All-Terrain Vehicle Sprayer

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Bachelor of Science

in Mechanical Engineering Technology

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ABSTRACT

The motivation for this project was to save me time, money, and effort. My family lives on a farm. It is my job to spray the yards, driveways and gardens for unwanted weeds. I am currently using backpack sprayer, which is tiring and time consuming. A backpack sprayer is a sprayer that you wear like a book bag. There is a pump for one hand and the other hand holds the spray nozzle. I would like to purchase an All-Terrain Vehicle sprayer. However, ATV Sprayers are expensive and are hard to find with all the features to decrease time, effort, and improvement. I will first be doing research to find what methods are already used and how I can better improve these. I will then design a sprayer to include all the features necessary. I will be using Autodesk Inventor 2018 for my project. This program can easily do part models, part drawing, assembly models, assembly drawings, and any finite element analysis necessary. For the manufacturing, the ATV sprayer will all welded, bolted or pinned together. Some parts will be pinned together for easy assembly/disassembly. There will be multiple different features included on this sprayer. The sprayer will have 20-gallon tank, 2.0-gpm motor and spray tips, and a garden hose attached with a spray nozzle. All of these features are included to decrease the time required to complete the job. The sprayer will also have an ON/OFF switch located by the driver, nozzles to turn different sections of the booms on or off; the sprayer will sit on the back of the ATV rack, and have another valve that will allow the operator to agitate the tank. All of these features are included to decrease the effort of the operator and increase the improvement of the job. Finally, the ATV sprayer will also have breakaway booms and adjustable boom height. These are included to control drift as wanted and help protect the ATV from accidently hitting any objects when operating.

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

Yards, fields and driveways are tiresome to spray with a backpack sprayer and sometimes are too small of an area to use a standard All-Terrain Vehicle (ATV) sprayer. I want to make a sprayer that is easy to maneuver, easy to use, and gets the job done quickly.

BACKGROUND

ATV sprayers are sprayers that will connect to an ATV to make spraying an area easier and quicker. The sprayers can attach to the ATV in a few different ways. It can attach on the back of the ATV as pull along sprayer. The problem with this type is that they can be hard to maneuver and do not offer a spray nozzle for being able to hit selective areas. Another kind of ATV sprayer is on that will sit on either to front or back rack on the ATV. The problem with this kind is easier to maneuver and usually offers a hose for being able to hit a specific spot. However, the sprayer sits higher up so it is more prone to having a lot of drift if it is a windy day. ATV sprayers are nice for a few reasons. They can cover a lot of area in a little time. The person operating the sprayer also does not have to carry the sprayer and walk the area they want to spray. However, you could be over spraying an area and wasting the liquid if the area being sprayed is smaller than the width of the booms. Sometimes the area will be too small or too tight for an ATV sprayer. Backpack sprayer are nice because they can get small areas and the spray is more controlled. However, if you want to spray a large area it will be tiresome and take a long time to complete.

RESEARCH

SCOPE OF THE PROBLEM

I want to combine the ATV sprayer and backpack into one sprayer. I am addressing this problem because currently I am the one who needs to spray the yard, driveways, and small sections of our family's fields and gardens. Currently I use a backpack sprayer, which is tiresome work. An ATV sprayer would make the job a lot easier. The sprayer cannot have to be a controlled spray so crop, grass, and flowers do not get killed form overspray.

CURRENT STATE OF THE ART

Currently there are models that have the ATV sprayer and backpack spryer combined into one unit. Crop Care makes a sprayer that is attached to the back of an ATV. This is one of the best sprayers currently in production. It sits on the back of the ATV so it is easy to maneuver. There is a hose attached to it with a long 14 feet hose. The tank is 25 gallons so it can last a while before you will need to fill up again. The booms are 160" and have breakaway protection. The sprayer runs on a 3 gallon per minute pump that operates from the 12-volt battery on the ATV. (1) Horse Tack makes a similar sprayer. The tank size is the same and the pump runs the same as Crop Care. Horse Tack has a spray hose attached that is 15 feet long. The motor sprays at a rate of 2.1 gpm and the booms are 140". The downside is the booms do not have breakaway protection. (2) Top Air makes a sprayer that is a pull behind model. This model is quite different compared to the first two. The tank is 200 gallons

equipped with a 5.5 horsepower Honda Motor. The booms are either 45 feet or 60 feet. There is not a hose attached. (3) Rural King makes a sprayer similar to Crop Care and Horse Tack. The biggest difference is there is no booms. There is on nozzle on the back that covers 16 feet. There is a hose attached for being able to hit specific areas. There is a 15-gallon tank. The pump runs of the 12-volt battery on the ATV and sprays at a rate of 2.2 gpm. (4) Superior Industries offers a sprayer that only has a hose and no booms. It has a 15-gallon tank, 10-foot hose, sprays at a rate of 1.5 gpm, and runs of the 12-volt ATV battery. (5)

END USER

The end consumer needs a sprayer that is easy to assembly onto an ATV, easy to use, is efficient, and can get the job done correctly in a timely manner. The major target audience are going to be a person who owns a lot of land. This could be crops, grass, driveways, or gardens. They will be a man or woman older than 16 who has a lot of land to spray. They will also be able to drive an ATV. They will be someone who does not want to or cannot carry a backpack sprayer. They will also be someone who does not have a lot of time to walk all their land to spray it with a backpack sprayer. They are expecting a sprayer that is easy to maneuver and can quickly get the job done. The end user will also want a sprayer that is efficient and can easily get specific areas.

CONCLUSIONS AND SUMMARY OF RESEARCH

A few common themes are an ATV sprayer that also has the concept of a backpack sprayer included. This ties into my customer because they will want the speed offered by the ATV sprayer but the accuracy of the backpack sprayer. All the sprayers have a decent sized tank. This is good for the customer because if they are covering a large area they will not want to have to keep stopping to fill the tank. There are two main types of ATV sprayer available. One is a pull along model that hooks up to the ATV with a hitch. The other is a model that sits on the back of the ATV with the booms hanging off the back. The ones that sit on the back of the ATV seem to usually be a little smaller compared to the pull along models. This would be nice for a costumer covering a lot of ground but is not very practical for spraying yards and gardens.

CUSTOMER FEATURES

From research online, there has been a few features that the costumers think are important. The following are the feature, with their respected weight: easy to maneuver (.15/1.00), has breakaway booms (weighted 0.10/1.00), has appropriate boom length (weighted .15/1.00), has an easy to use ON/OFF switch (weighted 0.15/1.00), has an attached spray hose (weighted 0.20/1.00), has drift control (weighted 0.15/1.00), and has a large tank (weighted 0.10/1.00).

PRODUCT OBJECTIVES

To address to ease of maneuvering I want to make a sprayer that attaches to the back rack of the ATV. This will be better than attaching it as a pull along model for backing up purposes. I want to make the booms able to breakaway in case of an accident. The boom length will be similar to current models already made. The ON/OFF switch will be in an easy to use place for convenience. I plan to attach a hose that is at least 10 feet long for controlled spray. To

help with drift control I want to make the boom height adjustable. This will get the spray closer to the ground on a windy day. Finally, I want to attach at least a 15-gallon tank.

QUALITY FUNCTION DEPLOYMENT

			Engineering Requirements (units)														**Customer Satisfaction Rating** (0.00 - 1.00)			
		Importance wt.	Force required for booms to bend (lbs)	Boom Length (in.)	Force required to turn switch (lbs)	Length of attached hose (ft)	How sprayer attaches to ATV (Pull along or	Height of Booms (in.)	Tank size (gal.)											
	Customer Requirements		1	2	3	4	5	6	7	8	9	10	11	12	13	14	CP	A	B	C
1	Easy to Maneuver	0.15					9													
2	Breakaway Booms	0.10	9																	
3	Boom Length	0.15		9																
4	ON/OFF Switch	0.15			9															
5	Attached Spray Hose	0.20				9														
6	Drift Control	0.15						9												
7	Large Tank	0.10							9											
8																				
9																				
10																				
	Total Importance	1.00	0.9	1.35	1.35	1.8	1.35	1.35	0.9											
	Engineering requirement importance																			
Performance	Current Product																			
	Crop Care		N/A	160	N/A	14	A	N/A	25											
	Superior Industries			480	N/A	0	A	N/A	200											
	Top Air			0	N/A	10	PA	N/A	15											
	New Product Targets		5	160	1	10	A	24-60	20											

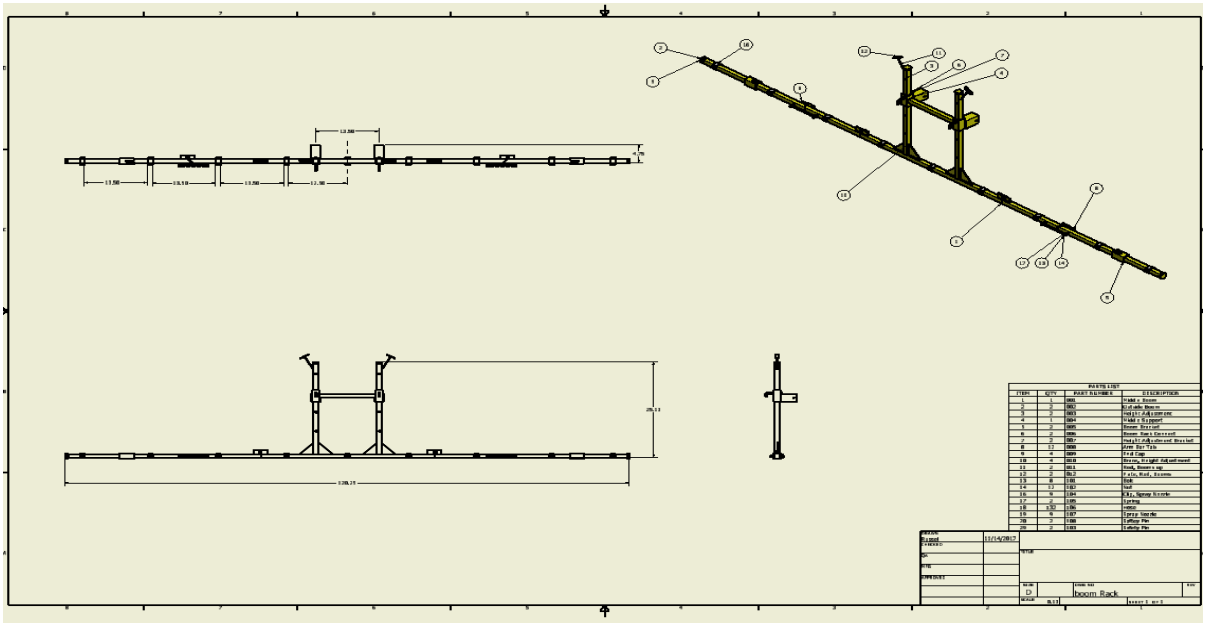
DESIGN

Design alternatives and selection

There were three designs being considered. Option one was a sprayer that attached to the back of the ATV and the booms hang of the back of the ATV. Option two was a sprayer that hooked up to the ATV with a hitch pin and was a pull behind model. Option three was a sprayer that sits on the back of the ATV and has a nozzle that sprays and covers an area with the one nozzle. Option one was the selected option. This is because it meet my desires the best. Option two fell short for the reasons of maneuverability. It is harder to back up and get into corners with a pull behind model. Another problem is all he controls would be on the ATV in the back or you would need a spate controller. Option three fell short purely off the back that you cannot control the spray. It would be very difficult to manage the drift control. It would have been nice to not have to worry about hitting the booms on anything when driving but if you cannot control your drift, I believe it is not worth it. Option one was the same with controlling the drift as option two. However, one is easier to maneuver and will be able to have the controls right by the driver. Option one is way easier to control drift, then option three, with the booms being adjustable

Drawings

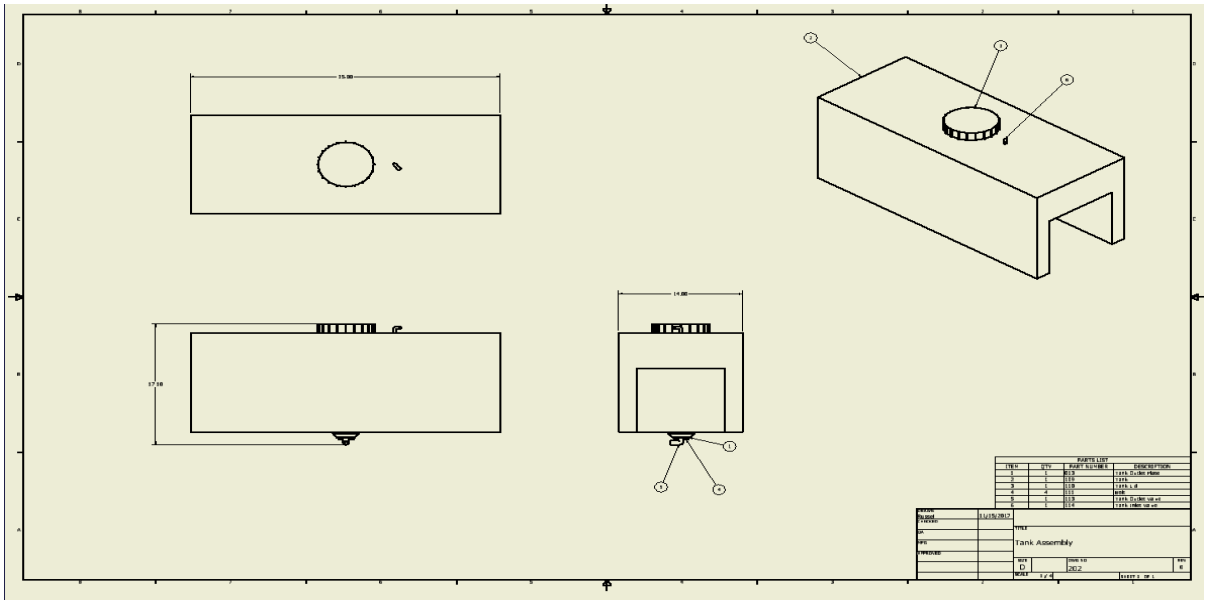
Part 201 Boom Rack



Overall Dimensions

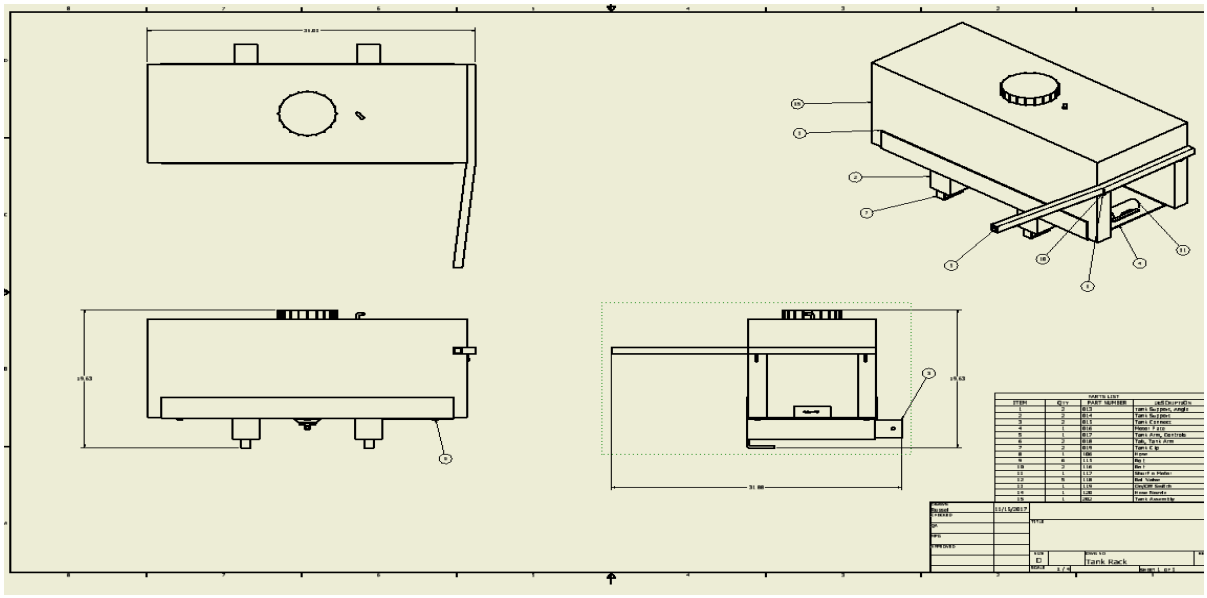
120.25” * 25.125 * 8.00”

Part 202 Tank Assembly



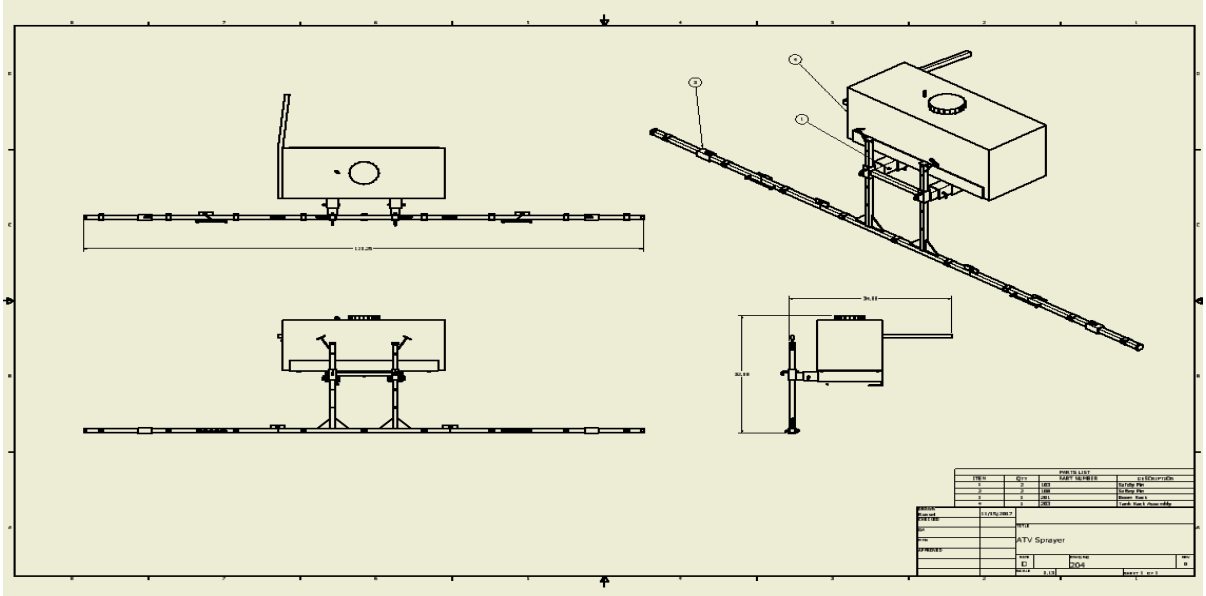
Overall Dimensions
35” * 17 * 14”

Part 203 Tank Rack



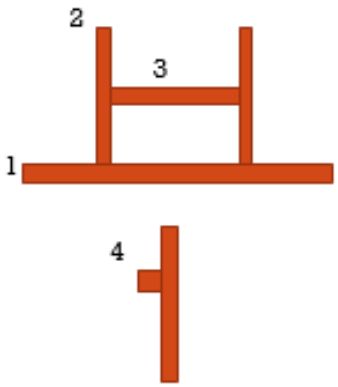
Overall Dimensions
36” * 20 * 32”

Part 204 ATV Sprayer



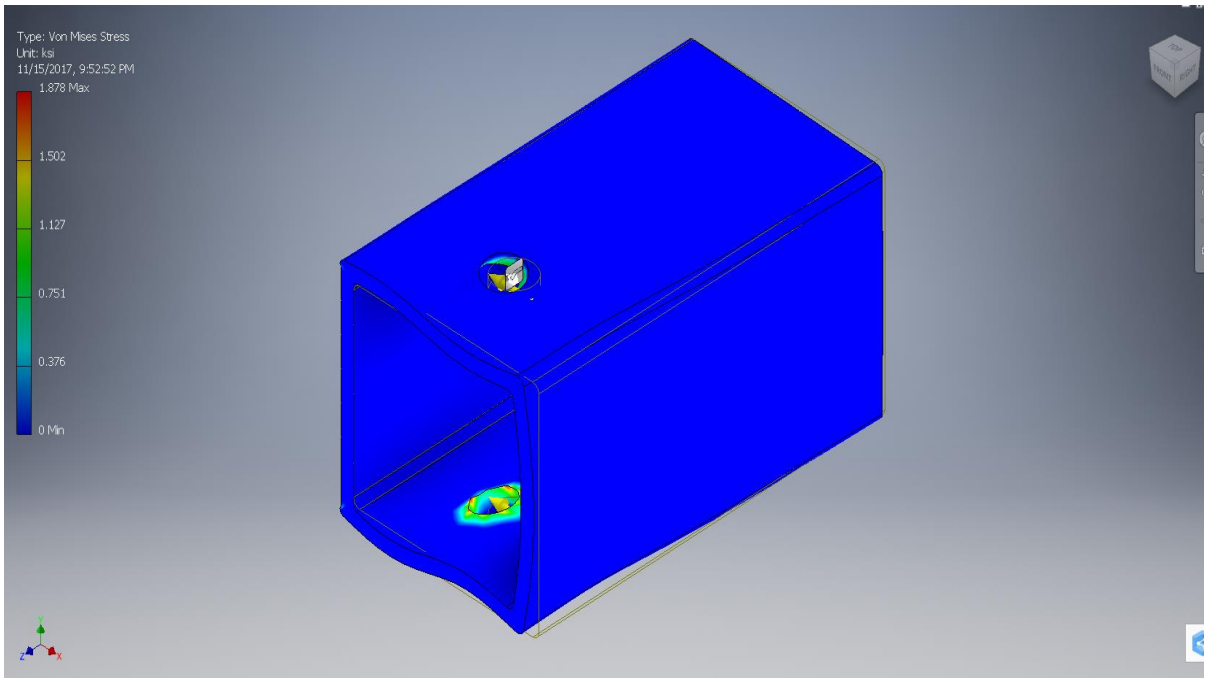
Overall Dimensions
120.25” * 36.625” * 35”
Height adjustable 15” down.

Loading Conditions and Design Analysis



This is a sketch if the back rack. The force applied to the box iron for the back rack to hang needs to be calculated in order to make sure the selected material is strong enough. In order to do this, the weight of the back rack will need to be calculated. Piece one is 10 ft. 2x2x1/8 box iron (1). Piece two is 4 ft. 2x2x1/8 box iron (2). Piece three is 3 ft. 2x2x1/8 box iron (1). Piece four is ½ ft. 4x4x1/8 box iron (2). Giving us a total of 20 ft. 2x2x1/8 and 1 ft. 4x4x1/8. 2x2x1/8 is 3.07 lb. /ft. *20 ft. = 61.4 lbs. 4x4x1/8 is 6.34 lb. /ft. * 1 ft. = 6.34 lbs. This gives us a total of 67.74 lbs. The area the force is applied to is a four inches by three inches. This gives us an area of twelve squared inches. The tensile strength of box iron is 276 MPa, which is converted to 40020 pounds per inch squared. Dividing the weight by the area will give us a tensile strength of 5.645-pound per square inch.

The weight will be applied to the box iron where the rack attaches to get a finite element analysis (FEA). For this project, Autodesk Inventor 2018 was used. This program gave the following FEA



From this, we can see there is only a max load of 1.878ksi. The box iron selected can hold up to 40ksi. This will give a safety factor of 21.3.

Factors of Safety of Concern (if near design factor)

With the safety factor being 21.3 actual, there is not too many factors of concern. The rest of the sprayer sits on the back rack of the ATV and is supported by this,

Component Selection

Box iron was selected as the material for the frame. This is because box iron is cheap, durable, strong, and easy to work with. All the valves were stainless steel. Stainless steel was selected so the no chemicals that could possibly be used would harm the valves. The pump was selected to match what was already standard in the current market. Everything else was selected because it was what was already on hand. The tank was an old tank that was currently not being used by Glandorf Warehouse Inc. anymore.

Bill of Material

Part Number Key
0** - made parts
1** - purchased parts
2** - assemblies

Part 201 Boom Rack BOM

Part Number	Description
001	Middle Boom
002	Outside Boom
003	Height Adjustment
004	Middle Support
005	Boom Bracket
006	Boom Rack Connect

007	Height Adjustment Bracket
008	Arm Bar Tab
009	End Cap
010	Brace, Height Adjustment
011	Rod, Booms Up
012	Plate, Rod, Boom
101	Bolt
102	Nut
103	Clip, Spray Nozzle
104	Spring
105	Hose
106	Spray Nozzle
107	Safety Pin
108	Safety Clip

Part 202 Tank Assembly BOM

Part Number	Description
013	Tank Outlet Plate
109	Tank
110	Tank Lid
111	Bolt
113	Tank Outlet Valve
114	Tank Inlet Valve

Part 203 Tank Rack BOM

Part Number	Description
013	Tank Support, Angle
014	Tank Support
015	Tank Connect
016	Motor Plate
017	Tank Arm, Controls
018	Tab, Tank Arm
019	Tank Clip
106	Hose
115	Bolt
116	Bolt
117	ShurFlo Motor
118	Ball Valve
119	On/Off Switch
120	Hose Nozzle
202	Tank Assembly

Part 204 ATV Sprayer BOM

Part Number	Description
103	Safety Pin
108	Safety Clip
201	Boom Rack Assembly
203	Tank Rack Assembly

PROJECT MANAGEMENT

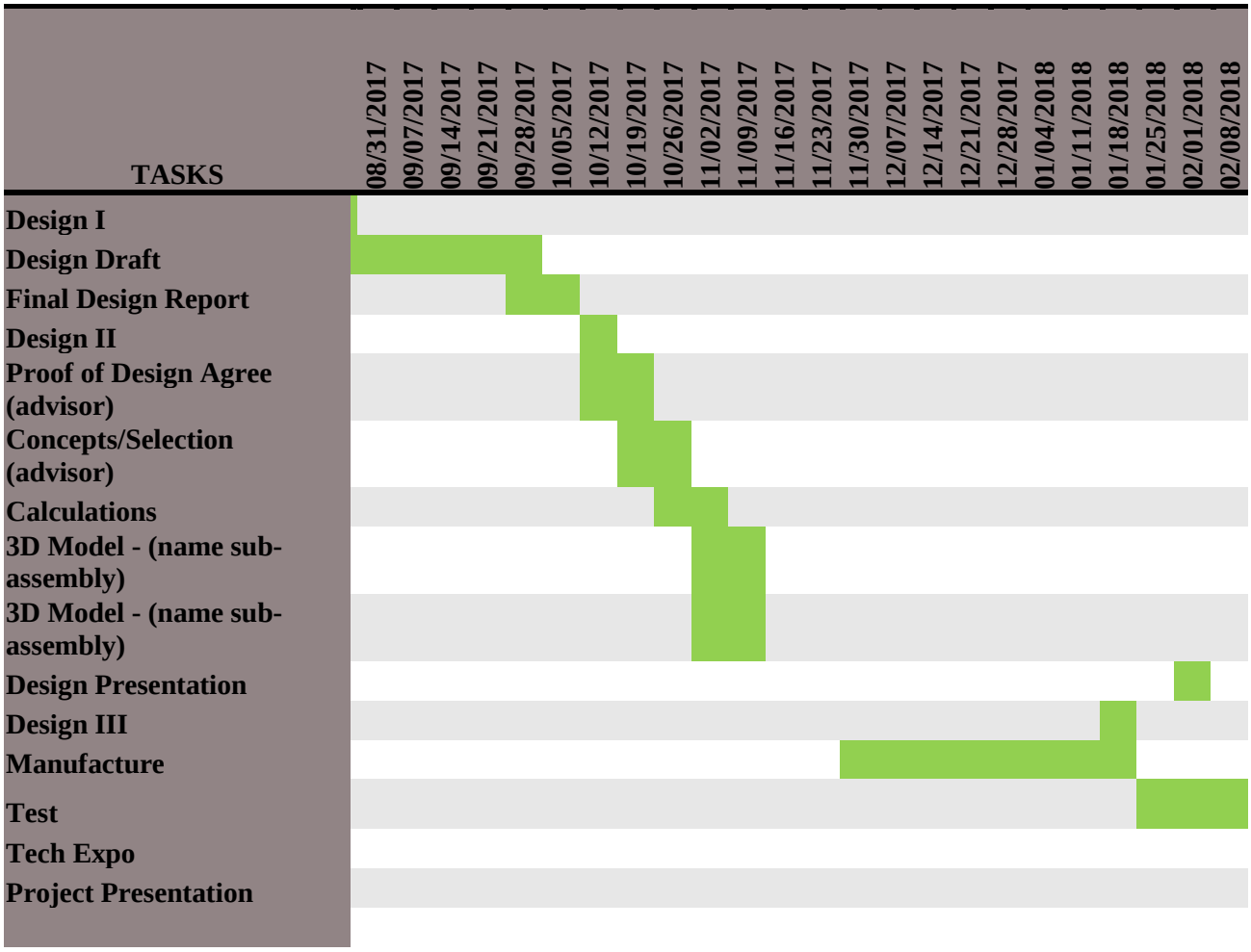
BUDGET, PROPOSED/ACTUAL

There is really no budget for this project. I will need to purchase a tank, hose, nozzles, motor, and the metal for the framework. Living on a farm, I am hoping I will be able to find some metal, hose and spray nozzles around the farm. Original budget was $450. The budget was higher because stainless steel and other higher quality parts were used instead of the plastic that was originally planned for. Glandorf Warehouse Inc. donated all parts ($816.05) in agreement that they have rights to use the sprayer when they may need to.

Parts Budget		
Item	**Qty**	**Price**
Tank	1	$ 268.75
Pump	1	$ 170.20
Stainless Steel Valves	5	$ 112.15
Hose	12.5'	$ 21.00
Hand Spray Nozzle	1	$ 3.85
Hose for Hand Nozzle	10'	$ 4.50
Swivel Hose Ends	8	$ 9.20
8002 Tips with Caps	9	$ 29.70
Tip Bodies	9	$ 67.86
Boom Clamps	9	$ 21.06
Stainless Steel Hose Clamps	25	$ 21.25
3/8 Plastic Street Elbow	1	$ 2.97
1/8 * 3/8 Plastic Hose Barb Elbow	1	$ 0.70
1/4 Stainless Steel ST T	4	$ 14.40
1/4 90 Street Elbow	1	$ 3.85
1/4 Close Nipple	9	$ 16.11
1/8 4x4 Box Iron	20	$ 27.20
1/8 2x2 Box Iron	1	$ 1.30
Scrap Steel	1	$ 20.00
Total Price		$816.05

SCHEDULE, PROPOSED /ACTUAL

Actual and proposed schedule went exactly as planned.



PLAN TO FINISH

I plan to have everything done and tested by March 25th.

MANUFACTURING

Manufacturing followed the time period and schedule as planned. I started by finding a tank that would fit my needs. Parts that could be bolted to the tank with already tapped holes were bolted in. The motor was mounted on a plate in the cutout on the tank. From here welding started. The welding was done with a MIG welder. After the tank was all bolted and mounted, I started working on the booms. The booms were designed to be ten feet long with a snap back feature include. The snapback was done with a spring and cutting the box iron to allow it to fold directly backwards without interfering with itself. The completely back rack was welding together as designed. Next, the spray tips were bolted onto the back rack. I put nine tips evenly spaced throughout. After this was complete, the back rack could be pinned onto the main tank assembly. This was done for easy and quick assembly and disassembly. Hoses were now ran from the tank to the valve controls. The valve controls control, which

sections of the sprayer is operating. Hose was then ran from the valves to the different sections of the booms. The hose was zip tied to the booms but not the tank assembly. This was done so when the back rack was taken off the hoses would come with it easily and no zip ties had to be cut. The motor was then hooked up to the ATV engine as well as the ON/OFF switch.

CONCLUSION

The project went very smoothly. I was able to follow my schedule just as planned. The budget ran a little high. This is because all the parts were upgraded to better and more reliable parts than originally planned. The originally parts budget was $450 but the actual ended up being $787.55. However, Glandorf Warehouse Inc. donated all parts and materials so it did not cost me personally anything. I was also able to follow my design exactly as planned. I was able to implement a few features to help reach my desired outcomes as well. I first wanted to figure out the best design to make this an easy sprayer to use and maneuver. In order to do this I designed the booms of the sprayer to be detachable from the sprayer. The sprayer was also designed to hook into the boom rack of the ATV without any bolting or screwing into the ATV. This makes assembly and disassembly simple and easy. It was also designed to sit on the back rack of the ATV for ease of maneuverability. Finally, an On/OFF switch was added to the sprayer. The sprayer hooks directly up to the battery of the ATV. The motor of the spray will not be functional with the sprayer switch in the off position. I also wanted to make sure to increase the quality of the job. One way I did this was by making the boom height adjustable. This is necessary to help control the drift of the spray. Another thing included was breakaway booms. This helps in case of an accident. If the driver gets too close to a building, tree, or anything else the booms will start to fold directly back on contact. Once there is no more contact the booms will snap back into place. This is important because accidents do happen and we do not want to cause harm to the operator, sprayer, or objects surrounding us. Another big factor I wanted to include was time. With everyone having such busy lives, I wanted to try to make sure this would help decrease the time of work they need to spend. One way I did this was include a tank of 20 gallons. The operator needs a decent size tank so they can spray for a while without needing to fill up so often. Another thing is to include a spray nozzle with ten feet of hose. This helps because the operator can drive right up to the garden and be able to walk around with the hose in order to get the hard to reach spots. I also wanted to include a motor that will pump two gallons per minute. This will allow the driver to drive faster and be positive the area is getting a good coverage. I was able to include all those features and a few more. Another feature I included was making different sections of the spray operate as chosen. By adding valves up by the driver, they are able to turn the middle, left or right sections on or off as they please. This will help with over spraying the area. An agitator valve was also added. This will allow the operator to mix the tank or release pressure in the tank as necessary. Overall, I was very happy with the way I was able to follow my schedule and the final results of the project. One thing I wish I could improve on was the cost. However, when you are using high-end priced parts the overall price will be increased. One improvement for this project would be to make sure the ATV sprayer is adjustable for most ATV. I know it will work for mine. However, I should have done some more research of how all ATV back racks are designed. If they are all not designed, the same I should make sure to either include a kit or make the rack adjustable to fit all ATVs.

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APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D