Stable Automation

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Abstract

People who have livestock cannot leave for any considerable amount of time without arranging for someone to provide feed and drinking water their animals, so the proposed solution is to automate the stable. In this particular project there are two types of animals being addressed: sheep and chickens. The feed system should hold four bushels of grain for each type of animal, and be able to supply any grain/pellet based feed smaller than shelled corn to at least two different kinds of animals. The stable should also make water constantly available to the animals. When the temperature rises above 90 degrees fahrenheit, the fans in the barn should be on, and when the temperature falls below 32 degrees fahrenheit, the water heaters should be on.

When choosing a design for the feed system, it was important to find something versatile, yet rigid enough to supply various types of feed. The system must also have controllability for various types of animals and a manual override. In order to automate the system, a PLC will be used. For user convenience, a touch screen panel will be incorporated to the system in order to adjust desired feed levels and times. Complete control over the system will be available through the touch screen while in automatic mode, or toggle switches while in manual mode.

Project Overview

The objective of this project is to design a system that will take care of livestock in a small barn for weeks at a time without any human interaction. The barn consists of 24 chickens and 6 sheep, however the system is adaptable to other animals. This is accomplished by using a click PLC to control feed and water kept in hoppers in the barn. Feed is dispensed a set number of times throughout the day and water is dispensed when the water level in the pens become low. To accomplish this task many steps have to be taken, starting from the design process. Criteria and constraints have to be careful thought out and met to ensure a successful project. The main constraints were as follows: the project has a budget of 2000 dollars, animals must have both feed and water available every day, and the project must meet ABET regulations. Finding the best ways to meet this list involves using knowledge gained in all engineering classes, such as dynamics for the movement of the feed via a motor, or fluids for the water lines to each pens.

In the early stages of the design process many ideas were generated and both knowledge of machinery as well as the constraints set forward led to a unique and applicable design. With a relatively small budget, cost was a big constraint, the system had to meet all of our requirements, but many expensive parts could not be used. This budget restriction lead to many changes in the final design over the first few months. For instance, the original goal was to purchase pumps with a system of valves that could be controlled using the PLC. However, this solution quickly showed that the price would put the project way over budget. The solution was finally revised to the design described in the section titled "Water System". Another large initial concern was generating a feed system which had the capability to dispense a user defined amount of feed. This solution involved many pros and cons of different possible solutions. The solution chosen can be found in the section titled "Feed System". Even though the solution requires many hours in testing to calculate a feed dispense rate, it is a time consuming challenge which is worth the effort. Many of these changes were made based of other constraints. Ease of maintenance, space efficiency, and a water resistant system where all constraints that in the end affected the final design of the system. The final feed design consists of two feed hoppers that will be able to hold 6.3 bushels each and a flex auger that is connected to a small motor to drive food to the pens. The motor is controlled by the PLC and runs for a set time to deliver the correct amount of feed. The water system consists of two 30 gallon water barrels, one in each pen, one inch diameter pex piping used as the water lines, and two valves that shut off the water when the barrels are full. Thermocouples and heater have been installed in each barrel to control the temperature and insure the water does not freeze. Over much time designing, researching, and building the design has proven to be a inexpensive but reliable solution. With total donations included and recommendations for better product components, the solution comes to about $3500 for a consumer to purchase.

Feed System

The feed system will hold each animals feed until the time at which they are fed. The feed will then travel to the feed troughs to be dispensed. The feed system is comprised of two main components. The first major component is the hopper which will hold the feed. The hopper is constructed from 1"x 1" angle iron and has overall dimensions of 2'x 2'x 3'. The second component is the auger which drives the feed to the location of the trough. The auger in this application is a flexible auger at roughly 5' long. The entire feed system can be seen below.

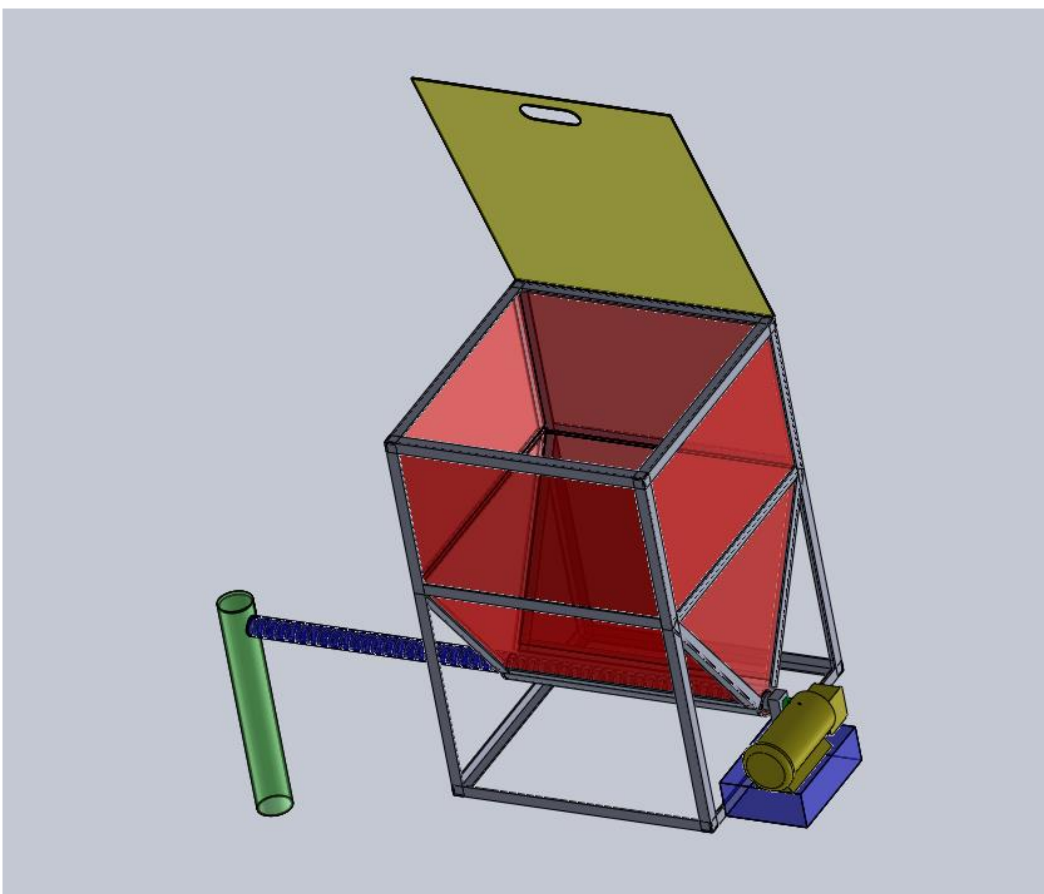

Figure 1:Feed System

The hopper holds 6.3 bushels of feed with a lid to prevent pests from getting in. The auger is driven by a gearmotor which produces 65 in-lb of torque and operates at 29 rpm. The required torque that was calculated came to 29 in-lb in a worst case scenario, returning a safety factor of 2.25. The auger runs inside of a 2” pvc pipe which sends the feed to a drop tube directly above the trough. The auger is joined by a custom machined shaft that turns within a pillow block with a dynamic load rating of 66.15 lbs. The purpose of the pillow block is to control the axial and radial loading from the variation in feed.

The slanted drop walls are angled at 65 degrees from horizontal, which is within the optimal range of angles based on grain carts (gravity wagons) and grain bins. All walls will be constructed using painted plywood due to budget constraints. There will be two sensors on each hopper which will serve two different purposes. The first sensor is a proximity sensor which will detect if the feed level falls below twenty-five percent or 1.6 bushels. This will then alert the user, using a failure light, that the bins are low and need to be refilled. The second sensor is a light sensor which detects the feed as it falls. If the light sensor fails to trip, then the feed has therefore not passed and will alert the user with the failure light.

Water System

The water system is comprised of one water reservoir for each type of animal. The chicken waterer consists of a series of cups mounted in a PVC pipe that each have a valve in them that will fill the cup with water when the chicken’s beaks touch the valves. The PVC pipe is fed from a 30 gallon reservoir with float switches to indicate high and low water level. These switches are tied into the PLC and the PLC uses them to open and close the sprinkler valve in the water line and maintain a positive water level in the reservoir. The sheep waterer is identical to the chicken waterer except that instead of the water flowing into a PVC pipe with inline cups, it feeds into a float valve that maintains a constant water level in an open trough.

The biggest concern about the water system was that it would freeze when winter time comes. Several measures were taken to ensure that the cold winter weather does not affect the performance of the water system. The water supply lines were initially run straight up to the rafters of the barn, then gently sloped down to the reservoirs so that when the valve is shut and the line is depressurized, the majority of the water drains back into the reservoirs. The remaining water in the vertical section of pipe that rises to the rafters is kept liquid by a thermostatically controlled electric tracing wire and insulation. The water in each reservoir is kept liquid by a 300 watt submersible heater that is turned on and off by the PLC based on the temperature in the reservoir. There are also heat lamps controlled by the PLC above the water trough and water cups to keep the water in these locations liquid.

PLC and Components

The PLC used for this project is the Click series. This series is inexpensive, easy to use, and perfect for the application of this project. For ease of the user a touch screen is incorporated to control certain aspects of the process. The three inch touch screen can be used to specify the feed times and feed amounts, along with manual control capabilities for the feed and water systems.

Float level switches are read by the PLC to determine the water level of the water tanks. Valves are then controlled by the PLC to fill the water tanks when necessary. Thermocouples connected to the controller determine the temperature of the ambient air, each water tank, and the electrical cabinet. When the air temperature is lower than 35F, submersed water heaters in the tanks are turned on. Conversely, when the air temperature is over 80F, fans in the barn and electrical cabinet are energized. The program then has temperature limits to turn off heaters and fans when not needed to conserve energy. Temperature values of the air and water are displayed live to the touch screen, and errors are shown if any temperature is in a specified extreme range.

For the feed system, user specified feed times and amounts determine the process. The user will input the desired time of day to the touch screen, and feed amount per feeding to start the process. The PLC will then turn on the motor to the feed hopper accordingly. Low feed levels in the feed hopper are determined by a capacitive proximity sensor, and alert the user with a message on the touch screen display. Laser sensors are incorporated into the chute of the feed system so the PLC can determine if feed is moving to the trough when the motors are on. Feed amounts delivered to the trough are then determined by run times of the motor found through extensive testing.

Conclusion

Overall, the project has been a great experience towards applying the recently gained knowledge to real world application. The project has involved many hours of research, especially when it comes to electronic compatibility. The biggest challenge has been finding products which can be purchased that fit the given budget. However, these products must also be durable enough to be placed in a barn with high and low temperatures, along with lots of dust. Therefore, sustainability was the largest focus of this project. The project has met the budget constraint of $2000, due to a few anonymous donors, leaving the current project budget about $200 to spare.

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