Automated Conveyor Cleaning System

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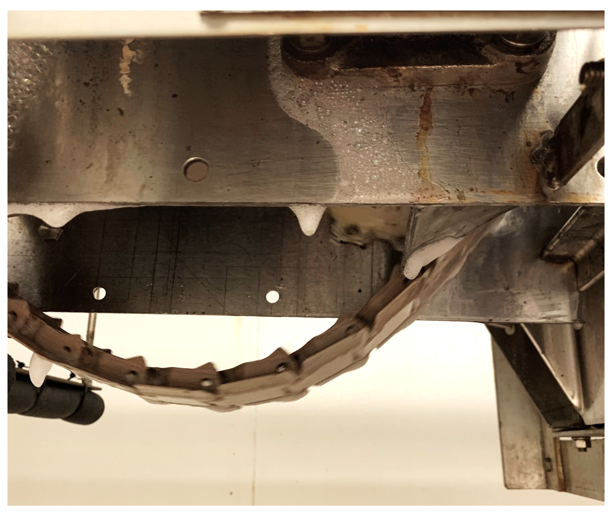
Project Description + Justification

A Capstone Project partnered with Shamrock Farms

Shamrock Farms is a family-owned food distributor and manufacturer. The Shamrock Farms Dairy Facility is based in Phoenix, Arizona. A variety of dairy products are processed and sent out from this location.

The conveyor lines can become contaminated with harmful bacteria that can grow in milk and dairy by-products. This requires an intense cleaning process to ensure the food's safety and the integrity of the Shamrock Foods.

Current Process	New Process
• Cleaning approach is with a spray bottle and rag • Duration of cleaning is 24 hours ◦ $96,000 lost in revenue per contamination cleaning cycle	• Automated cleaning mechanism that will be powered with a 120V pump to push fluid 50ft horizontally and 10ft vertically • 20 minutes for setup/teardown process • Duration of cleaning 6-8 hours ◦ $72,000 revenue saved per contamination



This is one section of the conveyor belt that the automated conveyor cleaning system would attach to.

The purpose of this project is to design and build an automated conveyor belt cleaner that will pump a chemical cleaner to the conveyor belt through a system of tubes and nozzles. This will effectively clean the conveyor system.

The system will be designed and constructed in a way such that it can fit into 3 separate locations within the Shamrock Dairy. These conveyor lines run 24/7 to transport packaged food products which will eventually be sent out to customers.
The cleanliness of these conveyor lines is extremely important.

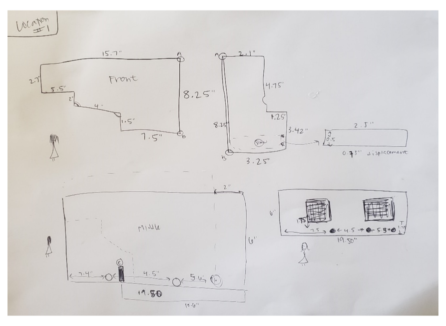
Contaminations within this facility require up to 24 hours to fully clean the lines by hand, which results in up to a $96,000 loss in revenue. The device created for this Capstone project plans to significantly shorten the cleaning time.

The chemical cleaner is provided by Shamrock Foods. The finished product will include a pump to transport the chemical through tubing up to the basin, which will attach to the cage of the conveyor belt system. The chemical will enter the basin and be released through a series of nozzles, which are designed to maximize the chemical's contact with the belt.
After hitting the conveyor line at a high pressure, the chemicals and all other deposits will empty out to a floor drain.

The Capstone budget will pay for the cost of materials for the system, including a centrifugal pump, and the welding.
The design requires a third-party welder to fabricate the basin

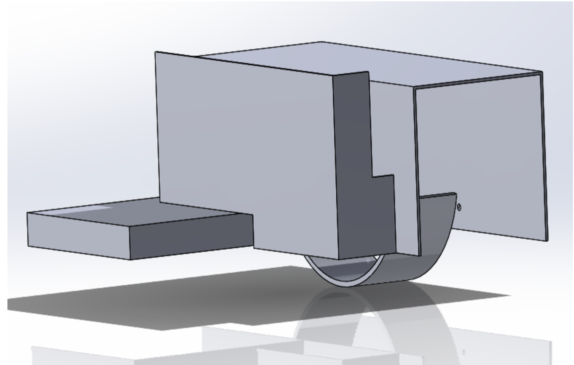
Overview of Design Process

1 Pre-existing System – The images below show the process taken to create an exact Solidworks model with all the similarities of all three systems at Shamrock



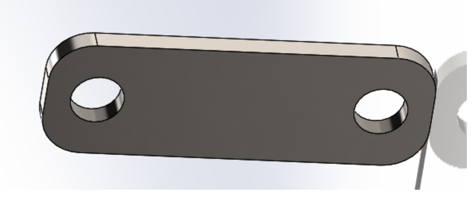
Sketch of system at Shamrock

Cardboard Prototype

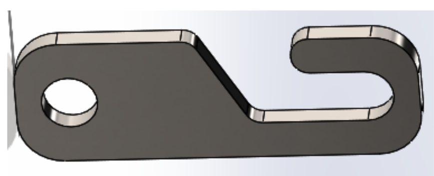


Solidworks model based on dimensions collected

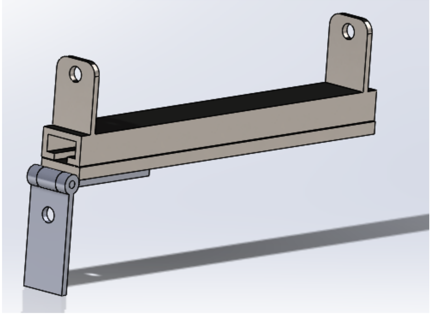
2 Attachment Device – Choosing an attachment was the next step in the process and the following 3 designs were created as options. After great deliberations and decision matrices, the team decided to move forward with the hook design.



Double Holes



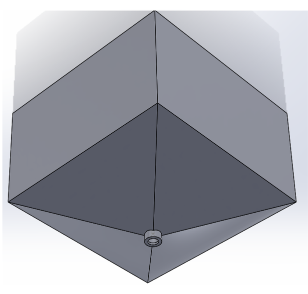
Hooks



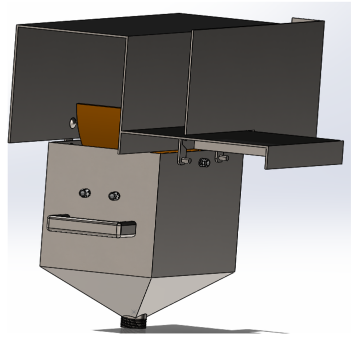
Slider and hinge

3 Nozzles – The next decision that had to be made the type, number and placement of the nozzles in the basin unit. The team went with 5 High-impact flat spray nozzles located around the side of the basin unit that will contact the conveyor system.

4 Basin – The majority of the design was centered around the basin unit. The images below show a timeline of how the basin has evolved from the first rendering to the final design.

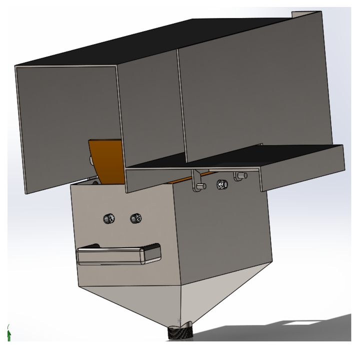


Original idea



Second design

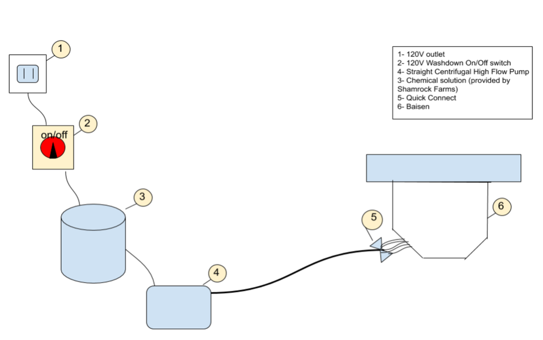
Cardboard prototype based on second design



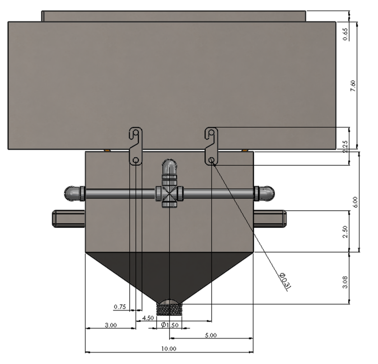
Final design updated from prototype testing

5 Pump – After all components of the basin unit were completed, calculations were preformed in order to find a pump that was able to perform under the given conditions. The team decided to go with a centrifugal pump with the capacity to run off of 120 VAC and has a pressure of 100 psi at the nozzles.

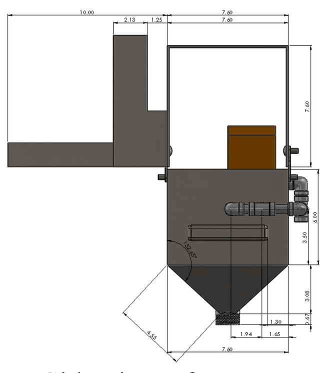
6 Final Design – The images below show a schematic of all the complete system, drawings of the basin unit with dimensions (in inches) and a section view of inside of the system including the spray pattern of the nozzles on the conveyor system.



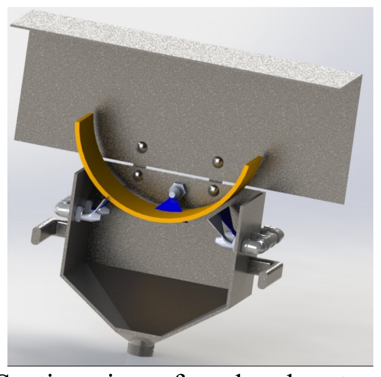
Mechanical Schematic



Front view of system



Side view of system

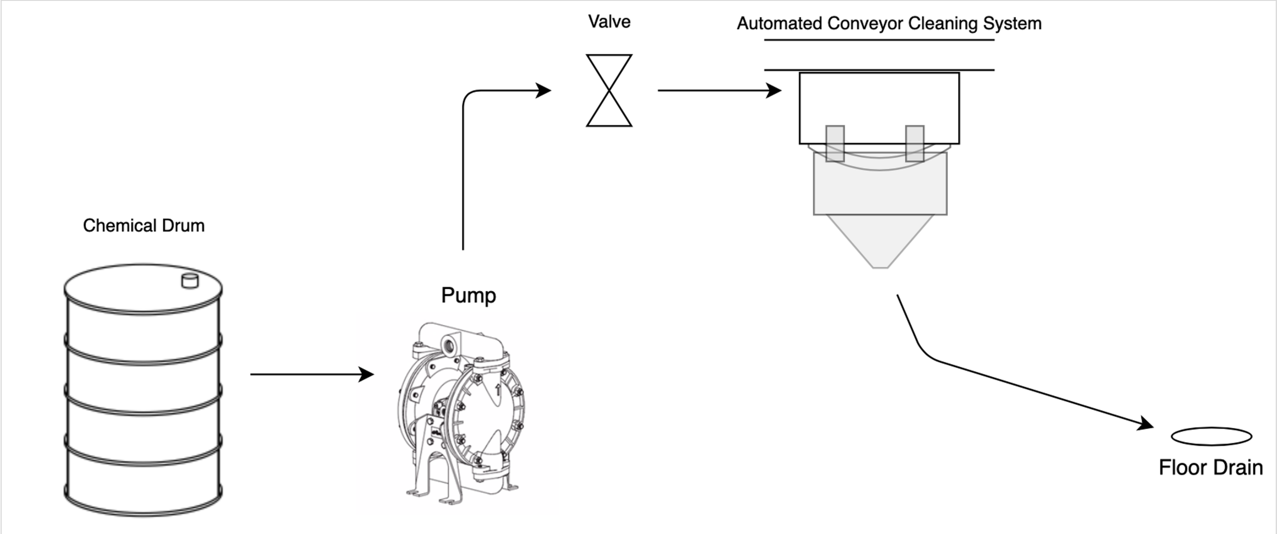


Section view of rendered system

Functional Requirements

Each of the requirements listed below are to ensure the proper usage of the product, and safety of the Shamrock Farms employees, as well as the overall function of the Automated Conveyor Cleaning System.

- Should be able to be used by any Shamrock Employee.
- Should be easily storable with in easy reach of the production site.
- Must be made of FDA approved materials i.e.; plastics, metals, rubbers, etc. (FDA: 21 CFR 178 and FDA: 21 CFR 179).
- Must be adjustable to all three production lines within the facility.
- Must be light weight- no more then what one employee can lift as per OSHA (Material Handling: Heavy Lifting).
- Must clean a moving belt.
- Must reduce the current cleaning operation time.
- Must be self cleaning before and after the use.
- The setup and break down time should be less then 20 minuets.
- Must be able to clean the conveyor belts of any contaminates.
- Must have handles that will allow for easy pick up and insulation of the product.
- System must be automated.
- Must provide FDA wash down approved pump.



Full System in Order

Relevant Data Summaries + Calculations

$Diameter\ (D) = 0.03175mm$

$Flow\ Rate\ (Q)\left(\frac{m^3}{s}\right) = 9.46E-05$

$Area\ (A) = 0.000791$

$\frac{Flow\ Rate}{Area} = velocity = 1.20E-1\frac{m}{s}$

$Velocity, v\ \left(\frac{m}{s}\right) = 1.20E-1\frac{m}{s}$

$Diamere\ (m) = 0.0254$

$Kinematic\ Viscosity\ (70\ degree\ F) = 9.77E-07$

$Reynolds = \frac{Velocity * Diameter}{Kinematic\ Viscosity}$

$Reynolds\ Number = 3109.1036$

$v\ \left(\frac{m^2}{s}\right) = 0.000791$

$L\ (m) = 17.2212$

$V\ \left(\frac{m}{s}\right) = 0.11959$

$g\ \left(\frac{m}{s^2}\right) = 9.81$

$D\ (m^2) = 0.001008$

$Horizontal\ (head\ loss) = \frac{32(v)(L)(V)}{(g)(D)}$

$Horizontal\ (head\ loss) = \frac{32\left(0.000791\frac{m^2}{s}\right)(17.2212m)\left(\frac{0.11959m}{s}\right)}{\left(\frac{9.81m}{s^2}\right)(0.001008\ m^2)}$

$Horizontal\ (head\ loss) = 5.273635m = 17.29ft$

$Vertical\ @10ft\ (3.048m) = 5.273635m + 3.048m = 8.322m = 27.29ft$

$\frac{p(1)}{y} + z(1) = \frac{p(2)}{y} + z2 + \frac{32uLV}{y(D^2)} = Pressure\ output\ at\ nozzle$

$9.77E-7\ \left(\frac{m^2}{s}\right) x\ \frac{125psi}{9.77E-07\left(\frac{m^2}{s}\right)} + 0 - 3.048m\ x\ \frac{32(0.000791)(17.22ft)\left(\frac{0.059795m}{s}\right)}{\left(9.77E-07\frac{m^2}{s}\right)(0.001008m^2)}$

$Pressure\ at\ nozzle = 99.1psi$

- Hand Calculations
  - Projected outcome = 99.1 psi

	Flow Rate, gpm			
	@ 20 psi	@ 40 psi	@ 100 psi	@ 500 psi
Brass				
1/4 NPT Male	0.7	1	1.5	3.5

- High Impact Deflected Spray Nozzle
  - At 100 psi
  - 1.5 gpm
  - For 5 nozzles = 7.5 gpm

- Theoretical Flow Rate = 7.5 gpm

- Pump output: 121 psi
- Horizontal head loss: 5.27 m
- Vertical head loss: 8.32 m
- Pressure output: 99.4 psi
- Outputting 7.5 GPM
- Velocity: 0.11959 m/s

Deflected Spray Nozzle

Testing Tubing

Testing Nozzles and Pipes

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