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Improving 15-S Laboratory Model Concentrating Table

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Indiana University – Purdue University Fort Wayne
Department of Engineering
ME 487 – ME 488

Capstone Senior Design Project

Report #2

Project Title: Improving 15-S Laboratory Model Concentrating Table

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Date: December 15, 2013

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Abstract

Deister Concentrator, LLC. of Fort Wayne currently produces a 15-S Laboratory Model Concentrating Table. The table is used in laboratory environments and in small scale mining applications with larger scale models available. A sample mixture is washed across the table's oscillating surface to separate the valuable ore from undesired material due to a difference in specific gravity.

Deister Concentrator, LLC. wishes to improve the table by adding additional functions that would be available as add-ons for existing tables. More adjustments, recycling water, and a feeder are the most desired improvements. Any other improvements to increase the functionality, marketability, or profitability of the table are also to be considered.

This text discusses all the requirements specified for improving the 15-S Concentrating Table conducted by IPFW's senior capstone design team during the 2013 spring semester. The evolution of improving the table also focuses on the development of conceptual designs, design evaluation, cost analysis, and the final upgraded prototype of the 15-S Laboratory Model Concentrating Table.

Section I: Detailed Description

Final Design from Senior Design I

From Senior Design I in the spring of 2013, the team went through a design and analysis of different possibilities for improvements. Senior Design I went through a process of generating a problem statement, brainstorming of ideas, conceptual designs, evaluation of conceptual designs, creating a detailed final design, and cost estimation. The final design we had developed is shown Figure 1.

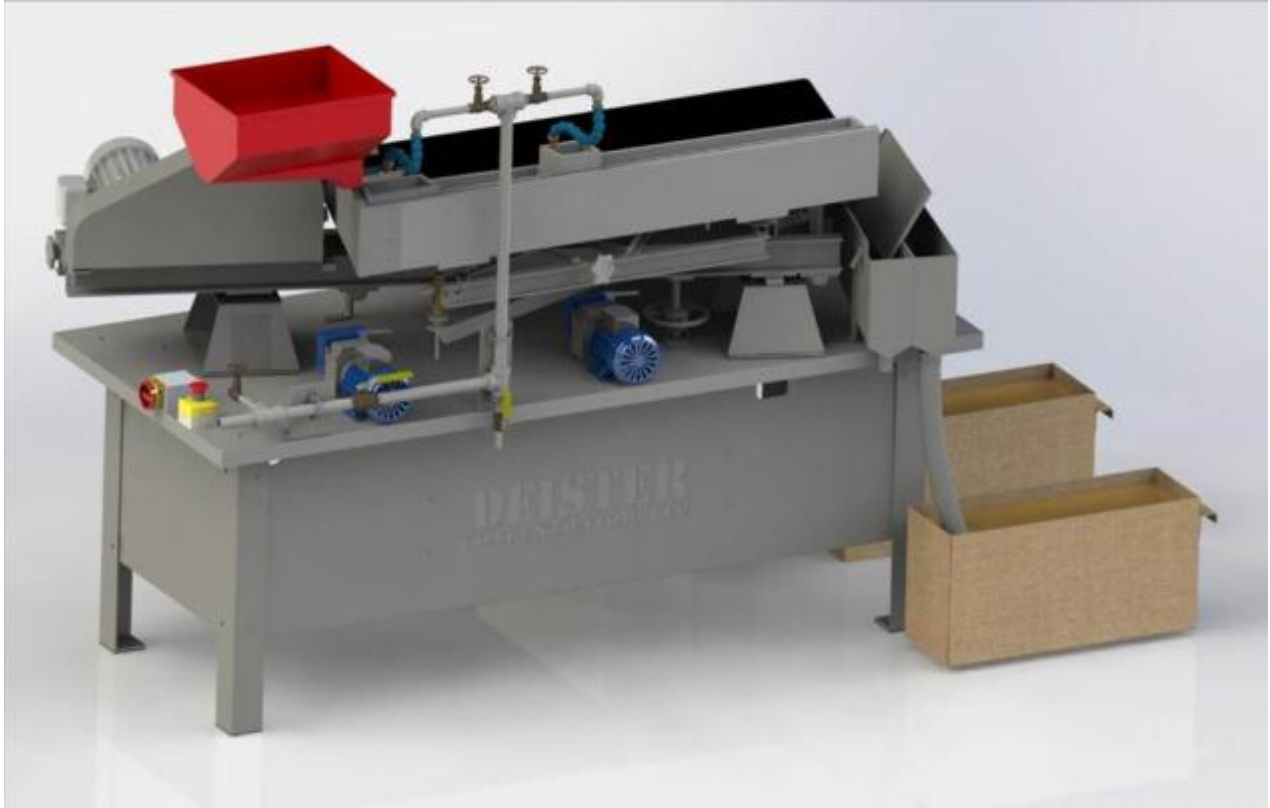


Figure 1: The Final Design of the Table with all First Choices

Water Supply and Disposal

The final water circulation method consisted of the Cole-Parmer peristaltic pump and banana screen filters. This pump allows for variable water flow rates at the turn of a knob. The key element of this design includes recirculating water while minimizing total water consumption. The peristaltic pumps are not at risk of “running dry” as many other pumps are and the tubing can be quickly and easily changed when switching between different slurry mixtures to keep each sample clean and to minimize debris which may be left from previous testing. The filter was to allow the table to run longer by making consistent separation between the desirable product and the wash water. The banana screen was to be installed into collection bins to filter the water and wanted material. The water at the bottom of the bin could either be pumped back through the system after screening, or simply discarded.

Tilt Adjustment

The final design changes for the tilt adjustment will incorporate an increase in the angle of the wedge rod. As stated in the problem statement, it has 5/16 of an inch per foot of tilt. This equates to 1.49 degrees. Increasing the tilt 20% will give a final angle on the table, 1.79 degrees.

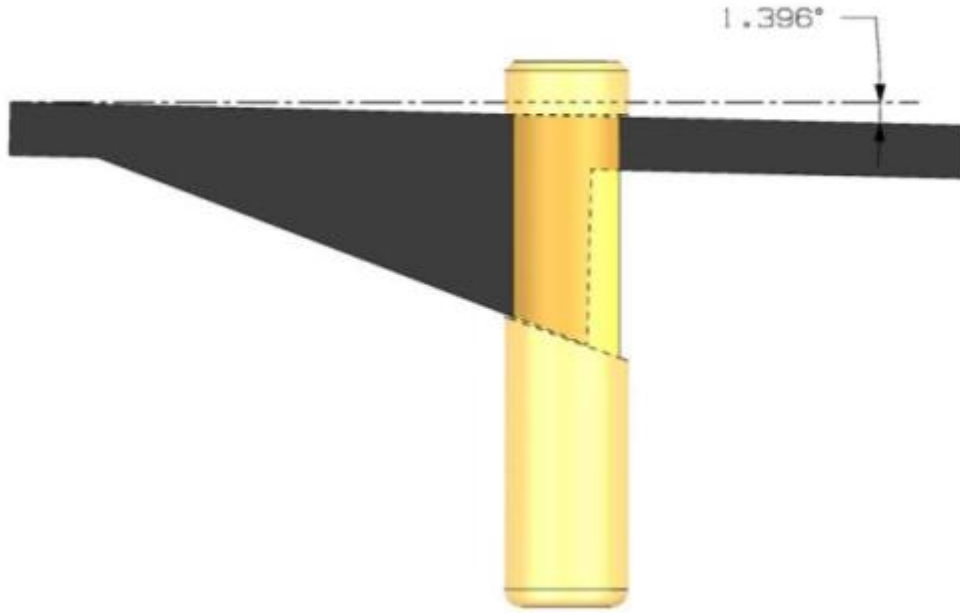


Figure 2: Current Tilt on Wedge Rod and Tilting Post

Slurry Feed System

The stroke actuated feeder uses the reciprocating motion of the table top to move a slurry box in and out of a fixed slurry hopper. The reciprocating motion of the slurry box will gather a minute amount of material each time. There is an adjustable slide at the bottom of the hopper which prevents material from building-up in the opening, controlling the flow of slurry.

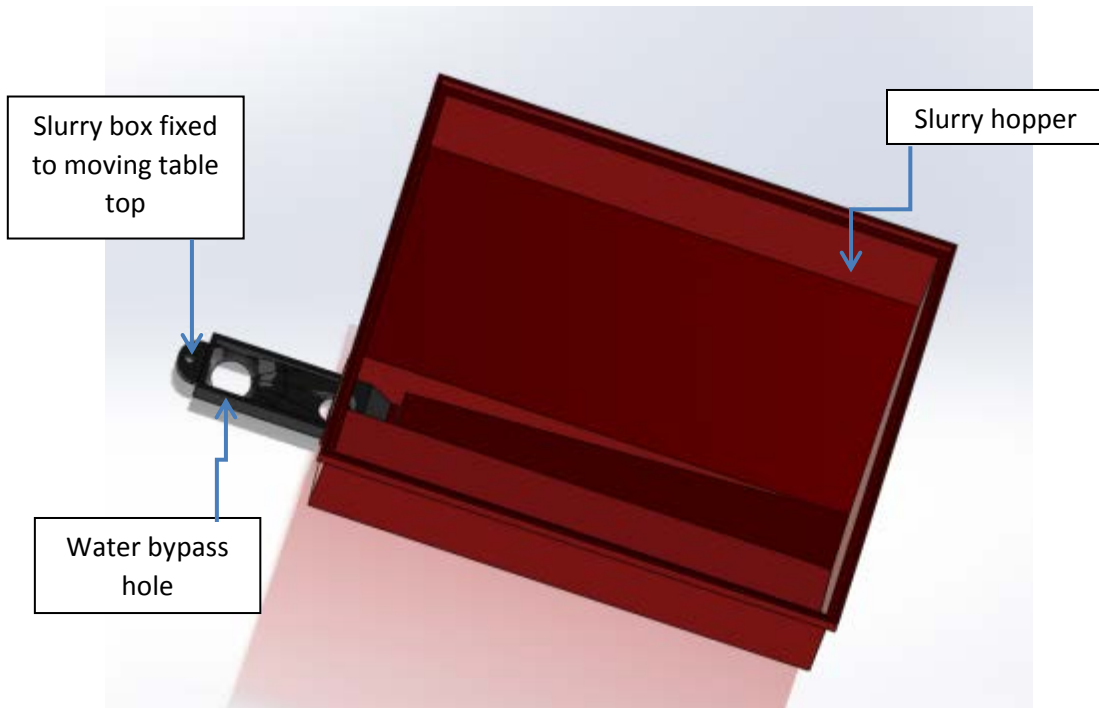


Figure 3: Stroke Actuated Feeder

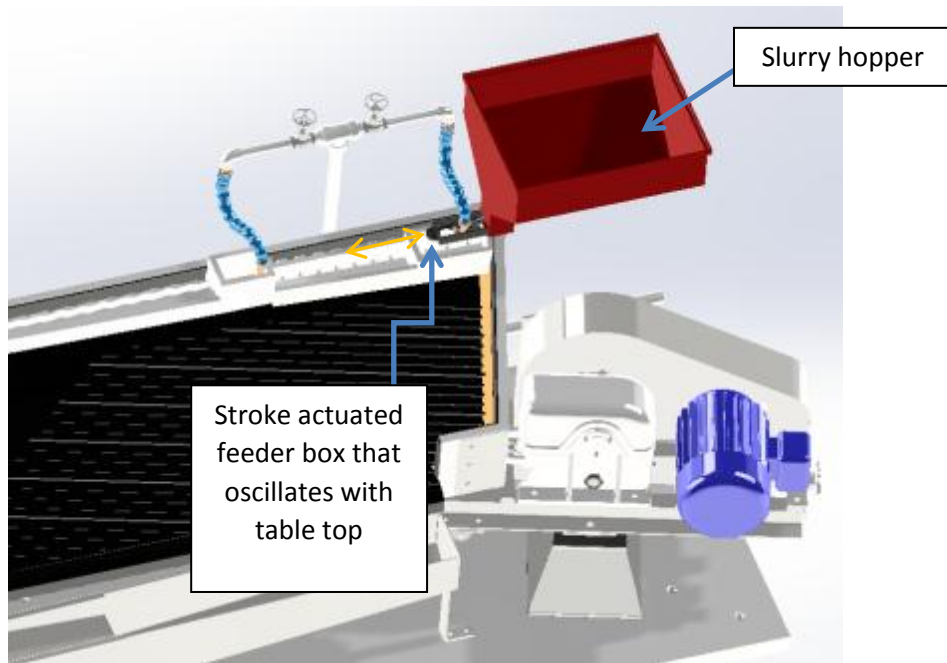


Figure 4: Stroke Actuated Feeder on Table

Safety

To make the Deister 15S Laboratory table safer for all operators and maintenance personnel, an emergency motor stop and lock-out/tag-out system was to be implemented into the electric circuit of the table. This section will show the approximate locations of the e-stop and lock-out/tag-out components of the system as seen in Figure 5.

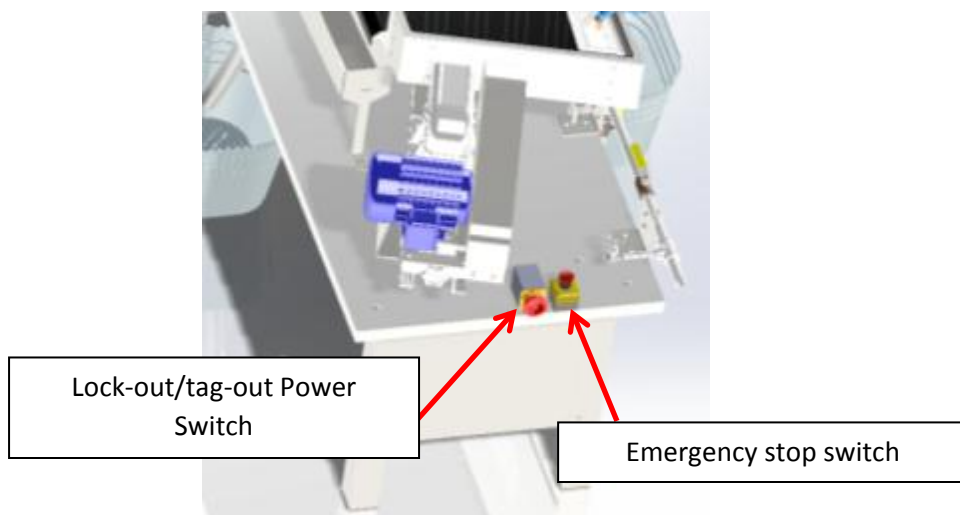


Figure 5: Emergency Stop Switch and Location

Background

Deister Concentrator of Fort Wayne, Indiana wishes to increase the functionality of their 15S Laboratory Concentration Table. The 15S Laboratory Concentration Table is a scaled down version of larger tables which are used in mining production. These tables separate metal ore from their lighter tailing components by utilizing vibration and differentials in specific gravity. A picture of the 15S Laboratory Concentration Table is shown in Figure 6.



Figure 6: 15S Laboratory Concentration Table

The oscillation of the table is belt-driven by a 1/2 hp electric motor. A variable speed pulley attached to the shaft of the motor controls the speed of oscillation. A cam system converts the rotational motion to linear motion and establishes the magnitude of vibration. The 82" by 35" table is constructed with red wood or cedar then covered with rubber. Small raised ridges, called riffles, are attached to the rubber. A mixture of ore and water are added to a small feed box where dressing water washes the slurry onto the reciprocating table. The vibration of the table along with the riffles separates the valuable ore from the undesired excess. The high gravity material is transferred to the concentrate launder on the end of the table (see Figure 7). The angular position of the tabletop with respect to the horizontal plane facilitates this motion, this position is controlled by adjusting the tilt and end elevation of the table. The end elevation can be adjusted up to 1.4 inch per foot. The tilt of the table (corner to corner) can be adjusted up to 5/16 inch per foot.

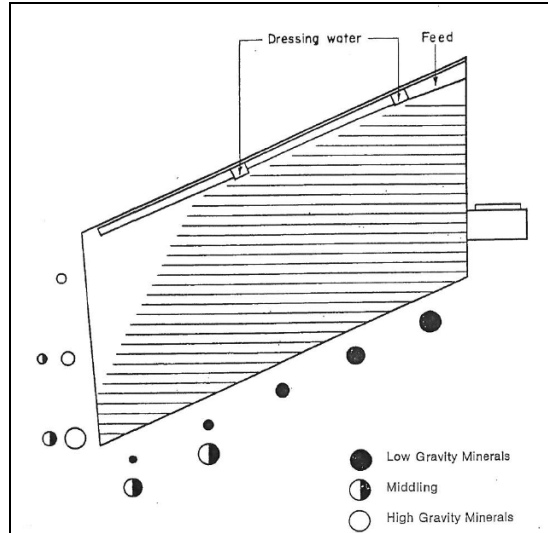


Figure 7: Top View of Shaking Table Top

The main goal of the current design project is to improve the functionality of the concentration table through validation and optimization of the current design, the automation of current manual feed processes, increasing the range of adjustable machine settings, decreasing the system's environmental impact, and implementing safety features that are not currently on the machine.

We had four categories of focus. The first was water supply and disposal. For this sections, the Cole-Parmer peristaltic was the best option from our weighting. The screens fit the best for water filtration system. For the tilt adjustment category, increasing of the wedge rod was determined the best. For the slurry feed system section, the stroke actuated feeder was chosen. The final section was safety. There were no choices in this segment and so an e-stop and lock out/tag out switch were added.

Requirements:

The final design changes, when possible, will be compatible with the current design and available as bolt on upgrades for older tables. The current water supply for the separation of materials is a continuous feed from an open source, with no option to reclaim used water. There is to be a system added that allows for the reprocessing and filtering of the water. The current design has a tilt adjustment of up to 5/16 inch per foot. The new design is to have an additional 1/16 inch per foot or 20% of tilt to meet customer demand allowing for a larger range of processing. Slurry, a mixture of water and test sample, is currently done manually using a spoon. A new method of adding slurry to the machine with minimal operator intervention is desired.

- Improvements must bolt on to the existing table
- Recycle water
- Increase tilt adjustment by at least 20% or 1/16 inch per foot
- An addition of a feeder

Specifications:

This concentrating table is an international product sold and distributed to customers in many countries with a diverse range of operating conditions. Therefore, the final design shall be robust, durable, safe to operate, and suitable for use in harsh environments. The changes shall be ergonomically friendly and intuitive.

- Durable for a variety of environments
- Ergonomically friendly

Parameters:

The given, or fixed, parameters are those that will be the guidelines for the improvement of the vibrating table so that changes to the original table design are minimized. This will allow for the improvements to be marketed as bolt on upgrades to existing designs.

- The foot print of the table is 82 inches by 35 inches and shall not be changed
- Deck material is redwood and/or cedar and shall not be changed
- Maximum tilt allowable shall not exceed 1/2 inch per foot overall

Design Variables:

Deister Concentrator has not constrained the design group to any specific requirements. The final design concept is at the discretion of the design team. Factors such as reliability, intuitiveness, marketability, and cost effectiveness will be considered in all designs.

- The system should have adjustable settings for water flow as well as slurry feed
- The presence of safety features is limited and any additions that will enhance user safety will be considered

Limitations:

The functionality of the 15-S Laboratory Concentration Table must be held to retain the basic function of the table. The design group is limited to adding designs that will increase value of the unit to the customer.

- No major changes to reciprocating tabletop
- Design changes are to be economically reasonable and pre-approved by the company

Safety/Environment/Economics:

The table is used to process metal ore, and any modifications that will limit (minimize) the environmental impact will be looked into by our team. Due to the age of the design, the presence of safety features is currently limited. Upon initial inspection of the table by the group, we determined that the design could benefit from the addition of an emergency stop and a lock-out/tag-out system.

- Lock out/tag out as per title 29 of the Code of Federal Regulations (CFR) Part 1910.147
- E-stop
- Material/Waste

Section II: Building Process

Building Phase 1: Constructing Components

First phase was constructing pieces by ourselves. The focus of this section was fabricating pieces for the table. This included the legs for the tilt adjustment, components frame, feeder stand, filters, and mounting plates for flow meters, mixer, and the water valves. This section describes how we constructed these components.

Building Phase 1: Adjustable Legs

The table legs were removed for modification. The original leg bottoms were cut off using a band saw shown in Figure 8. Nuts were welded to the inside of the leg to affix the adjustable extensions shown in Figure 10.



Figure 8: Cutting Bottoms



Figure 9: Welding nuts

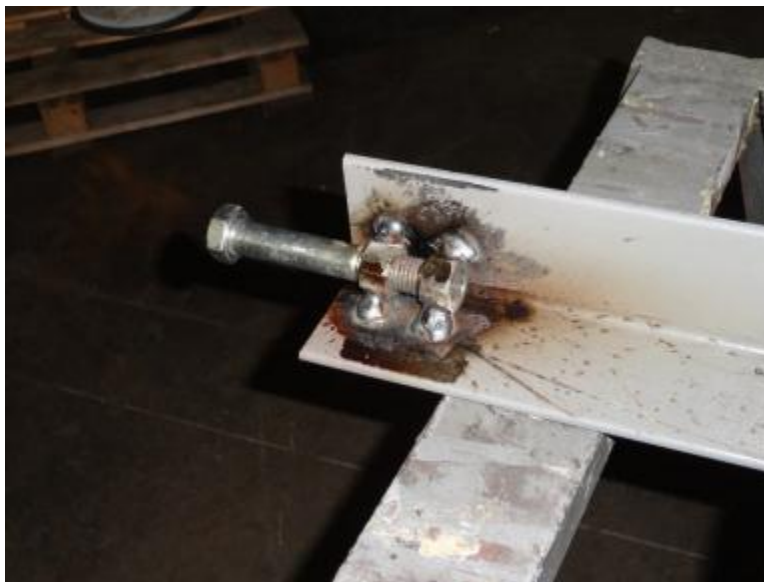


Figure 10: Nuts after Welding



Figure 11: Frame Preparation for Painting



Figure 12: Finished Adjustable Legs

Building Phase 1: Frame

The frame used to support the hopper, mixer, vibratory feeder, water lines, and electrical box was constructed and designed entirely by the senior design team. The frame was constructed out of 1 1/4" x 1 1/4" x 3/16" square tubing. Individual pieces were cut and then welded together. The frame was then sanded and painted Deister grey. Rubber mounts were made added to the mounting points of vibratory feeder to reduce vibration transmission. The following figures show the building of the frame.

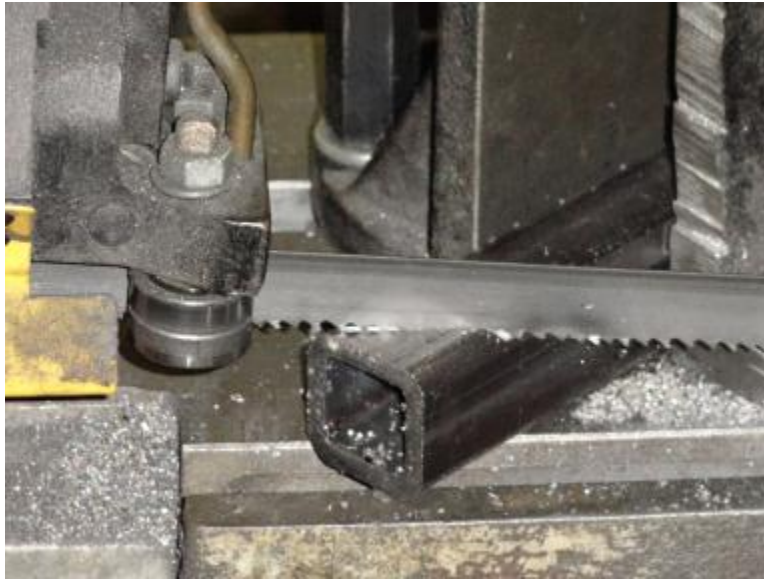


Figure 13: Cutting Frame Material for Welding



Figure 14: Frame Preparation



Figure 15: Welded Frame Ready for Paint



Figure 16: Finished Frame

Building Phase 1: Mounting Plates

Two mounting plates were constructed out of 16 gauge sheet metal. Each piece was individually cut. Holes were also drilled for proper mounting. The brackets were painted black as an accent color. The brackets include electrical outlet and water flow meter. A third mounting plate was constructed out of 3/16" steel flat stock to mount the control valves for the water supply. The following figures show the construction of these components.



Figure 17: Marking Mounting Plates



Figure 18: Drilling Mounting Holes



Figure 19: Mounting Plate Ready for Paint



Figure 20: Finished Water Flow Meter



Figure 21: Finished Electrical Outlet Plate

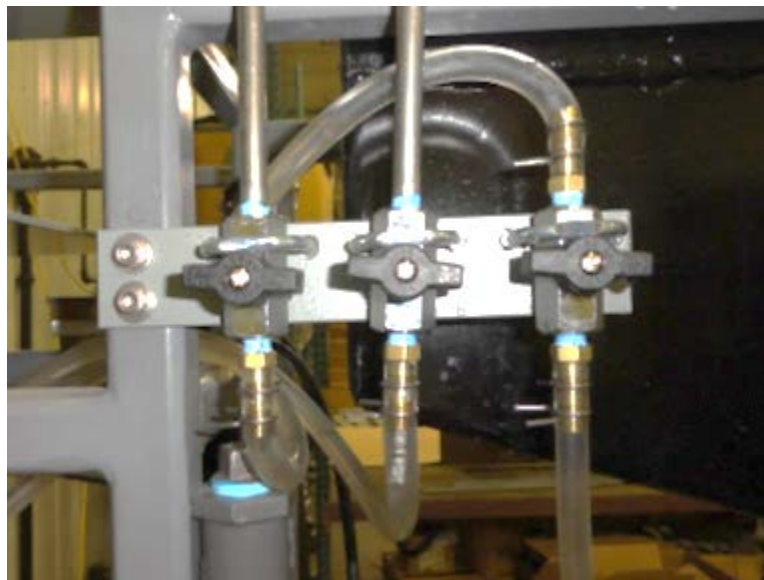


Figure 22: Water Flow Mounting Bracket

Building Phase 1: Mixer Bracket/Mount

The frame mount was milled out of aluminum. It was slotted to provide rotational stability to the extension arm and then mounted to the frame. The extension arm was constructed of steel flat stock. A slot was milled to provide height adjustment. The end of the arm was cut out with

a concave circle to allow the mixer bracket to be welded to it. The resulting bracket is shown in Figure 23.



Figure 23: Mixer Mount

Building Phase 1: Filters

For the filters, 2" PVC pipe was utilized. Slots were machined in the pipe to allow water flow shown in Figure 24. Screens of various mesh size were then wrapped around the pipe to allow water flow and prevent valuable material from passing through the filter exiting the container shown in Figure 25.



Figure 24: Filter Housing Without Screen

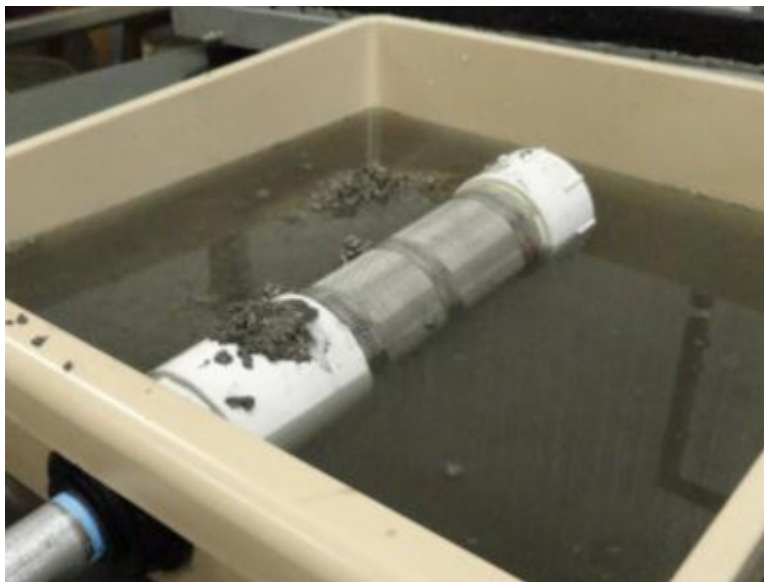


Figure 25: Filter With Screen Filtering

Building Phase 1: Stand

After assembling the frame, it was determined that vibration from the concentrating table was adversely affecting the vibratory feeder. A secondary platform was constructed to hold the frame assembly and eliminate any unwanted vibrations from the concentrating table. The platform was constructed out of 1 1/4" x 1 1/4" x 3/16" square tubing. A non-skid mesh floor was utilized to prevent any slippage from a wet floor and painted yellow. The platform also provides a raised surface for adding dry mix to the vibratory feeder. The following figures show the stand in use.



Figure 26: Stand During Assembly



Figure 27: Stand During Testing

Building Phase 2: Incorporating Purchased Components

In this phase of the building operation, purchased components were fitted to the table and tied in with existing systems. Three primary components will be discussed; the vibratory feeder, material hopper, and mixer. This section will outline what the component was, why it is important to the system as a whole, and how we installed it on the table.

Building Phase 2: Vibratory Feeder

The vibratory feeder is shown below in Figure 28.



Figure 28: The Vibratory Feeder as Received

This feeder was chosen due to its ability to precisely feed a variable amount of material into the table and its 1.5 cubic yards of material storage. The feeder operates using vibration to move the material from the conical hopper across the chute and into the mixing hopper. The magnitude of vibration frequency can be varied to effectively change the feed rate of material. This flexibility allows a wide range of materials that can be ran across the table.

The control panel for the vibratory feeder is mounted to the back of the unit and allows quick adjustments of the feed rate. The panel consists simply of a power switch and a knob that varies the magnitude of vibration frequency to control how much material is fed.

To mount the vibratory feeder, it was decided that simple anti-vibration mounts would be needed to reduce noise and rubbing between the frame of the feeder and the frame of the feed system. Using 1/2" thick gum rubber and an aluminum spacer, mounts were created. The mounts can be seen in Figure 29.



Figure 29: This Picture Shows the Vibration Mounts Used to Secure the Vibratory Feeder

Figure 30 shows how the vibration feeder is incorporated into the feed system. The chute is seen emptying into the black mixer hopper.



Figure 30: The Vibrating Feeder Moves Material into the Hopper

Building Phase 2: Mixing Hopper

The mixing hopper is shown in Figure 31.

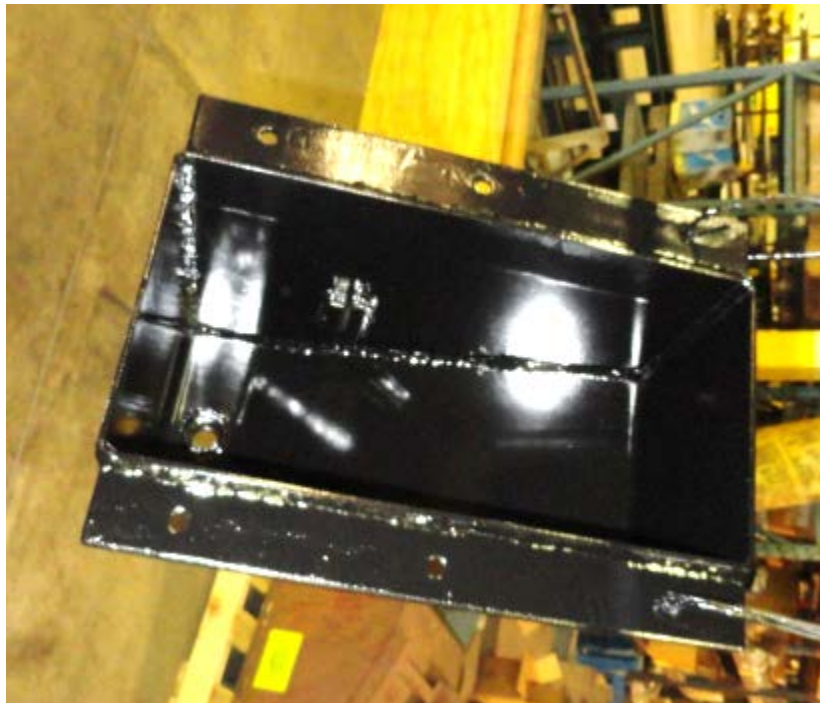


Figure 31: Inside of the Mixing Hopper

This mixing hopper design was chosen because it allows material to be mixed with water to form a slurry before it goes into the feedbox of the table. This is important to prevent large clumps of material from reaching the table. The hopper consists of two primary areas; the mixing basin, and the table-feed basin. Both areas are separated by a removable baffle. The installation of the hopper was straightforward and incorporated the use of six (6) 5/16"-18 bolts and locking washers to secure the hopper to the frame. This is shown in Figure 32.



Figure 32: Mixing Hopper Secured Frame with Six 5/16"-18 Bolts and Locking Washers

To get the material from the hopper down into the feedbox of the table, a valve was installed on the hopper, and clear hose was used to direct material appropriately. This can be seen in Figure 33. The valve allows material feed to be stopped if the operator needs to clear the table or service it.

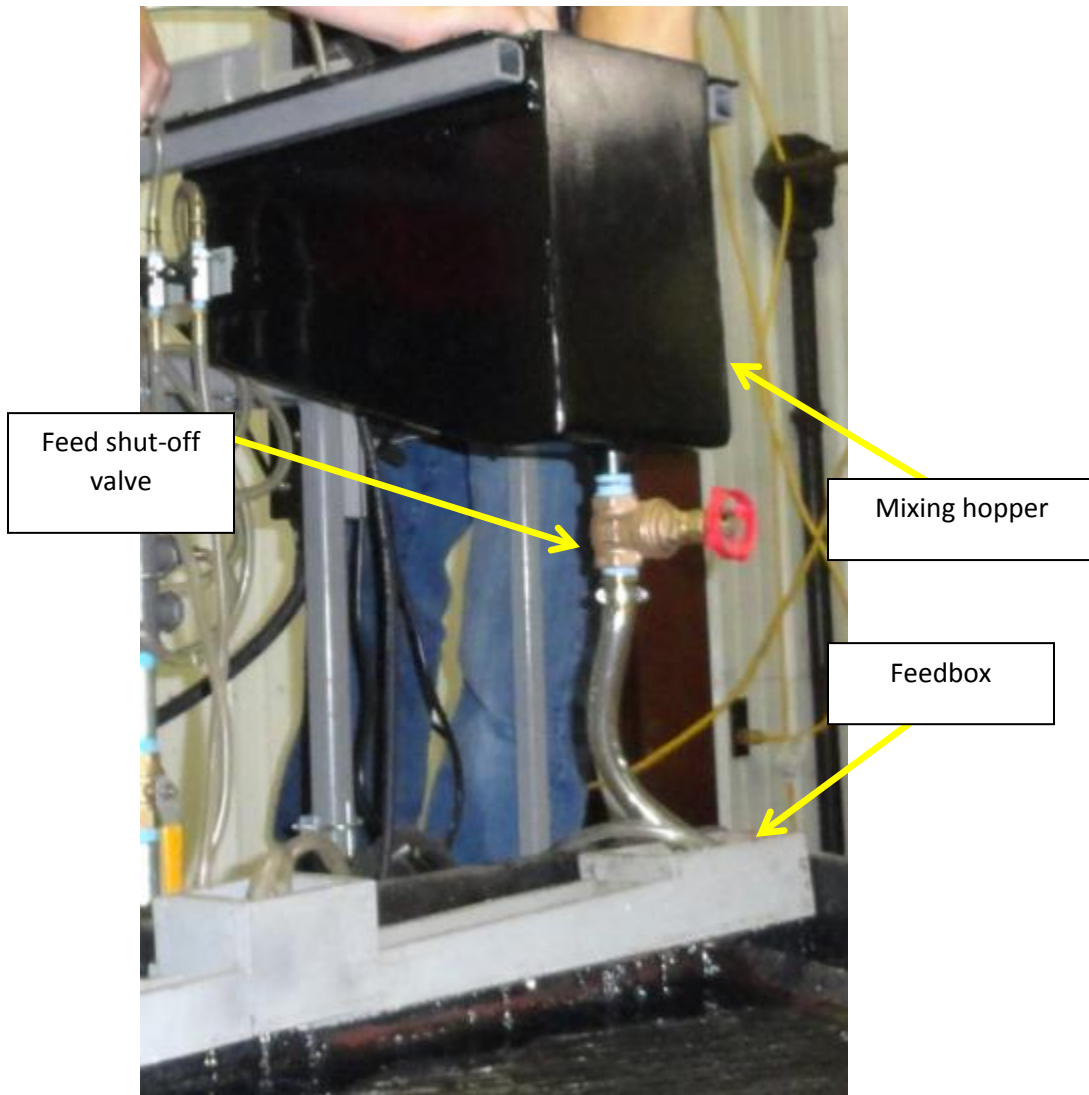


Figure 33: Feed Slurry Flow through Exit Orifice of Hopper

Building Phase 2: Motorized Mixer

The motorized mixer that was chosen is shown in Figure 34. This unit features a variable speed control and a load meter that indicates when the mixer is being overloaded. This feature is required to accommodate the different samples that will inevitably be ran over the table.



Figure 34: The Arrow Engineering Motorized Mixer

To incorporate the mixer into the feed system, an adjustable mount was designed. The mount allows the height and angle of the mixer to be adjusted. The mixer mount that was designed and milled by the team is shown in Figure 35.

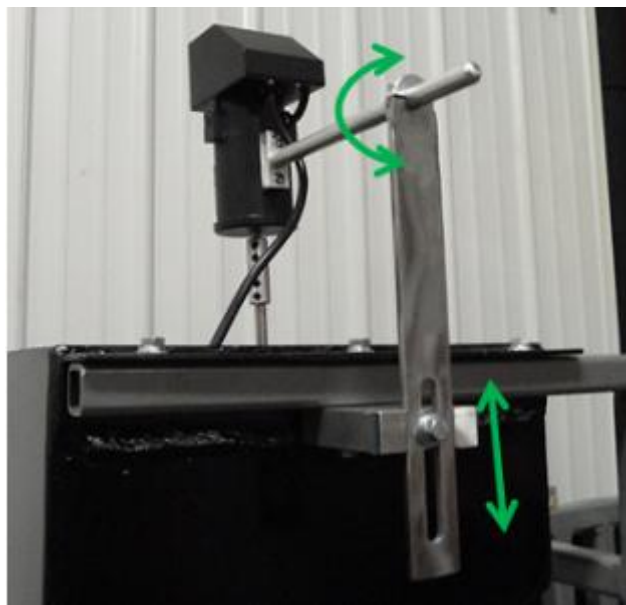


Figure 35: Milled Adjustable Mixer Mount

Building Phase 2: Coming together

This section will detail the incorporation of the three components of building phase two; the vibration feeder, mixing hopper, and motorized mixer. Figure 36 is a photograph of these components working together.

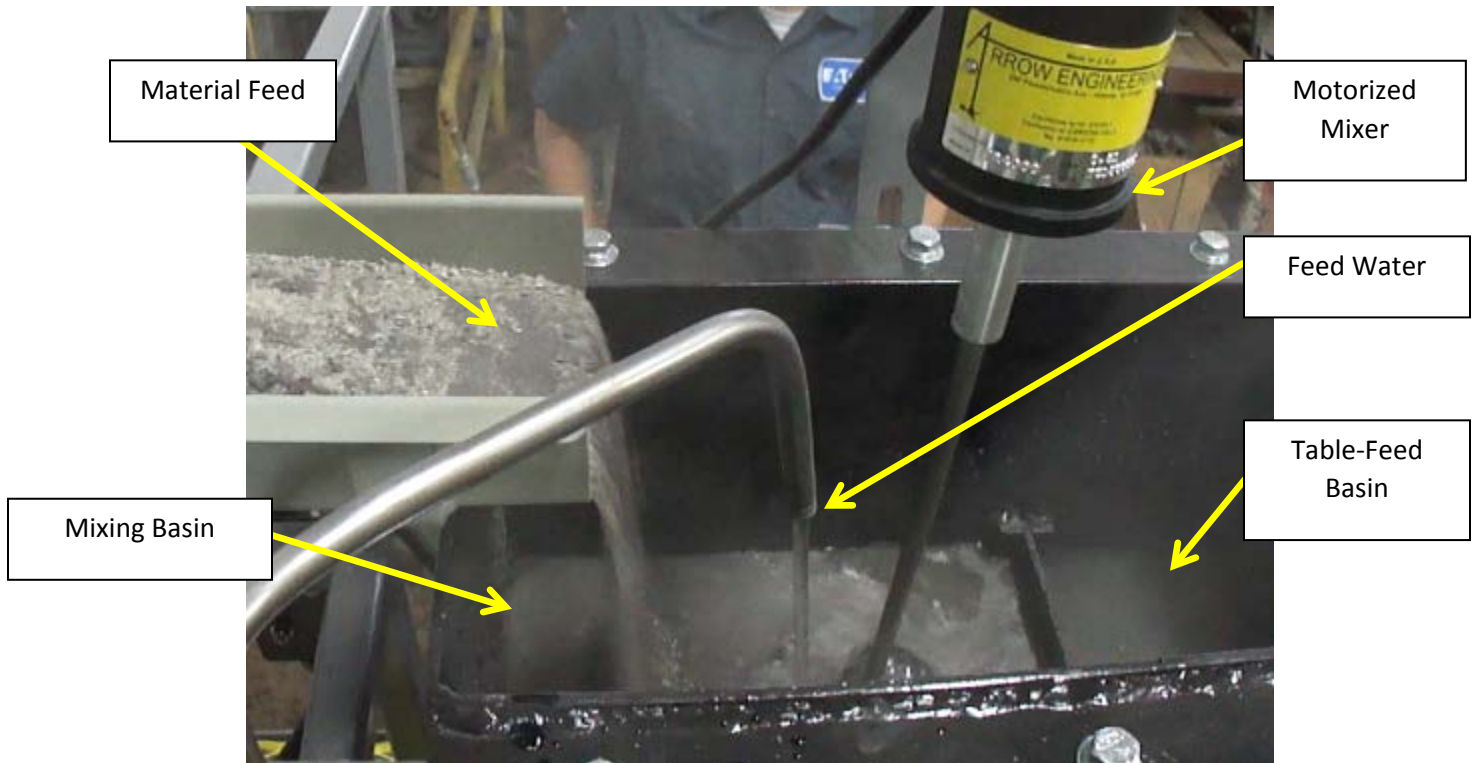


Figure 36: Inside of the Mixing Hopper Functioning

As seen in Figure 36, there are quite a few elements coming together in the mixing hopper. First, material is fed from the vibratory feeder into the mixing basin. Here, water is added and the material is mixed with the motorized mixer. This suspends all water soluble elements before they enter the table. This process also breaks up any chunks of material. The mixed slurry material then flows into the table-feed basin where it exits through an orifice and down into the feedbox of the 15S concentrating table shown previously as Figure 33.

After conducting testing with this configuration, we tried an unscreened sample consisting of larger rocks to simulate a worst case scenario. Typically, these rocks would be screened out of each sample before being ran across the table. In this test, we discovered that the rocks would clog the exit orifice at the bottom of the hopper. It was decided by the group that a configuration of the mixing system would need to be devised to handle this type of a scenario. After trying various configurations, we determined that removing the hopper baffle and tilting the motorized mixer towards the feed resulted in optimal performance of the feed system with this unscreened, rocky sample. This configuration separated the

rocks so they could leave the hopper individually instead of in clumps that would clog the orifice. This configuration is shown in Figure 37.



Figure 37: To Accommodate a Rocky Sample, Tilting the Mixer into the Feed and Removing the Hopper Baffle Resulted in Optimal Performance

With the standard configuration in Figure 36 and the alternate configuration in Figure 37, the feed system is able to handle a wide range of material samples.

Building Phase 3: Water System and Filtration

With the feeder, hopper, and frame appropriately mounted to the platform, the watering supply system was constructed. The water supply is a major component of the table and had to be properly placed in order for the table to function correctly. To promote separation, material must flow from the feeder to the collection bins or drain efficiently. Included in the water supply system is the filtration system. This was needed in order to dispense water without allowing excessive debris from going down the drain. Water is needed in three locations; the hopper, the feedbox (supplied through the Table-feed basin of the hopper), and the wash water box.

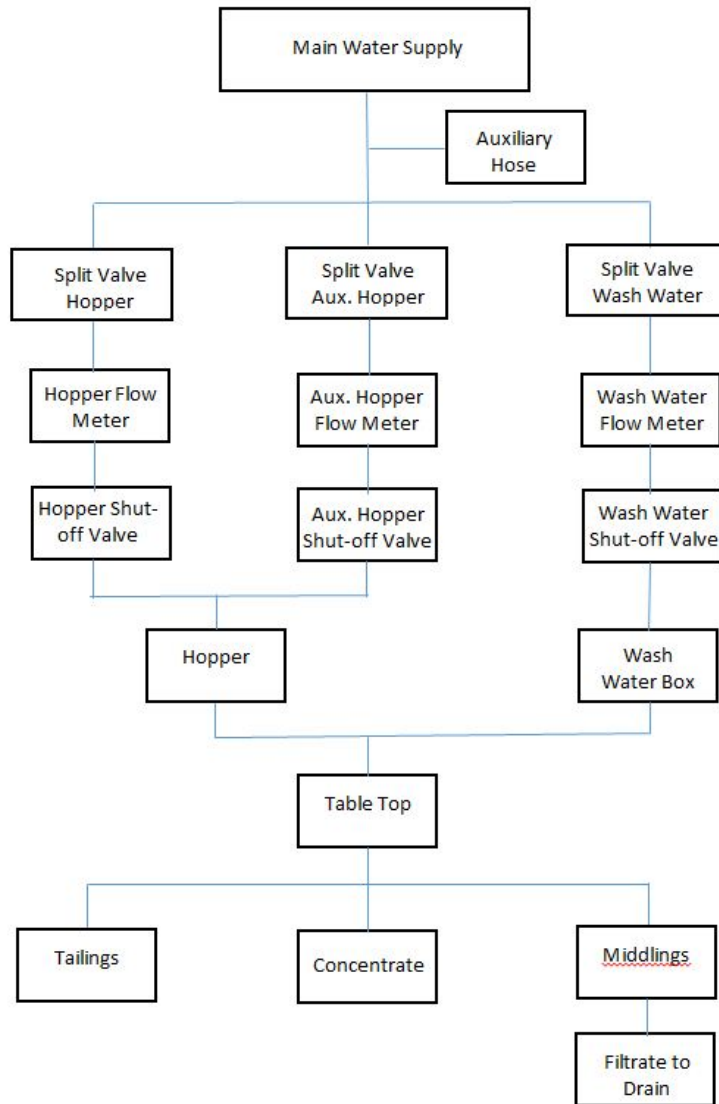


Figure 38: Water Flow Path

The water supply enters the system from a hose that attaches to the piping on the lower left corner of Figure 39. The vertical valve controls the water supply to the table and the horizontal valve controls water supply to the auxiliary hose. The auxiliary hose is seen connected opposite of the supply hose. The auxiliary hose is useful at the end of a test operation when debris needs to be rinsed off the table. As seen in Figure 39 at the top, the piping divides into three clear lines that supply each of the flow meters. The water lines entering the flowing meters can be seen in Figure 40 which is the backside of flow meter plate created by the group.



Figure 39: Water Supply System – Main Distribution Piping

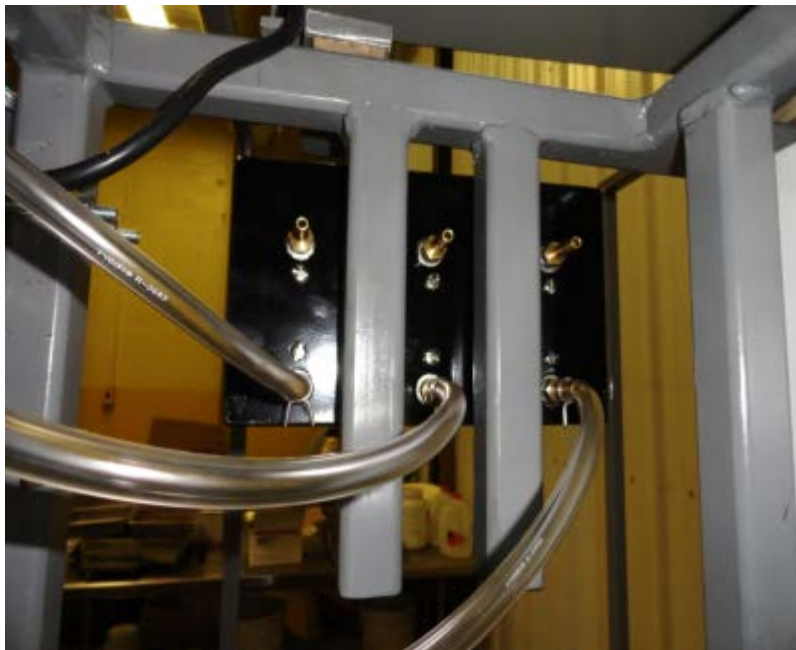


Figure 40: Backside of Flow Meters

Figure 40 shows the construction stage of the flow meters. The inlet water supply is attached but the outlet lines had not been attached yet. Figure 41 displays the front side of the flow meter panel. The flow meters from left to right supply water to: the hopper mixing basin, the hopper feed basin, and the wash water box on the table itself.



Figure 41: Flow Meters that Supply the Mixing Basin, Feed Basin, and Wash Box

After the water leaves the flow meters it then travels to 3 individual valves, seen in Figure 43, where the water can be shut-off for each individual flow. From left to right the valves follow the same pattern as the flow meters: the mixing basin, the feed basin, and the wash water box. The left most valve has a pipe that supplies water to the hopper. This pipe feeds water into the mixing basin of the hopper approximately where the dry material falls of the feeder chute. The middle value has a pipe that also directs water into the hopper on the feed basin side. The pipe was bent so that the water supply is directly above the exit drain in the hopper where it is then directly supplied to the feedbox. The reason the pipe empties the water directly over the drain is to help prevent material from clogging. The two pipes were made of 1/8" steel pipe and were bent to appropriate angles and lengths using a pipe bender. The valve shown on the right of Figure 41 is used to control the flow to the wash water box.

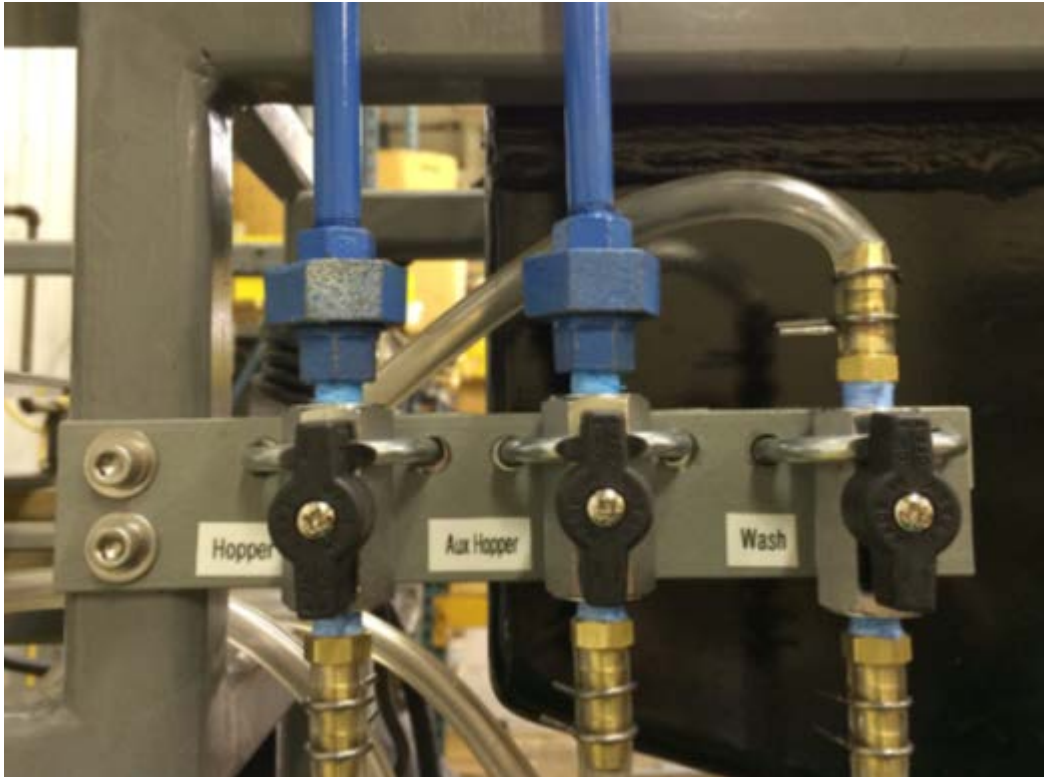


Figure 42: Shut-off Valves for Water Exiting the Flow Meters



Figure 43: Shut-off Valves and Supply Lines to Mixing Basin and Feed Basins of the Hopper



Figure 44: Top View of Hopper with Placement of Pipes and Mixer

Figure 45 displays how the slurry mixture exits the hopper and enters the feed box. Figure 46 shows how the supply line to the wash water box is attached to the wash box. Using a zip tie to hold the tubing allows for the tubing to move with movement of the table.



Figure 45: Drain Hose from Hopper to Feedbox

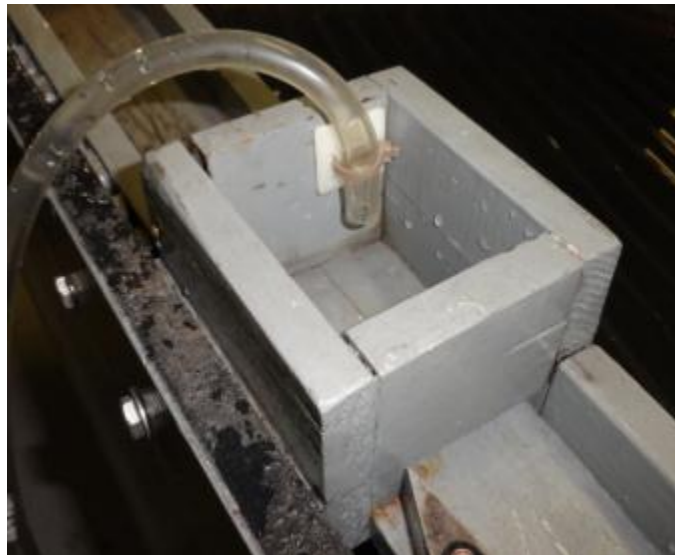


Figure 46: Water Supply Line to Wash Water Box



Figure 47: Wash Water and Slurry Flow Entering the Un-modified Table

Once the water has been supplied to the appropriate locations it then washes onto the table where it then runs off the table to the tailing, concentrate, or middling bins. The tailing collection bin is shown in Figure 48 and the middling collection been is shown in Figure 50.



Figure 48: Tailing Collection Bin with Drain Hose

From Figure 48 a hose is attached to the tailing collection bin to drain the water. The water travels through a filter to limit the amount of refuse material from going down the drain. Figure 49 displays the filter setup inside the tailing bin.



Figure 49: Filter in Tailing Bin

Both the concentrate and middling collection bins are round bins. Figure 50 shows the middling collection bin during a test run. However both the concentrate and middling bins were not built with filtration screens since both the water and sample collected in the bins for the entire length of the operation is minimal to the amount of water collected in the tailing bin. Also, there can't be any risk of losing concentrate material.



Figure 50: Middling Collection Bin

Figure 51 shows the setup of all the collection bins. The concentrate is the left most circular bin, the other circular bin is the middlings, and the bin under the table is the tailing bin.



Figure 51: Collection Bins in their Appropriate Locations Under the Table

Building Phase 3: Electrical and Wiring

First the component types were chosen based on the need of the system for independent power to the concentration table and the auxiliary components. Next the components were sized in order to handle the load of the individual components on the system as well as the desired power supply of 100V 60 Hz. Next, in order to promote a safety, several safety measures were installed including circuit breakers to protect the system from overload and emergency stop switches to stop the machine if needed. Once the components arrived, they were laid out and prepared for the installation process. The components used are shown in Figure 52.



Figure 52 : Electrical Components and Supplies

Next, the location for each of the components to be mounted in the panel door were chosen. This included, the switches, main lock-out/tag-out disconnect, an emergency stop, and indicator lights. Several configurations were possible, with several additional components as shown in Figure 53 and Figure 54. The final design layout was chosen to be that shown in Figure 54 due to the overall simplicity, and also the aesthetic design of the layout, which allowed for more free space and less holes placed in the NEMA 12 wash down enclosure.



Figure 53 : Possible Panel Layout #1



Figure 54 : Possible Panel Layout #2.

Once the component locations were chosen the panel door was laid out, marked, and holes were placed in the panel for all of the pass-through components, as well as holes for the main power supply, table power supply, and the auxiliary and second e-stop power supply. The layout and hole-making process is shown in Figure 55. The holes allow for not only the pass-through of the disconnects, but also for the bolts that hold the switches in place.

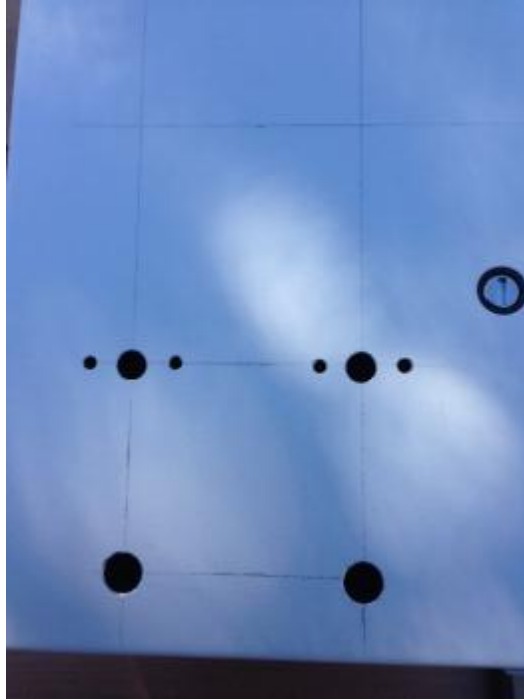


Figure 55 : Panel Hole Layout Process

Once the front panel layout was completed the layout of the interior mounting panel could begin. It was decided to use a modular DIN rail system in order to mount the internal components both for simplicity as well as for flexibility. The DIN rail system is also an industry standard for electrical panels and connections and allows the installed to quickly and easily swap out and exchange components while never needing to splice any wiring. The DIN rail system allows the use of all components while only requiring the drilling of four 12 1/4" holes in the interior mounting panel and the installation of two short pieces of rail. This installation system can be seen in Figure 56.



Figure 56 : Installation of DIN Rails

Once the DIN rails were installed the installation of components and terminal blocks could begin. Figure 57 shows the box in mid-assembly with all major components installed and the wiring process initiated. Once the components and terminal blocks are installed it is a simple matter of cutting and installing the 12 gauge AWG copper wire in the appropriate locations, using terminal blocks and jumpers where necessary. Note that the wiring for the electrical panel in this figure is now complete except for the numbering process and the entrance/exit cables which will distribute the usable power. In a production environment boxes at this point could be re-boxed and stored or sold as high-level replacement components.



Figure 57 : Nearly Complete Electrical Box



Figure 58 : Nearly Complete Control Panel

Once the electrical control box was completed it could then be mounted to the mixer and the final power distribution wires can be connected as shown in Figure 59. With all connections complete, the

box mounted, and the remainder of the components plugged in the box was tested and seen to be in proper functioning order as shown in Figure 60.



Figure 59 : Completed Control Box Interior



Figure 60 : Completed Control Box Exterior

Cost Analysis

For the budget for this project Deister set aside a \$6000 budget with a variable ceiling if justifiably necessary. This budget was to include not only the development of the unit, but also the final build cost of the unit including any materials, labor, and fabrication that was required. In order to meet the budget set by Deister it was necessary for the team to design a relatively simple yet robust system that could be quickly and easily assembled by the shop personnel as well as a system that was able of quick troubleshooting if an error were to occur in the field. The build budget can be seen below in Table 1.

Table 1 : General Budget to Cost Comparison

Budget	
Category	Cost
Electrical	690.02
Plumbing	289.17
Mixing Hopper	120
Frame	750
Vibrating Feeder	2853.77
Total	4702.96
Budget	6000
Remaining Budget	1297.04
Budget Used	78.38%

Section III: Testing

The parameters that were tested were separated into four categories: water management, feed supply, tilt adjustment, and safety. The following is a list of the parameters that were tested for each category.

Water Management Testing

Parameters to be tested

- Water flows from supply hose across table to collection bins (visual)
- Through the entire sample run the test should be continuous in operation and therefore not interrupted to drain the collection bins for a minimum of 30 minutes
- Water from the collection bins able to be moved to a drain or waste water bin (visual)
- With the screens in place a minimum reduction of 50% of tailing material should be filtered from the tailing compared to the current method

Step by step testing procedure

1. Ensure that the oscillating table top is flat.
2. Ensure that the flow meter leading from the water source to the feed hopper is fully open.
3. Run the water for 30 minutes continuously and allow water to drain into bins.
4. If bins allow continuous operation for 30 minutes, continue test for another 10 minutes, for a total of 40 minutes of continuous operation, to see if the system will outperform expectations.
5. Once complete the bins must be able to be moved to a waste water drain.
6. Run a previously weighed amount of slurry through the system with the filter attached.
7. Once finished measure the amount of slurry trapped by the filter.

Testing Results and Conclusions

Testing showed that water did flow from the supply hose across the table top and to the collection bins. The sample run was continuous in operation throughout the entire 40 minute test period, and once complete, the collection bins were able to be moved to a proper area for drainage. To ensure that the filtration system worked, the original sample was weighed in at 12.46 pounds and ran through the system with the filter in place. Once the sample run was complete the amount of material caught by the filter was found to weigh 11.48 pounds, equal to 92% of the original weight. This shows that the filtration system greatly outperformed our parameter of 50% tailing material filtration. Figure 61 shows the water flowing from the mixing hopper, into the feedbox, across the table, and into the collection bins. Figure 62 shows the filter separating the tailing material from the water during testing. Figure 63 shows the tailing material that was collected by the filter being collected for measurement.



Figure 61: Water Flowing from Mixing Hopper, to Feedbox, across the Table, and Into the Collection Bins



Figure 62: Filter Separating Tailings from Water



Figure 63: Tailing Material that was Captured by the Filter

Feed Supply Testing

Parameters to be tested

- The dry sample moves from the feeder to the mixer and then to the feedbox (visual)
- Capable of delivering material to table top up to 120 pounds per hour
- At a constant speed setting for both feeder and mixer the consistency of a given material should remain steady, with steady defined as the percent solids of the slurry mixture varying no more than $\pm 10\%$
- The feeder is able to handle larger quantities of dry material than the current design
- The feeder is capable of varying speeds

Step by step testing procedure

1. Weigh the test sample.
2. Load the sample into the feeder.
3. Set feeder at 25% feed rate.

4. Run sample to the end of the feeder shoot.
5. Start timer when sample reaches the end of the feeder shoot.
6. Stop timer once last of material leaves the feeder shoot.
7. Calculate amount of material delivered by feeder per hour.
8. Repeat steps 4-7 twice.
9. Set feeder at 0% feed rate and repeat steps 4-7 twice.

Testing results and conclusions

Testing showed that the dry sample indeed travels from the feeder to the mixer and then to the feedbox without the aid of an operator. Table 2 shows the time it took for a 10.37 pound test sample to be ran through the feed system and how many pounds per hour this would be.

Table 2: Results from Feed System Testing

Feed Speed	Time (minutes)	Pounds per Hour
25%	1.48	419.46
25%	1.72	362.45
25%	1.62	384.87
0%	5.00	124.44
0%	5.00	124.44

These results show that the system is successful in achieving 120 pounds of material delivered from the feed system to the hopper. This test also proved that our system is also capable of maintaining a variability in pounds per hour delivered by $\pm 10\%$ while the feed speed is held constant. This table also shows that the feed system is capable of varying speeds as well. Also, the fact that we were able to load over ten pounds of test sample into the feed system in a single time shows that this new system is able to handle larger quantities of dry material than the previous design since the previous design was limited to feeding quantities about the size of a table spoon. Figure 65 shows the material exiting the feed hopper and entering the mixing hopper where it is then be fed to the feed box.



Figure 64: Material Loaded into Feed Hopper



Figure 65: Material from Feed System Entering Mixing Hopper

Tilt Adjustment Testing

Parameters to be tested

- Increase the available tilt of the oscillating table top by 20%, or 1/16 inch per foot.
- Stationary table has the ability to achieve stability on uneven ground.

Step by step testing procedures

1. Set oscillating table top tilt to maximum 5/16" per foot setting.
2. Adjust the four adjustable legs until 3/8" per foot of tilt is achieved on the oscillating table top.
3. Once 3/8" per foot tilt is achieved, set adjustable legs and oscillating table top tilt so that oscillating table top is parallel with the ground.
4. Move table frame to uneven surface.
5. Attempt to get oscillating table top parallel to ground only by adjusting the four adjustable legs.

Testing results and conclusions

The testing showed that we were successfully able to gain the minimum requirement of an additional 1/16" per foot tilt of the oscillating table top by adjusting the four adjustable table legs. We were also successful in gaining stability on uneven ground and making the oscillating table top parallel with the ground by adjusting the four adjustable table legs. Figure 66 shows how the table is able to achieve stability and levelness on uneven terrain by adjusting the adjustable table legs. These same adjustable legs were utilized to achieve the extra 1/16" per foot tilt of the oscillating table top.



Figure 66: Table Shown on Simulated Uneven Ground

Safety Testing

Parameters to be tested

- Power to the table must be interrupted and the machine de-energized after depressing one or both of the emergency stop buttons
- The table must be unable to re-energize while it is locked out

Step by step testing procedures

1. Ensure emergency stop switches are not depressed and the main power switch is on
2. Turn on oscillating table top motor, automatic feeder, and hopper mixer.
3. Depress one emergency stop switch and ensure all electrically operated components are de-energized.
4. Reset depressed emergency stop switch and ensure oscillating table top motor, automatic feeder, and hopper mixer and energized and operating.
5. Depress the other emergency stop switch and ensure all electrically operated components are de-energized.
6. Reset depressed emergency stop switch and turn off main power switch.
7. Place lock out device on the main power switch and lock it.

8. Make sure there is no way to turn the main power switch on while lockout device is locked in place.

Testing results and conclusions

Testing resulted in the verification that the emergency stop buttons are both successful in de-energizing the electrical systems of the table, as well as verification that the lock out system is successful in keeping the table from being re-energized while it is locked out. Figure 67 shows the emergency stop location and the main power switch locked out.



Figure 67: Emergency Stop and Locked out Main Switch

Section IV: Evaluation and Recommendations

Evaluation

The results of our improvements to the Deister 15-S Concentrating Table were successful. The requirements of the project were divided into four categories. The first category was the feed system which resulting in an additional structure. For feed rates we achieved greater than the 120 pounds per hour and at 25% achieved approximately 400 pounds per hour. The size of the feeder allowed for 265 cubic inches of material can be added. The adjustments allowed for variable slurry and feed rates. These made our feed system pass all the tests. The next section was the water reuse and removal. For the water and material distribution, they all pass through the table on the correct path. The water system also had no leaks. The filters in the bucket allowed for longer run times and removal of water while retaining the material. These satisfied our requirements for the water system. The third category was the tilt adjustment which was completed with the addition of adjusting legs. This also had an added bonus of stabilizing the table on unlevelled surfaces. This was tested on uneven surfaces and checked with a level. They all passed. The final category was safety which was completed by adding two e-stops and a lock out/tag out system to the table. They were tested and worked. The final requirement was all improvements must be bolt on or stand alone. This was also satisfied. So the completed success and all requirements were completed.

Recommendations

There are a few recommendations that we have for improving our final design. First we would like to redesign the mixing hopper. The current design utilizes a “flat” bottom, but we would like to change this to a V-bottom to aid in the transfer of incoming material to the exit orifice. After a run of sample there was residual material left in the hopper that required using the auxiliary hose to wash out the remaining material. Another recommendation is to change the height of the secondary stand railing. Also, the railing height interferes with the control panel for the vibratory feeder. Lowering the height of the railing would make access to the controls on the panel easier.

Conclusions

In conclusion, the Deister 15-S Laboratory Table meet all the requirements set in place by Deister with minor adjustments to the conceptual design. These adjustments were required by Deister themselves to reduce cost manufacturing. After construction and testing were complete, it was found that the table was capable of meeting or exceeding in some cases the design requirements. The additions to the table allowed for the table to eliminate the need for the entire length of operation, along with creating a more consistent feed of material and water to the table. The additions to the table also allowed water to be removed from the system to allow for an entire test sample to be run without having to interrupt operation. The table provides much safer for users with the addition of safety devices. The table will remain at Deister to continue to run test sample. The final design was under that budget, with a final cost of roughly \$4,700 which Deister plans to market at a retail price of \$7,860 with minor adjustment that will reduction production cost.

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