Vol. 3 No. 1 Edisi Januari 2026 E. ISSN. 3032-2472
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MODIFICATION OF TYRE MACHINE SYSTEM WITH MITSUBISHI PLC AUTOMATIC FOOT LENGTH GAUGE

MODIFIKASI SISTEM MESIN BAN DENGAN MITSUBISHI PLC PENGUKUR PANJANG KAKI OTOMATIS

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DOI: https://doi.org/10.62567/micjo.v3i1.1919

Abstract

One of the steps in the tyre manufacturing process is the Tyre Building Machine. The tread is the last component to be fitted to the tyre carcass after all other components have been installed. When measuring the length of the pre-adjusted tread, errors or variations often occur in the measurements taken by the measuring device due to its lack of accuracy. This prevents operators from using the tyre tread and can result in a large amount of scrap and wasted time during the tyre manufacturing process. To overcome this problem, a redesigned tread length measurement system with a higher level of accuracy was created to minimise tread length fluctuations during tyre manufacturing. The results of the tread length measurement procedure using the ENC-1-1-24-N type rotary encoder can function according to the program created. This is validated by the tread length measurement data. The results of the HMI display design and the software created can operate according to the desired instructions. To change the tread length, the operator only needs to enter the number on the HMI panel.

Keywords : HMI, Mitsubishi PLC, Operator, Rotary Encoder.

Abstrak

Salah satu langkah dalam proses pembuatan ban adalah Mesin Pembuat Ban. Tapak ban merupakan komponen terakhir yang dipasang pada rangka ban setelah semua komponen lainnya dipasang. Ketika mengukur panjang tapak yang telah disesuaikan sebelumnya, sering kali terjadi kesalahan atau variasi dalam pengukuran yang dilakukan oleh alat ukur karena keakuratan alat tersebut masih kurang. Hal ini membuat operator tidak dapat menggunakan tapak ban dan dapat mengakibatkan sejumlah besar skrap dan waktu yang terbuang selama proses pembuatan ban Untuk mengatasi masalah ini, sistem pengukuran panjang telapak yang didesain ulang dengan tingkat akurasi yang lebih tinggi dibuat untuk meminimalkan fluktuasi panjang telapak yang terjadi selama pembuatan ban. Hasil dari prosedur pengukuran panjang tapak dengan rotary encoder tipe ENC-1-1-24-N dapat berfungsi sesuai dengan program yang dibuat. divalidasi oleh data pengukuran panjang tapak. Hasil desain tampilan HMI dan

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perangkat lunak yang dibuat dapat beroperasi sesuai dengan instruksi yang diinginkan. Untuk mengubah panjang tapak, operator hanya perlu memasukkan angka pada panel HMI.

Kata Kunci : Enkoder Putar, HMI, Mitsubishi PLC, Operator..

1. INTRODUCTION

Competition in the industrial sector continues to increase significantly. Companies are striving to improve the quality of their products. Innovation and adaptation are essential to improving the tyre production process. The tyre production process consists of various essential processes that must be carried out. The stages begin with the mixing of raw materials, followed by the manufacture of semi-finished tread materials, followed by the assembly of these semi-finished materials, and ending with the drying process, which transforms the tyre building machine into a ready-to-sell product. The GP-211 R SERIES motorcycle tyre, a premium product with a wide and thick tread pattern specifically designed to provide driving stability at high speeds, was launched by PT. XYZ, Tbk in 2020. A PLC (Programmable Logic Controller) is a digital device with analogue or digital input or output modules that can control various machines or processes. PLCs are equipped with programmable memory to store commands for performing specific tasks, including logic, calculations, sequencing, timing, and arithmetic. Tyre products go through several production stages before becoming the tyres we use every day. Additionally, various factors can affect tyre quality, one of which is the tyre tread pattern, which is an important component.

In 1839, Charles Goodyear made an important discovery about the vulcanisation process of rubber. The term "vulcanisation" comes from Vulcan, the god of fire in Roman mythology. Initially, Goodyear referred to his discovery as fire-resistant rubber rather than vulcanisation. In recognition of his achievement, Goodyear's name was immortalised through his association with the famous American rubber company, Goodyear Tyre and Rubber Company, founded by Frank Seiberling in 1898. In 1845, Thomson and Dunlop invented the tyre, which was initially called a "living tyre" or "air tyre." Therefore, Thomson and Dunlop are recognised as the "founders of the tyre." Technological advances led Charles Kingston Welch to invent the inner tube, while William Erskine Bartlett created the outer tyre. The tyre is the final part of the tyre that is mounted on the frame in the tyre manufacturing machine, after all other components have been installed. When measuring the length of a pre-adjusted tyre, errors or variations often occur in the measurements taken by the measuring device because the accuracy of the device is not yet precise. This prevents the operator from using the tyre and can result in a lot of waste and wasted time during the tyre manufacturing process.

The tyre manufacturing process involves several stages before it finally becomes the product we use in our daily lives. In addition, tyre quality can be influenced by various factors, with the tread being the main feature that affects its quality. In tyre manufacturing machines, the tread is the last element to be integrated into the tyre structure after all other elements have been assembled. Inaccuracies or variations often occur during the measurement of pre-adjusted

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tyre treads due to inadequate measuring instruments, resulting in operators being unable to use the treads, which ultimately leads to significant waste and time wastage in the tyre production process. Quality Control (QC) data collected from April to June 2024 shows that the average tread length measurement for LEB defects on tyre building machines varies between 5 and 10, resulting in an LEB defect percentage of 1218 of total production. This number exceeds management's target for LEB defects, which is set at a maximum of 1232 of total production.

The researchers used an improvisational method, utilising PLC and HMI as the main sources in accordance with experimental principles. The aim of the research was to modify the PLC and HMI control system by adding a tread fix length system. PLC and HMI simulations were carried out, accompanied by practical testing of the equipment and electrical evaluation. Given the problems mentioned above, the author intends to modify the tread length measuring device to achieve a higher level of precision and thus reduce the level of tread length variation that occurs during the tyre manufacturing process. This is the background for the author to modify the tread length measuring device.

2. RESEARCH METHOD

To compile this research, the author required references from previous studies covering facts, methodologies, approaches, theoretical discussions, and theoretical questions. The material in these studies was essential to validate the author's conclusions, improve accuracy, and provide clarity, thereby making the research more effective and accountable. For example, further research has been completed. The following are previous studies that have been conducted for reference.

Mahar Adi Wijaya and colleagues, 2021. "Utilization of Fuzzy Logic for Wind Speed Assessment and Wind Direction Identification." This study seeks to assess wind velocity and ascertain its orientation through fuzzy logic methodologies. The objective of this experiment is to assess the operational protocols of the previously constructed gadget by incorporating all available instruments and software. The analysis was conducted utilizing Matlab and Compass software. Sinka Wilyanti and colleagues, 2021. "Conveyor Control System for Product Counting Utilizing a Programmable Logic Controller (PLC)." This project intends to design and create a prototype of a conveyor control system for product counting utilizing a PLC. The system employs ladder diagram programming via the CX-Programmer 9.5 software, which functions as the command interface within the PLC and produces the requisite outputs for managing and operating the product counting conveyor prototype. The research commenced with a literature assessment, succeeded by the design and construction of the conveyor, DC motor, power supply, control circuit, proximity sensor, digital counter, and PLC. Andrial Saputra and colleagues, 2021. Automated Correction System for Packaging Machinery Utilizing PLC Controllers. This study on the Automatic Correction System is a control system operated by a PLC (Programmable Logic Controller) aimed at minimizing overlap in packaged items. The PLC (Programmable Logic Controller) acquires input signals from photoelectric amplifier sensors, which are included into the system and serve as overlap detectors and trigger inputs for the PLC. "Design and Implementation of PLC Trainer Workstation" by Matthew Oluwole and colleagues, 2022. This study seeks to create a desktop PLC trainer workstation for applications in industrial automation engineering. Despite the numerous PLC trainers provided and recorded by researchers, they neglect to incorporate hardware connections for input/output devices and automatic PLC device symbols, including fundamental operations or PLCs, along with their associated descriptions that have been addressed. The subjects addressed in this article to enhance participants' proficiency in PLC programming are delineated below. The integrated PLC workstation features pushbuttons and switches for input signals, along with a fan, indicator lights, and a bell for output signals.

Modification of a PLC and Visual Basic-Based Compressor Machine Monitoring System, Baehaqi, 2022. The surveillance interface for this altered system employs Visual Basic, but machine regulation is managed by a Mitsubishi PLC. Both pertain to computer instructions depicted by ladder diagrams and code. The communication media employs Mx Component software. The prototype design produced favorable outcomes due to many experiments exhibiting 100% accuracy and a 0% error rate. Data storage was 99% more efficient than prior methods within two seconds. This modification yields a cumulative save of 186 sheets of paper monthly. Repairs to the monitor or PLC control can be executed promptly without necessitating communication with the manufacturer in the event of damage. The GOT1000 monitor exhibited superior tolerance to elevated temperatures near the compressor machine. Syahril Ardi and colleagues, 2022. The implementation of Programmable Logic Controllers (PLCs) and Human-Machine Interfaces (HMIs) to establish a monitoring and control system for waste boiler treatment processes. This research seeks to provide an automated monitoring and control system for the operational wastewater treatment plant. The control system design was finalized by integrating sensors and actuators linked to a modular PLC, which functions as the control system. This system is engineered to engage with personal computers (PCs) for ongoing process surveillance. This technology enables real-time monitoring of processes and guarantees enhanced consistency and efficiency in pH level regulation during boiler wastewater treatment. 2023 Sumardi Sadi. Employing a Programmable Logic Controller (PLC) to establish a Human-Machine Interface for a Chin Ei shoe sole manufacturing machine. This project involves developing a graphical representation of Chin as a human-machine interface (HMI) displayed on a computer screen. The system is unsustainable. This research employs an experimental methodology. This HMI enables users to manage and halt the processing system, as well as modify control parameters. The enhancement of the HMI on this system facilitates the use of the control buttons of the Chin Ei Shoe Sole Making Machine, rendering it simple, effective, efficient, and pleasurable. The use of a Programmable Logic Controller-based Product Counting Conveyor Control System is one of seven previous research methods related to and similar to this study. Automation, HMI and PLC are used in this study. However, due to the presence of a photocell sensor, the ENC-1-1-N-24 model Rotary Encoder and HMI function according to the desired instructions. The operator only needs to enter a number on the HMI screen to adjust the tread length.

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A. Equipment and System Design

This section will discuss system architecture, system block diagrams, system requirements, hardware design, software design, and system workflow

1) Block Diagram

A block diagram of the modified tread length measurement system with rotary encoder can be found below.

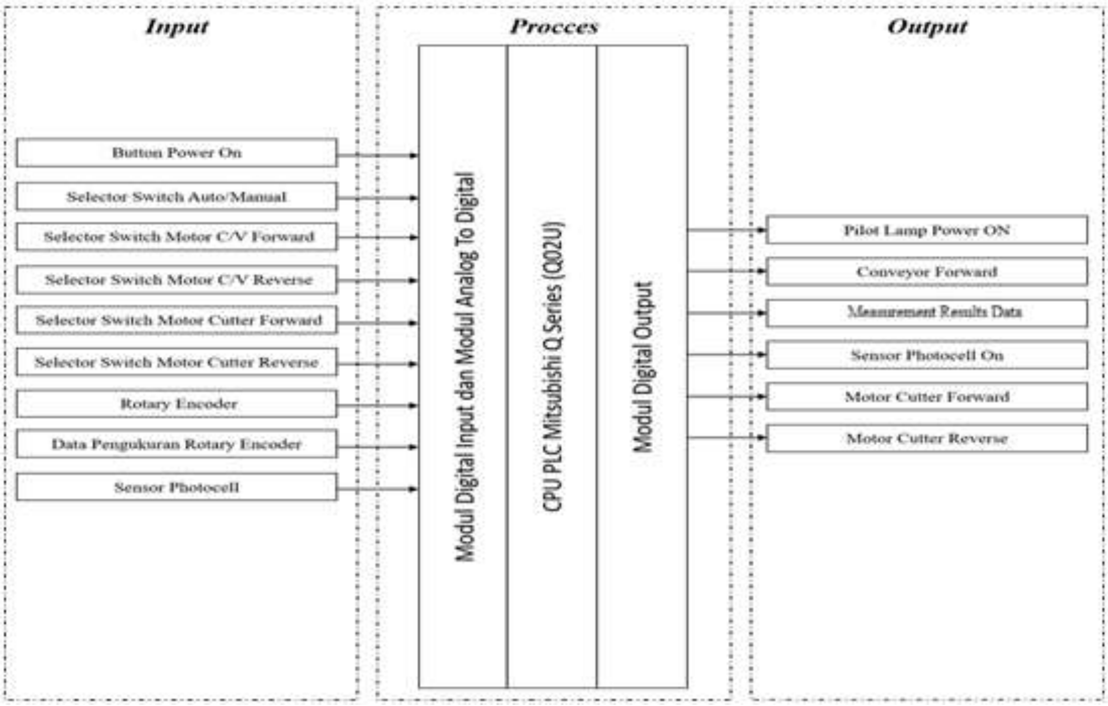

Figure 1. Block Diagram

Based on Figure 1, the block diagram of the device is divided into input, process, and output blocks. There are control devices included in these blocks, including:

1) Blok Input

Control devices included in the input are the Power ON button, Auto/Manual Selector Switch, Motor C/V Forward Selector Switch, Motor C/V Reverse Selector Switch, Motor Cutter Forward Selector Switch, Motor Cutter Reverse Selector Switch, Rotary Encoder, Rotary Encoder Measurement Data, and Photocell Sensor. In this experiment, the author uses a Photocell Sensor and Rotary Encoder as inputs for the PLC.

2) Process Block

The device included in the process block is a Mitsubishi Q02U type PLC CPU. The PLC functions to receive input signals, then based on a program created with GX works 2 in the form of ladder diagram programming language, the PLC outputs the process results in the form of ON or OFF signals sent to the output block.

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3) Output Block

Devices or equipment included in the output block are: Pilot Lamp Power ON, C/V Forward, Measurement Data with Rotary Encoder, Photocell Sensor ON, Cutter Motor Forward, Cutter Motor Reverse. This output uses contacts from the photocell sensor and measurement data on tread length using a rotary encoder. The device receives the PLC process results in the form of 24 VDC voltage.

2) Flowchart

This study utilised a design method based on the actual conditions of the Building Tyre machine at PT. XYZ Tbk. In this research method, the design stages were created in the form of the design stage, the manufacturing stage, and the testing stage. The success of the equipment was obtained through observation and testing.

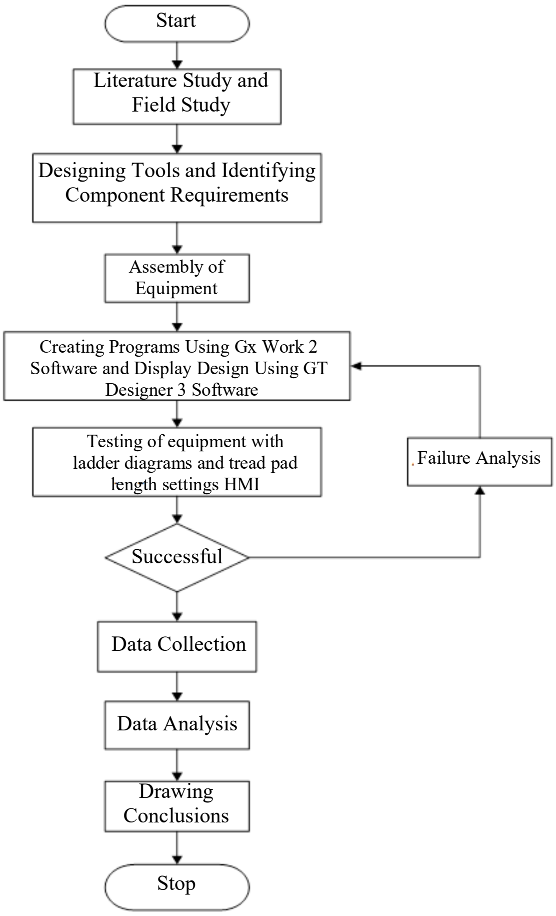

Figure 2. Research Flowchart

The process flow of specific stages is illustrated in the research flow chart in Figure 2. The types of measurement media used in formulating problems for data processing are clearly seen from this research flow chart. The instruments used as inputs and outputs are also explained. The research implementation process was carried out in the following manner, taking into account the research flow chart above.

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1. To identify problems that frequently arise during tread length measurement procedures using rotary encoders, the problems must first be identified and formulated.
2. Research and understand how to create a modified tread length measurement system using a Mitsubishi Q-type PLC and the following techniques.
   a) Books and research reports that provide a literature analysis of the designed system.
   b) Talk to your supervisor and discuss with individuals who understand the nature of the research and the methods that need to be developed.
3. Create a design for the hardware and software and determine the necessary components.
4. Assemble the gadgets, use GT Designer 3 to design the temperature display on the GOT1000 HMI, and use GX Works 2 to create a ladder diagram program.
5. Check and test the entire system. The author's research methodology involves a literature review, as well as the assembly of tools and additional components to modify the tread length measuring equipment. The author's research will concentrate on the data generated by the rotary encoder with a photocell sensor. The sensor will identify the arrival of the tread, enabling the rotary encoder to generate data according to the programmed parameters. If the tread length is still insufficient or even exceeds the specified parameters, the operator will adjust the tread length.

B. System Architecture

This research requires various aspects for its implementation, including special research tools. The technology designed for this research is a modified tread length measuring device, equipped with a smaller rotary encoder to improve accuracy, reduce variation in data calculations, and a photoelectric sensor to start tread length calculations. All components are directly connected to a PLC (Programmable Logic Controller) and HMI (Human Machine Interface) to facilitate instrument monitoring within this architecture.

Figure 3. Tread Length Measurement Procedure

A rotary encoder is used in the tread length measurement procedure. Since the rotary encoder only receives one pulse from the comparison wheel, the rotation data from one rotation of the rotary encoder is 1:1000 mm, and the accuracy of the current model is very high. On the

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other hand, the rotary encoder that will replace it has a lower precision level of 1:1 mm and directly detects the pulses of the rotating wheel.

A photocell sensor has been included in the modified design used in this study. The purpose of this modified encoder design is to reduce computational errors in tread length measurement data caused by the previous encoder. Additionally, using the GX Work 2 application, a photocell sensor has been added to this design as a start and finish, or SET and RESET, on the encoder programmer. Furthermore, this design utilises an HMI (Human Machine Interface) connected to a PLC to display the specified tread length information and make it easier for the operator to reset the tread length if it still does not meet the specifications. In this way, the potential for variation caused by encoder calculations is reduced.

C. Hardware Design

In this case, the hardware design involved replacing the E30S4-3-T-5.24 rotary encoder with an ENC-1-1-N-24 rotary encoder and adding a photocell sensor. This system consists of several components, each with its own function as described in the previous chapter. This sensor is connected to the QD62 analogue input module on the PLC control system. This subsection explains the design of the hardware system used in this system.

Figure 4. Tyre Machine Control System

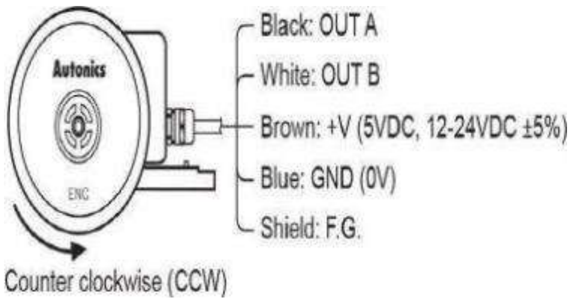

Figure 5. Rotary Encoder ENC-1-1-N-24

Table 1. Cable Rotary Encoder ENC-1-1-N-24

No. Pin	Cable Colour	Description
1	Black	Output A

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2	White	Output B
3	Brown	P24VDC
4	Blue	N24VDC
5	Shield	Ground

D. Software Assembly

Software design involves creating ladder diagrams using GX Works 2 software and creating displays on the HMI (Human Machine Interface) using GT Designer 3 software.

Figure 6. GT Designer 3 interface

E. PLC Program Design

The PLC program is designed using GX Works 2 software to read input equipment signals, then output to activate the ultrasonic cutter motor which functions to cut the tread if the tread length is in accordance with the predetermined data or, in other words, the data in the PLC has been achieved.

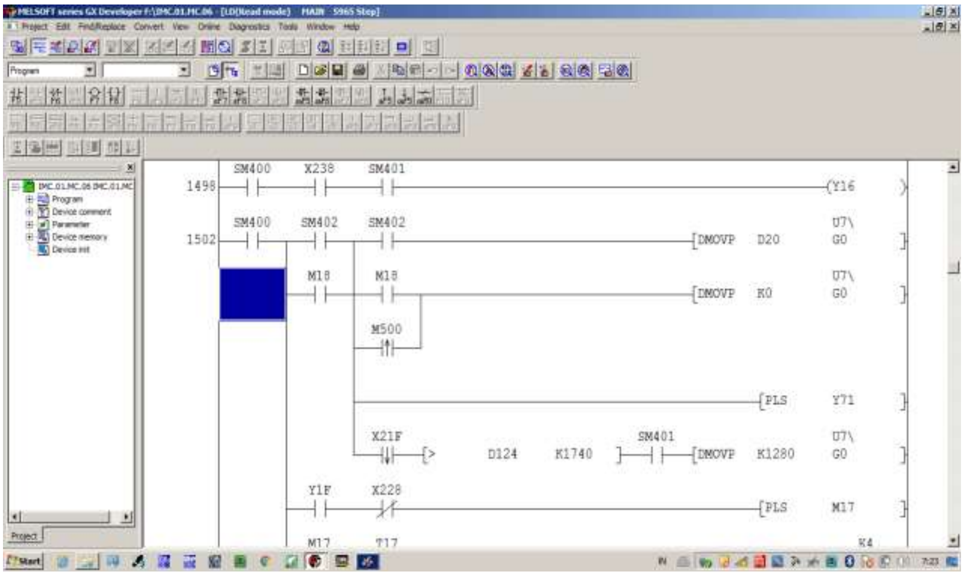

Figure 7. Rotary Encoder Ladder Diagram

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F. HMI Design

HMI (Human Machine Interface) is a component of the modified tread length measurement system. HMI (Human Machine Interface) displays the actual tread length measurement data read by the rotary encoder. This HMI (Human Machine Interface) is also used for remote configuration and monitoring of tread length measurements using a touch screen.

Figure 8. Measurement of HMI Footprint Length

G. Photocell Sensor Design

As explained in the previous subsection, the photocell sensor functions as a trigger to start calculating rotary encoder data. This photocell sensor is also used to further minimise errors in tread length calculations.

Figure 9. Leuze LE5 / N Photocell Sensor

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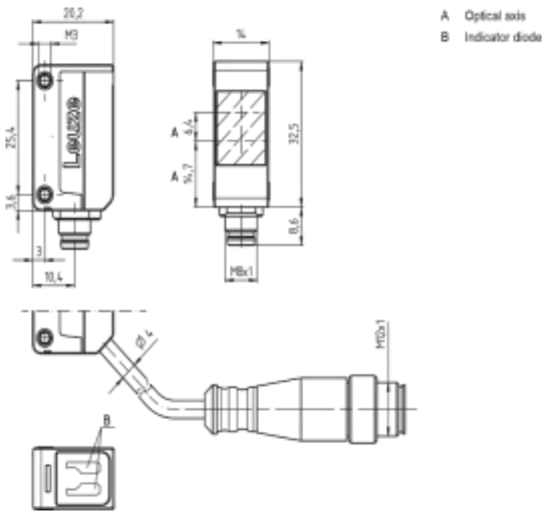

Figure 10. Photosensor Circuit

Figure 11. Photocell Sensor Placement Design

The photocell sensor will be placed on the building's tyre machine. The photocell sensor is installed by making a hole for the placement of bolts used to tighten the photocell sensor and its cable.

H. Modified Meter System Flow

The following is a system flow chart that illustrates how the system for modifying the tread length measuring device on a Building Tyre machine works.

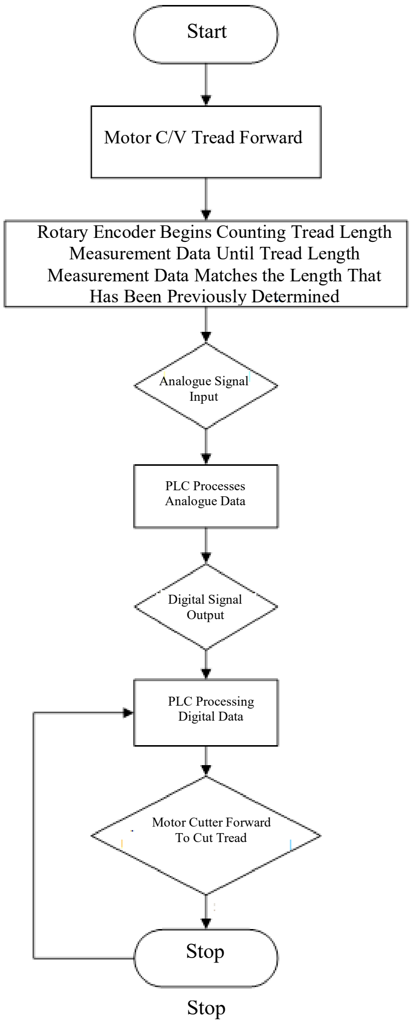

Figure 12. Device System Flowchart

Modified Foot Length Measuring Device Based on the flow chart of the modified foot length measuring device above, it can be explained that.

a. The conveyor motor carrying the foot will move forward until the foot length matches the set length.
b. After that, the rotary encoder will begin to calculate the specified foot length data on the HMI (Human Machine Interface) screen.
c. The data generated from the rotary encoder is analogue data.
d. Next, the analogue data will be processed by the QD62 PLC module into digital data.
e. The digital data generated will be processed on the PLC. The processed digital data is used as a reference to control the actuator. That is, to run the ultrasonic cutter motor to cut the tread to the desired length, which has been set on the HMI screen.
f. If the tread length is not yet correct, the QD62 PLC module will continue to process the data until it is correct. Because if the data is not correct, the ultrasonic cutter motor will not

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operate, or in other words, the conditions required by the ultrasonic cutter motor have not been met.

3. RESULT AND DISCUSSION

Modification of the tread length measurement system on a Mitsubishi PLC-based tyre manufacturing machine. Overall, the purpose of testing this system is to determine the accuracy of tread length measurements using a rotary encoder in order to obtain measurement results that meet the specified requirements.

A. Hardware Design Results

In this situation, hardware replacement involves replacing the Rotary Encoder The E50S8 model with the ENC-1-1-N-24 Rotary Encoder. The Rotary Encoder is designed to independently determine the tread length connected to the Programmable Logic Controller (PLC). In addition, the modification system incorporates a photocell sensor in its hardware, which serves as a means to start and reset the tread length calculation in the PLC program. The modified system consists of several components, each with a specific function, which have been described in the previous chapter. The Rotary Encoder is connected to the QD62 module, which is part of the PLC control system, as shown in Figure 13. This subsection provides a detailed explanation of the hardware system design.

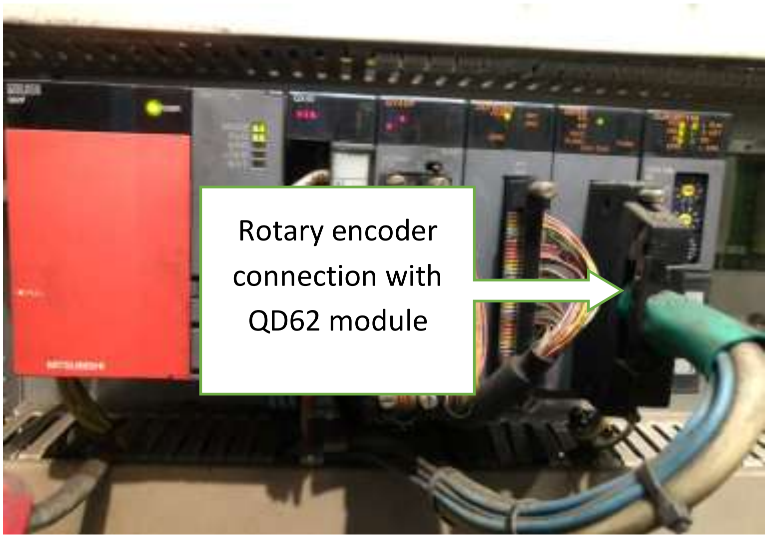

Figure 13. Developing a Control System

To connect the components, you need to have a circuit diagram to guide the hardware assembly.

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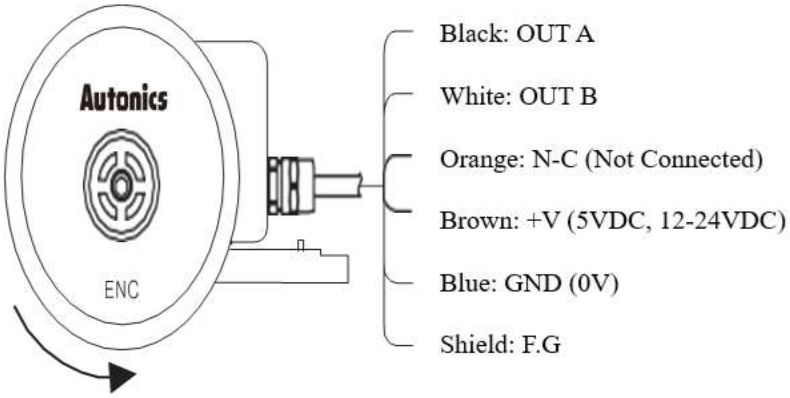

Figure 14. Rotary Encoder Circuit

Table 2. Rotary Encoder Cable Wiring

No. Pin	Cable Colour	Description
1	Black	Out A
2	White	Out B
3	Brown	N-C (Not Connected)
4	Blue	+5 (5VDC, 12-24VDC)
5	Shield	GND (0V)
6	Black	F.G

B. Photocell Sensor Design Results

In this design, there is an addition of hardware, namely a photocell sensor. The photocell sensor functions as a trigger for measuring tread length. Input from the photocell sensor will be used to regulate and reset data in PLC programming. In this context, the data referred to is tread length measurement data obtained through the use of a rotary encoder.

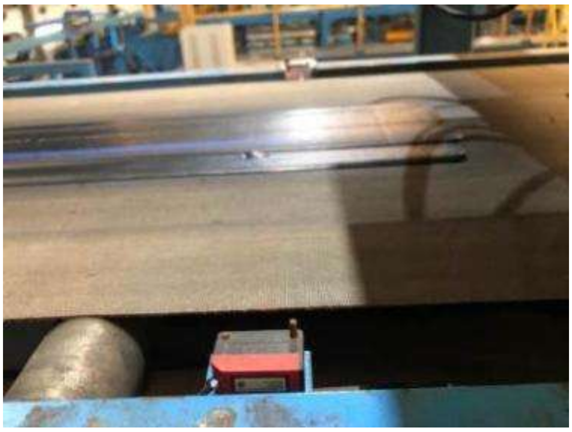

Figure 15. Photocell Sensor Design for Building a Tyre Machine

C. Software Design Results

Software refers to data that is formatted and stored digitally. To develop software on this customised system, it is necessary to use a programming language that is compiled with a compiler application. This process converts the code into a format that can be understood and executed by the hardware. The design of this software consists of two components: the design of the PLC communication system with HMI, and the design of the HMI itself.

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1) PLC program design results

The modified system uses ladder diagram programming language through the gx work 2 application. Ladder diagrams show configurations that resemble electrical circuits. Ladder diagrams consist of power rails positioned on the right and left sides of the image. These power rails are connected to rungs with switch elements and specific coil components, as described in the previous chapter. The ladder diagram scanning process involves sequentially checking each room from left to right and transitioning between rooms from top to bottom.

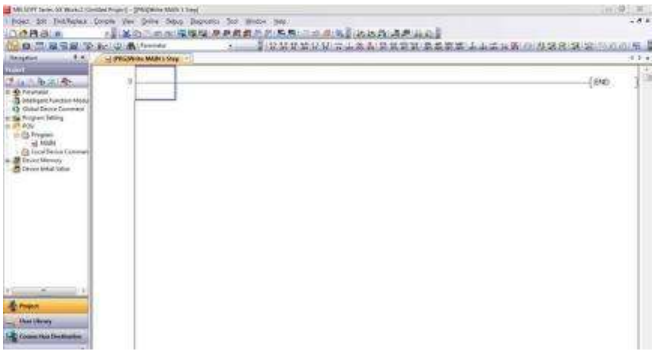

Figure 16. Gx Work 2 Interface

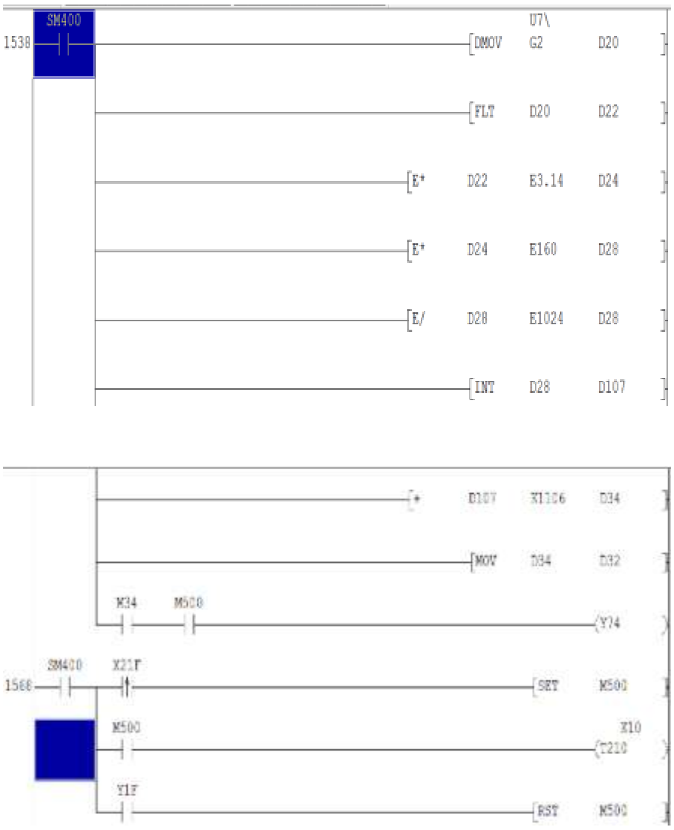

Figure 17. Programme for Comparing Footprint Length Measurements

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The findings of the tread length measurement programme are generated automatically. The rotary encoder located at address d20 will generate an analogue signal, which will then be translated into a digital value. The transformed digital value is stored in the data memory at address d22. Next, the value at address d22 is multiplied by a constant factor of 3.14. After the multiplication result is transferred to memory address d24, the data at address d24 is then modified by adding a constant value of 160. Next, the multiplication result is transferred again to address d28. According to the ladder diagram provided, the condition for achieving the desired value is to apply an arithmetic algorithm that converts the value to a decimal integer. This conversion ensures that the calculated result is accurate and corresponds to the actual value. The decimal representation of the value is stored at memory address d28. The previous calculation result will be converted back to integer format so that it can be used as a condition for managing data related to tread length. The integer value has been stored at memory location d107.

The command in step 1579 of the ladder diagram allows the rotary encoder to reset the tread length calculation, especially when the tread obstructs the reflection of light from the photocell sensor to the reflector. The ladder diagram shows that the input from the photocell sensor at address X21F will be active when the tread obstructs the reflection of light from the sensor, thereby activating the main relay M500 for one second. Next, the Y1F output will be activated to reset the main relay M500.

2) HMI (Human Machine Interface) Design Results

HMI is a component in automatic control and tread length measurement monitoring. HMI displays data results according to tread length specifications. This HMI is used to automatically set tread length remotely using a touch screen.

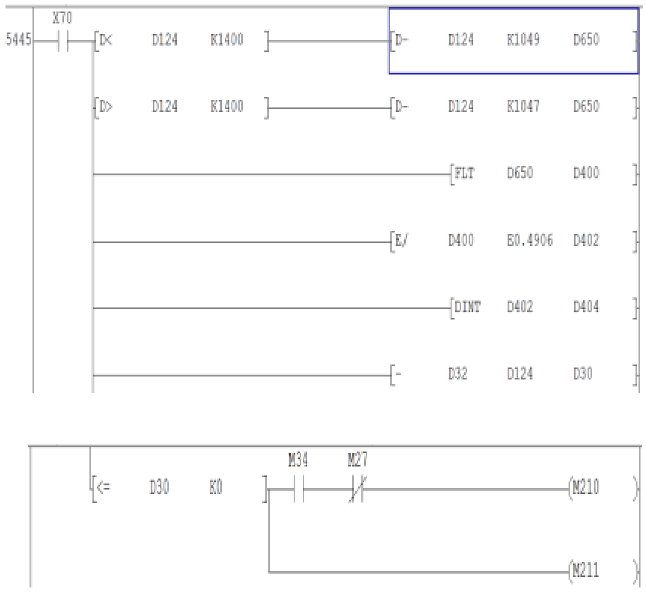

Figure 18. HMI Control Programme

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Figure 19. Monitoring Screen Display

D. PLC Program Testing

The purpose of this test is to assess the functionality of the updated rotary encoder on the tyre building machine in the tread length measurement process.

Table 3. Rotary Encoder Functionality

No. Pin	Description	Encoding Code
1	Machine	IMC.01.MC.06
2	GT Code	G274
3	Size	90/90-14M/C 46P NR83T/L
4	Machine Type	BTU
5	GT Weight	GND (0V)
6	Max. Tolerance	3140
7	Min. Tolerance	2898
8	GT Width	209 ±6mm
9	Max. Thickness	215
10	Min. Thickness	203
11	Tread	1225 ±7mm
12	Display	1230
13	Max. Thickness	1232
14	Min. Thickness	1218

This test will evaluate whether the encoder can operate according to the commands specified in the PLC program. The findings from the automatic program test are provided in Table 4.

Table 4. Tread Length Measurement Results Before

No	GT weight	GT width	Tread Length	Average Tread Length	Average GT Width
1	2978	210	1233	8	1
2	3014	209	1233	8	0
3	3032	210	1233	8	1

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4	3004	209	1231	6	0
5	3010	210	1233	8	1
6	3000	210	1234	9	1
7	3025	210	1233	8	1
8	3012	209	1233	8	0
9	3022	210	1234	9	1
10	3007	210	1233	8	1
11	3000	210	1232	7	1
12	3012	210	1234	9	1
13	3004	210	1233	8	1
14	2999	210	1231	6	1
15	2998	209	1231	6	0
16	3001	209	1235	10	0
17	3012	210	1233	8	1
18	3006	210	1231	6	1
19	3009	210	1231	6	1
20	3019	210	1232	7	1
21	3000	209	1231	6	0
22	2999	209	1231	6	0
23	2997	209	1230	5	0
24	2999	210	1230	5	1
25	3002	210	1231	6	1
26	3014	210	1231	6	1
27	3017	209	1232	7	0
28	3011	209	1232	7	0
29	3010	210	1230	5	1
30	3002	210	1231	6	1

Table 5. Results of Tread Length Measurement Testing After

No	GT weight	GT width	Tread Length	Average Tread Length	Average GT Width
1	2978	210	1229	-1	1
2	3014	209	1228	-2	0
3	3032	210	1231	1	1
4	3004	209	1228	-2	0
5	3010	210	1230	0	1
6	3000	210	1232	2	1
7	3025	210	1228	-2	1

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8	3012	209	1231	1	0
9	3022	210	1230	0	1
10	3007	210	1230	0	1
11	3000	210	1229	-1	1
12	3012	210	1229	-1	1
13	3004	210	1230	0	1
14	2999	210	1229	-1	1
15	2998	209	1228	-2	0
16	3001	209	1228	-2	0
17	3012	210	1231	1	1
18	3006	210	1231	1	1
19	3009	210	1228	-2	1
20	3019	210	1230	0	1
21	3000	209	1232	2	0
22	2999	209	1229	-1	0
23	2997	209	1230	0	0
24	2999	210	1229	-1	1
25	3002	210	1228	-2	1
26	3014	210	1231	1	1
27	3017	209	1228	-2	0
28	3011	209	1229	-1	0
29	3010	210	1230	0	1
30	3002	210	1232	2	1

The test table constructed shows a clear difference in tread length measurements before and after modification. Significant variations in tread length were observed in tests on the E80S rotary encoder before correction. The application of the E-N-C-1-1-24-N type rotary encoder and photoelectric sensor as triggers to start and stop the PLC program in the tread length calculation produced satisfactory results, as seen in the data presented in the table. Although there were discrepancies between experiments, these deviations were not excessive and did not significantly deviate from the specified tread length.

4. CONCLUSION

Based on the results of data analysis and discussion in the previous chapter, the researcher concluded that the tread length can be measured using an ENC-1-1-24-N type rotary encoder, which operates according to a pre-programmed sequence. This is supported by empirical evidence obtained from tread length measurements. The display design on the HMI and the program have been successfully implemented to meet the desired instructions. The operator only needs to enter the desired number on the HMI panel to modify the tread length. Existing research can still be improved and refined. The following are the author's recommendations for development A price calculation study should be carried out on the tools used to accurately

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measure the impact and costs associated with this research. It is important to create a program for calculating tread length to ensure the accuracy of the SET and RESET programs.

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