Design of control system for cover washing machine in the automotive manufacturing industry

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Abstract. In this paper, it discusses research conducted in the automotive manufacturing industry. In this case that is in the process of manufacturing the two-wheeled vehicle parts cover. In manufacturing the cover parts includes several processes, namely: Melting, Casting, Finishing, Machining, Painting, and Assembling. The washing process is the process of cleaning the chips and coolants that attach to the part, namely by spraying water and wind. The previous washing process used a manual method, namely by dipping the part in a container filled with water and then spraying it clean free of coolant. This method still has drawbacks, namely that there are still coolant marks left in the part. Coolant that has been attached to the part will be difficult to clean when it has dried. We conduct research by designing a cover washing machine that is integrated with the PLC (Programmable Logic Controller). In this case, the control system has 60 Input-Output, consisting of 36 inputs and 24 outputs. This machine construction uses the Rotary Table principle, so that the operator's work becomes more effective. In addition, the results reduce the amount of rejection in the painting process by 5% and increase the amount of production from 400 pieces per day to 700 pieces per day.

1. Introduction
This research was conducted in the automotive manufacturing industry engaged in manufacturing aluminum automotive components. The growth of the automotive industry is currently very rapid, where cars and motorbikes have become a public need for transportation facilities. To meet the needs of society, quality and reliable automotive components are needed. In addition to having to comply with safety standards, it must also provide comfort when used.

One of the products produced is Cover, which are the crank case protective component and the engine on two-wheeled vehicles. Cover is made through several processes including: Melting, Casting, Finishing, Machining, Painting, and Assembling. In the Machining process there is one process, namely washing or commonly called Part washing before being taken to the next process.

In the previous, washing process used the manual method by dipping the part in a container filled with water and then spraying it clean free of coolant. But this method still has many disadvantages, namely that there are still coolant marks left in the part. Coolant will leave spots on the part if it dries. Considering after the washing process is the process of painting or painting if there is still coolant left behind, automatically the painting results become uneven. This research also aims to reduce the amount of rejection or defects caused by machines or Man Power. How is to design a cover washing machine control system by automatically [1-3].

2. Methodology and design
This company is a company engaged in the manufacture of automotive products ranging from 2W (2 wheels) and 4W (4 wheels) with the Die Casting method. One of the products produced is Cover.
Figure 1 shows an illustration of the process of manufacturing Cover products. The Cover Washing Machine is in the Machining process.

![Diagram of processing stages (Melting, Casting, Finishing, Machining, Painting, Assembling, Finish Good)](image)

**Figure 1.** The cover manufacturing process

Based on industry demands, there are two conditions in the cover manufacturing process, namely: the first is the need for additional production, one of which is by adding new machines, turning machines from manuals into automatic, and by reducing cycle time. Secondly, it is necessary to change the engine. In this case, the existing machine cannot support the production target [4-5].

2.1. **Machine Work Process**

In summary, the cover washing machine work process includes:

- Manual Loading, which is the process of placing parts on washing machine jigs. Water Blow, Air Blow, Flush on-off, which is: the water starts to be sprayed, followed by air spraying, after a few seconds Flush will light up for a few seconds and then die.
- Rotary Table On-Off, that is: the jig table will start rotating again still counter clockwise and will stop after the sensor detects.
- Gripper On-Off, namely: in the third process here the girpper will drop back to hold the part, then the Air Blade will light up to make sure the part is completely clean, then the girpper will go back up and the motor starts to spin again.
- Unloading, namely: after the part returns to its original place, it's time for the operator to take the washed part and replace the next part.

2.2. **Design of the machine**

Figure 2 shows the parts in the Cover Washing machine, as follows:

1. Three Phase Motor, it used to rotate the rotary table.
2. Push Button, it is to run the machine manually.
3. Rotary Table is a place to put parts to be washed so as not to shake.
4. The main panel is a panel that contains controls as well as other electrical devices.
5. The control panel, it used to facilitate movement, can also change the mode on the machine.

![Diagram of parts in washing cover machine](image)

**Figure 2.** The parts in the washing cover machine
2.3. Control System Design

Figure 3 shows a block diagram of the system control design. This block diagram is an overview of the communication process on the washing cover machine control system. PLC receives the input signals from input devices in the form of switches, buttons, and proximity sensors. PLC provides a signal to the relay to activate the valve solenoids and the cylinders. PLC communicates to give signals to the inverter to run an electric motor [6].

![Block Diagram of Control System](image)

**Figure 3.** The diagram block of control system

3. Research and Discussion

In the process of manufacturing the control system this time is divided into 2 parts, namely electric wiring and design programming. Layout or placement of the components to be used must pay attention to the strategic and economic side; therefore the box panel is used as the placement of these components. This washing machine is equipped with two box panels, which consist of the main panel and the control panel. Figure 4 shows the realization of the cover washing machine and its description.

![Cover Washing Machine](image)

**Figure 4.** Cover Washing Machine
Description of cover washing machine:
1. Rotary Table. The rotating table is driven by a motor, functioning as a place to put parts.
2. Proximity Sensor. Proximity sensor detects rotation on the rotary table.
3. Lifter Nozzle. Rotary table retention time stops rotating.
4. Safety. If there is a hand that passes through the sensor, the machine will automatically stop.
5. Push Button & Emergency Stop. To start or stop the engine

In this Cover Washing Machine there are 3 main rooms, namely:
- Room 1, it is used for Loading and Unloading parts, can be done manually by the operator or done by a robot.
- Room 2, it is used to clean parts by spraying water and air.
- Room 3, it is used to make sure parts are clean or not, using a tool called a water blade.

Figure 5 shows the comparison of manual machines with automatic cover washing machines.

![Figure 5](image)

Figure 5. The comparison of manual machines with automatic cover washing machines.

3.1. Design of Programming
Programming on the Cover Washing machine uses hardware and software. The laptop is used as a hardware device in which the CX-Programmer software is installed. Figure 5 shows the flow chart of the cover washing machine work process. The program is divided into several work processes in one cycle and is automatic.

![Figure 6](image)

Figure 6. Flow Chart Program
The program is divided into several work processes in one cycle and is automatic. To run the auto program you must first press bstart1 and bstart2 buttons which have input addresses 1.02 and 1.04 which function to rotate the rotary table. After the auto process starts, the rotary table will rotate. After the sensor at the input address 2.07 works, the rotary table will stop and the stopper will go up and activate op1. At the input of 2.07 a div up is used which if the sensor detects many times but the data is sent only once.

The Rotary Ready program is used to ensure that the rotary table is ready to run or stop. This program is done to make it easier to detect the work of the rotary table, if there is one process that has not been running, the rotary table will not be able to turn on. The Rotary Table Start program is used to run W10.01 relay. If the relay is active, the rotary table will run. The Rotary Program Table run is a program used to run a motor on the rotary table. After being marked by W10.01 that is on, the motor will run. The function of the 011 timer is to make a pause or delay for 1 second.

After the Rotary Table rotates and the limit switch detected, the water spray will light up, provided the op1 is running. Water Spray is controlled by a counter and each sequence will move as many numbers as indicated by the counter. After that the water spray will stop and continue with the Air Spray. Similar to the Water Spray, the Air Spray is controlled using a counter and will move as much as printed on the counter. The difference is the delay using a timer which serves to provide a lag time so that the spraying of the wind carried out is more controlled and provides cleaner results. Manual programs are used to test each machine part before starting the machine automatically. The manual program uses two start & stop buttons, and a selector switch located on the front panel.

3.2. Results Analysis

By designing a cover washing machine, it has an impact on the reject reduction in the painting section by 5%. Part that is not clean from coolant if left for too long will cause mold that is difficult to clean and will result in difficult to process into painting. Also the parts will avoid the chips resulting from cutting machining, if not cleaned, the parts will be dirty because many chips are left on the part and have the same effect, which is difficult to paint. The Cover washing machine here also succeeded in adding production because the cycle time decreased from 50 second to 40 second and it produced 700 pieces per day from the previous one which could only produce 400 pieces per day. The dimensions of the machine are also in accordance with the layout available at The Company which has a length of 1.3 meters, a width of 1.05 meters, and a height of 2.32 meters. A high upward shape can save available space and is easier to operate by the operator. The standard part used also meets the requirements of The Company by using parts that are easy to find and use brands that have been used frequently such as Omron, Fuji Electric, Schneider so that machine maintenance becomes easier.

4. Conclusions

In this paper we have discussed the research on Control System Design of Cover Washing Machine With PLC-based in the Automotive Manufacturing Industry. The wiring on the machine panel is carried out by industry standards, namely in the form of marking on each cable used. The machine program uses the Rotary Table principle or rotating jig table. The resulting work effectiveness of the operator increased, thereby reducing the number of reject paintings by 5% and increasing the production of 400 pieces per day to 700 pieces per day. Cover Washing Machine control system is made with dimensions of 1,350 mm x 1,055 mm x 2,332 mm using Omron CP1E PLC as controller, proximity sensor as input and 3 Phase Motor as output. The control system has 60 Input-Outputs, consisting of 36 inputs and 24 outputs. In next research, a seal can be added to the door, so that the water inside is not spilled out. A review of the duration of spraying is needed to be completely clean from the coolant.

5. References

[1] Ardi, S., D Ardyansyah, 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.
[2] Ardi, S., A Ponco, RA Latief, 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, 2017.

[3] Ardi, S., H Abdurrahman, 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, 2017.

[4] Alphonsus, E.R., Abdullah, M.O., A review on the applications of programmable logic controllers (PLCs), Renewable and Sustainable Energy Reviews 60 (2016), 1185-1205.

[5] Gökhan Gelena, Murat Uzamb, The synthesis and PLC implementation of hybrid modular supervisors for real time control of an experimental manufacturing system, Journal of Manufacturing Systems 33 (2014) 535–550.

[6] Ardi, S., Defi, W.Y., Control systems modification of loading and unloading in oil filling machine based on programmable logic controller for manufacturing industry, AIP Conf. Proc. 2021, 060029-1–060029-6 (2018); https://doi.org/10.1063/1.5062793.