

Milk Mixer

Final Report

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Abstract

In the past, the process for mixing powdered milk with water to feed calves has required manual labor or expensive mixing equipment. The manual mixing process is time consuming, as it requires the ingredients to be loaded, mixed, and dispensed manually. This process also includes manual cleaning of the equipment. Motorized mixing equipment is often unaffordable for the average farmer. In addition, many mixing systems on the market are motorized, which reduces manual input, but they still require manual loading of the ingredients.

The purpose of this project was to design and construct a mixing system that is time saving and affordable for the average farmer. The project consisted of building an apparatus to dispense measured amounts of powder and water to be mixed for a specified number of animals. In addition, a washing device was assembled. Also included in the project was the implementation of a microcontroller that serves to control the entire mixing process. This mixing system improves upon most available systems in that it automates the entire mixing process from the loading of the ingredients to the dispensing of the product and the sanitizing of the apparatus.

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INTRODUCTION

Description

The original milk mixing process was a completely manual procedure. All of the measurements were done by hand, as well as the milk dispensing and washing. Because of this, the process was very time consuming. In addition, the ingredient measurements were not very precise resulting in a milk mixture with improper proportions.

The goal of this project was to design and construct a system that combines and blends water and milk powder (known as Milk Replacer) to create milk that is suitable for feeding calves. The system included automation of the following: measurement of raw materials, the mixing process, dispensing of finished product, and washing of the mixing equipment.

The need, therefore, was for a solution, which would be less labor intensive, less time consuming and more precise. In addition, the solution would be user friendly and low cost, thus making it affordable and practical for the small-scale farmer.

Objectives

1. To build a system that had a mixing capacity of at least 50 animals per batch (25 gallons).
2. To build the complete system for under \$500.

3. To build a system that required only four manual procedures:
 - (1) Input the number of calves.
 - (2) Input the time of mixing.
 - (3) Dump the milk powder into the bin.
 - (4) Dispense the final product.
4. To design a program for the MK11 microcontroller that did not require computer literacy to operate, and house the controller within a NEMA Type 4 enclosure.
5. To construct a system that had a mixing time of less than five minutes and total process time of less than fifteen minutes.

Literature Review

Mixing systems are integral parts of many manufacturing processes. They are used in pharmaceutical companies, dairy processing plants, chemical manufacturing, and many other applications. However, the majority of these systems are intended to handle large quantities of material and therefore are unsuitable for small-batch mixing.

Small self-contained blending systems are available through custom fabricating firms.

These systems are typically constructed of stainless steel and use high-tech blending techniques. Many companies offer complete blending systems or the particular parts of a system. Many of these products are designed specifically for a particular task.

JBW Systems, Inc. sells a product called the *JBW Mixing System*. This system is a light self-contained unit, which is suitable for small quantities of powder-in-liquid mixing. However, the proportions of liquid and powder must be manually placed in the mixer.

Flo Trend Mixing Systems manufactures a system called *Jet Shear II*. This tank-free device utilizes unique nozzles to create a flow pattern in order to blend two materials. However, this system is not designed to mix solids in liquids and does not incorporate a metering system for the ingredients.

TSPF Heifer Services, a subsidiary of AGWAY Inc., mixes the milk for their calves in an open-topped stainless steel tank. The water is supplied from a water heater and the volume is monitored via an inline flow meter. The powder is measured and poured into the mixing tank by the operator. The actual mixing is accomplished by an impeller mounted, via a stainless steel shaft, to a variable speed motor mounted at the top of the tank.

In the past 30 years, the microcontroller has become an integral part of the world of automation and control. The microcontroller is a relatively recent development that has branched off the larger PLC's (programmable logic controllers). In the late 1970's, several years after its introduction, the PLC market was around \$80 million. By 1990, with more affordable computer hardware and a higher level of capabilities,

the market for PLC's grew to \$1 billion and it continues to increase exponentially to this day (Webb 5). Today, PLC's are used in most manufacturing industries as process controllers, as well as in building energy and security control systems. As PLC's continue to get smaller and smaller, the uses for them continue to grow.

Many leading automation and control companies have already developed microcontrollers. Allen-Bradley and Rockwell Automation have a microcontroller on the market called the Pico Controller. This small controller performs simple logic, timing, counting, and real-time clock operations. Although the Pico Controller was designed for ease-of-use without any programming software, it still requires knowledge of logic functions and data input to program and run the controller.

GE-Fanuc also has several microcontrollers on the market called the Versamax Micro and Nano PLC's. These PLC's are also small and perform the same functions as a larger PLC, but programming software is required, which in turn requires extensive knowledge of programming logic. These units are not cheap; a small Nano PLC with an operator interface can cost well over \$500.

Various other companies have developed microcontrollers such as Modicon (Schneider Automation) and Square D. These controllers can be quite expensive and the user interface is such that one needs knowledge of programming logic.

From our research we concluded that there was not anything quite like what we were looking for available on the market. A few of the systems had parts that we liked, but none of them that we found did the complete process and all of them were more costly than what we were looking for.

Solution

Our Solution

Our solution sought to fix some of the problems that we saw with the technology available on the market. We wanted to build a system that was entirely automated and effectively mixed the milk, but was not high priced.

Regarding the mechanical areas of this project, the action items of concern included the following:

- 1) Water was metered to ensure that the appropriate quantity was dispensed for each batch of milk. This was monitored by timing the flow at a known flow rate (gpm). A solenoid valve was installed in the water inlet line to control the flow.
- 2) An auger was used as a powder-metering device to ensure that the appropriate quantity of powder was mixed with water. In addition, the auger was utilized to transport the powder from the holding bin to the mixing tank. The appropriate quantity of powder was dispensed by monitoring the running time of the auger.

- 3) The mixing was performed in a thirty-gallon barrel and utilized an impeller to do the mixing. This impeller was mounted on a vertical shaft connected to an electric motor, which was mounted at the top of the tank.
- 4) The impeller was selected to ensure that the shear in the mixture was great enough to completely mix the powder in the water (e.g. no lumps larger 1-mm). The impeller was machined from aluminum for corrosion resistance.
- 5) A solenoid valve was installed on the mixing tank outlet line to enable the controller to measure the appropriate quantity of milk for each calf (1/2 gallon). In addition, this valve was programmed to open at the end of the wash and rinse cycles to allow the water to drain from the mixing tank.
- 6) Soap was dispensed into the mixing tank, during the wash cycle, by utilizing a detergent container mounted over the mixing tank. The amount of detergent that drained into the tank per wash cycle was controlled by a solenoid valve.

The electrical portion of the project consisted of programming a microcontroller, which controlled the following items:

- 1) At the time designated by the user, the controller began the process by opening the water inlet valve.
- 2) The controller used timing based on the flow rate until the appropriate quantity of water entered the mixing tank, at which time the controller closed the valve.

- 3) The controller was integrated with the powder dispensing process in the following manner:
 - a) The controller started the powder measuring process by turning on the auger after the water had entered the tank.
 - b) Using a timer, the controller ensured that the auger dispensed the appropriate quantity of powder into the tank.
- 4) When the proper quantities of powder and water were in the mixing tank the controller initiated the mixing process by starting the motor. The motor ran for a predetermined amount of time (until all of the powder was suspended in the water) at which time the controller turned the motor off.
- 5) The controller was programmed to open the outlet solenoid valve for a set amount of time (long enough for $\frac{1}{2}$ gallon of milk to be released) when a button is pressed on the keyboard.
- 6) When all of the milk was drained from the mixing tank, the controller initiated the washing process and dispensed the detergent and water into the tank. At the completion of the cycle, the controller opened the outlet valve to allow the tank to drain.

The only input that the user needed to perform was: the number of animals that were to be fed and dispensing the milk at the end of the mixing cycle. The temperature of the water inflow did not need to be controlled by the microcontroller because it was set to the appropriate temperature at the hot water heater.

Alternative Solutions

There were other alternatives that we looked at during the design phase of the project. First, there was a question of whether to use an inline mixer or a rotating agitator. The inline mixer had the advantage of not having moving parts, but it had a major drawback in that it was very difficult to clean so we decided that a rotating agitator was better for our project.

Second, for the powder measurement we thought of using a dumping hopper, which utilized load cells, to determine the weight of the powder in the hopper. The controller would have determined how much weight of powder was needed for a particular number of calves, weighed that quantity, and dumped it into the tank. However, this idea seemed to be much more complex than using an auger and had a greater potential for problems. In addition, the load cells would have been expensive and difficult to manipulate.

Third, the detergent was originally going to flow into the water line via a drip line and from there it would enter the tank. However, this design had several drawbacks. There was the problem of knowing how much detergent was dispensed. In addition, it did not seem like a good idea to have the detergent flow through the same line that the water flowed through that was used for the milk.

Fourth, for the impeller and shaft we had to decide whether to use aluminum or stainless steel. Stainless steel was ruled out because of cost and problems associated with welding and machining. However, if we had bought a pre-assembled shaft and impeller, stainless steel would have been the preferred material.

Fifth, a stainless steel mixing tank would have been ideal, but because of our monetary constraints we chose plastic because it was much cheaper. In addition, it was easier to make modifications to the plastic drum than it would have been for a stainless steel drum.

Sixth, our original design called for us to design and build the entire microcontroller. However, we decided that it would be better use of our time to program a controller than to build one.

Seventh, we could have bought a commercial microcontroller to control the system such as the Allen Bradley Pico Controller. However, the high cost of these types of controllers was out of our budget range.

Design Process

Analysis/Experimental Work

Our experimentation and analysis included five specific tests that were conducted during and after the construction of the mixing system. These tests were as follows:

- 1) We measured the flow rate of the incoming water from the hot water heater to the mixing system. The experimentation was done by utilizing a five-gallon bucket and a stopwatch. The procedure was repeated five times to yield a mean flow rate.
- 2) We experimented with the mixing time until we found the optimal duration for obtaining the most homogeneous mix. This was accomplished by using the motor, impeller and tank, which were used in the final prototype. Tests were performed for various batch sizes to ascertain the required time for the mixing process. To measure the homogeneity of the milk mixture a cheese cloth was used to measure the quantity and size of any lumps remaining in the milk.
- 3) We analyzed the weight that the load bearing structure needed to withstand and designed the structure accordingly. This was particularly important for the structure, which supported the mixing tank. This structure was analyzed on paper using static analysis. The expected load included the maximum amount of water and milk, which, could be in the tank, as well

as the weight of an average person. This was to ensure that the frame would be able to withstand someone standing on the frame.

- 4) We tested the programming of the microcontroller by hooking up LED's that would indicate when each controlled entity was operating.
- 5) We tested the functionality of our relay board by hooking up the power supply and the solenoid valves to ensure that each relay circuit operated properly. This required the use of a multimeter to check for proper currents and voltages.

Design

Mechanical

The mechanical aspects of the design included: mixing tank, powder holding bin, powder dispensing auger, solenoid valves, impeller, mixing motor, motor mount, impeller shaft, supporting structures, and water piping (See Appendix I,A).

To construct the mixing tank the top was cut off of a used 30-gallon plastic drum. In addition, a 3/4-inch hole was drilled in the center of the bottom of the drum and the outlet pipe was attached in that hole. The drum was supported in a stand constructed of angle iron and steel strips (See Appendix I,B).

The powder holding bin consisted of a fifteen-gallon plastic drum (See Appendix

I,F). The top and bottom were cut off of the bin and the top was replaced with a rubber gasket to seal the top from moisture. A funneling device was constructed from Plexiglas to direct the flow of the powder from the bin into the lower end of the auger.

The powder-dispensing auger was donated by a local farmer and was powered by a single-phase, $\frac{1}{2}$ horsepower, 120 Volt, AC motor, which will operate at 1725 revolutions per minute (See Appendix I,G). The motor ran through a reducing gearbox so that the powder flow was slow enough for the controller to precisely measure the powder.

Three solenoid valves were used in the mixing system. One was placed on the water inlet pipe to allow the appropriate amount of water to enter the tank. Another controlled the flow out of the tank. The third dispensed the detergent into the water during the washing process. All of these valves were placed on timers in the controller and opened and closed at the direction of the controller. In this manner, the controller was able to dispense the desired amounts of liquid at the appropriate times.

The impeller was constructed of aluminum because of its cost and durability. The diameter of the impeller was determined to be at least $\frac{1}{10}$ th of the diameter of the tank. The design was simple and resembled a fan blade. There were two blades on the impeller offset at 180° and set at 30° from the horizontal (See Appendix I,E).

Originally, the design called for us to purchase an aluminum or plastic fan blade and use it for the mixing process, but during initial mixing testing we found that these blades did not have the structural integrity needed to mix the water. Therefore, we determined that we needed to build our own impeller from heavier aluminum.

The impeller was connected to the motor via a ½" X 2' shaft. This shaft was pinned to the hub of the impeller and connected to the motor with a flange and bolts. The shaft was constructed of aluminum as well because of its resistance to corrosion.

The mixing motor was a single-phase, 1/3 horsepower, 120 Volt, AC motor, which operated at 1740 revolutions per minute. The motor was mounted at the top of the tank through the use of a mounting bracket and was angled at 5 degrees from vertical. The motor mount was made of steel and bolted to the mixing tank stand.

Piping for the water consisted of 1/2-inch PVC and brass and was glued at the appropriate places. One pipe was run from the water heater for the clean water. The dispensing piping was attached to the bottom of the mixing tank by utilizing a bolt-on pipe flange. A horizontal section of PVC was run from under the tank to make it easier for the user to place a bucket under the end of the pipe.

The detergent container was made of 4-inch clear PVC and was placed vertically above the mixing tank. The detergent ran from the container through the solenoid valve and into the tank (See Appendix I,H).

Electrical

The components for the electrical aspects of this project consisted of a NEMA Type 4 enclosure (Appendix I,L), a microcontroller that implemented the Motorola 68HC11 microprocessor (Appendix I,M), a relay board (Appendix I,N), a keyboard for data entry, and an LCD to view data (Appendix I,L). The inputs to the microcontroller included the keyboard, a system on/off switch, and an emergency cut pushbutton.

The outputs included the motors and the solenoid valves.

Several programs needed to be written for the microcontroller to perform its designed processes. First, a program was written that responded to the on/off switch and turned the microprocessor, LCD, and keyboard on and off. Then, a program was written that required the input of the number of calves, which were to be fed. It was assumed that for every calf fed, there needed to be a half-gallon of the milk solution dispensed. Of course, there was a separate program or subroutine to convert from decimal to hexadecimal. The program calculated the time needed to dispense the correct proportion of water, which was based on the number of calves entered. The powder dispensing was done using a timer to control the amount of time that the auger operated. The quantity of power was predetermined by the input of the number of calves. The mixing time was also predetermined by the number of calves.

The washing program was a set program that was not dependent on any variables. This used the timer once again to dispense a specific amount of hot water and soap

solution. The flow charts for the preceding programs can be seen in Appendix I,I-K.

There was also an emergency cut pushbutton that sent an input to stop all processes when depressed.

Implementation

Construction

Mechanical:

Impeller: The impeller was constructed of 1/8" thick aluminum plate in conjunction with a 1" O.D. aluminum hub with an I.D. of 1/2". The impeller was a two-blade design with the blades 180° from each other. The blades were angled at 30° from horizontal and welded in slots on the hub using a TIG welder. The blades were 1.25" wide and 2" long. The slots in the hub were cut with a milling machine.

Impeller Shaft: A 2' long by 1/2" diameter aluminum rod was used as the shaft for the mixing operation. One end of the shaft was fastened in the impeller hub by utilizing two stainless steel pins. The upper end of the shaft was linked to the motor shaft by using a coupler secured with bolts (See Appendix I,C).

As previously mentioned, the initial impeller design did not include the machining of an impeller, but through testing we found that it was necessary to design and construct an aluminum impeller from a heavier material.

Mixing Tank: The top of the 30-gallon drum was removed and a 3/4" hole was cut in the bottom for the drain pipe. One-half inch diameter brass pipe was placed in the hole in the bottom of the tank, and was held in place using a flange.

Powder Auger: A three-inch auger encased in thick-walled PVC was used for the powder transfer and measurement. The total auger length was 4' and the flighting length was 3.5'. An eight-inch long section of the auger casing was removed from the top at the lower end of the auger. This was to allow for the powder entry into the auger by gravity flow. The powder entered the auger via a cut in the bottom of the casing near the upper end of the flighting.

The powder auger was fastened to the reducing gearbox by utilizing a pin through the shaft. The output shaft of the gearbox was machined to fit inside the hollow auger shaft. However, the set screws that were designed to hold the shaft in the gearbox were unable to withstand the axial loading and the torque from the auger. Therefore, it was necessary to drill a hole and replace the set screws with a pin.

Powder Storage Bin: The top and bottom of the 15-gallon plastic drum were removed. A hinged lid was constructed to seal the top and allow the user to fill the storage bin. A funneling device was constructed from Plexiglas to funnel the powder into the auger. The Plexiglas proved challenging to cut and resulted in small cracks near the edges of the cut pieces. Because of the difficulty in the cutting process the pieces of the funneling device did not meet as well as they should have and small openings resulted. However, all of the seams were filled with Lexel caulking which

effectively filled the gaps and provided structural integrity to the entire funneling device. Wooden bracing was added to render additional structural integrity and to keep the top-heavy bin from toppling over under the weight of the powder.

Design Changes: The original design called for the use of a plastic or aluminum fan blade to be used as the mixing impeller. These were to be purchased at a low cost and would have saved manufacturing time. However, initial testing with the 3-4" fan blades proved that they were unable to withstand the forces involved in the mixing process.

After initial testing of the final impeller design it was determined that the original shaft length was too long (3 feet). The shaft deflections were dramatic because of the transverse loading at the impeller and the long moment arm (the shaft). To reduce this effect the shaft was shortened by 33%.

The preliminary design for the powder auger utilized a motor connected direct drive to the auger. The motor was geared down so that its shaft speed was 4 rpm.

Testing proved that this speed was insufficient to transport the required amount of powder in the allotted amount of time. Using another motor connected through a gearbox to the auger solved this problem.

Electrical

Relay Board: A relay board needed to be built that would receive the signals from the controller and turn each component on and off. This used 5 similar circuits each consisting of 2 resistors, 1 transistor, 1 relay, 1 diode, and 2 connectors. Wire leads were soldered to connect the electrical components. The circuits were mounted onto a pre-drilled PCB board. See Appendix I,D for circuit schematic.

Enclosure: The controller and relay board were protected using a stainless steel NEMA Type 4 enclosure. This was prepared by drilling holes to mount the microcontroller and relay boards to the grounding plate of the enclosure. Holes were also cut in this casing to allow the keyboard and LCD to be connected to the controller. In addition, two holes were drilled to allow the connection of PVC conduit. The 24 VAC transformer was mounted inside the enclosure and the power supply for the microcontroller was mounted on the outside wall of the enclosure. The LCD was mounted on the face of the enclosure and was encased with Plexiglas to protect it.

Connection: The various motors and solenoid valves were wired to the controller through PVC conduit channels.

Operation

Testing began with the determination of the water flow rate into the mixing tank. After a series of tests the mean flow rate was determined to be 5.21 gallons per minute.

Test #	Amount of Water (Gallons)	Time (Seconds)	Rate (GPM)
1	1.25	13	5.77
2	1.25	12	6.25
3	1.25	13	5.77
4	5	63	4.76
5	5	72	4.17
6	5	66	4.55
		Average	5.21

The powder auger was tested by placing a bucket underneath the powder exit to the amount of powder that flowed from the auger per time. The test was conducted four times and the results averaged to find a resultant mean powder flow rate. It was determined that the mean powder flow rate was 9.11 cups per minute.

Test #	Powder (Cups)	Time (s)	Rate (Cups/Min)
1	9	60	9
2	17.5	120	8.75
3	9.5	60	9.5
4	46	300	9.2
		Average	9.11

Through testing with the completed system it was concluded that a mixing time of one minute was sufficient for any batch of milk no matter the size. Since this amount of time was so short we decided to make the mixing time a constant to reduce the number of computations that the controller would need to perform for a given mixing process.

Testing proved that our solution met most of the objectives we had for our system. Our first objective, that the system be able to handle milk for 50 calves (25 gallons), was met simply by using a 30-gallon drum for the mixing process. The only foreseeable problem for that many calves may be an excess of splashing due to the vortex in the mixture and the nearly full tank.

Our second objective, to build the system for less than \$500, was clearly met in that we spent less than \$200 to build our prototype system. However, our costs were somewhat lower than what it would cost for production due to numerous gifts-in-kind. Our third objective, to have only four manual procedures, was nearly met. Our solution requires only that the user fill the powder bin, enter the number of

calves, fill the detergent container and dispense the milk into the buckets by pressing enter on the keyboard and rotating the buckets beneath the dispensing pipe. The detergent filling was added to the manual processes and the internal clock was not incorporated in the system to allow the user to enter the desired time of day for the mixer to operate.

Our fourth objective, to use a controller that does not require computer literacy to operate and to house it in a NEMA Type 4 enclosure, were met by programming the controller to prompt the user for inputs through simple menus. The entire microcontroller was housed in a sealed steel enclosure to protect it from moisture damage.

The final objective, to have a mixing time of less than five minutes and a process time of less than fifteen minutes, was not quite met. The mixing time proved to be much less than the five minutes that we allowed for, but the powder dispensing, milk dispensing and washing cycles occupied the remainder of the fifteen minutes that we allowed for the process time. However, the user needed only be present for nine minutes of the process to input the number of calves and dispense the milk into the buckets.

Process Time (50Calves)	
Water Dispensing	5 minutes
Powder Dispensing	2.75 minutes
Mixing	1 minute
Milk Dispensing	8.3 minutes
Washing	3 minutes
Total Time	≈ 20 minutes

Schedule

Project Management

The project was divided by electrical and mechanical orientation. Steve concentrated on the mechanical design, testing and construction. In addition Steve was responsible for advising the overall project because of his intimate knowledge of the calf raising process as well as the setting in which the milk mixer was to be used. Dan focused on programming the controller, while Chris designed and constructed the electrical hardware needed to operate the solenoid valves and motors. Everyone was involved in the implementation process on the farm as well as the testing of the completed project. In addition, the required paperwork and reports for the project were divided evenly among the group members to ensure equal input.

Gantt Chart

The Gantt Chart (Appendix II) shows clearly what the goals of the project were and how the system was to be designed, constructed, and tested in a timely manner. The Chart also shows what the actual completion dates were on each of the pieces of the project.

Schedule Changes

There were a few unforeseen problems encountered during the construction phase of which challenged us to remain on schedule with the entire project.

First, the purchased fan blades were not suitable for the mixing process which required us to design and machine an impeller which could handle the stresses. This process took an extra day and took time that could have been used for testing purposes.

Second, the motor that was to be used for the powder auger was not nearly fast enough and a replacement motor needed to be located and mounted. However, the mounting process was not as simple because the motor was much heavier and did not have the same distance from the mounting holes to the shaft center. In addition, it was determined that the motor ran too fast and needed to be run through a reducing gearbox to slow it down. This entire process added a couple days to the building process and took time which should have been used in additional testing.

Third, the original LCD that we purchased was not sent with good literature, which resulted in several weeks of unproductive time spent trying to understand how the display was designed to work. In the end the display was not usable and we were forced to use a smaller LCD instead. The time spent on the display could have been better used to aid in programming the controller.

Budget

Materials List			
Mixing Materials	Our Cost (\$)	Production Materials	Production Cost (\$)
Motor: 1/4 hp, 1725 rpm, 1.4 amp	Gift-In-Kind	See (a)	152
Shaft: 2' x 1/2"	3.33	See (b)	40.70
Aluminum Impeller	Gift-In-Kind	See (c)	100
Mixing Tank: 30-gallon plastic drum	Gift-In-Kind	Same	5
Angle Iron	Gift-In-Kind	Same	20
Machining Costs	Gift-In-Kind	Same	15
Powder System Materials			
Motor: 1/4 hp, 1725 rpm, 1.4 amp	Gift-In-Kind	See (a)	152
Reducing Gearbox	Gift-In-Kind	Same	150
Motor/Gearbox Coupler	Gift-In-Kind	See (e)	28.92
Auger: 4' x 3"	Gift-In-Kind	Same	150
Auger Casing: 4'-PVC	5	Same	5
Stand: Angle Iron	Gift-In-Kind	Same	20
Plexiglas	25	Same	25
Misc. Mounting Hardware	Gift-In-Kind	Same	10
Powder Bin: 15-gallon plastic drum	Gift-In-Kind	Same	5

Lexel Caulk	6	Same	6
Machining Costs	Gift-In-Kind	Same	15
Misc. Materials Costs			
PVC/Brass Pipe	15	Same	15
Solenoid Valves (3)	Gift-In-Kind	Same	300
Wiring Materials	30	Same	30
Electrical Materials Costs			
Electrical Enclosure	Gift-In-Kind	Same	150
Microcontroller	Gift-In-Kind	AB Pico Controller	305
Relay Board	36	None	0
Keyboard	Gift-In-Kind	None	0
LCD	Gift-In-Kind	None	0
Wiring	Gift-In-Kind	Same	20
Solenoid Valve Transformer	10.59	Same	10.59

- a) Grainger Number: 3K308
- b) Grainger Number: 5JZ29
- c) Grainger Number: 2888378
- d) Grainger Number: 2L030, 2L068

Conclusion

Overall the milk mixer project was a success. As stated earlier most of the objectives were met and the ones that were not did not stop the farmer from using the system. The result of the all of the research, design, construction and testing was a system that efficiently mixes milk that the farmer could use to feed his calves. That was the most important objective of all and it was met by the system that we designed and built.

Throughout the process we learned how to manage our time, how to set realistic goals and the importance of teamwork for the success of a project. In addition, we learned that it always took more time to build and test something than we anticipated. Other things that we learned included: how to present a project effectively and professionally, how to write professional documentation and how to approach a project of this magnitude effectively.

Recommendations for Future Work

There are a variety of things that could be done to improve on this project. Each of these things would make the project operate more efficiently, effectively or ensure that the mixer would have a reasonable working life.

First, the impeller could have more work done on it to ensure that it is best designed for optimal mixing without wasting energy or causing unnecessary stresses in that material. Future work could involve testing various blade angles, lengths and widths.

Second, the impeller shaft could be analyzed to determine how many cycles it could take before failure. In addition, it could be concluded whether stainless steel would be a better option for the impeller and shaft.

Third, a moisture resistant motor could replace the existing mixing motor to ensure long life.

Fourth, the solenoid valves could be shielded with some type of sealed cover to minimize moisture intake. This would help to lengthen the overall life of the mixer.

Fifth, the program could have additional work done to add the internal clock ability and thus make it possible for the operator to key in the time of day that he would like the milk to be mixed.

Sixth, a different solenoid valve could be used on the milk dispensing pipe. The existing valve opens and closes slowly and it would be better to have a valve which could operate at a faster rate.

Seventh, the system could be set up to automatically dispense the milk to the calves through some type of lines. This would allow the user to leave the farm on vacation for a few days and ensure that his calves would still be fed in his absence.

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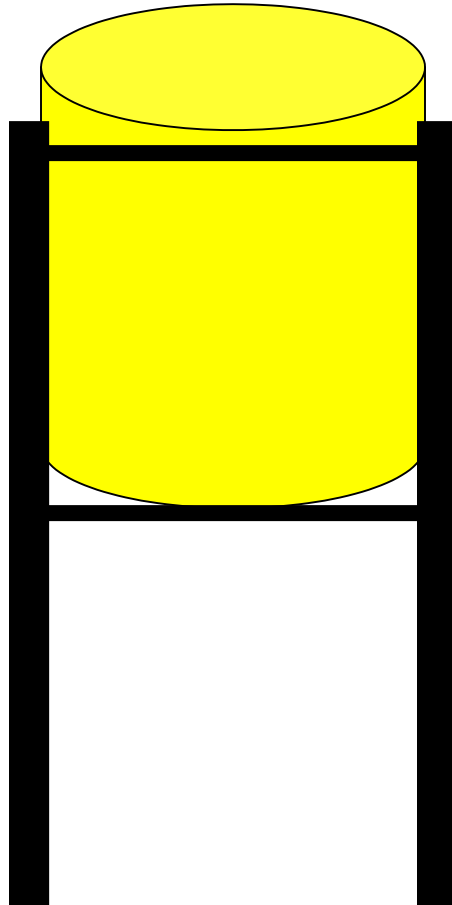
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APPENDIX I

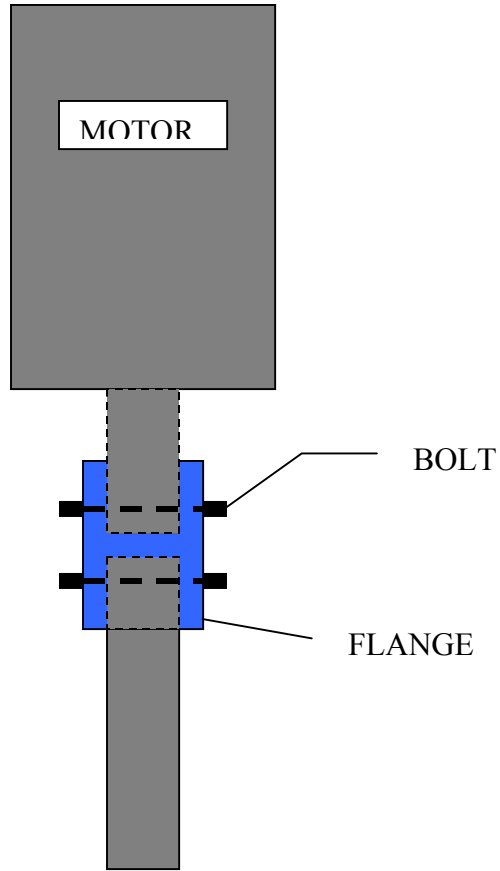
Drawings

Appendix I,B

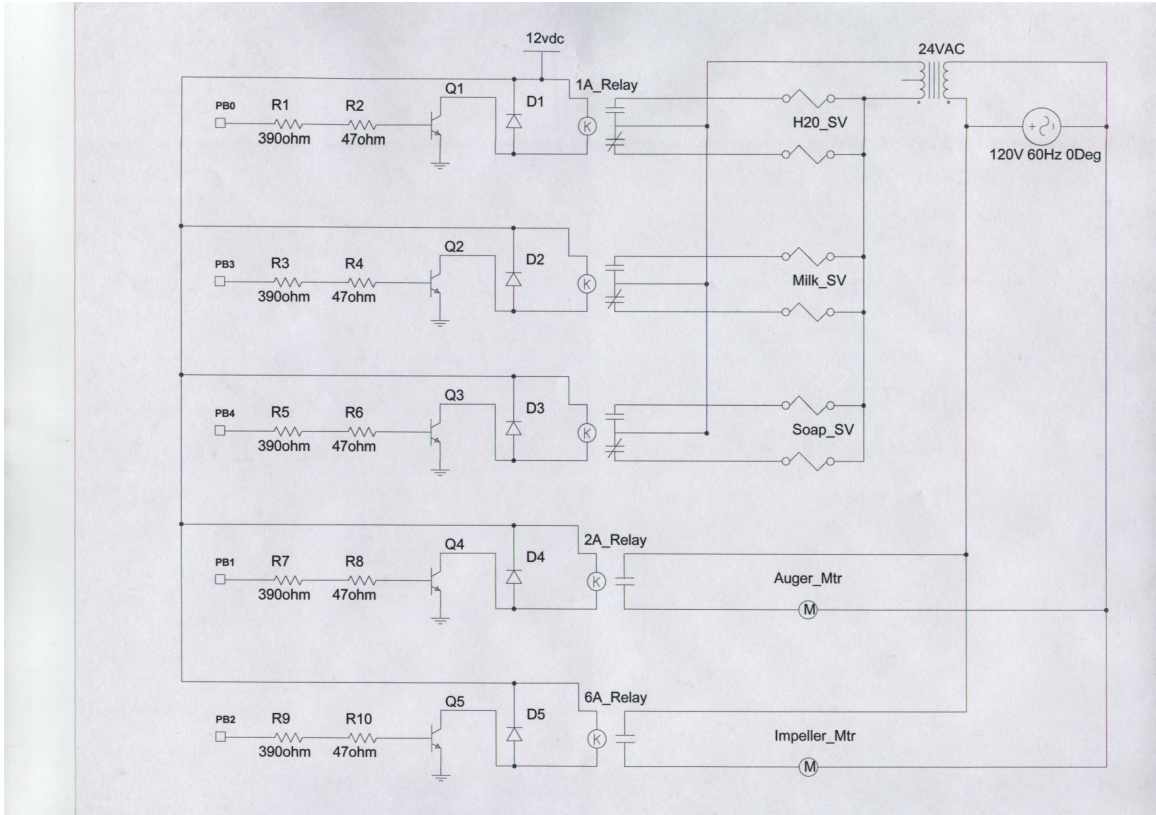
Front View



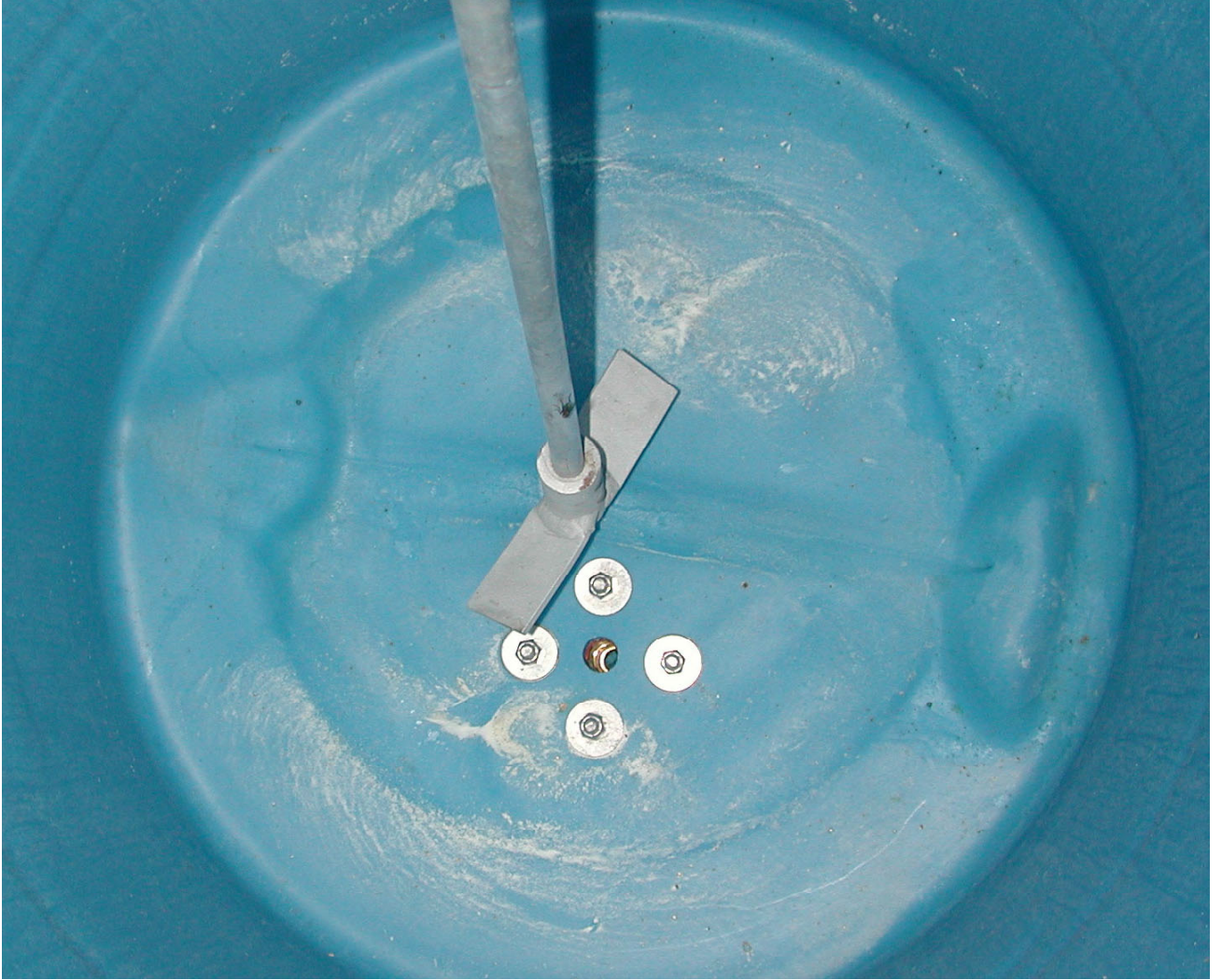
Appendix I,C



Appendix I,D



Appendix I.E



Appendix I,F



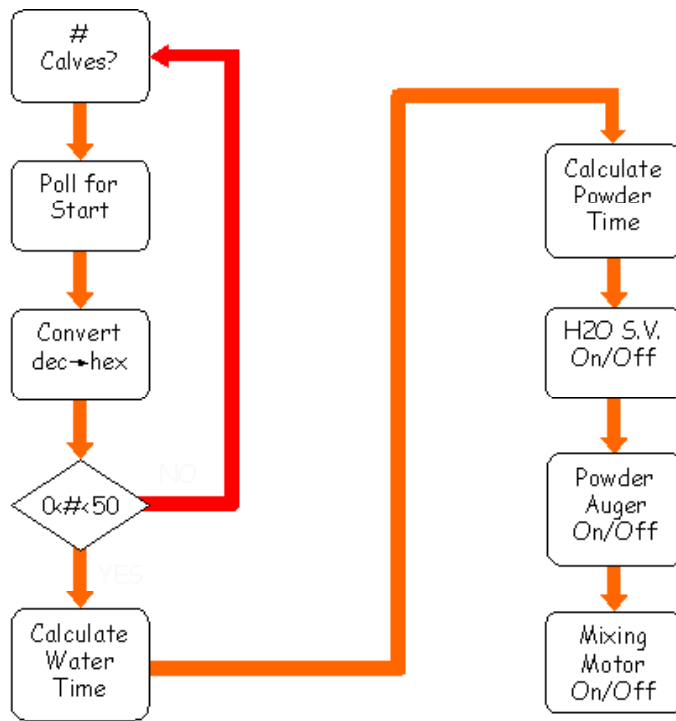
Appendix I.G



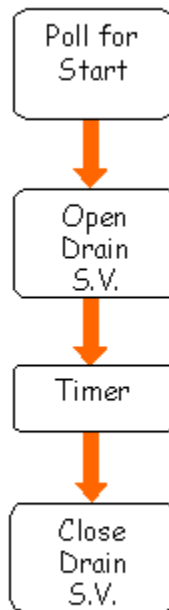
Appendix I.H



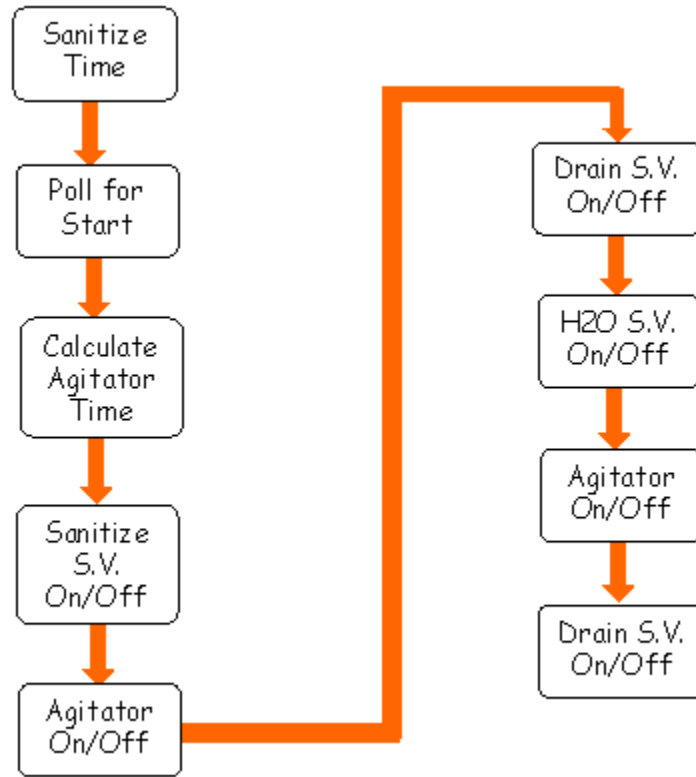
Appendix I.I



Appendix I.J



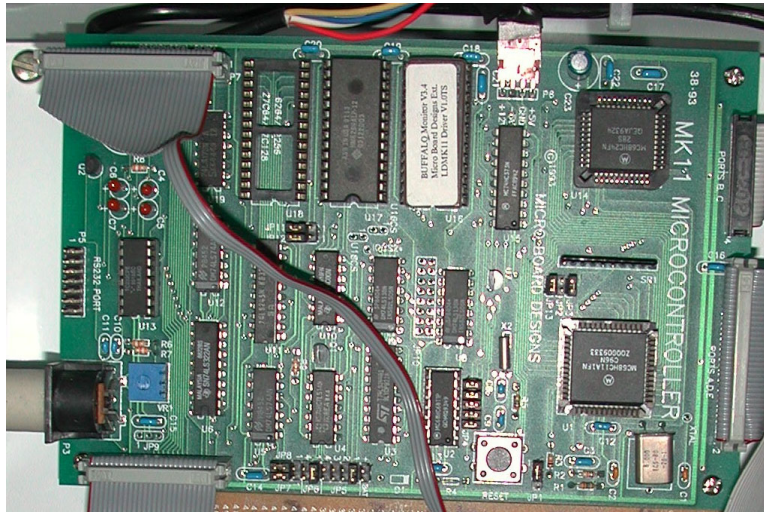
Appendix I.K



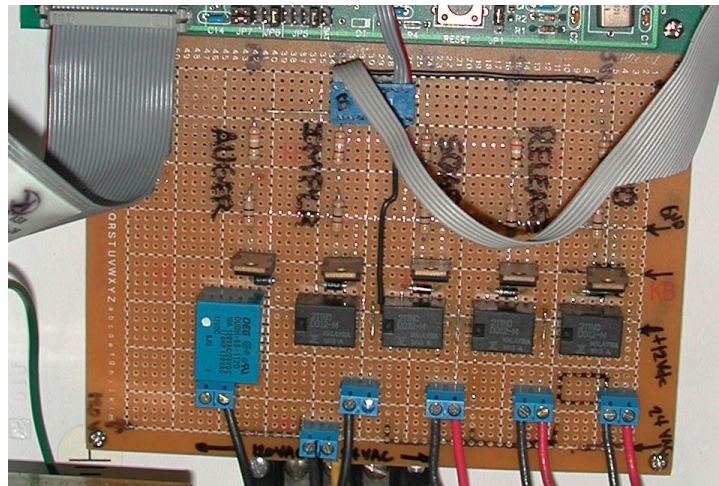
Appendix I.L



Appendix I.M



Appendix I.N



APPENDIX

II

Gantt Chart

APPENDIX III

Specifications

Mechanical System:

Input Conditions:

1. Water Inflow > 3 gallons per minute
2. Powder Inflow > 25 pounds per minute
3. Water Temperature: $110\text{ }^{\circ}\text{F} < T < 120\text{ }^{\circ}\text{F}$
4. Mixing Motor
 - a. Power > $\frac{1}{2}$ horsepower
 - b. Maximum Speed > 1,700 revolutions per minute
 - c. Voltage = 120 V
5. Processing Time
 - a. Water Metering Time < 10 minutes
 - b. Powder Metering Time < 5 minutes
 - c. Mixing Time < 5 minutes

Output Conditions:

1. Dispensing Time < 10 minutes
2. Completely Blended Milk: Unmixed Powder < 0.5% Volume

Parts Conditions:

1. Powder Storage Capacity > 100 pounds / 4 feedings
2. Powder Measurement Increments = 1 pound
3. Mixing Tank Capacity > 30 gallons
4. Washing Capability – Immediately following milk dispensing
 - a. Water Temperature: $T > 180\text{ }^{\circ}\text{F}$
 - b. Liquid Detergent
5. Sanitizing Capability – Directly before mixing process
 - a. Water Temperature: $T > 180^{\circ}\text{F}$
 - b. Liquid Sanitizer
6. Pneumatic Cylinder

- a. Stroke > 1 foot
- b. Force > 10 psi

ELECTRICAL SYSTEM:

Input Conditions:

1. Keypad capability – start, stop, numerical data input
2. Load cell input capability

Output Conditions:

1. Solenoid valve controls (2)
2. Discrete motor control
3. Pneumatic cylinder control
4. Alphanumeric LCD capability

Internal Conditions:

1. Timing capability
2. Decimal to Hexadecimal conversion
3. Mathematical operations capability

Power Requirements:

1. Supply power = 120 VAC, 60 Hz