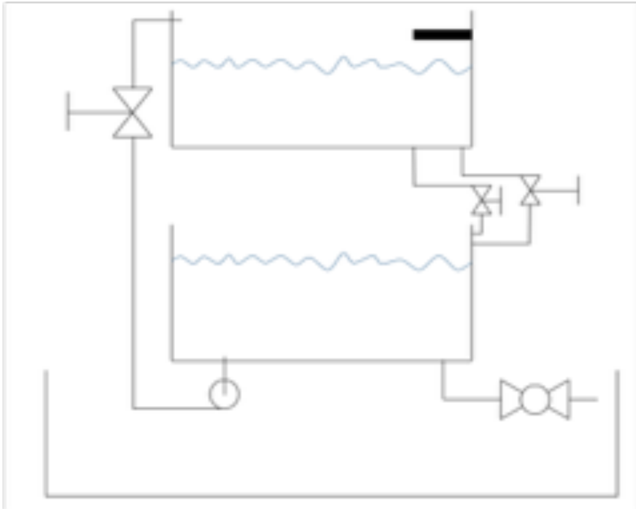

Figure 1.1 Simple Diagram

Results & Discussion

The stand was first designed to be connected in parallel and connected pointing away from each other at each intersection, but afterwards ideas were changed and decided to connect them towards each other, which needed much less aluminum. This way the tank couldn't be placed onto the structure. Therefore, one horizontal rod had to be shifted closer to the middle to make the tank fit. This way, there were more space vacant for the the control of the valves on the pipe, which wasn't in the original plan.

The pump's generator power wasn't enough for the pump, so it was burnt upon connecting, so the pump had to be directly connected to an outlet on the wall in order to work. This way, the flow switch lost its purpose in the structure, also, the project couldn't be mobile.

The first test trial of the project was a failure. There were leaks everywhere, in the brass connectors, in the intersections between the rubber pipes and hard pipes, in the valves, and in the holes. There was only one apparent solution, to bind all the leak sites with a water-resistant tape. After they were applied to the intersections between brass connectors and hard pipes, metal tightens were applied to the intersections between rubber pipes and hard pipes.

The second test trial had much less leaks than the first one, but there was still a large amount of water leaking from the bottom of the tanks. It was because the bottom of the tank wasn't smooth enough, so the brass connector was not perfectly horizontal, and there was a large fissure which was spewing out water. The were two solutions to the problem, one to make the bottom of the tank smoother, one to switch the tank and move the hole to the side of the tank, which is smooth.

Overall, the materials that were used were very suitable for the job. The rods were supposed to be sawed by hand, so aluminum made a decent outer structure because of its ease to be sawed. Also, aluminum forms a protective layer made of aluminum oxide. That way, the material will not rust and will remain rigid for a long time. The tanks were polymers, because of its resistance to water and light weight. Plastic is easy to be drilled through, and reshaped to fill gaps, so polymers are the most suitable candidate for the material of the tank.

The connectors were made of brass because of its hardness and unwilling to bend. If a bendable material, such as aluminum was used to make the connectors, the pipes would be very difficult to remain pointing in one direction. The pipes were also polymers because they don't serve a stabilizing function, just a material used to pass on water, so it should be as cheap as possible. The rubber pipes were used because of their ease to be reshaped. They controlled the direction of the water coming out, and also they had to be connected to the pump, which requires rubber pipes.

Flow rates were tricky to be measured, especially for the pipes in the bottom. The pump was relatively easy, because the flow rate is consistent regardless of the water level of the tank. A water bottle, which has a fixed volume, was used to measure the flow rate, because the time taken to fill the bottle can be recorded. The two factors needed to calculate the flow rate is volume and time, so the flow rate could be calculated. The pump's flow rate was measured when the valve was turned on a half, one, one and a half, two, two and a half, three, three and a half, four, and four and a half turns. Only one of the two pipes under the upper tank was measured, for the two pipes are identical. The pipe's flow rate was measured when its valve was turned on a half, one, one and a half, two, two and a half, three, three and a half, four, and four and a half turns. The flow rates' units are all cubic meters per hour.

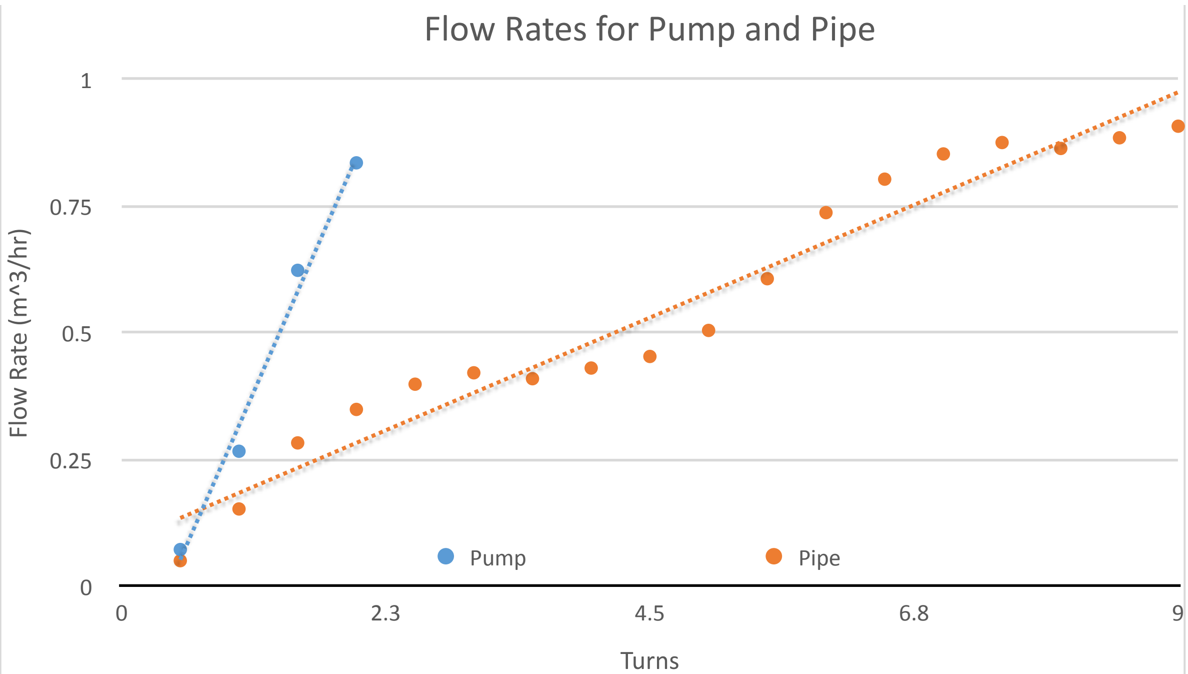

Figure 1.2 Flow Rate Chart

After the flow rates were measured, it was easy to keep the input and output of water in the upper tank equal. Then, the water level could easily be managed and kept constant even with the pump running. All that should be done is to use the gate valves, which is more precise than the ball valve, to control the flow rates in the different pipes, and slowly raise or lower the water level, and when the water level is at the favored height, make the input and output of water in the upper tank equal to maintain that water level.

It was only then the fact that the gate valve was to slow was discovered. The ball valve, though only ninety degrees between opening and closing (in contrast to the many complete loops of the gate valve), was much faster and easy to manage. The gate valve was extremely slow to turn on and off, and was hard to keep track of the number of loops left to turn the valve off or on. The ball valve had only 90 degrees , and was proportional, so it was actually much more suitable for the situation. But without turning back, the number of loops to turn the gate valve on or off was recorded, and the flow rate could be easily measured.

Fluid Mechanics and Process Analysis skills were also used in the process of the making and testing the project. Due to the general conservation equation, without generation and consumption, input plus output equals accumulation. This way, the rate in which the water level grows can be easily calculated. Also, in a closed circuit, without leaks and loss, the mass per second into each pipe is equal to the mass per second out, therefore, the mass and momentum are all the same. According to the Bernoulli equation formula, the higher the water level, the more pressure at the bottom of the tank, and vice versa. That way, the flow rate of the pipe in the bottom of the upper tank would change according to the water level. The solution was to measure the flow rate in a few representative water levels, and calculate the average across them.

Conclusion

Through the project, skills such as knowing which materials to use for the different purposes, and knowing what methods to apply to the different building processes were abundantly needed. Making the aluminum structure, drilling holes, and connecting the pipes all created valuable hand-on experiences. Major setbacks during the project included leaks and difficulties in measuring the flow rate, but they were all solved. Some physics and chemistry laws were used in calculations and construction, and has made lasting impressions.

References

1. “Rig Building Handout” p.2-4 *Foundation Laboratory*