

**DESIGN, CONSTRUCTION, AND EVALUATION OF A SPILL GUARD
MAT CLEANING SYSTEM**

by

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ABSTRACT

This senior project addresses the design and construction of a spill guard mat cleaning system prototype used by Rain for Rent. The cleaning system was built with separate cleaning and rolling mechanisms, which made the process of cleaning and rolling the mats safer and more efficient. The purpose of this project was to create and test a cleaning system that will make this day-to-day task safer and reduce non-billable hours for the company.

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INTRODUCTION

The oil industry in Kern County is a major part of the economy. Rain for Rent is a company that focuses on water storage and handling for oilfield applications. Some uses include storing water and chemicals used for drilling and fracking. Drilling and fracking are a major part of today's oil industry with many new advances. Fracking is a process of injecting liquid with chemicals in it deep down into rocks at very high pressure that cause cracks in the earth that allow natural gas and oil to fall into existing wells. These liquids and chemicals are stored in tanks rented to the customer by Rain for Rent. Some of the chemicals stored in these tanks are hazardous and Rain for Rent must have containment systems set up in order to stop a spill if a tank leaks. EPA regulations in the oilfields categorize a spill as any amount of liquid over 42 gallons or one barrel spilled onto the ground. This regulation was implemented during the oil pollution act of 1990. Spillguards are used as primary containment systems under the tanks that are rented to customers. See Figure 1.

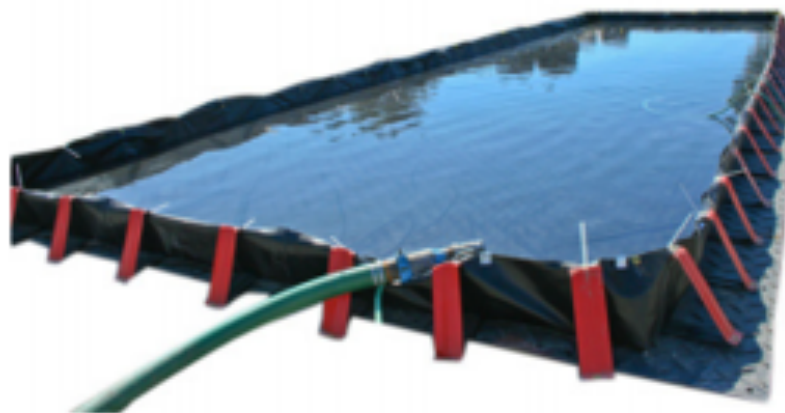


Figure 1. Spillguard.

Spill guard mats are used as a secondary containment system underneath spill guards. After being used out in the field these mats are taken back to the branch and cleaned using a pressure washer then rolled up by hand and put away until next use. Mats must be cleaned after every use because many oilfield companies have rules about bringing equipment that has possible contamination on to leases. Some Rain for Rent branches across the states have as many as

three crews working eight hours a day just on cleaning and rolling spill guard mats. The majority of other branches still use the cleaning and rolling by hand method which is inefficient and time consuming. The objective of this project is to design and build a piece of equipment that can be used at any Rain for Rent branch location to make the process of cleaning and rolling spill guard mats safer and more efficient. The main design parameters faced go as follows: this piece of equipment must be able to cut down in house labor costs and must be able to clean and roll mats an average of 1.5 times faster than the regular hand washing process. Other parameters for this project are that the metal frame will be built to eighth inch tolerances. The major advantage that was being looked at in regards to building the mat cleaning system was it promotes and increases safety by minimizing peoples lifting and bending stress. One of the main goals of this project is to decrease the number of lifting and bending incidents that are reported at work. Safety is very important to Rain for Rent as a company and they strive to make a safer working environment for their employees every day. According to ("Materials Handling: Heavy Lifting.") "Lifting loads heavier than about 50 pounds will increase the risk of injury." Since each mat weighs roughly 150lbs it is important that the system being built will reduce the lifting and bending stresses that make the original process harder. A key role in the design of the mat roller is that there are two handles that make lifting the mats after washing and rolling much easier. Also the final rolling station should sit 4' high, which puts it in the ""power zone" height, which is about mid-thigh to mid-chest." ("Materials Handling: Heavy Lifting.") Reducing the hazards on this job can help promote safety and wellbeing of employees and reduce risks of incidents happening.

LITERATURE REVIEW

Preliminary research played a critical role in the design of this project. Rain for Rent tanks are commonly used in many municipal and oilfield applications. The most common tank being used are bilevel tanks. See figure 2 for a detailed drawing of the bilevel tanks.

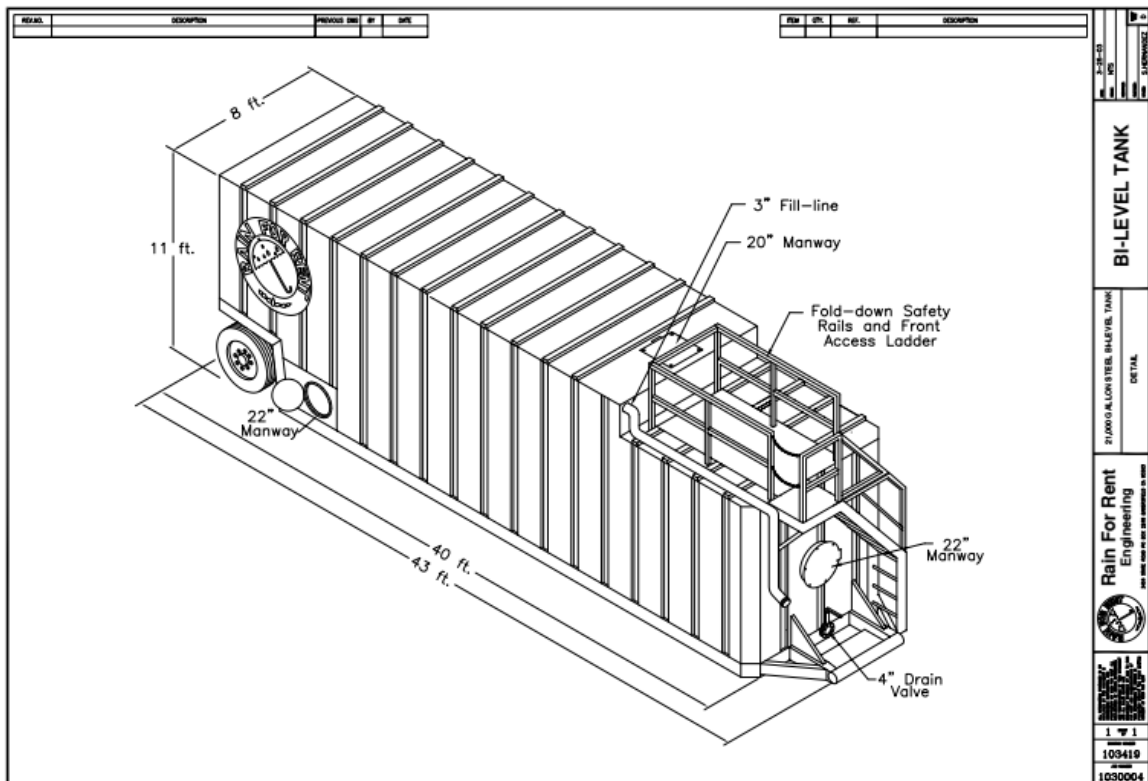


Figure 2. Bilevel Tank Drawing

Spill guards are commonly placed under these tanks to ensure 100% containment if there is a total spill of the tank. Under these spill guards mats are placed as a secondary containment system in case the spill guard has a tear in it and the spill guard leaks. After the tank comes off rent, the tank, spill guard, and mat are all brought back to the yard and the spill guard and mat are cleaned before being rolled up and put away for next use. The system being designed will make this process of cleaning and rolling mats more efficient. For preliminary design The Steel Construction Manual was used to look at stresses that would be put on the piece of equipment in order to size steel. After looking at load calculations 2x2x1/8" high-speed steel was the optimal steel to build the washing system out of.

After finding the correct sprayers for the application a pipe designation was needed. Looking at pressure from the nozzles and clamps, and doing research from ("PVC Pipes - Pressure Ratings.") 1" schedule 40 pipe was determined to be the optimal pipe for the cleaning process. Figure 4 gives a representation of the pressure ratings that were taken into consideration during pipe sizing and durability.

Table 1. Pressure ratings for PVC Pipe (- Pressure Ratings. Web. 1 Dec. 2015.)

PVC				
Nominal Pipe Size (inches)	Required Minimum Burst Pressure (psi)		Maximum Operating Pressure (psi)	
	Schedule 40 ¹⁾	Schedule 80 ²⁾	Schedule 40	Schedule 80
1/2	1910	2720	358	509
3/4	1540	2200	289	413
1	1440	2020	270	378
1 1/4	1180	1660	221	312
1 1/2	1060	1510	198	282
2	890	1290	166	243
2 1/2	870	1360	182	255
3	840	1200	158	225
4	710	1110	133	194
5	620	1040	117	173
6	560	930	106	167
8	500	890	93	148
10	450	790	84	140
12	420	600	79	137

While doing research on the roller and alignment system, professor Holtz suggested looking into fruit conveyor systems and how they worked. Shibuya Seiki Company is a fruit processing system company that designs and builds processing systems. Looking at their conveyor systems and sorting systems helped in the design of the mat cleaning system. After analyzing the tray conveyor and pin sorting system the alignment bar was designed. The tray conveyor sorted each individual piece of fruit into its own tray that was then sent where it needed to go based on size and weight. The conveyor for the trays ran on small chain driven rails that had sprockets on either end that kept them

moving at a steady pace. For the alignment bar, the decision was made to build an alignment system that could mimic these chain roller systems that would keep the mats from rolling up and being off center.

Another major part of the project that needed to be analyzed was the spraying system. Research was done on car wash assemblies and spraying systems which were analyzed to see if there is a similarity that could be used with the washing portion of the system that is being built. For this application an article was found on a home car wash system that was found beneficial for pressures needed in order to make the washing portion of the mat cleaning system work well. Jeffrey Yago the publisher of the article stated he used a fifteen hundred psi pump with standard pressure washer hose and nozzles to make his home car wash run efficiently. The water source that is normally used at Rain for Rent branches is a fire hydrant that is on the premises. Therefore research needed to be done on how much pressure and what flow rate could be obtained through that. The testing will be done at several different branch locations across the U.S. but the Bakersfield branch was used as an example for this portion. After contacting the city the flow rate and pressure given on that specific hydrant was approximately 65psi with 600 gallons per minute. Those were the parameters that were used for the design of the spraying and cleaning system the mat roller would use.

PROCEDURES

Some branches such as branch 75 in Denver Colorado have already come up with a design and built a piece of equipment to roll mats which they believe is more efficient. Rain for Rent would like to create a new piece of equipment that is standardized across the country that will be more efficient and promote safety. Figure 3 is design that Branch 75 in Colorado came up with. This was the basis for the new design for the cleaning and rolling system.



Figure 3. Branch 75 Design for mat roller.

For preliminary research the New Product Development team took a sample of twelve branches that have the largest spillguard inventory and gave them a list of questions to answer to see if the need for a piece of equipment built will even be useful. After receiving a substantial amount of feedback the preliminary design was started.

The base design was copied from the model Branch 75 in Colorado came up with. From that design an initial design was created of how the system would work. Figure 4 shown below shows the preliminary auto cad drawing that was designed to understand how this piece of equipment would work.

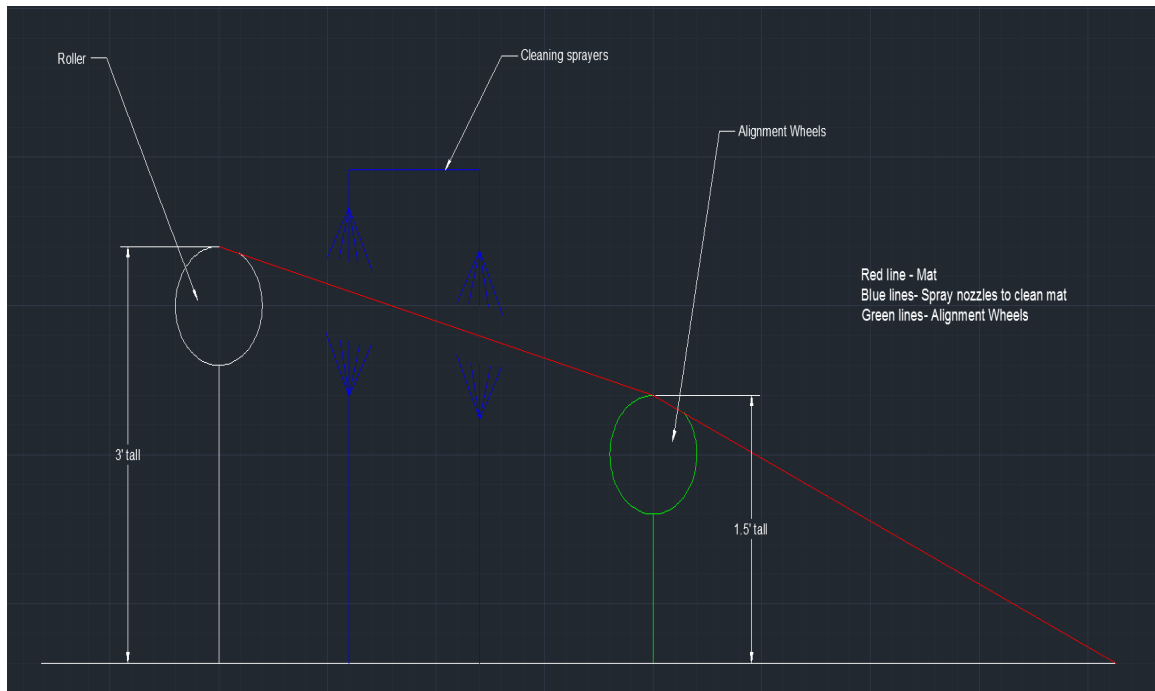


Figure 4. Initial auto cad drawing of system.

After review by the head of the new product development department, the design team came up with this as the base idea for how the system should work and perform. After this initial design there were many meetings and conference calls with operations managers from all across the country to see what initial changes needed to be made to make the application more efficient and realistic. The majority of the feedback that was used had to do with the idea of how the mats will be taken off the roller and how they will be attached to the system to go through the system without trouble.

Once the initial design was complete, the frame for the cleaning system was designed. A trip was taken to Branch 31 in Bakersfield to take dimensions and weights of the mats, all mats are standardized across the company so all mats are same width and length. Parameters were set that the roller has to hold a capacity of one hundred and fifty pounds; that is the average weight for the mats. The mats are five foot wide and fifty foot long.

Taking all of the parameters into consideration the next step was to design the base frame for the system. The frame was designed in solid works out of 2x2x1/8" tubing. Since the frame is built out of such strong tubing there are forklift pockets incorporated in the frame so that it will make it much easier to move

around the yard. The forklift pockets are made out of 4x8x1/8" tubing. Figure 5 shows the frame with forklift pockets drawn up in solid works.

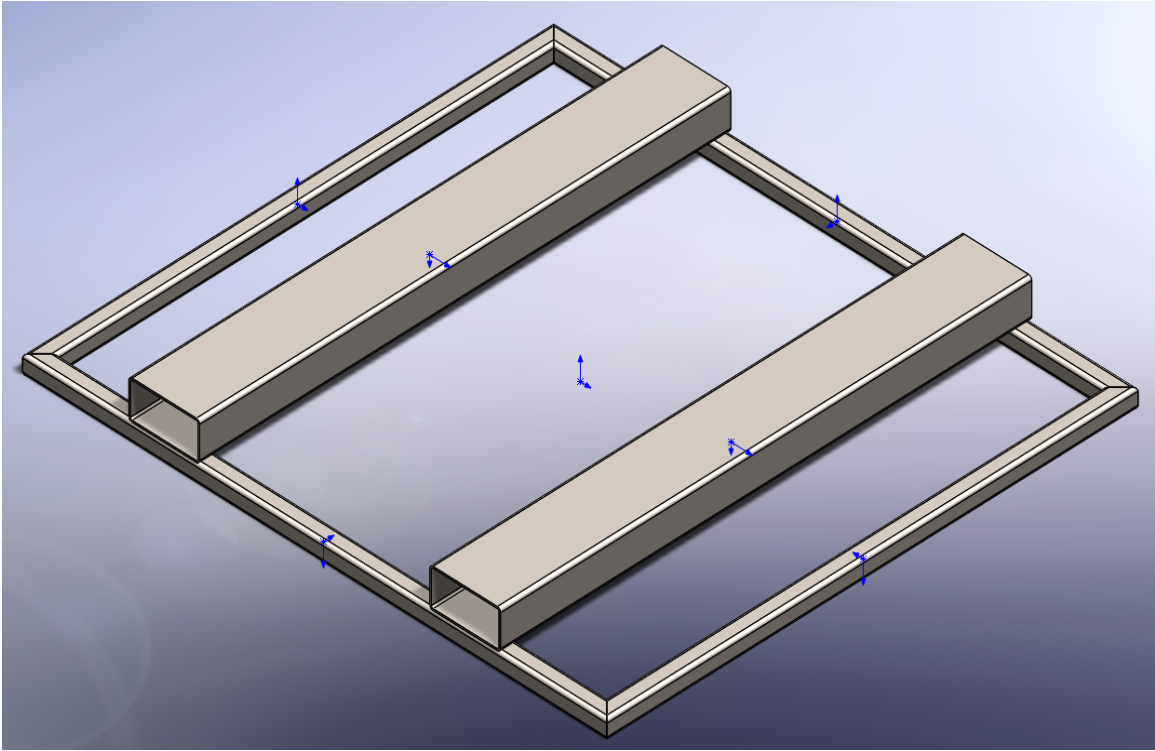


Figure 5. Solid Works Frame with Forklift Pockets.

After the initial framework was drawn up on solid works, individual components were then drawn and added to the assembly starting with the mat alignment bar. The mat alignment bar was drawn within the parameters that the mats must be able to roll across the alignment bar without snagging or tearing and the bar must align the mat within the system so at the end roller the mat is rolled uniformly every time. The supports on the side of the bar and the middle beam are all made of 2x2x1/8" tubing and the aligning components will be cut out of a 3x5x1/8" plate. Figure 6 shows the solid works design that was drawn for the mat alignment bar that will be used for the application.

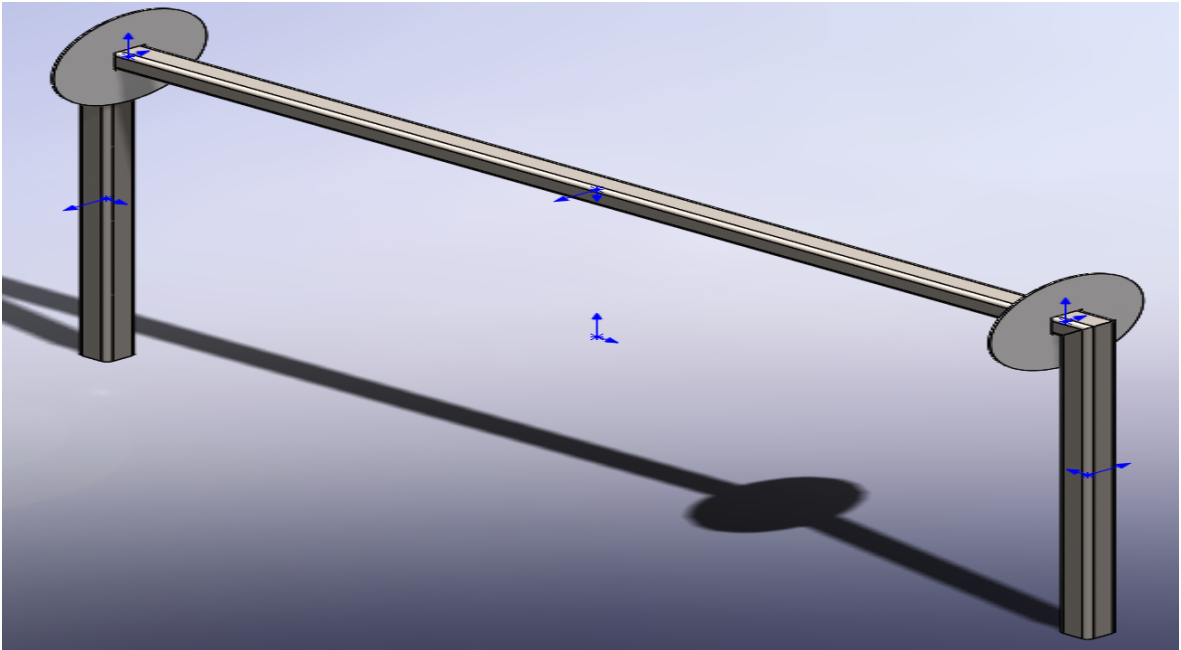


Figure 6. Solid Works for Alignment Roller.

The next step in the process was to design the washing bars. The initial washing bar was designed and then the second bar mirrored and the height of the second bar will be increased by one foot. This system was made out of 2x2/1/8" tubing that will be cut at 45 degree angles and welded together. Figure 7 Shows the solid works drawing for the washing bars.

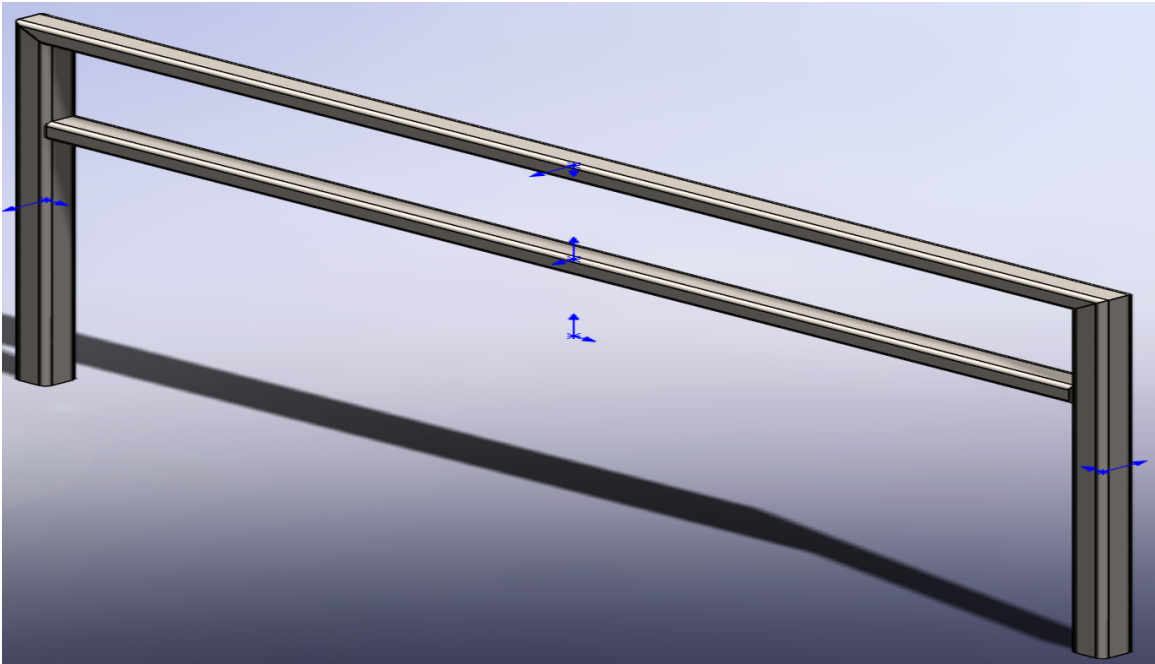


Figure 7. Solid Works for Washing Bars.

The final bar that needed to be designed was the bar that will hold the roller at the end of the system. That bar was also drawn on solid works and was made out of 2X2X1/8" tubing with angle iron slotted on the top so the roller will hold in place while the mat is being washed and roller. Figure 8 shows the solid works drawing for the rolling bar.

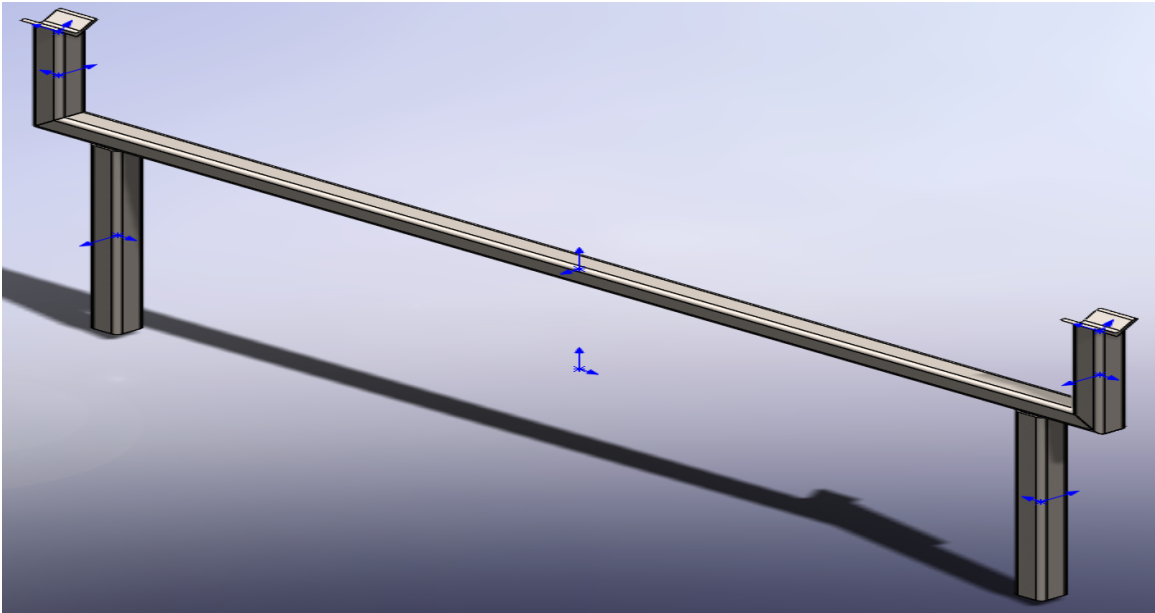


Figure 8. Final Bar for Roller.

For the rolling mechanism an assembly was drawn up on solid works. 2x2x1/8" tubing was used for one side of the roller while 1.5x1.5x1/8" tubing was used for the other side. In the solid works drawing it can be seen that pins will hold these together and the 1.5x1.5x1/8" tubing can collapse into the 2x2x1/8" so that way you can pull the rolling mechanism out of the middle of the rolled up mat. There will also be two pieces of 1.5" steel pipe welded to each side so that the roller will sit down inside the angle iron. Figure 9 shows the rolling system designed on solid works. Cable will be hooked to the eyes in the middle of the bar with alligator clamps in order to be able to pull the mats through the system.

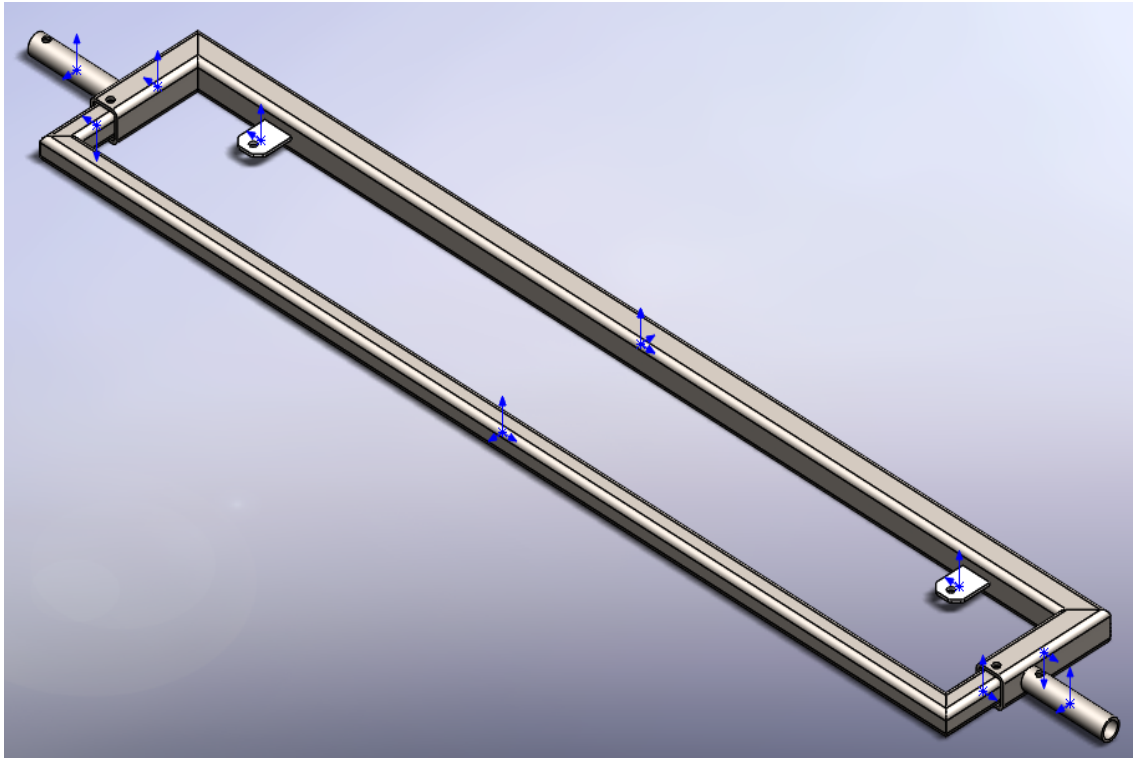


Figure 9. Rolling mechanism.

The final portion of the design was to design a handle for the roller. The roller is made out of 1.5" pipe that can be attached using a pin to the pipe on the roller. Figure 10 shows the solid works drawing that was used for this.

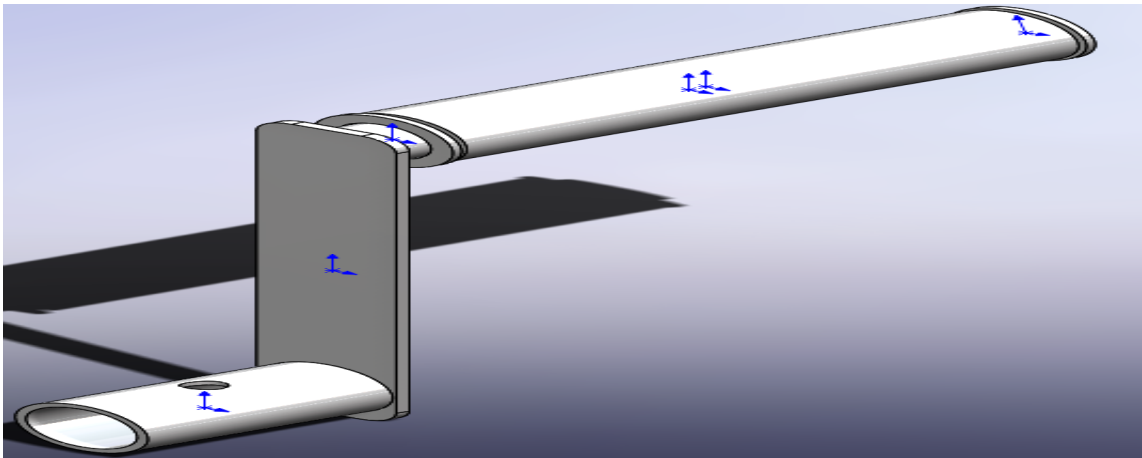


Figure 10. Handle for roller

The finished assembly was put together using solidworks. Figure 11 shows the finished assembly.

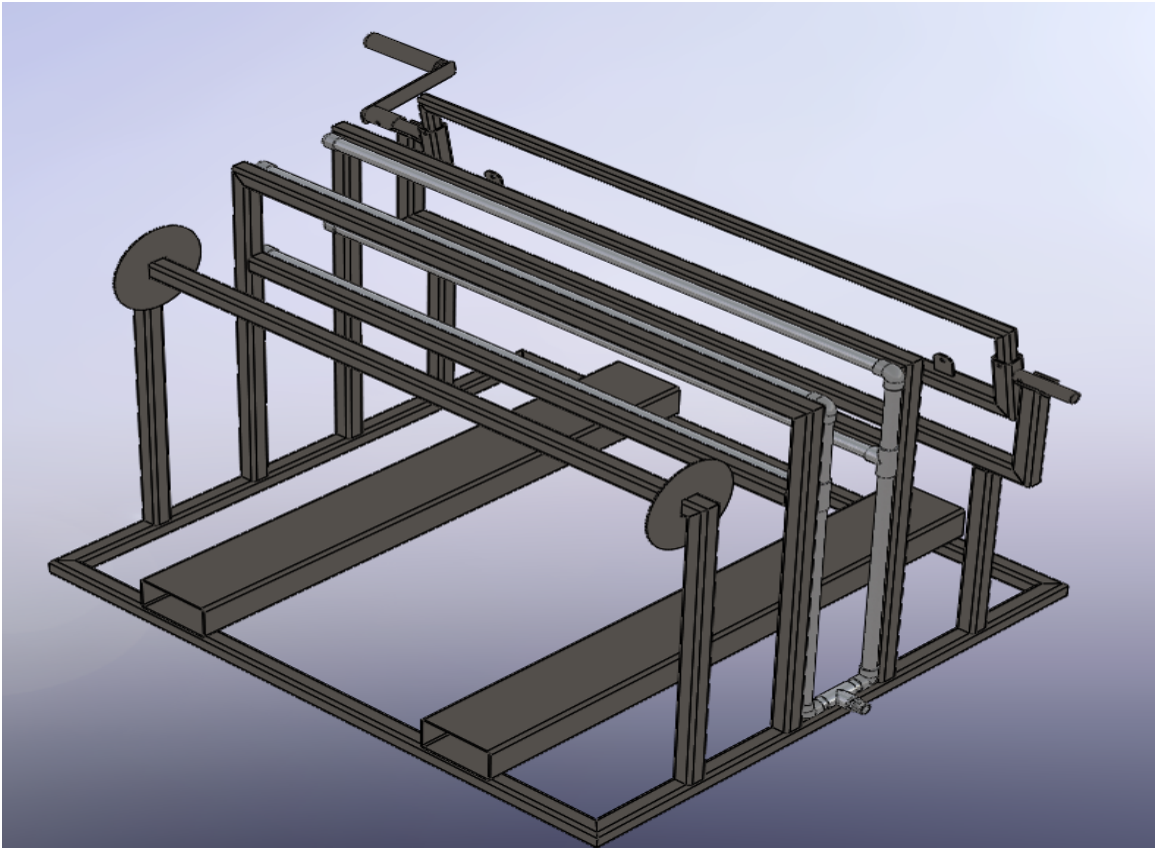


Figure 11. Finished assembly

In the finished assembly the pipe was added that the nozzles attach to just to be able to visualize what the system will look like. The pipe will be pvc pipe when being first built and doing testing and if the system works more efficient then possible steel pipe will be looked at to take place of pvc to increase longevity. The most difficult part of the design being done has been to find the optimal spray nozzles for the application. After speaking with J.P Robinette and Ken Kross they directed towards looking into car wash systems because they wanted to see the washing and rolling system kind of mirror the design of a car wash assembly. Spray.com has a very large inventory of different kinds of spray nozzles, which could be used for this application. With the mat being 5' wide the design for the spraying system was found to be 5 nozzles per head on 20" centers. The optimal sprayer for this application would be the Pro Max Clip Eyelet spray nozzle with a 65-degree nozzle in the sprayer. At 8" vertical spacing to the mat this nozzle will evenly distribute 60psi to the mat surface while using a flow rate of 6gpm through each nozzle. These sprayers can be implemented onto PVC pipe as well as steel pipe, which makes them very versatile if testing this product proves it should be implemented into the Rain for Rent fleet. The clamps

that will be used are also from spray.com. The clamps are a double clamp system that has a pressure tolerance of 150psi, which is more than double the operating pressure of the nozzle.

After the final design for the cleaning system was approved it was time to build the project. After the bill of materials was ordered a cut list was created in order to stay more organized while cutting out all of the material. See table 2 below.

Table 2. Cut list for senior project.

Cut List for Senior Project				
Components	Quantity Cut	Length inches	Size Tube	Cut Angles
Frame				
	2	60"	2x2x1/8	Two 45 angles
	2	66"	2x2x1/8	Two 45 angles
	2	60"	8x4x3/16	Two square ends
Alignment Bar				
	2	36"	2x2x1/8	One 45 angle
	1	66"	2x2x1/8	Two 45 angles
	2	10" Circles	1/8 Plate	
Washing Station 1				
	2	42"	2x2x1/8	One 45 angle
	1	66"	2x2x1/8	Two 45 angles
	1	60"	2x2x1/8	Two square ends
Washing Station 2				
	2	42"	2x2x1/8	One 45 angle
	1	66"	2x2x1/8	Two 45 angles
	1	60"	2x2x1/8	Two square ends
Roller Frame				
	2	22"	2x2x1/8	Two square ends
	2	12.5"	2x2x1/8	One 45 angle
	1	74"	2x2x1/8	Two 45 angles
Roller				
	1	67 5/8"	2x2x1/8	Two 45 angles
	2	8"	2x2x1/8	One 45 angle
	1	67 1/2"	1.5x1.5x1/8	Two 45 angles
	2	6"	1.5x1.5x1/8	One 45 angle
	2	6"	1" Pipe	Square ends

After the cut list was produced all of the steel was cut on a Marvel vertical band saw. Each cut was made using precision taking measurements and verifying them before any cutting took place. Each piece was cut out individually. After all of the pieces were cut they were transported to the shop where fabrication began. The figure below shows an example of how the steel was cut out on the Marvel saw.



Figure 12. Cutting material on the marvel saw.

The first step in the fabrication process was to build the lower frame. In order to do this each component going into the lower frame had to be beveled in order to fit together well. After each component was beveled the frame was squared up. This was done by using a framing square in the corners and finding when each piece was exactly at ninety degrees then clamping it down so it did not move. After squaring the lower frame a level was used to make sure each piece was sitting flush with each other so the frame would be exactly square and level. Figure 13 below shows an example of how this was carried out.

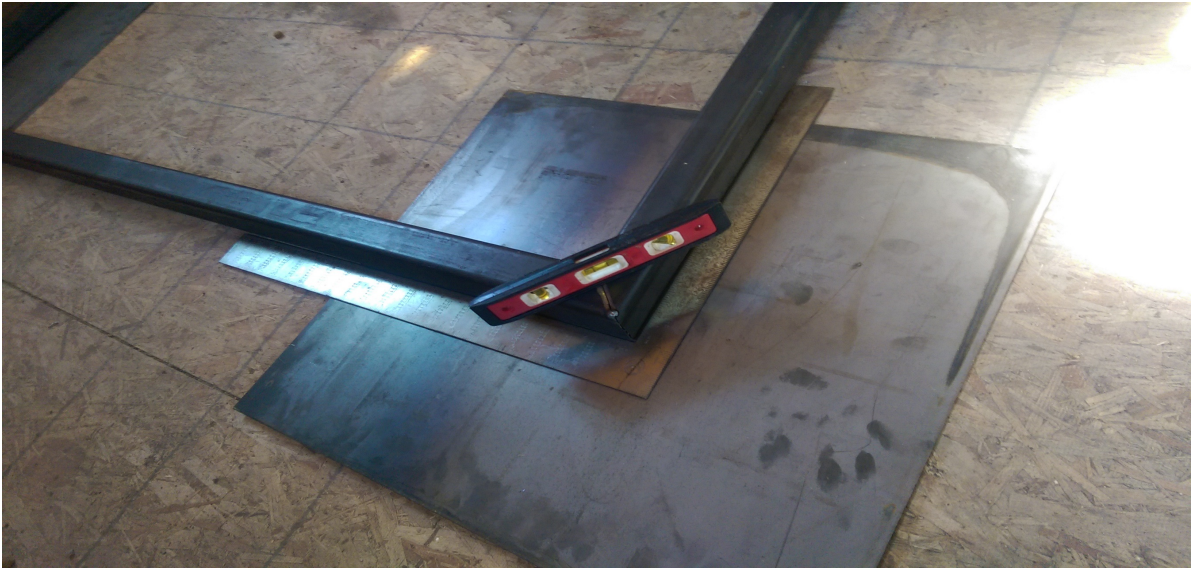


Figure 13. Squaring and leveling bottom frame.

Once the lower frame was squared, leveled, and clamped down to hold its position four tack welds were placed in each corner to hold the frame together. After the tacks were done the beveled edges were welded starting in one corner and following with the opposite corner opposite side to prevent the metal from distorting. Figure 14 below shows an example of how the welds were done.



Figure 14. Welding frame together.

Once all the beveled edges were welded the fillet welds on the inside were done and the outside welds were done as well. Then all the beveled welds were ground down flush so the lower frame could be wiped down and would be ready to be painted. Figure 15 shows an example of the finished product once the beveled welds were ground down.



Figure 15. Grinding welds flush with tubing.

Once the frame was welded together in order to make sure the frame was square, diagonal dimensions were taken in order to ensure the frame was square. The tolerances for this project were within 1/8".

The second step in the fabrication process was to build the two washing station frames. One washing frame was built then the second frame was to be matched to the first. To begin this process the cross member was squared with the vertical bars with a framing square and speed square. Then the upper portion was tacked together. Then a measurement was taken twenty-two inches from the bottom and was marked using soapstone. After the mark was placed the middle cross member was tacked in place. To avoid distortion the bar across the bottom was tacked before the frame was welded out so the metal vertical members would not bow. Figure 16 shows an example of how that was done.



Figure 16. Washing stations tacked together.

Once the two washing station frames were welded together, all beveled welds were ground down flush with the steel.

For the alignment bar a few different procedures were needed. First the plates that will keep the mats aligned needed to be cut out on the Plasma cutting machine. In order for this to take place an auto cad drawing of each circle had to be drawn. The circles were drawn with an eight-inch radius with two and one eighth inch squares cut out of the center so they could be welded on to the square tubing. Once the auto cad drawing was finished it was saved as a dxf file, which got transferred to the plasma cutter. Ten-gauge steel was used for the circles. Figure 17 below shows the circles being cut out on the plasma cutter.

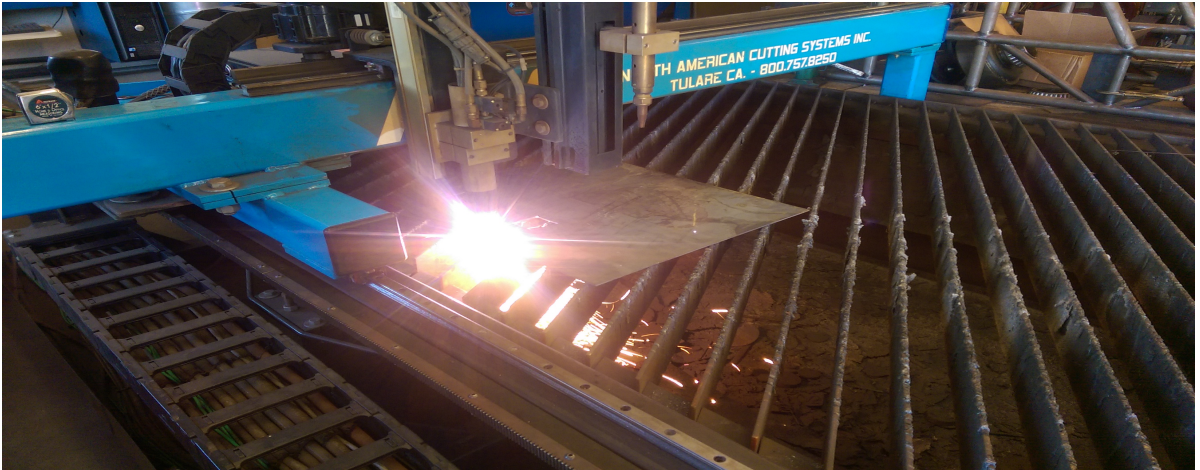


Figure 17. Cutting out circles on plasma cutter.

After the holes were cut out the alignment bar station could be built. The frame for the alignment bar mimicked the washing station frame. The alignment bar was made thirty-six inches tall so the mat is centered while going through the washing stations. The corners of the tubing were squared up and welded together, then the circles were welded on the inside. Figure 18 shown below is the finished alignment bar.



Figure 18. Finished alignment bar

The roller frame was a very key aspect of the project. During the build the roller frame was made wider than the bottom frame in order for the roller to be able to roll and stay in the middle of the alignment bar. Two supports were welded to the bottom of the frame then a cross member was welded to those. After that process was done, the two uprights were built. These were cut at a forty-five degree angle and welded to the ends of the cross member in order to make the frame for the roller to sit in. Figure 19 below shows how the cross member was welded to each support and the frame was built.



Figure 19. Initial roller frame welded to bottom frame.

After the initial roller frame was built forty-five degree cuts were made in the top of the tubing and angle iron was welded in to keep the roller seated while rolling was taking place. Gussets were also welded to the bottom supports in order to strengthen the roller frame because the rolling process creates quite a bit of stress on that part of the frame. Figure 20 below shows the finished roller frame.



Figure 20. Finished roller frame.

The build of the roller assembly was very unique. The first thing that needed to be done was to cut the two cross members that would act as the main roller assembly. These pieces were cut at forty-five degree angles on each side and were sixty-six inches long. The first cross member was cut out of 2x2 steel while the second cross member was cut out of 1.5x1.5. The idea for this is that once the mat is rolled up the roller assembly can collapse and be pulled out from the middle of the mat. After the cross members were finished, two pieces were cut out of 1.5 inch tubing and two pieces were cut out of 2 inch tubing. Each of these pieces were cut at a forty-five degree on one end and left square on the other.

These pieces were then welded to the cross members. See figure 21 below to show an example.



Figure 21. Tube welded to cross member on roller.

After this was done, each cross member was drilled with a 9/16" hole in order for pins to be able to be put through to hold the whole assembly together. Figure 22 below shows the steps taken to do that. First the center of each member was marked out using a grey pencil and marker, and then these were center punched and drilled.



Figure 22. Layout of holes being drilled.

For the final portion of the assembly, handles were welded on to the rolling mechanism. These handles were constructed out of one-inch pipe that was cut to seven-inch lengths. Also, the tabs welded to the inside of the assembly were used in order to hook cable that runs through the system with clamps in order to grab the mat at the beginning of the process. Figure 23 below shows the finished assembly.



Figure 23. Finished roller.

The pvc assembly portion of the project was the least labor intensive. The first thing that was done was cutting four cross members each five and a half feet and gluing caps to each of them. The second step was marking the spacing for the sprayers and drilling a 9/16" hole where each was marked so the sprayer assemblies could slide on. The sprayers have rubber seals to seat in the hole to make sure there is no leaking around the holes. Figure 24 below shows an example of the sprayer assembly.

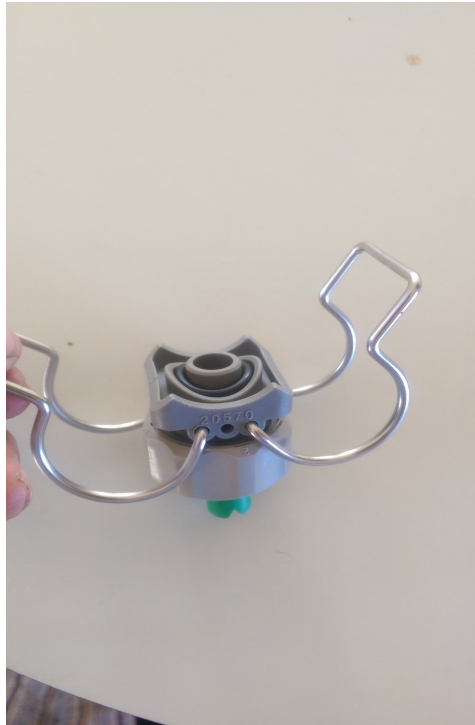


Figure 24. Sprayer assembly

The clamps that were used will hold up to 150psi. After each of the sprayers were attached ninety degree elbows were glued to the top two members and tees were glued to the bottom two. Pipe was then glued from the elbows to the tees in order for water to flow through everything. At the bottom of the washing station all four members came into one ball valve that was then adapted to a camlock fitting in order to hook up to a hose that went to a hydrant. Figure 25 below shows the finished pvc fittings put together and mounted to the frame.

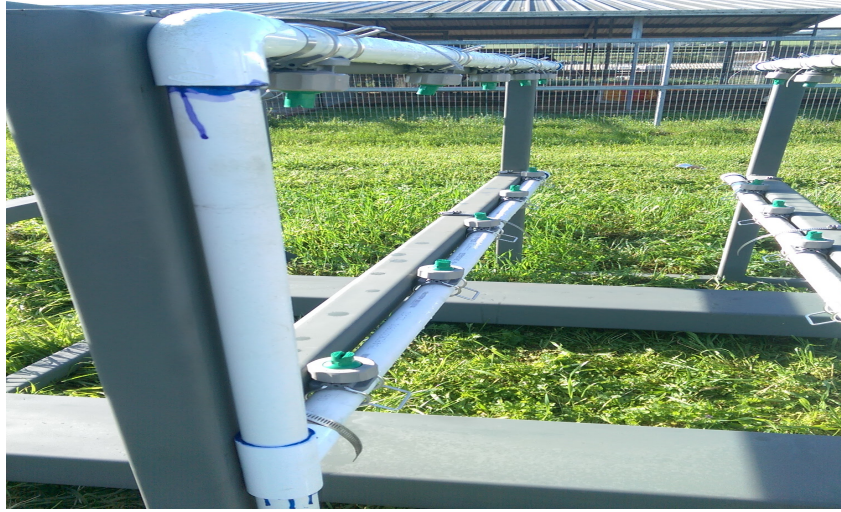


Figure 25. Finished pvc assembly.

RESULTS

After the build was finished, testing was done. For testing purposes, the cleaning system was run ten times plugged in to a water source. Taking an average of the time it took from start to finish the mat cleaning system only took seven minutes to wash, roll, and put away. This is on average eight minutes faster than any three man crew that was washing the mats in the past. Also, instead of needing a three man crew for this specific task the job was able to be done with just a two man crew. Using a two man crew meets the objective criteria because it will cut down the cost of labor hours that can not be billed to the customer.

The spraying mechanism worked very well. The initial washing station removed mud from the top and bottom of the mat that was not stuck, and soaked the mud and chemicals that were caked on. The second washing station removed the rest of the debris that was left on after going through the first station. Four sprayers were used on the first washing station and five sprayers were used on the final washing station to ensure that the coverage of the mat was uniform. Adding a fifth sprayer on the final washing station allowed for the uniformity to be better spread because the final washing station had a smaller center to center distance, which allowed for the final washing station sprayers to be off center from the initial sprayers improving the uniformity. Below are a few figures that show the finished product and how it works.



Figure 26. Finished built assembly.



Figure 27. Rolling and washing mat.



Figure 28. Washing and rolling assembly.



Figure 29. Mat rolled on roller.



Figure 30. Rolling assembly.

DISCUSSION

Safety:

Looking at the mat cleaning system from a safety stand point, there are advantages and disadvantages. Some advantages in safety that the new system brings to the table is less bending and lifting, more uniform lifting, and less labor all together. The idea of less bending and lifting is decreased by the height of the roller. Since the mats are being rolled forty inches off the ground the employees do not have to bend over to the ground to pick up the mat. Since the mat is forty inches in the air it is considered in the "power zone" by OSHA requirements. The second advantage of more uniform lifting is seen by the handles that were put on the roller. In the past, employees had to stick their arms inside the mat in order to pick it up. With the addition of the handles this gives the employees that are doing this process all day a safe and secure place to hold when moving the mats around. The final advantage to safety the cleaning system has is it uses less labor. The rolling and cleaning process now takes a three man crew, with the new cleaning system Rain for Rent will only need a two man crew. Since the labor crew is cut down by one man this gives an advantage to safety because it is one less employee that could potentially get hurt.

There are a few disadvantages of the cleaning system as well. Eventually if there is an electric motor that runs the roller the system will have to be guarded. Also the mats need to be cleaned inside a spill guard in order to trap the waste water so that it does not pollute any nearby storm drains.

Testing:

After testing was done, results found that the time it took to complete the process using the mat cleaning system took half the time as the system being used right now. This is a very crucial aspect of efficiency when looking at costs of labor. One of the main objectives of this project was to be able to decrease the amount of money spent on non-billable hours. Testing shows that this piece of equipment will do that in two ways. The first was is by cutting the time of the process by half. This means that almost twice as many mats can be done in one day as there are right now. The second is with the new system Rain for Rent only needs two employees working on the process a day instead of three. During a normal eight hour day the price charged to the customer for one employee is \$45 per hour. With this process only needing two people, this gives the opportunity for each branch to make an average of \$360 more a day with that employee being able to go work where his hours can be billed to the customer.

COST ANALYSIS:

When looking at this project in terms of cost, refer to tables below to look at the cost of materials.

Table 3. Cost of parts.

Cost Analysis for One Piece of Equipment:			
Parts List	Quantity	Price Per ft./ Fitting	Line Cost
2X2X1/8 tube	85	\$ 4.26	\$ 362.10
8X4X1/8 tube	12	\$ 8.43	\$ 101.16
3X5X1/8 plate	1	\$ 6.25	\$ 6.25
angle iron	2	\$ 4.62	\$ 9.24
Sch40 1" Pipe Steel	30	\$ 0.39	\$ 11.70
1" Sch40 Caps Steel	4	\$ 1.33	\$ 5.32
1" Sch40 Elbow Steel	4	\$ 1.81	\$ 7.24
1" Sch40 Tee Steel	3	\$ 2.64	\$ 7.92
1" Sch40 Coupler Steel	1	\$ 2.16	\$ 2.16
1/2" Steel Braided Cable	20	\$ 1.58	\$ 31.60
1/2" Clevis Shackle	2	\$ 8.20	\$ 16.40
1" Sch 40 pipe on hinges	2	\$ 10.00	\$ 20.00
1" #6540 Nozzles Double Clamp Assembly	20	\$ 4.54	\$ 90.80
Hitch Pins	3	\$ 4.79	\$ 14.37
1.5" steel Pipe on handle and knuckle	2	\$ 145.66	\$ 291.33
1.5X1.5X1/8 tube	8	\$ 2.41	\$ 19.28
Alligator Clamps	2	\$ 9.47	\$ 18.94
		Total	\$ 1,015.81

Table 4. Cost of labor.

Cost Analysis For labor :			
	Hours	Price per Hours	Total
Assembly / Welding Labor	10	\$ 90.00	\$ 900.00
Engineering / Design time	8	\$ 100.00	\$ 800.00
		Total:	\$ 1,700.00

Table 5. Total cost analysis.

Total Cost:	
Labor:	\$ 1,700.00
Matierals Cost:	\$ 1,015.00
Total:	\$ 2,715.00

After analyzing these three tables, the total cost for the project is \$2,715.00. With over fifty branches in the United States this translates to just over \$140,000 to implement this system at each branch across the U.S. Since the going rate for an installer is \$45 per hour it would take just over sixty hours for this piece of machinery to pay for itself. After the first system was built, the design costs would be subtracted from that total cost which would make the system even cheaper. Since it only takes sixty hours to pay for itself, this system would be very economically reasonable to build and implement at each branch. This would cut down non-billable hours and allow employees to work on other jobs that help bring the company revenue.

RECOMENDATION

To make the mat cleaning system less labor intensive an electric motor could be added in place of the hand crank. If the electric motor is added to the system there must be precautions taken to properly guard all the moving parts of the mechanism.

Another recommendation that could be made is to turn the whole system vertical. Turning the mat cleaning system vertical would decrease the overall foot print of the system, which could ultimately make it lighter and easier to move around. Another big advantage of turning the system vertical would be the sprayers would wash the system vertically so all the debris would run straight off the mat before being rolled up. One big advantage of this would be the debris would not run down the rest of the mat potentially blocking debris that is caked on later on down the mat.

Adding two more sprayers on the front washing station would also help get better water distribution over the mat when cleaning is taking place. There are four sprayers on the initial station and five on the second washing station. If you added two more sprayers on the front station the water being sprayed across the front washing station would reach completely across the mat.

The last recommendation would be to use some sort of clevis instead of the alligator clips on the rolling mechanism. If holes were drilled in the mat and the clevis' could be attached to the holes, it would make the mat easier to initially roll over the alignment bar. The alligator clips that are used now sometimes get stuck when going over the alignment bar and the employee must manually get the mat across the alignment bar before going through the washing stations.

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APPENDIX A

How project meets requirements for ASM Major:

<p>ASM Approach - Agricultural Systems Management involves the development of solutions to technological, business or management problems associated with agricultural or related industries. A systems approach, interdisciplinary experience, and agricultural training in specialized areas are common features of this type of problem solving. While technical in nature, this approach must also have a clear and present emphasis on planning and management of time, people, and other resources.</p>	
Systems approach	The project involves the integration of a design and build with economic analysis and creating a design that will be most efficient in the application installed.
Interdisciplinary features	The project touches on aspects of mechanical systems, agricultural safety and cost and time management.
Specialized agricultural knowledge	The project applies specialized knowledge in the areas of mechanical and fabrication systems, agricultural safety, and cost analysis.
<p>Design Parameters and Constraints - The project should directly or indirectly address the categories constraints listed below. If not directly applicable, it must be described how these constraints could become a consideration after project completion.</p>	
Physical	The overall footprint of the cleaning system is 5.5'wide by 5' long.
Economic	The cost of manufacturing with design time and labor would be roughly \$2,715. It would take roughly 60 hours of employee labor to pay for the build.
Environmental	The mat cleaning system will cut down on the overall amount of water used by eliminating human error. This will be done by a valve that is turned on and off only when the mat is run through the cleaning stations.
Sustainability	The cleaning system could reuse water out of the spill guard if a small submersible pump was used to bring water back to the system.
Manufacturability	Since the cleaning system is made out of square tubing, manufacturability is very user friendly.
Health and Safety	The cleaning system reduces the amount of lifting and bending being done by the employees as well as gives them better handles when doing their lifting and bending.

Ethical	The cleaning system will be safer than the process being used now.
Social	The efficiency of the cleaning system will now allow for non billable hours to be reduced.
Political	Reduce overall water consumption by only running while mats are being cleaned instead of the hose constantly being turned on.
Aesthetic	The finished system will be primered before taken to Rain for Rent where they will paint it Rain for Rent blue.