INTERNATIONAL JOURNAL OF INNOVATION IN MECHANICAL CONSTRUCTION AND ENERGY
Vol. 1 No. 2 (2024), 102-114

IJIMCE
https://ijimce.ppj.unp.ac.id/index.php/ijimce
University of Negeri Padang

International Journal of Innovation in Mechanical Construction and Energy

ISSN: 3046-9112 e-ISSN: 3046-9104

Design and Construction of a Fish Seed Counting Tool Using Infrared Proximity Sensors Based on PLC and HMI

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Recived 18 May 2024; Accepted 28 June 2024; Available online 30 June 2024

Abstract

Fish hatcheries are a significant endeavor in aquaculture with promising economic potential. However, the manual process of counting fish seeds is time-consuming and inefficient. This paper examines a prototype of a fish seed counting device based on a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) that can expedite the counting process. The device is designed using infrared proximity sensors, a DC power window motor, a solenoid valve, and is controlled by a PLC and HMI. The infrared proximity sensor is placed under the fish passageway to detect fish presence. The counting results are displayed on the HMI screen. After counting, the DC motor closes the fish passageway, and the fish in the plastic packaging are automatically tied for oxygen filling. Testing results indicate that this fish seed counting device functions well and can improve the efficiency of the fish seed counting process.

Keywords: PLC , HMI, sensor proximity infrared, motor DC, solenoid valve

INTRODUCTION

Indonesia is a country rich in natural resources, especially in the marine and land sectors which are abundant. This natural wealth not only has high economic potential, but also has invaluable strategic value [1]. The fisheries and trade sectors are the main pillars of the Indonesian economy, making a significant contribution to national income [2]. Smart and sustainable use of natural resources is the key to supporting sustainable economic growth and community welfare.

Recent technological developments have led humans to be creative in creating tools that apply technology in them with the aim of making human tasks easier in daily activities.[3]. However, there are several business fields that are still rarely touched by technology, this does not mean that technology cannot be integrated in these business fields. One of them is the fish farming business sector. The fish farming business will be more advanced and developed if it is supported by technology. There are several types of work in the fisheries sector, namely cultivating, maintaining and selling fish. Fish farmers will sell their fish seeds to consumers at a unit price system. Based on the results of observations and surveys that the author has conducted in

Padang Snakehead Fish (Pak Edi's Pond) in Tanjung Village, Gunung Sarik Village, Kuranji District, Padang City. Where snakehead fish farming businesses there still use human labor (manual), such as in calculating the seeds to be sold. Of course, this is very time consuming if done manually or conventionally. The problem is what if there are consumers who buy in large quantities, for example 1,000-10,000 fish, then it will automatically take a long time and require more than one employee to count the fish seeds. Of course, this is a big obstacle for snakehead fish breeders.

The problems above made the author interested in making a PLC and HMI based fish seed counting tool. This tool uses sensors*proximity infrared*which is used to count the number of fish and to control sensors using a PLC (Programmable Logic Controller). HMI (Human Machine Interface) is basically used to visualize data from sensor measurements or automation processes that occur in the PLC. It is hoped that this tool can make work easier, save energy and time and increase seeding productivity.

RESEARCH METHODS

This research aims to design and build a fish seed counting tool that uses a proximity infrared sensor based on a PLC (Programmable Logic Controller) and HMI (Human Machine Interface). This tool is designed to increase efficiency and accuracy in the fish seed counting process, replacing manual methods that are prone to errors and time consuming. This can be seen in the schematic **Fig.1.** Research Scheme.

Fig. 1. Research Scheme

1. Study of literature
   Literature study related to infrared proximity sensor technology, PLC, and HMI that will be used in this research. Also review similar applications in the fishing industry or related fields to understand technological developments and practical applications.

2. Mechanical Design
   Design of the mechanical part of the fish seed counter, including the placement of the infrared proximity sensor and supporting mechanisms. Make sure this design allows the sensor to detect fish seeds accurately and efficiently.

3. Material Collection
   In this section are all the materials and components needed to make the tool, such as infrared proximity sensors, PLC, HMI, other electronic components, as well as mechanical materials for the physical design of the tool.

4. Electrical System Design
   Design the electrical system which includes power settings, connections between sensors, PLC, and HMI, as well as other necessary electrical devices. Make sure the design considers energy efficiency and operational safety. Development of PLC and HMI based fish seed counting tools, electrical system design is crucial [4]. This planning includes power design as well as connection arrangements between sensors, PLC, and HMI, along with other relevant electrical components. This design must consider energy efficiency so that the operation of the equipment is more energy efficient, as well as ensuring operational safety during use [5]. For example, when the fish count reaches the number set on the counter, the fish passage blocking hopper will close using a power window motor to prevent more fish from entering the package or container at the bottom. After the fish enters as requested, the DC motor will attract and tie the packaging with a yellow light on as an indicator that the binding motor is working. Next, the tool will activate the solenoid valve

from the oxygen cylinder to the fish packaging with a blue indicator light on to indicate the oxygen filling process. Once the package is completely filled, the motor will pull the strap again to ensure the package is properly sealed before manual closing. After all processes are complete, the user can reset all circuits by pressing the push button at the bottom, returning to the initial position in preparation for the next calculation. **Fig. 2.** of the block diagram of a PLC and HMI based fish seed counter tool provides a visual illustration of the structure and relationship of components in this tool.

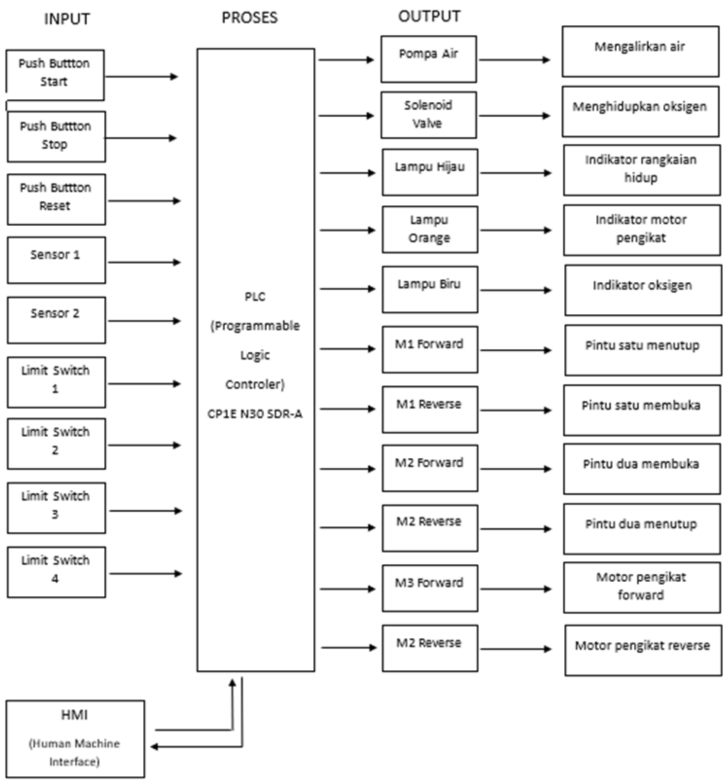

Fig. 2. Block Diagram

5. Results
   In this research, testing of the tool that has been assembled is to ensure its functionality is as expected. Evaluation of the accuracy of counting fish seeds using a PLC-based proximity infrared sensor and ease of use via the HMI interface.

DISCUSSION AND RESULTS

Observation and analysis of test results and observations from PLC and HMI based fish seed counting tools. This activity was carried out with the aim of finding out*trouble*existing on the tool and to ensure that the components installed are in accordance with the circuit. The tests that will be carried out are measuring the output voltage on the infrared proximity sensor, testing distance readings from the infrared proximity sensor, and testing the relay from the infrared proximity sensor to the PLC.

1. Study of literature
   An in-depth literature study regarding proximity infrared, PLC, and HMI sensor technology which is planned to be used in this research is a crucial step in building a fish seed counting tool. The infrared proximity sensor was chosen because of its ability to detect objects without physical contact, which is very relevant in the context of counting fish seeds which requires high accuracy and a fast process. PLCs and HMIs were also selected as an integral part of the design to automatically regulate and monitor the process, enabling efficient

operations and precise control in an industrial fishing environment. A review of the applications of this technology in the fishing industry and related fields will provide an in-depth understanding of its practical implementation, as well as ensuring that the tool design developed can address the specific challenges faced in the environmental context of fish seed production. Thus, this research not only integrates advanced technology in practical solutions for the fishing industry, but also encourages further development in the field of automation and effective monitoring of fish seed production processes.

2. Mechanical Design

Mechanical development in the design of a fish seed counter using a PLC and HMI based proximity infrared sensor is an important stage in this research. This mechanical design includes the optimal physical system design of the tool to support the function of the infrared proximity sensor in detecting and counting fish seeds accurately [6]. Selection of sensor location, integration with a drive mechanism for picking and transferring fish seeds, as well as a robust and efficient structural design are the main aspects considered. Thus, this mechanical design stage not only aims to support the technical functionality of the tool, but also to optimize performance and reliability in daily use in the field. This mechanical design can be seen in the design drawings in **Fig. 3,4,5** and **Fig. 6.**

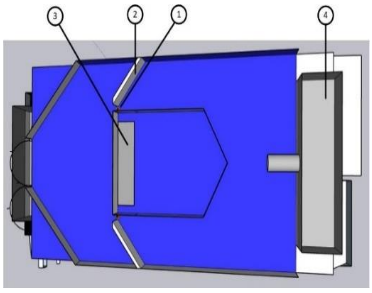

Fig. 3 Construction of PLC and HMI Based Fish Seed Counter Tools Top View

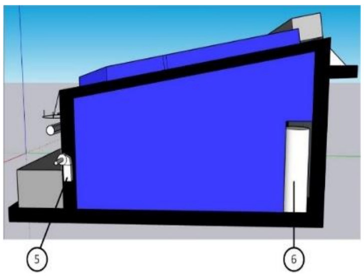

Fig. 4 Construction of PLC and HMI Based Fish Seed Counter Tool Side View

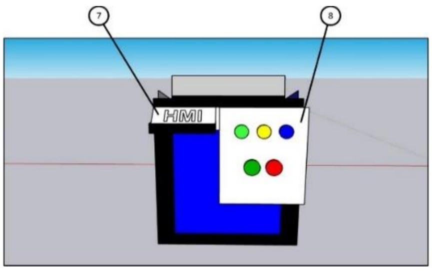

Fig. 5. Construction of a Fish Seed Counter Based on PLC and HMI Rear View

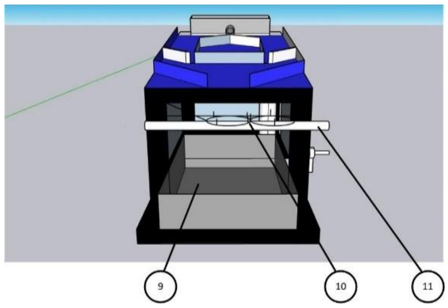

Fig. 6. Construction of a Fish Seed Counter Based on PLC and HMI Front View

Information:

1. Infrared Proximity Sensor
   It is a tool that functions to count all the number of fish that pass through its surface [7].
2. Door Open Close
   Functions as a regulator of the passage of fish. This door is moved using a DC power window motor.
3. A hole with a funnel

Functions as a place for fish that are no longer included in the calculation to pass to the bottom container.

4. Upper Container
   Functions to accommodate fish before they pass through the sensor.
5. DC Power Window Motors
   Functions to pull the rope used to tie the plastic if the number of fish requests has been met [8].
6. Oxygen
   Functions to fill oxygen into plastic which is controlled using a solenoid valve.
7. HMI
   Functions to increase the level of interaction between the machine and the operator through the display on the computer screen and fulfill users' needs for information on the system.
8. *Box*Panel
   It is a box that contains the control circuit of a PLC and HMI based fish seed counting tool [9].
9. Bottom Container
   Functions to accommodate fish before they are taken for calculation and to accommodate fish that are not included in the calculation.
10. Iron Hook
    It is an iron shaped like a circle that functions to attach plastic to hold the fish that have been counted.
11. Pipe
    Serves to maintain the position of the rope so it doesn't fall.

3. Collection of Materials.
   Collecting materials for research on "design of a fish seed counting tool using a PLC and HMI based infrared proximity sensor" is a crucial initial stage in ensuring the success of the tool development. This process involves the acquisition of all the main components needed, such as infrared proximity sensors, PLC, HMI, as well as other mechanical and electronic materials that support the operational functions of the tool. Material selection must take into account quality, suitability of technical specifications, and availability on the market to support the design and construction of the tool effectively. The following are some of the materials used in this research can be seen in the **Table 1**.

Table. 1. Material Description

No.	Material Name	Description	Amount
1	PLC CP1E- N30SDR-A	A system or tool for controlling and monitoring work or Machine	1
2	HMI type NB7W-TW00B	A system that can bringing humans together with machine technology	1
3	12 V DC Power Window Motor	A device that converts electrical energy into energy kinetic or movement	3
4	PWM (Pulse Width Modulation)	A component that functions to regulate motor speed	2
5	5 Volt DC Relay 8 Chanels	As an electronic component which processes signals in the control system	1

6	NPN Infrared Proximity Sensor	Electronic sensors capable of calculating objects around them without physical touch	2
7	*DC Power Supplies*	A series of electronic components designed to supply electrical power from AC to DC	2
8	AC 220 V Relay	As an electronic component which processes signals in the control system	4
9	Indicator Light	As an indicator to turn on and off Suite	2
10	*Push Button*	As input for activates and deactivates the circuit	3
11	MCB 1 phase 6 A	As a protection system on Suite	1
12	Water pump	A tool that works for	
12	NYAF cable 1.5 mm	Used as a conductor of electricity	Enough
13	NYAF cable 0.75 mm	Used as a conductor of electricity	Enough

From **Table. 1** above, the equipment used in the material assembly process are tools such as an electric welding machine, electric grinder, soldering iron, saw blade pliers, combination pliers, and screwdrivers used integrally in this research to build and test a fish seed counting tool using a proximity infrared sensor. PLC and HMI. Electric welding machines are used to weld mechanical circuits and structures of tools precisely and strongly, while electric grinders help in the process of adjusting and cutting the necessary components. Solder is used to connect electronic components with precision and safety. Cutter pliers and combination pliers are used to install and tighten cable and component connections safely, while screwdrivers are used for assembly and detailed adjustments to the tool. The use of these tools not only ensures the solid and reliable physical construction of the counter, but also supports operational reliability during testing and implementation in the field.

4. Electrical System Design.
   The design of the electrical system in the project "design of a fish seed counter using PLC and HMI based infrared proximity sensors" is an important element that ensures proper integration between infrared proximity sensors, PLC and HMI in the operation of the equipment. This step includes careful planning regarding power requirements and connections between the main components of the tool. This design not only aims to support the function of detecting and counting fish seeds accurately, but also pays attention to energy efficiency and operational safety during use of the tool. By ensuring that each electrical component is installed and connected correctly, it is hoped that the equipment can operate stably and produce consistent data in a fishery production environment.

   1. PLC PlanningThe PLC used in the fish counter system is based on a PLC and HMI, namely a
      PLC with type CP1E-N30SDR-A where this PLC has 30 I/O, in this circuit, we need 10 inputs and 10 outputs.

2. HMI planning
   The HMI used in the PLC and HMI based fish counter system is the OMRON NB7W-TW00B HMI, which is used as a tool to increase interaction between the machine and the operator (human) through a screen display. The application used to operate this HMI is nb-designer.
3. Relay Planning
   The relays that will be used are 2 AC 220 V relays which will be used to reverse the direction of rotation of the motor when opening and closing the line and 1 DC 5 V 8 channel relay which will be used on sensors and motor fasteners when filling oxygen.
4. Motor Planning
   The motor that will be used is a 12 V DC motor with specifications for 3 DC power window motors which are used in the fish passage and in the oxygen binder.
5. Indicator Light Planning
   The light used is a pilot lamp, where this light will be installed on the door/wall panel to act as an indicator for running the tool.
6. Push Button Planning
   Push buttonthat will be used are the NC and NO push buttons, which function as ON and OFF buttons to start and stop the tool.
7. Sensor Planning
   The sensors that will be used are 2 infrared proximity sensors, with power supply specifications of 5 VDC, DC supply current of 25 mA, with a detection distance of 3-80 cm. There are 2 types of proximity sensors, namely NPN and PNP, in this fish seed counting tool we use the NPN type proximity sensor, so after testing the voltage on the COM of the proximity sensor when it does not detect an object, a voltage of 0 VDC is obtained and when the proximity sensor detects an object a voltage of 4.9 VDC is obtained
8. Power Supply Planning
   Power suppliesthat will be used are 2 DC power supplies and a 5 V power supply is used for sensors, relays and motors on the plastic fastening part and a 12 V power supply is used for the motor to open and close the track.
9. MCB planning
   The MCB that will be used is a 1 phase 6 Ampere MCB, this MCB is used for short circuit protection or overload on the circuit.
10. Limit Switch Planning
    Limit switches used is a 0.6 A DC limit switch, the limit switch is used to control the movement of the motor to close the output door when the fish demand has been met.

Electrical System Design.

FollowingThis outline outlines the design of the electrical system which is the backbone of the fish seed counter, starting from configuration and installation of electrical components to integration with infrared proximity sensors, PLC (Programmable Logic Controller), and HMI (Human Machine Interface). This technology is designed to increase efficiency and accuracy in the process of counting fish seeds, which was previously done manually and took time. With a carefully designed electrical system, this tool is expected to work stably and efficiently, making a real contribution to the fishing industry in Indonesia.

PLC Control Installation Circuit

Fig. 7. below shows an image of the PLC circuit in a PLC and HMI based fish seed counter.

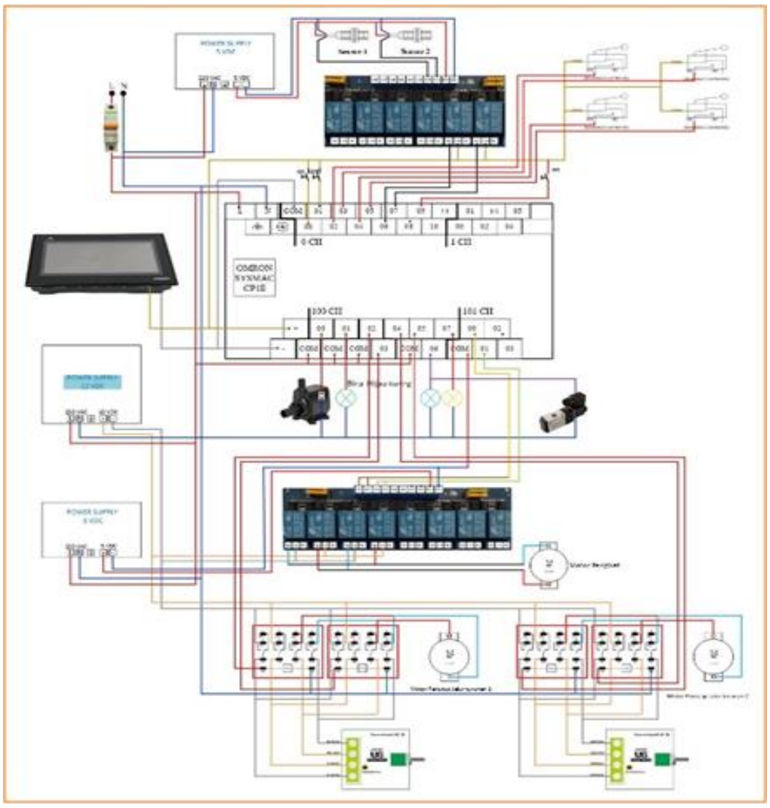

Fig. 7. PLC Circuit

Sensor Control Installation Circuit

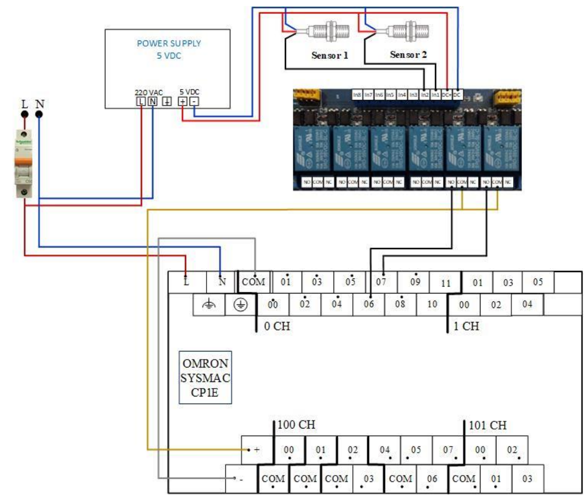

Fig. 8. Below shows an image of the PLC circuit in a PLC and HMI based fish seed counter.

HMI Visualization Mode Design

Where the design for the process that occurs in the PLC-based automatic laying hen feeding device and the HMI itself we use NB-designer which will create a visualization with the I/O address connected to the I/O address used in the PLC [10]. The design is transferred to the HMI and connected to the PLC, then the design that has been created in NB-designer is compiled and downloaded first so that it is connected to the PLC and HMI. by means of the program that has been created from the CX Program being transferred into the PLC.

HMI visualization design for PLC and HMI based fish seed counting tool. To make it easier to create a visualization design for a PLC and HMI based fish seed counting tool, we can see it as in **Fig. 9** below

Fig. 9. HMI Visualization Design

5. Results

Analysis of test results and observations from PLC and HMI based fish seed counting tools. This activity is carried out with the aim of finding out any problems with the equipment and to ensure that the components installed are in accordance with the circuit. The tests that will be carried out are measuring the output voltage on the infrared proximity sensor, testing distance readings from the infrared proximity sensor, and testing the relay from the infrared proximity sensor to the PLC.

Testing Results of the Infrared Proximity Sensor System on PLC and HMI

Measuring Output Voltage on Infrared Proximity Sensors

Measurement of the output voltage on the proximity infrared sensor is carried out to determine the voltage used when the sensor detects an object passing through the sensor and the voltage when the sensor does not detect any objects [11]. **Fig. 10**. below shows the sensor output voltage test

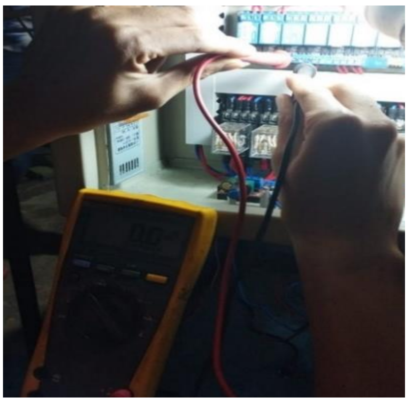

Fig. 10. Testing Sensor Output Voltage

Analysis of test results and observations from PLC and HMI based fish seed counting tools. This activity is carried out with the aim of finding out any problems with the equipment and to ensure that the components installed are in accordance with the circuit. The tests that will be carried out are measuring the output voltage on the infrared proximity sensor, testing distance readings from the infrared proximity sensor, and testing the relay from the infrared proximity sensor to the PLC.

From the test results, data is obtained that if the sensor detects an object, the voltage produced is 4.9 volts, whereas when the sensor does not detect an object the voltage produced is 0 volts. **Fig. 11**. below shows the sensor output voltage test.

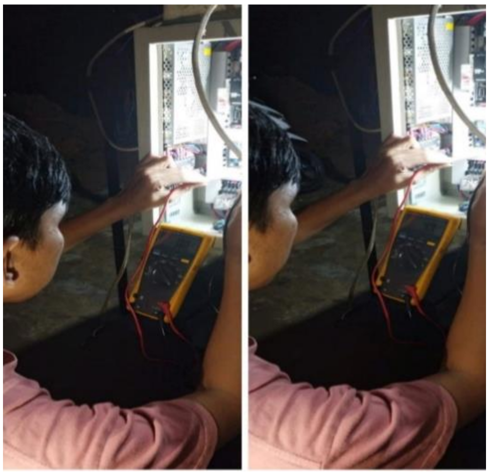

Fig. 11. Testing Sensor Output Voltage

Testing distance readings on proximity sensors aims to determine the distance at which the sensor can detect objects. It is known from the data written on the sensor, this sensor can detect objects as far as 3-80 cm. To adjust the distance that must be detected by the infrared proximity sensor, we can adjust it by turning the bolt behind the sensor**. Fig. 12**. below shows the distance reading test on the infrared proximity sensor.

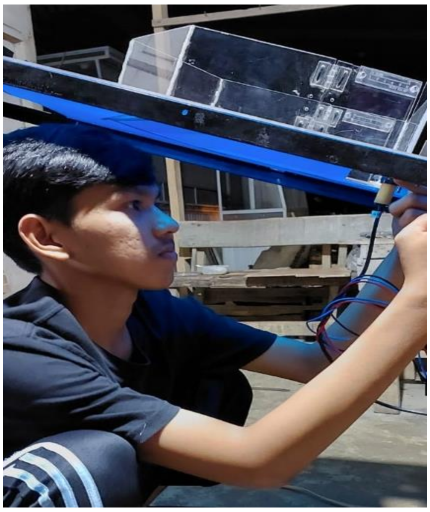

Fig. 12. Sensor Distance Reading Test*Infrared Proximity*
Infrared Proximity Sensor Testing on System Results

Testing Infrared Proximity Sensor Distance Readings

In the results of testing the infrared proximity sensor on this system, we will carry out tests based on the ladder diagram that has been created in Cx-Programmer **Fig. 13.** below shows the infrared proximity sensor test on a ladder diagram.

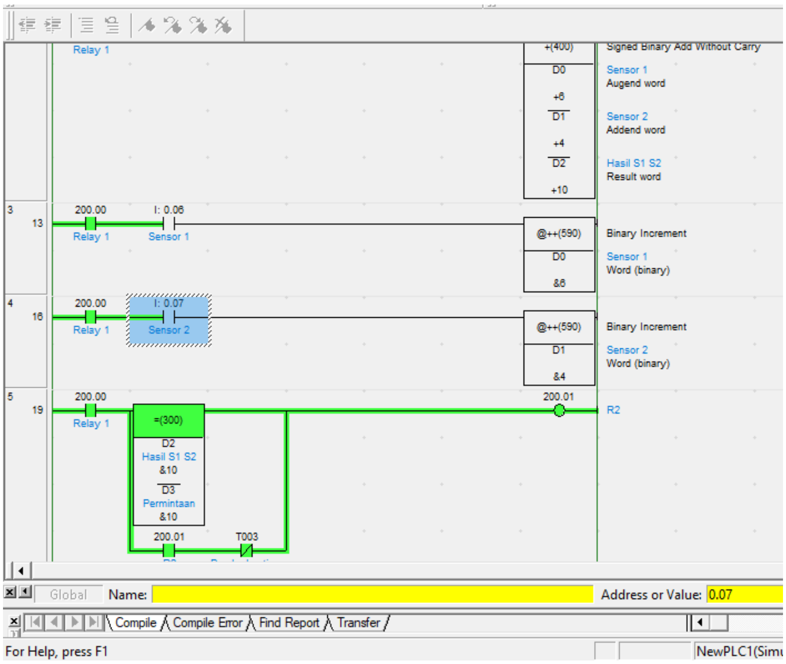

Fig. 13. Sensor Ladder Diagram*Infrared Proximity*

Each sensor has a task that is controlled by a binary in the PLC, each sensor has 1 binary that controls it, sensor 1 has a binner, namely D0, and sensor 2 also has a binner, namely D1. The binary resulting from the sum of the values of the two sensors is D2, while the number of fish requests is controlled by D3.

After the binners D0 and D1 work according to the request on D3, the PLC will send a command to the motor to close the fish passage door to the disposal which is no longer included in the calculation.

Infrared Proximity Sensor Analysis

a. Analysis of Infrared Proximity Sensor Circuits

In a series of PLC and HMI based fish seed counters, this infrared proximity sensor functions as input to the PLC. In this series the author uses two infrared proximity sensors which function to count the number of fish that fall from the container before heading to the plastic. In the ladder diagram in CX-Programmer the author makes a command so that the readings of the two sensors are added up.

In the infrared proximity sensor wiring diagram, the author connects a voltage of 5 volts DC to activate the coil on the relay. On each output cable from the sensor, the author connects it to the NO contact on the relay. When the sensor detects a fish passing by, the output on the sensor will activate the relay contact if the voltage reaches 4.9 volts and the relay sends a signal to the PLC to be displayed on the HMI for additional reading values on the sensor.

b. Analysis of Infrared Proximity Sensor Testing

Before carrying out the test, you should ensure that all components are installed and the circuit is working properly. First, provide a voltage supply to activate the PLC. Next, press the start button on the HMI and the water pump, 5 VDC relay, and sensor will be active. Next, set the number of requests for the desired number of fish on the HMI. After the request is set, put the fish in the top container that has been provided. When the fish descends on the path that has been created and passes the sensor, the sensor output will activate the relay and send a command to the PLC to display on the HMI that there is a reading on the sensor**. Table 2** below is the output voltage test results on the infrared proximity sensor.

Table 2. Sensor Output Voltage Testing*Infrared Proximity*

No.	Component	Information	Voltage (V)
1.	Left Sensor	Doesn't work	0
2.	Right Sensor	Doesn't work	0
3.	Left Sensor	Work	4.9
4.	Right Sensor	Work	4.9

When the sensor does not detect any fish passing by, the resulting output voltage is 0 volts, whereas when a fish passes through the sensor, the resulting output voltage is 4.9 volts.
In **Table 3** below are the results of a comparison of fish counting using a PLC and HMI based fish counter with manual calculations by hand.

Table 3. Comparison of Fish Seed Counting

No.	**Number of Requests**	**Number of Fish Counted at HMI**	**Calculated Amount in Container**	**Time(s)**		**Information**
				Tool	Manuals	
1.	10 heads	10	11	15	13	It is not in accordance with
2.	15 heads	15	15	7	15	In accordance
3.	20 heads	20	20	6	36	In accordance
4.	25 heads	25	23	5	36	It is not in accordance with
5.	30 heads	30	28	13	34	It is not in accordance with

Data from table 3 of the experimental results above can be concluded that based on the five experiments that have been carried out, one experiment was found where manual calculations were faster than using tools. This is caused by the water flowing in the path of the small fish's descent which prevents the fish from descending quickly into the holding container. The second problem found was that there were three trials where the calculations on the HMI did not match the fish in the holding container. This is because there are fish that are close together when passing the sensor, so that when two fish pass over the sensor at the same time it will count as one fish on the HMI. In the five experiments carried out, it can be seen that calculations using tools can increase time efficiency compared to manual calculations using imagination
In research regarding "Design of a Fish Seed Counting Tool Using PLC and HMI Based Infrared Proximity Sensors", several previous studies can be compared to identify research gaps and innovations offered. One relevant study is a fish monitoring and counting system using digital image processing which utilizes infrared sensors to detect and count fish based on the images taken. This system utilizes an Arduino module and a display on an LCD screen, which is different from the use of PLC and HMI in current research Aziz. At al [12]

Another study involves the use of PLCs for automatic counting applications, where proximity sensors are used to count objects passing through a conveyor, and the counting results are displayed and controlled automatically by the PLC SBharadwajReddy2020 [13]. In addition, research on automatic seed counting systems using proximity sensors and Atmega328 microcontrollers shows similar applications in agricultural and industrial contexts, which also strengthens the relevance of using proximity sensor technology in efficient counting processesTran at al [14].

From this comparison, research on PLC and HMI based fish seed counting tools offers advantages in real-time data visualization and better integration between sensors and control systems, compared to systems that only use a microcontroller or Arduino module without a human-machine interface (HMI). It is hoped that this will provide a more efficient and user-friendly solution for fish farmers, especially in terms of counting large quantities of fry quickly and accurately.

CONCLUSION

In this research, it can be concluded that in the process of designing, building and testing a PLC and HMI based fish seed counting tool, the author concludes that this tool has succeeded in fulfilling its objectives by using two infrared proximity sensors, three motors and four limit switches. Two motors function to adjust the fish passage door, while one motor is used to tie the plastic when filling oxygen. The infrared proximity sensor shows high accuracy in detecting fish that pass through the sensor area, then sends a signal to the relay and PLC, which increases the number of calculations on the HMI. This tool significantly increases time efficiency in the process of counting fish seeds, because the fish being counted pass through slippery surfaces quickly. The entire system works well, showing that the integration of PLC and HMI technology in the design of this tool can provide an effective and efficient solution for the fishing industry.

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