

# Design of Monitoring and Control of SCADA Systems on Curing Machine using PLC and HMI Wonderware InTouch

Syahril Ardi<sup>1</sup>, Nanda Indah Angger Lestari<sup>2</sup>

<sup>1</sup>Mechatronics Department, Politeknik Manufaktur Astra, Jakarta, Indonesia

<sup>2</sup>Engineering Production & Manufacturing, Politeknik Manufaktur Astra

\* Corresponding author e-mail: Syahril.ardi@polman.astra.ac.id

## Abstract

In this era, IoT applications in the manufacturing industry, especially in developing industry 4.0 continues to develop widely and rapidly. In this case, research related to the design and application of the Industrial Internet of things in the world of automotive manufacturing industry that produces tires for 2-wheeled vehicles. In the process of making a marketable tire, the process that is passed is the process of mixing, topping, extruding, bead wire, tire assembly, spraying, gimlet, and curing tire. In the last process, namely the curing tire, there is a process of collecting counter data which is carried out by the operator EBS (E-business switch), where the counter data collection is still done manually. After the data is retrieved, the EBS operator will input data into the EBS system. This process is considered inefficient because it is quite a time consuming, and the level of human error is quite high. This paper discusses the design and application of the SCADA System (Supervisory Control and Data Acquisition) on 6 curing machines using HMI Wonderware InTouch application, which functions for monitoring and control systems. In the PLC control system, it utilizes the Mitsubishi QJ71E71-100 Ethernet module as its communication module and uses Microsoft Access as a database. By designing this system, the level of accuracy produced is much higher. While EBS operators can monitor production results via a PC (Personal Computer) both in the interface, as well as data acquisition recorded in Microsoft Access.

*Keywords: Curing tire, PLC, SCADA, HMI Wonderware InTouch, Microsoft Access*

## 1. Introduction

This research was conducted at a manufacturing company that manufactures tires in a motorcycle. The process of making a tire in going through the following processes: the process of mixing, topping, extruding, bead wire, tire assembly, spraying, gimlet, and curing tire. In the tire curing process, there is a curing machine used to print a tire. Tire printing has raw materials in the form of green tires that have been made in the previous process. The raw material will be printed at a temperature of 175 °C for approximately 500 seconds, and the production results will be calculated with a digital counter that has been displayed on the machine's HMI. On each curing machine, there are 4 cavities, so that in one production will produce 4 tires at once.

In this process, there is a data retrieval activity of the amount of production of each cavity on the curing machine which is carried out by an EBS operator (E-business switch) every 45 minutes periodically. After the data is collected, the operator must then enter the data into the EBS system. This activity is considered inefficient because it takes a long time.

Furthermore, a SCADA system was designed on 6 curing machines, so that it can monitor and carry out the data acquisition process of the process that occurs. In this case, the interface designed for HMI Wonderware InTouch application, communication between the PLC and HMI via Ethernet, and testing the SCADA system.

Some studies and research related to the design of this control system, including (Owned, A, 2015); (G. Valencia-Palomo, J.A. Rossiter, 2011); (Wang, R., Song, X., Zhu, J., Gu, M, 2011); (Alexander Fay, et.all, 2015); (Gökhan Gelena, Murat Uzamb, 2014). Also, various studies have been conducted related to the use of PLCs as a control system and HMI, for various systems and machinery, especially in the area of manufacturing and automotive industries, including (Ardi, S .; Defi, W.Y, 2018); (Ardi, S., Cascarine, L.T, 2018); (Ardi, S., Tommy, M.I., Afianto, 2018); (Ardi, S., Nugraha, Z.A, 2018); (Ardi, S., Ardyansyah, D, 2018); (Ardi, S., Ponco, A., Latief, R.A. 2017); (Ardi, S., Abdurrahman, H, 2017); (Ardi, S., Al-Rasyid, A, 2016); (Ardi, S., Wibowo, B, 2017); (Ardi, S., Kusuma, R, 2016); (Ardi, S., Hidayat, A. 2015) through 4 stages, namely connection testing, interface testing, program testing, and database testing.

This system has increased the accuracy of data counter retrieval (E-business Switch). Also, this SCADA system can be applied to other machines, i.e. with some address adjustments.

## 2. Methodology

### 2.1 Product Introduction

The company where this research was carried out, producing outer tires and inner tubes. Tires are devices that cover the wheels. Tires are an important part of land vehicles and are used to reduce vibrations caused by road surface irregularities, protect wheels from wear and damage, and provide stability between the vehicle and the ground to increase acceleration and facilitate movement. Fig. 1 shows the process of making an outer tire, which is mixing (the process of mixing raw material), extruding (the process to refine a compound), callendering (making material ply & steel belt, JLB & cap ply). Cutting bias is the process of cutting nylon cord from the callendering process diagonally at a certain angle to a sheet called ply with a width according to the desired specifications. Building tire assembly is all core material forming Tire such as Bead wire, Ply cord, Thread, which are combined into one. Curing is the process of cooking a green tire into a finished tire. The final inspection is the process of checking a tire, the tire is visually inspected for defects or not.

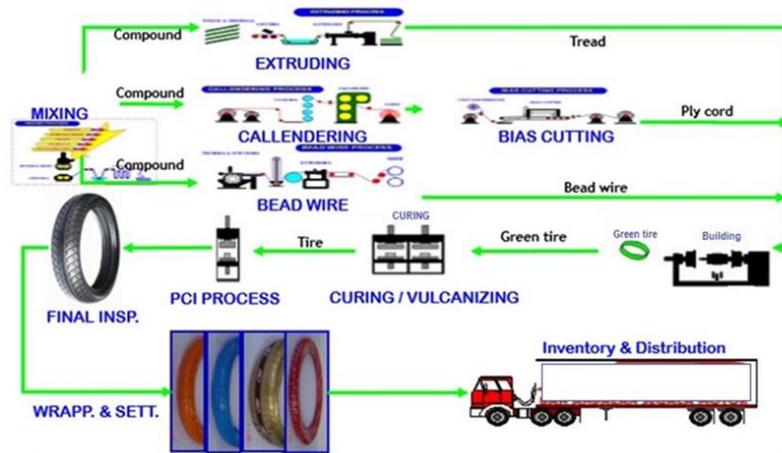


Fig.1: The process of making an outer tire

### 2.2 Curing Machines

The curing process is cooking or vulcanizing green tires into finished tires. Curing process or this cooking requires very hot temperatures and a very high amount of steam pressure. The green tire will be placed on the mold with the desired temperature for production. Fig. 2 shows an illustration a curing machine.



Fig. 2: an illustration a curing machine

### 2.3 Problem Analysis

The curing machine starts operating from the insertion of a green tire into the machine until it is finished cooking, then produces a finished tire, then sent to the next process. This process carried out continuously which is divided into 3 shifts in a day and the counter counts occur every time cooking and reset every shift. In this process, there is also an EBS Operator whose job is to retrieve the data counter manually. Data retrieval is done every 45 minutes for 1 shift, the operator will take as much as 8 times the data. Data retrieval is still done using a check-sheet and the operator goes around to each machine.

## 2.4 System criteria

The following are the required system criteria: creating a system that can be monitored remotely; on the interface, displays the counter, timer, and indication that the curing machine is on operated or not; interface that is easily understood by the user; have a security system so that not everyone can access the database; it can record production data on the curing machine for 3 shifts (24 hours); it can record accurate data.

## 2.5 Network Topology

Each curing machine is controlled by a Mitsubishi FX3U PLC, then the data from the PLC. It will be transferred to the PLC master, the Mitsubishi Q02U PLC via CC-Link. Fig. 3 shows the network topology. The curing process is cooking or vulcanizing green tires into finished tires. Curing process or this cooking requires very hot temperatures and a very high amount of steam pressure. The green tire will be placed on the mold with the desired temperature for production.

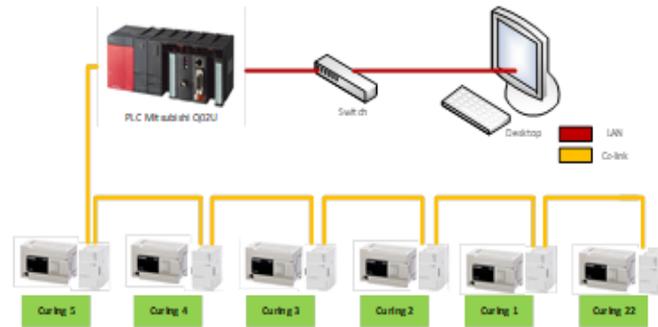


Fig. 3: Network topology

## 2.6 Interface design

From the pre-existing criteria, the following windows will be created, namely: Window log in, Window counter, Window chart counter, Window chart timer, and Window record

## 2.7 Program Design

When the user starts the system, the first window that will appear in the login window, after logging in, the next window that opens is the main window, the window counter on the curing machine. Two types of users can access this page, namely operator and guest. A striking difference between the two users is the range of access, the operator can open up to a database and graphics, but for guests can only monitor the main page. In this window, there are several other options (if the operator logs in), namely, the timer graph button, counter graph, and record. When the operator selects the timer graph button, it will display the timer graph screen of each curing machine historically, or this graph records the time data from the curing machine. When the operator selects the counter graph button, it displays a graph of the results of the curing machine. And when the operator selects a button to record, it will display a window for the operator to activate the connection between Wonderware and Microsoft access.

## 2.8 Database Design

In creating a database, Microsoft Access is used. The table to be displayed is a table that contains the main data needed by the EBS operator, namely the date of data retrieval, the time of data retrieval, the results of production of each cavity on each machine, and the total production results of each machine. The database will record the results every minute.

# 3. Results and Discussion

## 3.1 SCADA System Design

### Design of Connections Between Applications

In this case, the System Management Console software is used as a protocol between PLCs Mitsubishi Q02U with Wonderware InTouch. The communication module used on the PLC is the Ethernet module QJ71E71-100, because it uses the Ethernet module, the communication used is DASMTEthernet. In making connections there are several stages, the first is to create new channels and devices, this channel functions in configuring each of the existing games on objects on InTouch. Next is to set the PLC id and module. The order of determining the ID for the SMC is (255.255.255.255: N <Net Number>: <PC Number>). In the first part, 255.255.255.255 is replaced by the IP address of the Ethernet module used and the last is to create a new device group.

### Design of the Interface

Several types of windows exist, the first is the login window, where the user must log in first. Window counter all serves to display the main data needed by the operator such as cavity lights, cavity counters, curing timers, manual-auto indicators, exhaust indicators and curing indicators on-off. Fig. 4 displays the counter window and Table 1 shows the tag name on one of the machines, namely curing machine number 1.



Fig. 4: Counter all window

Table 1: Tag name on Curing machine 1

No	Name	Tag name	Tag Type
1	Lamp of cavity 1	Lamp1	I/O Discrete
2	Counter cavity 1	C1A	I/O Real
3	Lamp of cavity 2	Lamp2	I/O Discrete
4	Counter cavity 2	C1B	I/O Real
5	Lamp of cavity 3	Lamp3	I/O Discrete
6	Counter cavity 3	C1C	I/O Real
7	Lamp of cavity 4	Lamp4	I/O Discrete
8	Counter cavity 4	C1D	I/O Real
13	Timer Curing	C1Timer	I/O Real
14	Indicator of man-auto	LampPower1	I/O Discrete
15	Indicator of exhaust	Exhaust1	I/O Discrete
16	Curing on/off	Power1	I/O Discrete

The third window is the counter graph window, this window serves to display the amount of curing machine production in real-time.

The next window is the timer graph window, where this window contains historical graphs, the purpose of historical here is that the previous time graphs can be saved to the system. Figure 4 shows an example of the graphic display in curing choice number 1.

In making the Interfaces that can be run as desired, there are several compiler objects, namely, historical trend charts, legend trends. The last is the close button, this button allows you to close the window and return to the timer graph window. The last window is the record window, this window serves to display a button to activate the connection between Wonderware and the database that is on Microsoft Access.

### Input-Output Configuration

A new device and channel have been created in the System Management Console application before, the name of the device group is "mits" with an interval of 100 milliseconds. At each tag name when the type of the tag name is changed to type Input-Output, be it real Input-Output, discrete Input-Output, or analog Input-Output, the access name section will appear, in this section, the name of the device group will be added. was made. The first thing in making an access name is to create a new access name. Select the menu dictionary game, and select the access name button, then a list view will appear from the existing access name.

The next step is to open the device item in the System Management Console. After successfully opening device items, then 2 parts must be input, namely the name and the item reference section. The name part is the game that has been created in the Wonderware InTouch, while the item reference is the source of data that is in the PLC program.

### Design of Database

Design of database consists of 3 main stages, namely creating a table on Microsoft access, then uploading the table that has been made to the ODBC data source and after uploading it, the wonder software intouch is made a bindlist. Bindlist functions to connect between a label in a Microsoft access table and a tagname in a Wonderware InTouch. For example, the C1A tagname will be displayed in column 1A, C1B will be displayed in column 2A, and so on. After creating a bindlist, settings in the script window must also be done because this will affect the retrieval of data that will later be stored in the database.

### 3.2. Testing

Testing on this system is done after making connections, interfaces, and databases. This process is carried out to determine whether the design to manufacture has been functioning properly and as expected. Testing is divided into 4 parts, namely connection testing, interface testing, program testing, and database testing. Connection testing is done by ascertaining whether Wonderware InTouch can communicate with PLC or not. Communication between PLC and Wonderware InTouch uses the System Management Console software. Interface testing is done by running the program on Wonderware InTouch, various objects exist in each window. This test is done to see whether all components on the interface are running by the target. After testing the interface, it continues with the program testing. This test is done by aligning the active address on the PLC and the existing indicators on the Wonderware InTouch. In this experiment, a program reading from the PLC must be carried out, to monitor the program directly so that the test will give accurate results. When testing the program has been carried out, then the next is to test the database. This test is carried out to see whether the database is in line with expectations or still, has shortcomings that must be added.

### 3.3 Discussion

After doing various kinds of tests, such as connection testing, interface testing, program testing, and database testing. It can be concluded that the results are quite by the objectives of the author. The window counter all can display the data needed and display accurate data. Experiments are conducted at the beginning of shift 1, where at the beginning of every shift, the operator will reset the counter, and the calculation of production will start at 0. After Wonderware has successfully displayed data, the next thing is to activate the connection between the database and Wonderware. The results obtained are Wonderware successfully communicating with Microsoft Access, this is marked in the error message section in the record window will display the results "no error occurred" and the data in Wonderware InTouch can be recorded in Microsoft Access. If previously the operator is still doing data retrieval by visiting curing machines one by one, then with this system, the operator does not need to directly retrieve data. Operators only log in to InTouch Wonderware and retrieve records that are already in Microsoft Access. Human error is reduced by 100% because the data is taken directly from the PLC without manually retrieving it. Some additional features can also help the operator in analyzing work performance or problems that exist on the curing machine. Like when on one shift, if the production target is not reached, then the operator can see whether each cavity is working continuously, or there is one cavity that is not working. In Figure 5 the left shows the overall curing machine timer graph. Whereas in Fig. 5 the right shows the timer graph on the curing machine no. 3.

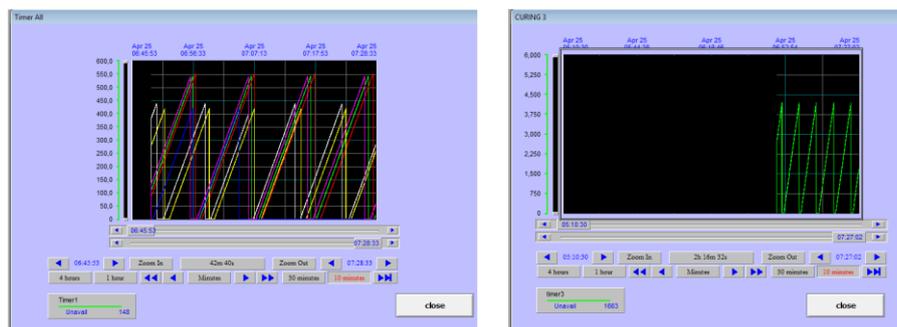


Fig. 5: The timer graph on the curing machine

## 4. Conclusion

The SCADA system design on 6 curing machines was made using HMI Wonderware InTouch application. The PLC utilizes the Mitsubishi QJ71E71-100 Ethernet module as a communication module and uses Microsoft Access as a database. The interface design of HMI Wonderware InTouch is quite simple because it uses an existing library, this library is obtained from the wizard menu, and every object in the wizard must be added a tag name,

this tag name functions for addressing of each object to which the address of the Input-Output PLC to be displayed is added. The communication design between PLC and HMI Wonderware InTouch utilizes the Ethernet module QJ71E71-100 using DASMT Ethernet communication in the System Management Console application. This system testing is carried out through 4 stages, namely connection testing, interface testing, program testing, and database testing. This system has increased the accuracy of data counter retrieval (E-business Switch). Also, this SCADA system can be applied to other machines, i.e. with some address adjustments.

## 5. Acknowledgment

We would like to acknowledge the support of Mechatronics Department, Politeknik Manufaktur Astra, and an Astra Group Company in this research paper for their helping in the elaboration of this work.

## 6. References

- Milik, A. 2015. On PLCs Control Program Hardware Implementation Selected Problems of Mapping and Scheduling. IFAC-PapersOnLine 48-4, 354-361.
- G. Valencia-Palomo, J.A. Rossiter. 2011. Programmable logic controller implementation of an auto-tuned predictive control based on minimal plant information. ISA Transactions 50, pp. 92-100.
- Rullan, A. 1997. Programmable Logic Controllers versus Personal Computers for Process Control. Computers ind. Engineering, Nos 1-2, pp. 421-424.
- Alexander Fay, et.all. 2015. Enhancing a model-based engineering approach for distributed manufacturing automation systems with characteristics and design patterns. The Journal of Systems and Software 101, 221–235.
- Gökhan Gelena, Murat Uzamb. 2014. The synthesis and PLC implementation of hybrid modular supervisors for real time control of an experimental manufacturing system. Journal of Manufacturing Systems 33, 535–550.
- Ardi, S.; Defi, W.Y. 2018. Control Systems Modification of Loading and Unloading in Oil Filling Machine Based on Programmable Logic Controller at Manufacturing Industry. AIP Conference Proceedings 2021, 060029; <https://doi.org/10.1063/1.5062793>
- Ardi, S., Cascarine, L.T. 2018. Design Control System of Auto Air Remaining Machine based on Programmable Logic Controller in the Automotive Manufacturing Industry. MATEC Web Conf., Volume 197, 2018, The 3rd Annual Applied Science and Engineering Conference (AASEC 2018).
- Ardi, S., Tommy, M.I., Afianto. 2018. Automation of Waste Treatment on the Washer Machine Based on PLC Control System in the Manufacturing Industry. July 2018, DOI: 10.1109/ICISCE.2018.00140
- Ardi, S., Nugraha, Z.A. 2018. Design Control System of Washing Oil Pan Machine Based on PLC in the Automotive Manufacturing Industry. Published in: 2018 International Conference on Electrical Engineering and Informatics (ICELTICS)
- Date of Conference: 19-20 Sept. 2018, Date Added to IEEE Xplore: 29 November 2018, INSPEC Accession Number: 18290112, DOI: 10.1109/ICELTICS.2018.8548819
- Ardi, S., Ardyansyah, D. 2018. Design Control Systems of Human Machine Interface in the NTVS-2894 Seat Grinder Machine to Increase the Productivity. IOP Conference Series: Materials Science and Engineering, 306 (1), 012112, (2018), doi:10.1088/1757-899X/306/1/012112
- Ardi, S., Ponco, A., Latief, R.A. 2017. Design of integrated SCADA systems in piston production manufacturing case study on the conveyor, the coolant, the hydraulic, and the alarm systems using PLC. IEEE Xplore, 187 – 191.
- Ardi, S., H Abdurrahman. 2017. Design of pokayoke systems to increase the efficiency of function check oxygen sensor machine using programmable logic controller in manufacturing industry, IEEE Xplore, 192 – 196.
- Ardi, S., Al-Rasyid, A. 2016. Design of Pokayoke Sensor Systems in Drill Oil Hole Machine to Detect the Presence of Drill using Programmable Logic Controller. Advanced Science Letters 22(7), pp. 1813-1816.