American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402
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http://asrjetsjournal.org/

Development of an Automatic Broiler Feeding System using PLC and HMI for Closed House System

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Abstract

Nowadays, the industrial revolution is changing many aspects of life, including how to raise broilers. The development of modern breeding methods for broilers is by using closed house system innovations. This system has several advantages, including temperature and humidity that must be maintained for broilers. In addition, to temperature and humidity, the broiler feeding systems also needs to be controlled because it will improve the quality of broilers. It is caused by the utilization of the majority of conventional feeding systems. Therefore, this research will develop a prototype of an automatic broiler chicken feeding system for the closed house system that is affordable for conventional chicken farmers. The main components used are PLC for system control applications, HMI for visualization display, and 2 proximity sensors as detectors. This automatic feeding system uses two proximity sensors that are controlled by a PLC, and settings using the SIMATIC Manager software. The prototype of the automatic broiler chicken feed system produced is very effective in use.

Keywords: broiler; closed house system; feed sensor; programmable logic controller; human machine interface.

1. Introduction

Poultry is a species of poultry used for human food cooking. The main types of poultry are chickens and turkeys, while additional poultry can include ducks, geese, quails, and pigeons. Chicken is the only type of poultry that has a high commercial value because the need for chicken meat is very large [1].

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The broiler is a term commonly used to refer to chickens produced with livestock technology that had economic characteristics in which it has characteristics of rapid growth. The broiler produces chicken with low feed conversion and is ready to be slaughtered at a relatively young age. In general, this broiler is ready to harvest at the age of 28-45 days with a body weight of 1.2 to 1.9 kg/head. Broilers are a result of a cross between a Cornish chicken from England and white play mouth rock chickens from America [2]. Cages are an important part of broiler maintenance management because they provide a place for all the day-to-day activities of broilers. A good cage ensures the comfort of broilers to get healthy broilers. In addition, the cage also serves to protect broilers from outside disturbances such as the heat of the sun, rain, and other animals so that broilers grow optimally according to their potential. Another function of the cage is to facilitate breeders to monitor and manage the maintenance of broilers to get the best and efficient results [3]. Indonesia is a very fertile agricultural country. The majority of the populations lives in various sectors, including agriculture, plantations, and livestock. One of many animal husbandry businesses developed in Indonesia today is a broiler farm. For broiler farms, the controlled maintenance of the closed house form will produce better quality broilers [4]. The industrial revolution has brought many changes, especially technological developments, that have made work easier. One of them is a closed house for broilers. The closed house for the broiler has several advantages, including temperature and humidity regulation that it can be adjusted to the needs of broilers, the resulting air pollution can be minimized, and direct human contact with broilers can be avoided so that the quality of broilers produced is better. Of course, this is inseparable from the application based on the existing technology of the closed house for broilers [5]. Cages that are commonly used in broiler farms are open-house systems and closed house systems. Most farmers in Indonesia are accustomed to using open-house systems. However, an opened-house system causes an adverse response when weather conditions do not support or there is a very drastic weather change. Maintenance of broilers using a closed house model is one of the technological innovation efforts to deal with extreme weather changes. The cage model of closed house is expected to minimize the adverse effects of environmental conditions or climate change outside the cage. The purpose of using a closed house system is to create a controlled microclimate in the cage, increase productivity, land efficiency and labor and create an environmentally friendly livestock business [3]. Several studies concluded that in order for a successful broiler farm, one of the efforts being made is to make a closed house system. This is because using a closed house system, the temperature and humidity of the room will be maintained. The closed house will be able to increase the cost-efficiency for broilers. When compared between a broiler in the closed house and the opened-model, it has a different weight of broiler produced at harvest. A broiler raised in the opened house with the closed house at the age of 1-7 days has a weight difference of 20.05 %, at the age of 8-14 days has a weight difference of 18.08 %, at the age of 15-21 days has a weight difference of 14.42 %, then at the age of 22-28 days has a weight difference of 26.48 %; and at the age of 29-35 days has a weight difference of 23.24 %. On the other hand, several studies in above have discussed solutions to monitor and control broiler farm operations and controlled environmental conditions [6,7,8]. However, the majority of studies do not discuss the automatic broiler feeding system, even though it is also an aspect of producing quality broilers. Therefore, this study will discuss the process of designing an automatic broiler feeding system with a screw conveyor mechanism. The research will focus on automatic broiler feeding control systems using PLC (Programmable Logic Controller) and HMI (Human Machine Interface). The main objective of this work is to design a control system for an automatic broiler feeding system using a screw conveyor mechanism, which is equipped with PLC and HMI.

The next goal is to analyze the working system of automatic feeding broiler that has been made, including the sensor.

2. Broiler feeding systems

As stated earlier, in addition to temperature and humidity, the feeding system for broilers determines the quality of broilers. Feeding during the initial period of the first week is done by continuous feeding. The continuous feeding is done as often as possible with small amounts at the time. Broiler chicks in this period are still in the learning stage and adapting to the environment so that feeding in small amounts is intended not to be wasted and a feed is not mixed with broiler manure [9]. The frequency of feeding broilers usually ranges from 5 times a day. By increasing the age of broilers, the frequency of feeding broilers will decrease until the 6th week only given twice a day [10]. The important thing to note is the aspect of mealtime. Timeliness of feeding needs to be maintained because feeding at the same time every day can increase the production cost efficiency. Mealtime is chosen at the right time so that the chicken can eat well and not much-wasted food [11]. In addition to automatic temperature and humidity regulation so that the quality of the broilers produced is well, the feeding system must also be controlled. This certainly makes it easier for farmers to provide and provide food for their broilers, especially if there are so many. On the other hand, an automatic feed system on the market today is very expensive. The price for an automatic feed system with a length of 120 meters is around IDR 40,000,000 - 55,000,000. Of course, it makes the most farmers unable to buy, especially for those who are just starting the broiler business with limited capital. The existing automatic feed system uses a screw conveyor system where the 120-meter screw is connected to the motor as the screwdriver so that food moves forward to the entire container when the screw is turned. The screw component of the feeding system based on the price breakdown of one of the automatic broilers feeding sellers is the most expensive automatic broiler feed system component. The price of a screw with a length of 120 meters is IDR 15,000,000 so the price per meter is IDR 125,000. Therefore, this study will discuss the process of designing an automatic broiler feeding system with a screw conveyor mechanism. The research will focus on automatic broiler feeding control systems using PLC and HMI. Of course, in terms of cost, this automatic broiler feeding system is cheaper than those on the market. It is precisely the advantage of this tool is equipped with PLC and HMI systems that are still rarely on the market. Surely this tool will use a screw conveyor system in which it is compared to the conveyor belt, it will be simpler if it is used to carry solids over a short distance [12]. It aims to help broiler breeders to reduce cost capital in the broiler farm.

2.1. Design of the automatic broiler feeding system

In this research, the PLC will be used to create a sensory integration program in the control system. Several broilers automation systems have been developed using a PLC that monitors environmental parameters (temperature and humidity) for 24 hours automatically, so as to reduce human error [13,14]. Furthermore, the PLC will be connected to the HMI system for easy application and visualization. The purpose of using HMI is to reduce the capacity of working memory, reduce processing speed, reduce the ability to distinguish relevant and irrelevant information during the task, increase the likelihood of errors and improve operator work efficiency [15]. The system of automatic broiler feeding is designed for a broiler farm. This means that the basic

concept of the machine is automatically broiler feeding using a screw conveyor mechanism [16,17,18]. The screw conveyors are often used for dosing and metering small amounts of materials, like particles of granules [19]. Next, the flow chart is useful for facilitating the understanding of the flow of the ongoing research process. In this study, the research steps are shown in Figure 1. The design of automatic broiler feeding is made for several components, namely for a feed hopper, a spiral auger, and the motor drive configuration system, in which it is shown in Figure 2.

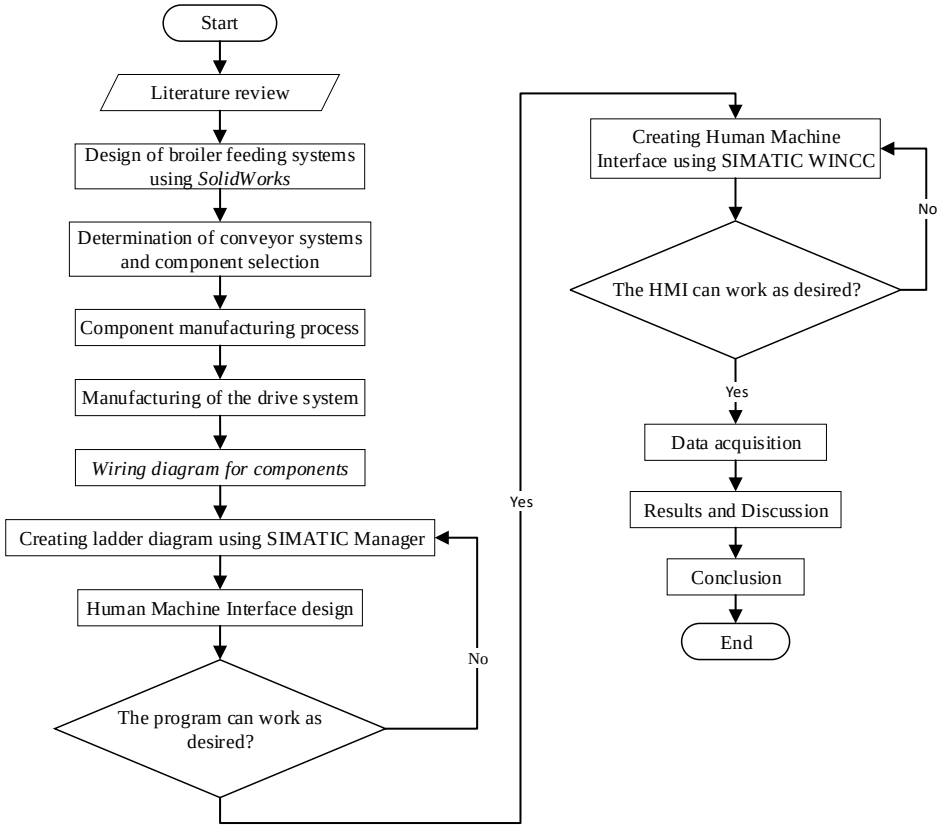


Figure 1: Flowchart of the research.

Figure 2: Design of broiler feeding system.

2.2. Wiring diagram

Design of the wiring diagram is useful for understanding the connection and correlation between sensor,

controller, actuator and HMI. The wiring diagram is shown in Figure 3.

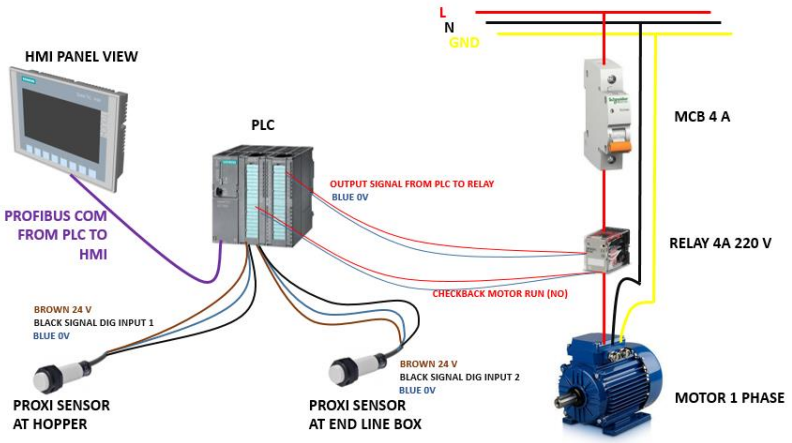
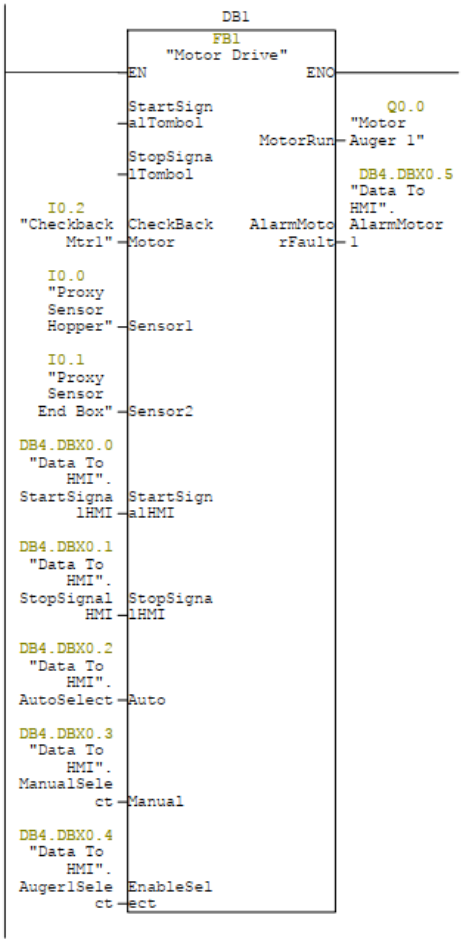


Figure 3: Wiring diagram of the system.

3. Results and Discussion

The limitation of this research is the design of software for broiler feeding system applications using Siemens PLC and visualization display using Siemens HMI. As a complementary sensor the control system uses 2 pieces of proximity sensors installed on the hopper and in the end line box, so that it works as expected. In this research, the tool is controlled using a PLC. The PLC functions as a 'brain' which accepts input values obtained from sensors and commands given by operators. This input value is then processed according to the control settings and the PLC gives the output value to the actuator. There are two inputs used in this research, namely proximity sensor and operator input via HMI. Moreover, there is one type of output which is a single-phase AC motor that is attached to a tool for turning spiral augers. There are several additional components used, namely relay and MCB 4A. Relays are used as electrical switches that get commands or low current electrical signals from PLC. Relay is used as a switch to turn on and turn off the AC motor. Next is MCB 4A which is used as a safety if there is a short circuit (short circuit) on the device. The software used to make the program on the PLC is SIMATIC Manager. SIMATIC Manager is a software developed by Siemens and can be connected and integrated directly with Siemens PLC and HMI. The appearance of the HMI must also be designed and made so that the operator is easy to operate. The design of the HMI was made using SIMATIC WINCC flexible software. The following are the steps for making a control system and programming logic used in this research. Open the SIMATIC Manager software. Determine the input and output program that will be given to the PLC. This determination is intended so that the program on the PLC has a clear classification between input and output. Determination of input and output is shown in Figure 4.



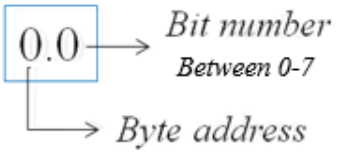


Figure 5: Address on input and output.

Figure 4: Determination of input and output variables.

In addition to determining input and output variables, the address of each input or output must also be determined. This address is formed from two numbers separated by periods (.). An explanation of address assignment is shown in Figure 5. After determining the address of each input and output, the initial value must also be determined. This initial value is true or false. Table of all types of input output along with address and initial value, shown in Figure 6.

Name	Data Type	Address	Initial Value	Comment
IN		0.0		
StartSignalTombol	Bool	0.0	FALSE	
StopSignalTombol	Bool	0.1	FALSE	
CheckBackMotor	Bool	0.2	FALSE	
Sensor1	Bool	0.3	FALSE	
Sensor2	Bool	0.4	FALSE	
StartSignalHMI	Bool	0.5	FALSE	
StopSignalHMI	Bool	0.6	FALSE	
Auto	Bool	0.7	FALSE	
Manual	Bool	1.0	FALSE	
EnableSelect	Bool	1.1	FALSE	
OUT		0.0		
MotorRun	Bool	2.0	FALSE	
AlarmMotorFault	Bool	2.1	FALSE	
IN_OUT		0.0		
STAT		0.0		
CommandRunStat	Bool	4.0	FALSE	
TEMP		0.0		

Figure 6: List of inputs and outputs

In the HMI design, the input values are made into two types, namely auto and manual. The auto function is made so that it can control more than one broiler feeding system. Then, the manual is to control each of each broiler feeding system. Further, making ladder diagrams based on predetermined values and outputs. The ladder diagrams are made from the main program of the tool. Figure 7 shows the results of the program that has been made.

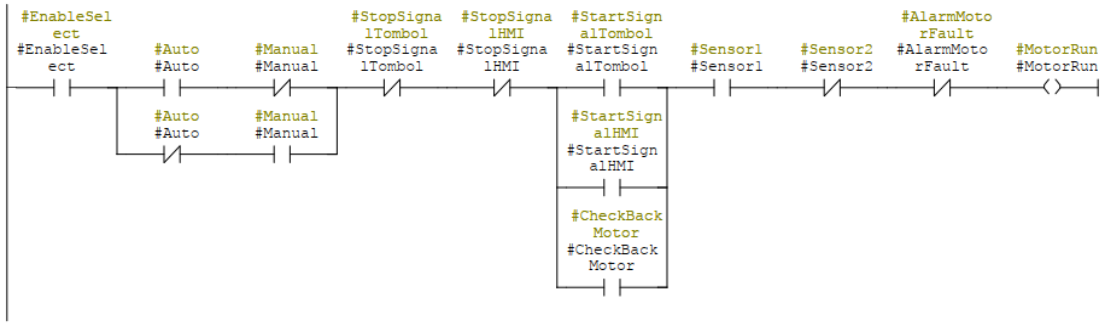


Figure 7: Ladder diagram of an automatic broiler feeding system.

In the program two types of program choices are given, namely auto and manual mode, the program is made parallel or logic ‘or’ then if one of them is enabled the tool will turn on. Then there are 'StartSignal Button', 'StartSignalHMI', and 'CheckBackMotor' which are related to the 'or' logic. If one of the three types of input is worth one or lit, then the signal will continue to the next stage, namely 'Sensor1' which is a proximity sensor located on the feed hooper. If there is chicken feed, the sensor gives a positive signal and is worth one on the sensor. In contrast to ‘Sensor2’ which normally closes, if there is chicken feed at the end-line box, the signal will be interrupted. After 'Sensor2' there is 'AlarmMotorFault' where this input is made with the purpose of safety. The Ladder diagram from the 'AlarmMotorFault' system is shown in Figure 8.

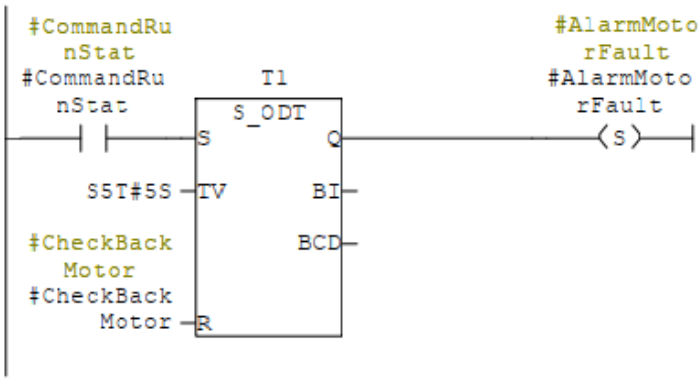


Figure 8: Motorcycle alarm system.

When the relay has received a signal from the PLC to turn on the motor, for the first 5 seconds the PLC waits for the feedback to be given by the relay. If the relay has signaled that the motor is working, there will be no signal termination. But if the relay does not provide a reverse signal to the PLC, 'AlarmMotorFault' will automatically disconnect the signal and turn off the system. First step, creating the HMI design using SIMATIC

WinCC flexible software. Before making an HMI design, we must connect between HMI and the PLC used. Figure 9 shows the HMI that has been connected with the PLC in the SIMATIC WinCC flexible software.

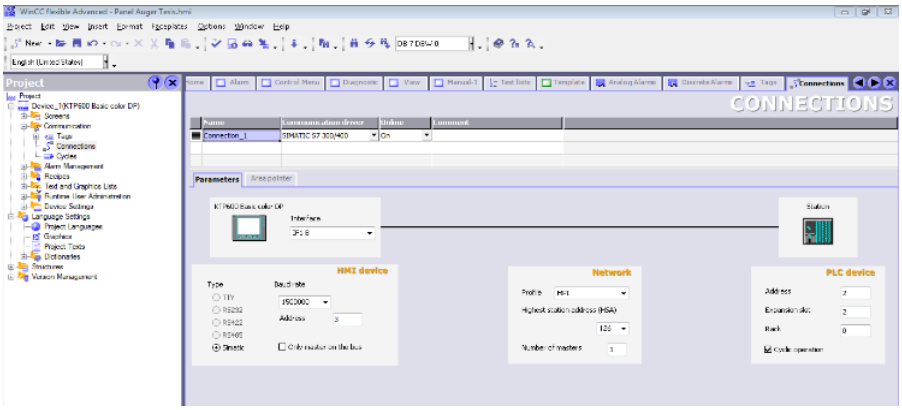


Figure 9: SIMATIC WinCC flexible software.

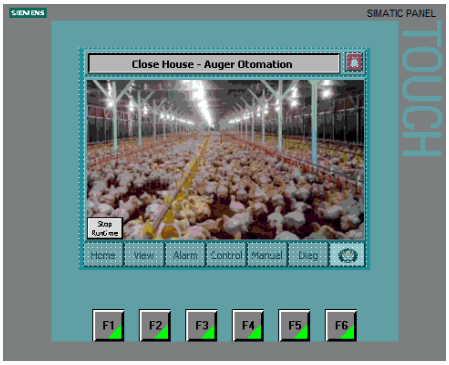


Figure 10: Display the home design on the HMI.

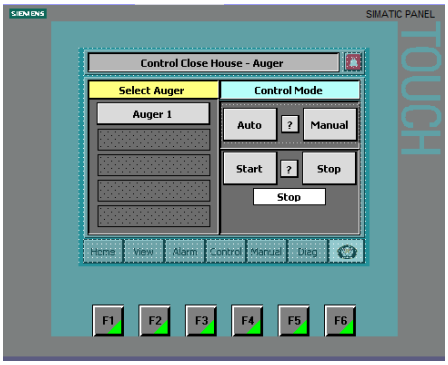


Figure 11: Control page design on the HMI.

In the HMI made, there are six pages consisting of home, status view, alarm, control, manual and diagnosis. Making the HMI design starts with creating a home page that is the initial default display. The home design on the HMI is shown in Figure 10. Then design the start page that contains the choice of auto or manual controls and the start and stop buttons shown in Figure 11.

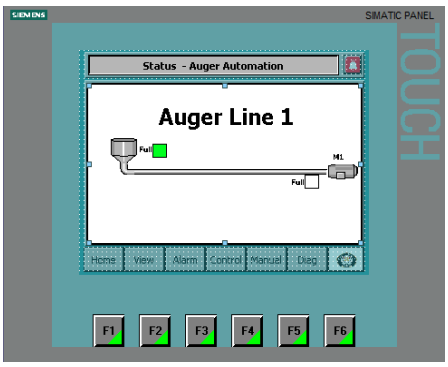


Figure 12: Status page design on HMI

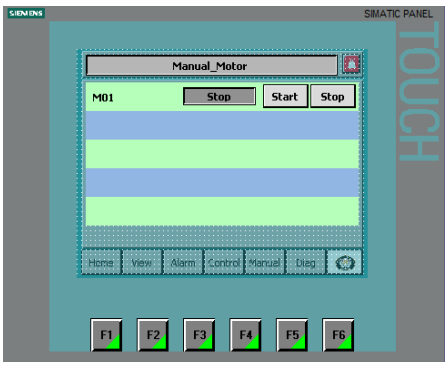


Figure 13: Manually designed pages on HMI

When before or after the feed system is activated, the operator can see the status of the feed hopper and the end-line box which has a proximity sensor installed. This status indicates whether the feed hopper and end-line box contain chicken feed or not. Figure 12 shows the design of the status page on the HMI. When the tool is operated manually, then there must be a special page that is used to set the auger which number will be set. The manual page is shown in Figure 13. There are two sensors installed on the device. If the sensor on the feed hopper detects empty feed or sensors in the end-line box, detecting feed accumulates, the motor will automatically turn off and alarm the operator. This alarm page also shows the exact date and time when the motorbike stopped and due to what sensor. The alarm design page on HMI is shown in Figure 14. The last page is the diagnosis page. On this page, only shows which programs are working. So, the operator can find out the program that works without having to open each control page on the HMI. The design of the diagnostic page is shown in Figure 15.

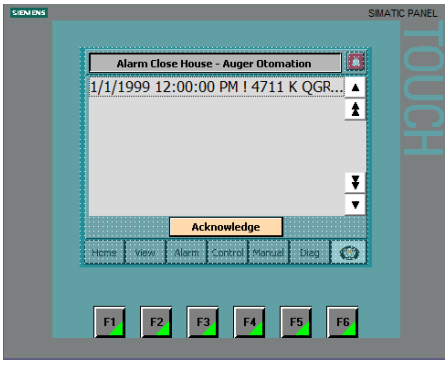


Figure 14: HMI alarm page design

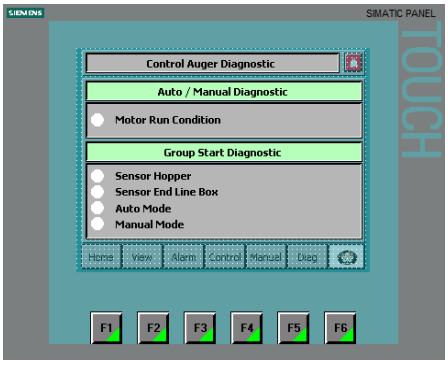


Figure 15: Diagnosis of page design on HMI

4. Conclusion

In the present work, there are several analyzes that have been successfully carried out and some conclusions that are in accordance with the research objectives and final assignments. The design of an automatic broiler feeding tool was obtained with several main components, namely feed hopper, spiral auger and drive system configuration. Modeling of the control system for broiler feeding systems is made using SIMATIC Manager software and Human Machine Interface (HMI) design using SIMATIC WinCC flexible software. Program modeling can work according to the input given. The capacitive proximity sensor installed in the feed hopper and end line box can function to detect feed properly and be able to control the program on the PLC. The automatic broiler feeding systems with screw conveyor mechanism is a practical chicken feeding tool, easy to use, and has an affordable cost. And also, it can improve the quality of broiler chickens.

5. Recommendations

For future research, design optimization can be done using a database scheduling control the amount of feed based on the age of broilers. This addition can be implemented by adding the capacity of the initial hopper or using the scales that are programmed automatically. Can also be developed to be made in several larger supported units (more than one room in the one of the broilers closed house system).

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