RESEARCH ON THE CONSTRUCTION AND DEVELOPMENT OF AN AUTOMATION PROTOTYPE FOR A CATTLE FARM

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SUMMARY: With the evolution of technology, more and more farmers use automated systems for their business, because they are much more efficient in terms of time and resources, thus considerably increasing production capacity.
The paper aims to make a functional prototype of a cattle farm on a much smaller scale, using components for hobby projects. In this paper I wanted to highlight the operation of three of the important systems in a farm, these being: ventilation, evacuation of manure from the alley, and watering.

KEY WORDS: farm, cattle, ventilation, watering, evacuation

1. Introduction

This research aimed to make a prototype of an automated cattle farm because more and more farmers want to automate their farms due to a lack of labor and to increase their production capacity.

For starters, the proposed prototype will have 3 automated systems: ventilation, manure evacuation, and watering.

In the animal shelters, the animals emit heat, humidity, carbon dioxide, and from manure and bedding, they emit ammonia, hydrogen sulfide, and strong odors, to which is added the dust from the handling of fodder or bedding. If all these noxious substances are not eliminated, concentrations of harmful, foul-smelling gases appear in the shelters, which, exceeding a certain limit, result in reduced growth spurts, decreased animal production, and even animal disease.

The environment must be dry, free of drafts, and well ventilated inside the shelter. At temperatures above about + 25 ° C, cattle reduce their feed consumption as well as milk production and/or weight gain. The most unfavorable conditions result when there is a combination of high temperatures, a high level of humidity (> 80%), and low air exchange. To avoid heat stress, it is necessary to pay special attention to the animals when the temperature exceeds + 20 ° C.

Thus for this prototype, we monitored the temperature in the room, and when the temperature exceeds the value of + 20 ° C the natural ventilation takes place by opening the shutter, but if the temperature rises above the value of + 25 ° C the fan will start while the shutter is opened to reduce the temperature below + 20 ° C.

At the same time, to encourage cattle to go to the feed area on very hot days, we will use a spray cooling system, because the best quick cooling solution is obtained by combining water sprayers with fans. Thus, when it is detected present in the feed area, water will be sprayed through the nozzles located in the upper part.

The next system is the manure cleaner, which is made with a scraper plug located in the back of the speakers, and it cleans the alley once every 2 minutes.

The last system proposed for this prototype is the one to be adapted.

Daily water requirements for cattle are influenced by air temperature, feed content, and milk production. Dairy cattle usually consume 30-100 liters in 24 hours. The watering rate for dairy cattle is 10 to 20 liters per minute if the water surface is free. They prefer water with a temperature of 15 - 20 ° C, which positively influences milk production.

Therefore for this prototype, we will use a tank fed from an external source in which the water temperature will be measured and will be brought to a value of 17 ° C, and then it will be distributed to the special drinkers whenever they have the level of water below 5 cm.

2. The current stage

For some time now, we have been witnessing a real revolution of robots in agriculture worldwide, and Romania taking quite big steps in this direction. The first steps in the field of agricultural robots in Romania, which ended with visible results, with the appearance of the robot "Banat", were made by a team of students from the University of Agricultural Sciences and Veterinary Medicine of Banat in Timisoara and the Polytechnic University of Timișoara. And the estimates are quite optimistic: in about five decades, every rural household will be supported by agricultural robots.

In Timiş County, the first dairy cattle farm in the west of the country has been operating since 2020, where robots do almost everything, from milking to cleaning and pushing feed. In addition to the construction of the new stable, with a manure tank located under the traffic alleys in the animal shelter, was also purchased an automated milking system Lely Astronaut, a 3,000-liter milk cooling tank, a feeding system with robot automatic feed pushing, automatic robot manure cleaning system, a Lely Luna cattle brush, a tractor and a front loader, as well as a vacuum.

However, the largest project of this type, in our country, is the one in Hunedoara County. A cattle farm with a population of 3,680 heads, daily production of 55,000 liters of milk, and a milking plant unique in the country by its size. At the Locator Agrar farm in Vadei village, Hunedoara county, the cattle are milked at a rotating installation with 72 seats (Fig.1).

Fig. 1. Rotary milking machine

3. System's structure

The preliminary general structure of the stand is highlighted in Figure 2. It shows the 3 types of connections between the main components, mechanical, electrical, and data connections.

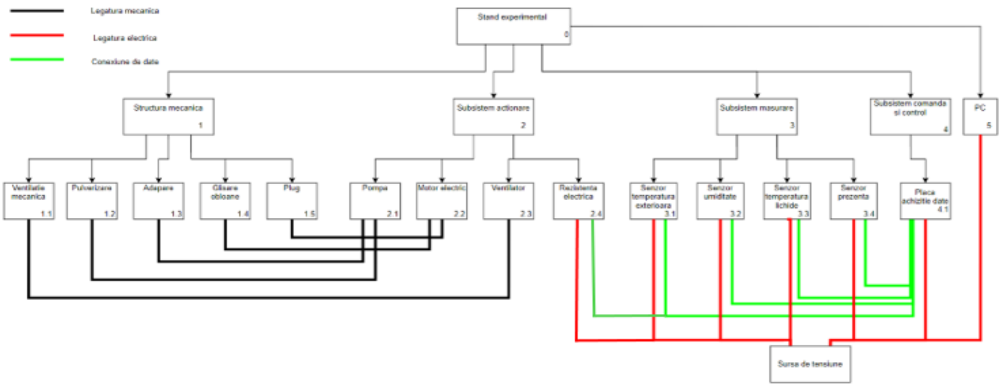

Fig. 2. General stand structure

For this prototype, we used a 12V and 10A source (fig. 3) to supply the components that needed this voltage. At the same time, with this source and with a lowering voltage module (fig. 4), we also supplied all the sensors with a voltage of 5V through a breadboard.

Fig. 3. 12V 10A Switching Voltage Source (120W)

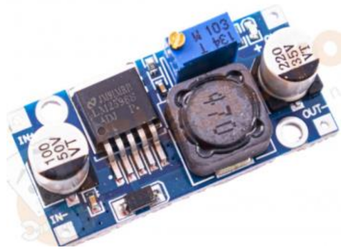

Fig. 4. LM2596 voltage drop mode

The data is collected with the help of two data acquisition boards compatible with Arduino UNO (fig. 5), and the orders are also given through this board.

Fig. 5. Arduino compatible UNO R3 development board

The programs used to read the sensors and control the motors are: Arduino and Labview MakerHub.

For the ventilation system we used a temperature and humidity sensor (fig.6) with which we took the data from the room and decided whether to start the ventilation or not.

Mechanical ventilation is performed by means of a fan (fig. 7) which is supplied with 12V, and with the help of a relay commands can be transmitted from the board to the fan.

Fig. 6. DHT22 temperature and humidity sensor

Fig. 7. PC fan, LHR Super fan, 80X80X25mm

Natural ventilation is achieved by opening the shutter, and for this, a servo motor was used that can rotate 360º (fig. 8), and can be controlled directly from the plate. And to have control over the shutter and to be sure that it is completely open or closed, I used 2 microswitches (fig.9).

Fig. 8. Motor Servo 360 12kg

Fig. 9. Mini switch (microswitch)

The values transmitted by the temperature sensor are read, using the second plate in the series, to be able to decide whether ventilation is needed or not. Also, it is checked if the window is open or closed at the beginning. Thus, if the temperature rises above 20 ºC, the shutter will open, sending the pulse value 1750 to the Servo motor, as long as the switch at the top is not pressed, and when it is actuated it means that the shutter is fully open and the motor must stop, thus receiving the value 1500. When the temperature drops below 20 ºC, the motor will rotate in the opposite direction, receiving the value 1300 until the switch at the bottom will operate. At the same time, if the temperature does not drop and is higher than 25 ºC, the fan will start at the same time.

For spray cooling, we used an ultrasonic presence sensor (fig. 10) to be able to spray water only when it detects the presence in that area. The water in this installation is distributed directly from the tank using a pump of the type shown in figure 11, also controlled from the plate, using a relay. And it is sprayed through a nozzle (fig. 12).

Fig. 10. HC-SR04 ultrasonic sensor

Fig. 11. 12V water pump

Fig. 12. Spray nozzle

Figure 13 shows the subprogram implemented in Labview for ventilation.

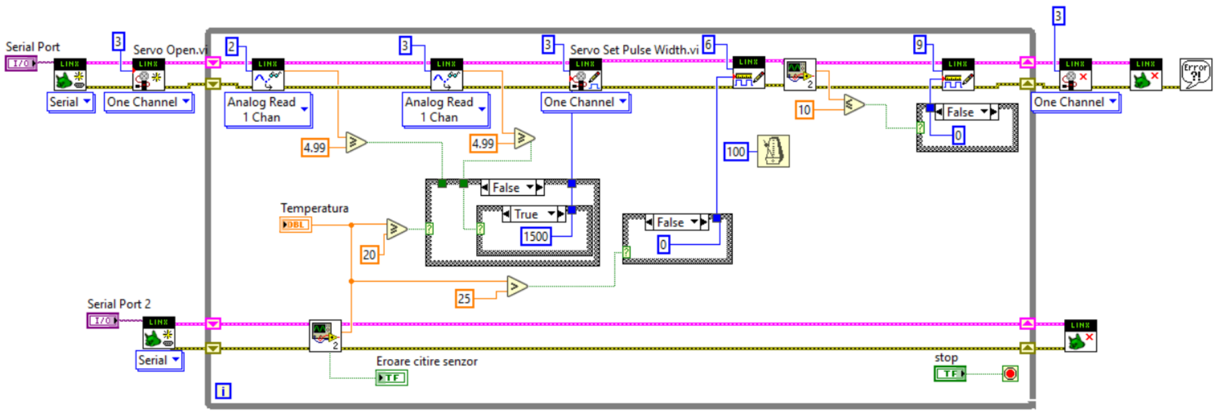

Fig. 13. Ventilation subprogram

The evacuation of manure on the main alley behind the pits was also done with the help of a servo motor, identical to the previous one, which drives a chain and 2 microswitches for the end of the stroke. The subroutine for this system is shown in Figure 14. This checks where the original plow is, and if it is not at the starting point, it is brought to that position. Furthermore, the plow is operated by pressing a Play button, to have control over it, and in case of a problem, it can be stopped quickly by pressing a button. Once the start button is pressed, the plow will perform a forward and backward movement every 2 minutes. Thus, it starts from point A, reaches point B, waits for a second, returns to point A, waits 2 minutes, and resumes the cycle.

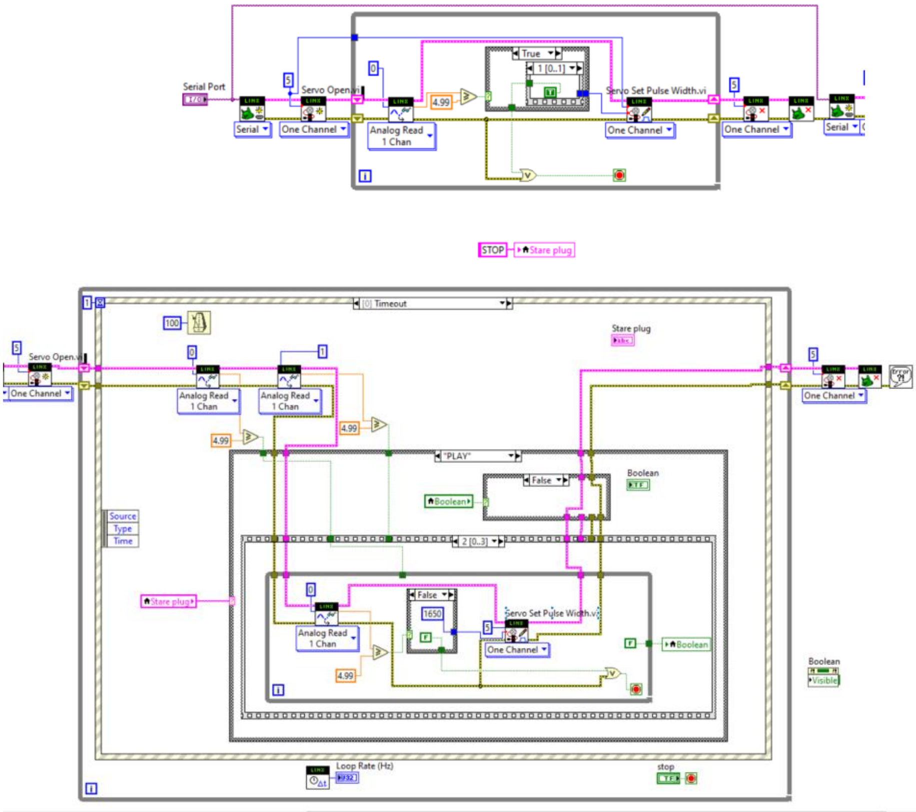

Fig. 14. Manure evacuation subprogram

The watering system consists of a tank, which is based on the 2 pumps for spraying and watering, in which there is a temperature sensor (fig. 15) and a heater (fig. 16). Thus, the water temperature is checked, and if it is below the value of 17 ºC, with the help of the plate and a relay, the heater is ordered and the water is brought to the desired temperature. After the water temperature reaches the preset value, the water is distributed in the installation using a pump identical to the one above. There is a water level sensor in the adapter (fig. 17) that constantly monitors how much water is in it. Therefore, as much water as needed is distributed in that waterer.

Fig. 15. DS18B20 temperature sensor

Fig. 16. Lansenfish LS-100W aquarium heater

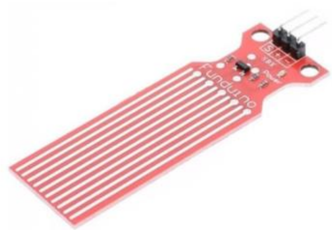

Fig. 17. Water level sensor

The subprogram for this system is shown in Figure 18.

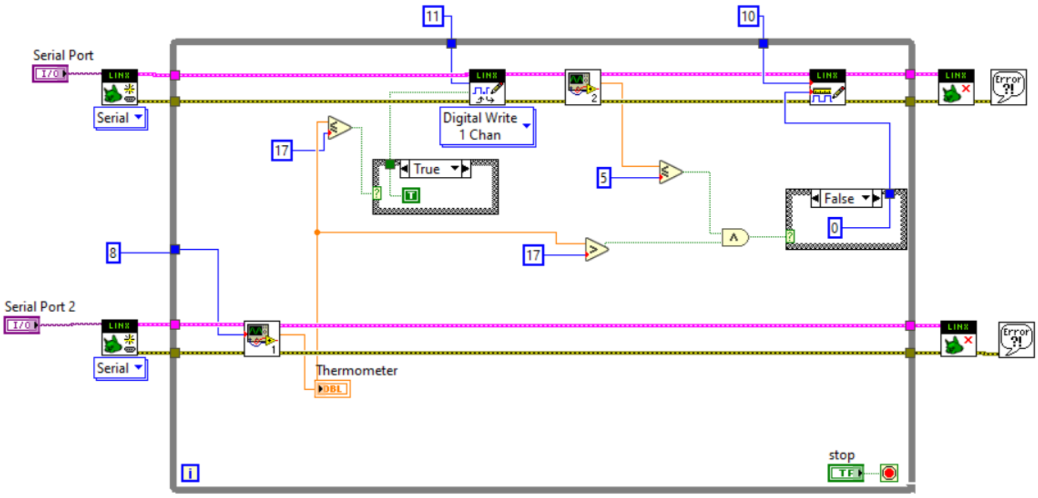

Fig. 18. Watering subprogram

4. Conclusion

In this paper, a functional automation prototype was made for a farm using much smaller scale components and various other common components to exemplify how it works.

In the future, other automated systems can be added to increase productivity as much as possible, and at the same time, an application with which to constantly monitor important parameters on the farm to have much more control over unforeseen events that may occur would be very effective.

5. Bibliography

[1]. https://www.revista-ferma.ro/articole/zootehnie/ferma-de-vaci-robotizata

[2]. https://www.revista-ferma.ro/articole/zootehnie/veri-racoroase-in-adapost-cu-sistemele-delaval

[3].https://portal.afir.info/Uploads/GHIDUL%20Solicitantului/PNDR2020/Standarde_de_ferma/Vaci%20vol%201_by%20EC_WEB.pdf

[4]. https://www.revista-ferma.ro/articole/masini-agricole/sisteme-de-climatizare-si-de-ventilare-in-ferme