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# DESIGN CONTROL SYSTEM OF MODULAR PRODUCTION SYSTEM DISTRIBUTION AND PICK & PLACE STATION

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***ABSTRACT***

*The development of automation in the industry is accelerating rapidly. The presence of automation is a technology that is very helpful in increasing production. Automation cannot be separated from the existence of a control system to regulate or process an instruction or order. The Modular Production System is a station unit consisting of various types of stations that simulate production system designs on a small scale before being realized in real situations. The work process of the Modular Production System is controlled using a PLC. PLC needs to be programmed to manage the work process of the Modular Production System. The programming language commonly used in PLC programming is ladder diagrams. The existence of a control system on the Modular Production System using PLC will make the Modular Production System run automatically. It can communicate with other Modular Production Systems to become more efficient. Therefore this design discusses controlling the Modular Production System using a PLC with a ladder diagram. The distribution stations and pick & place stations are selected for the Modular Production System. With a control system on the Modular Production System distribution station and pick & place station, the Modular Production System can work automatically and communicate with each other between stations. The result of the design is an increase in the efficiency of the system cycle time and process accuracy.*

***Keywords:*** *Automation, Modular Production System, PLC, Ladder Diagram.*

## 1. INTRODUCTION

In this modern era, the industry's automation development is accelerating rapidly. Almost most of the industry is now using automation. Automation in the industrial sector can help increase production. They are starting by improving product quality, production time efficiency, and cost reduction. Therefore, many industry players need automation designs to be applied to their respective industries. [1] Because automation offers advantages and convenience for industry players.

The development of automation cannot be separated from the development of control systems. The control system acts as a liaison between humans and technological systems. [2] The role of the control system dramatically determines the work efficiency of automation. The control system can be said to be the heart of automation. The PLC is one of the most frequently used control system components and the best choice for industrial automation (Programmable Logic Controller) [3]. The PLC is programmed in advance to control a process or the tool's operation. The program created must be adjusted to the needs and updated so that the system's performance remains efficient. However, this programming will take time for program creation and testing [4]. A modular Production System or MPS is a station unit used to simulate production system designs on a small scale before being realized in real situations [5]. To minimize the impact of damage that occurs with this modular engineering for industry [6]. MPS can simulate production system designs such as Separating Stations, Sorting Stations, Measuring Stations, Pick & Place Stations, Distribution Stations, Packaging Stations, Joining Stations, and Storage Stations.

This research aims to design a control system for the MPS Distribution Station and Pick & Place Station using PLC with the ladder diagram programming language to get more effective and efficient system work.

**Working Principle of The System**

MPS is a miniature industrial automation process that consists of various standard components and is used to simulate product processing [7]. MPS can act that production is always consistent, flexible, and high quality [8]. MPS This system is generally implemented using a PLC, which runs the program as needed to maintain security and sort the system [9]. MPS can also be interpreted as a station unit consisting of several actuators, cylinders, motors, or suction cups generated by a vacuum generator, complete with control components such as push buttons, sensors, and controllers. Where in MPS, there are mechanical, pneumatic, electrical, sensors, and PLC elements [10].

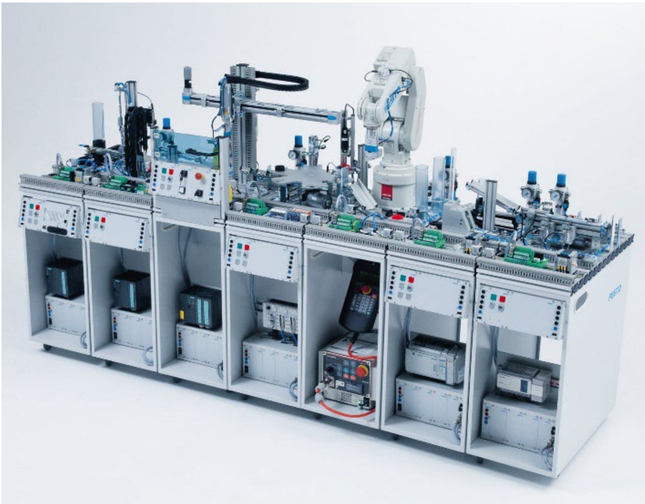

Figure 1. MPS [7]

MPS includes pneumatic and electro-pneumatic equipment controlled by PLC [11]. Where pneumatic equipment works and is driven by utilizing compressed air. While electro-pneumatic equipment is powered by compressed air, an electric voltage-controlled valve is needed to release the air [12].
PLC is a controller/regulator that works based on certain logic (if - then) that can be programmed & reprogrammed [13]. The PLC's working principle is receiving input signals, processing with the processing unit, and sending the signal to the output [14]. PLC receives data in the form of analog and digital signals from input device components. The signal is from the input device, which can be a switch, button, or sensor. PLC can also receive analog signals from input devices such as potentiometers, motor rotation, etc. This analog signal by the input module is converted into a digital signal. The CPU will process the signal to process the incoming signal and be processed according to the program made.
Furthermore, the CPU will make decisions in the form of signals. This signal will be forwarded to the output device to be processed and issued as output. [15]

## 2. RESEARCH METHOD

**Research Methodology**

This research was conducted using the development method to produce a more efficient output. With the development of MPS, it is expected to create a better production system.

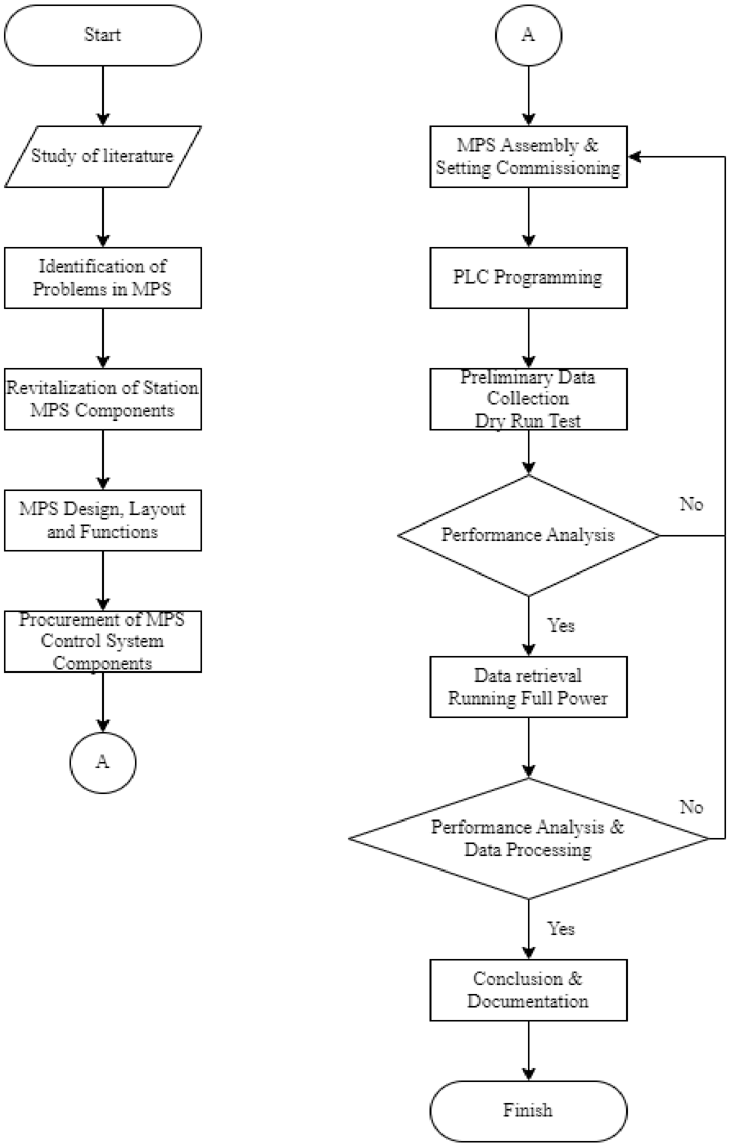


Fig 2. Research Flowchart

The design stage begins with a literature study regarding the MPS, followed by identifying the problems in the MPS Distribution Station. Because the MPS operates with manual override, the system is inefficient; consequently, the PLC makes the system work autonomously. And several components are damaged, so they need to be repaired or replaced. From the identification problem, some components are damaged and can not work properly, it can be seen which MPS components need to be improved. After that, the layout design and MPS function will be carried out. Then proceed with the procurement of control system components and assembly of the MPS Distribution Station and commissioning settings. After the MPS has been assembled, a PLC program will be created so that the MPS can operate automatically. After that, the initial dry run test data was collected, and the running full power data were analyzed. After obtaining the analysis results, conclusions will be drawn, and documentation will be carried out stating that the research is complete.

**PLC Control Scheme and Pneumatic Diagram**

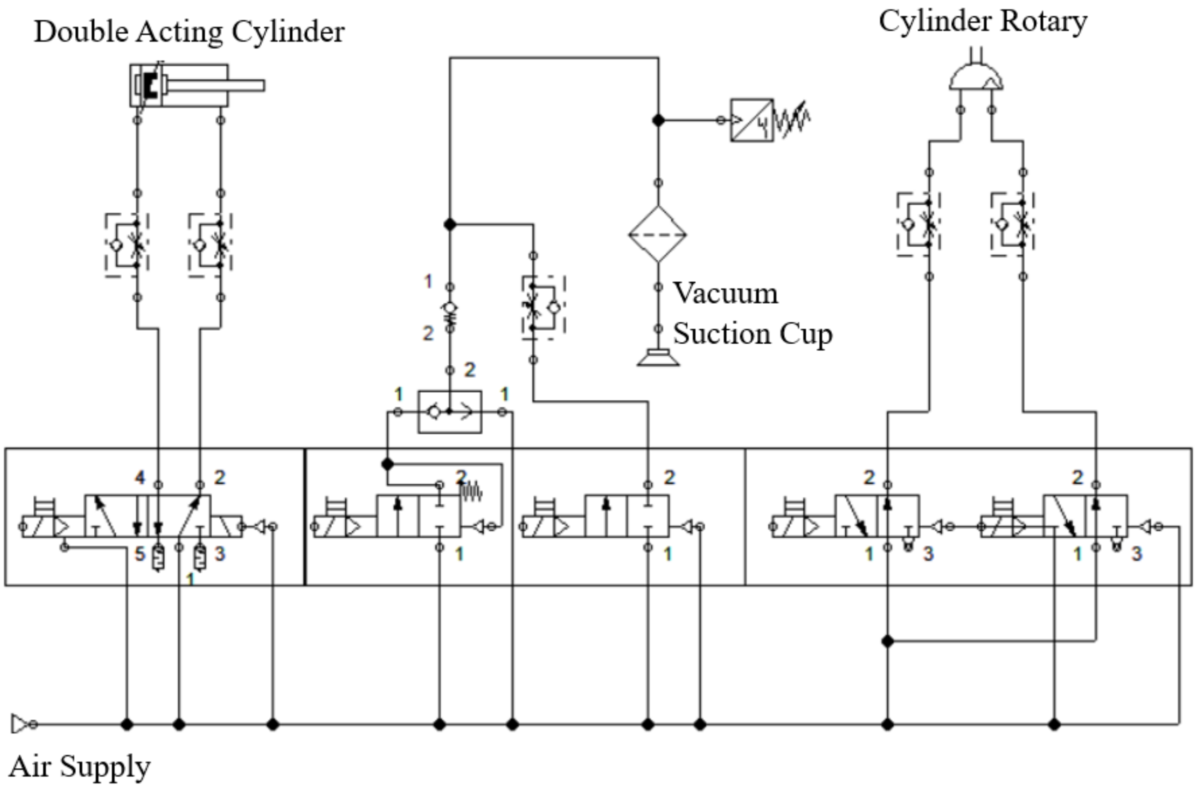


Figure 3. Pneumatic Diagram of Distribution Station

Table 1. I/O List Distribution Station

| No. | Input | | Output |
|---|---|---|---|
| 1. | Start Push Button | | Start Lamp |
| 2. | Stop Push Button | | Q1 Lamp |
| 3. | Reset Push Button | | Reset Lamp |
| 4. | Auto/Manual Switch Contact | PLC | Q2 Lamp |
| 5. | Proximity Sensor (1&2) | | Double Acting Cylinder |
| 6. | Through Beam Sensor | | |
| 7. | Vacuum Switch/Sensor | | Vacuum |
| 8. | Limit Switch (1&2) | | Cylinder Rotary |

PLC will be a controller to connect and process inputs into outputs. Input can be in the form of buttons and sensors, while the output is actuators. The PLC will process input from proximity sensors 1 and 2 and output as output to drive the double-acting cylinder. The input from the through-beam sensor will be processed by the PLC and output as output to control the movement of the double-acting cylinder. Input from limit switches 1 and 2 will be processed by the PLC and issued as output to drive the cylinder rotary. Input from the vacuum switch will be processed by the PLC and issued as output to control the suction cup work, whether vacuum or not.

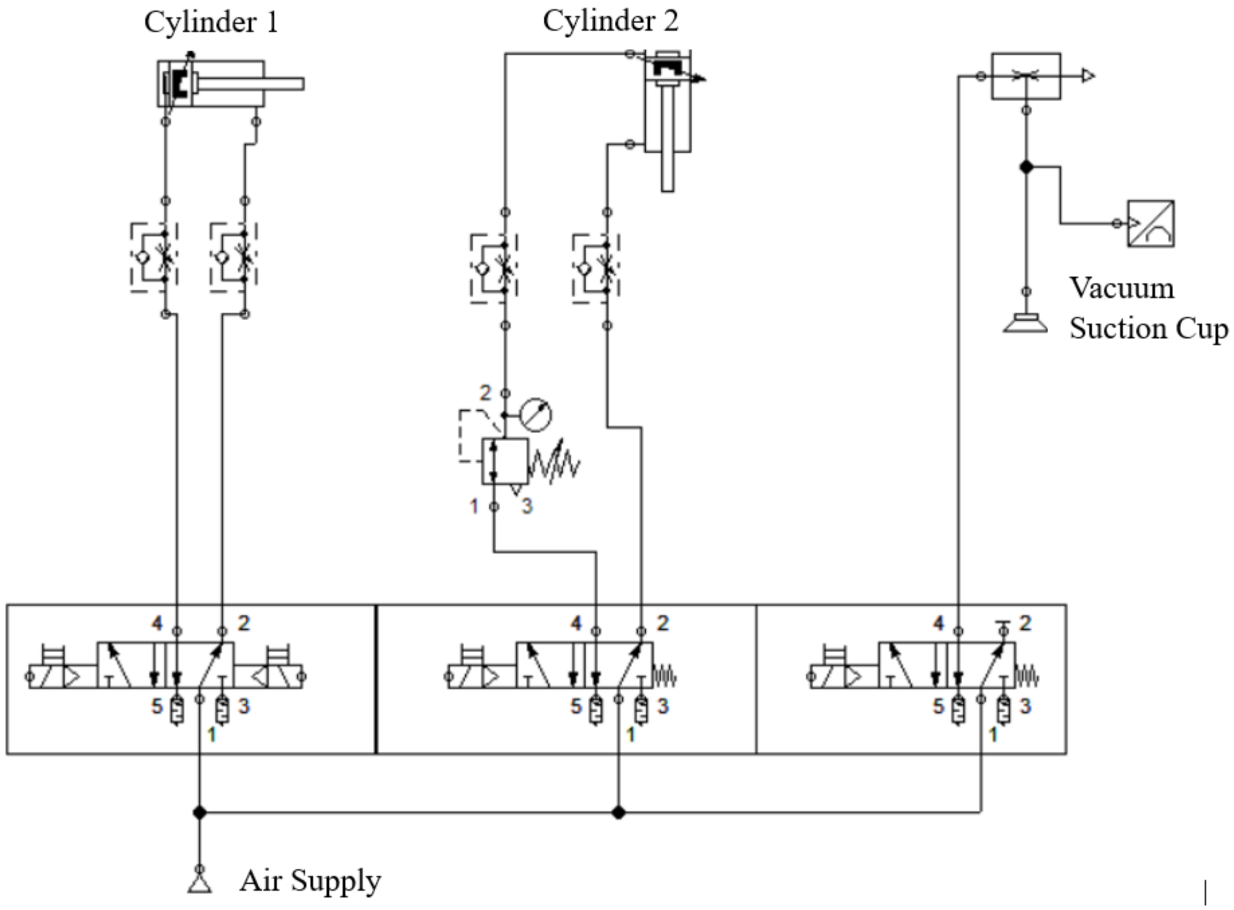


Figure 4. Pneumatic Diagram of Pick & Place Station

Table 2. I/O List Pick & Place Station

| No. | Input | | Output |
|---|---|---|---|
| 1. | Start Push Button | PLC | Start Lamp |
| 2. | Stop Push Button | | Q1 Lamp |
| 3. | Reset Push Button | | Reset Lamp |
| 4. | Auto/Manual Switch Contact | | Q2 Lamp |
| 5. | Proximity Sensor 1 | | Cylinder 1 |
| 6. | Proximity Sensor 2 | | Cylinder 2 |
| 7. | Diffuse Sensor | | Conveyor Module |
| 7. | Pressure Sensor | | Vacuum |
| 8. | Optic Sensor | | Separator |

PLC will be a controller to connect and process inputs into outputs. Input can be in the form of buttons and sensors, while the output is actuators. The PLC will process input from proximity sensors 1 and 2 and output as output to move the mini slider. Input from the diffuse sensor will be processed by the PLC and output as output to control the movement of the conveyor module. The input from the pressure sensor will be processed by the PLC and issued as output to control the work of the suction cup.

## 3. RESULTS AND DISCUSSIONS

The following results are from testing the PLC program on the MPS distribution station and pick & place station. This experiment was carried out twice using two driven parameters of 4 bar and 6 bar air pressure with ten times trials. This analysis aims to determine the most optimal pressure configuration parameters.

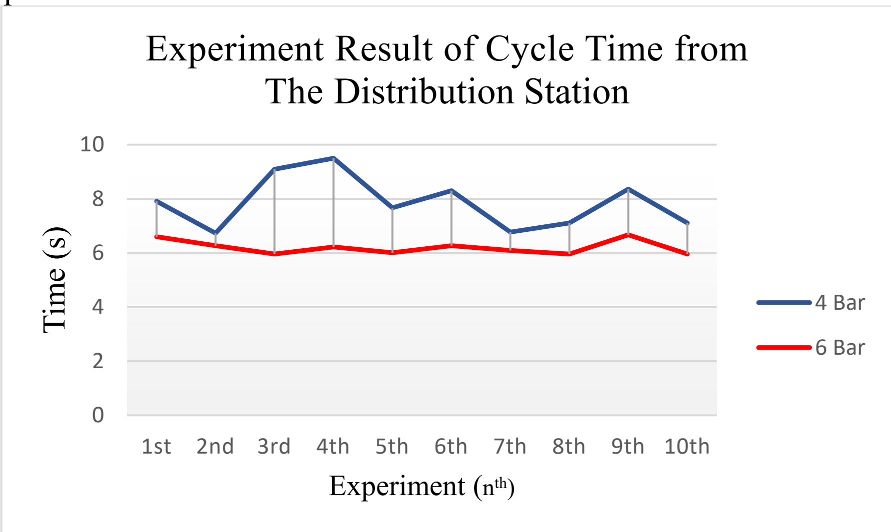


Figure 5. Experiment Result of Cycle Time from The Distribution Station

From 10 times experiments in the distribution station, when using 4 bar pressure, the total process cycle time was obtained for 1 minute 22 seconds. While using 6 bar pressure, the total process cycle time was obtained for 1 minute and 2 seconds.

If averaged for every one cycle in the distribution when using 4 bar pressure, the time is obtained for:

$$\bar{X} = \frac{\Sigma\ cycle\ time}{10\ experiments} = \frac{79\ sec}{10} = 7.9\ sec \quad \text{(1)}$$

While for an average for every one cycle in the distribution when using 6 bar pressure, the time is obtained for:

$$\bar{X} = \frac{\Sigma\ cycle\ time}{10\ experiments} = \frac{62\ sec}{10} = 6.2\ sec \quad \text{(2)}$$

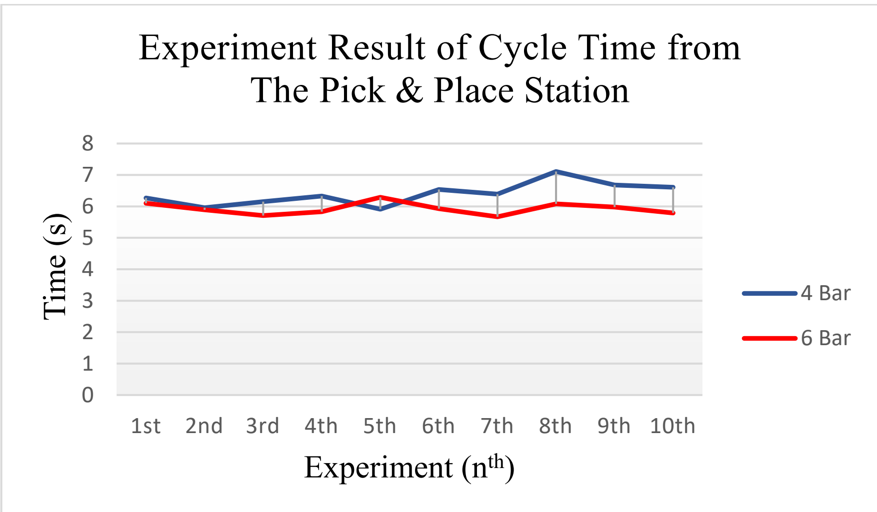


Figure 6. Experiment Result of Cycle Time from The Pick & Place Station

From 10 times experiments in the pick & place station, when using 4 bar pressure, the total process cycle time was obtained for 1 minute 4 seconds. While using 6 bar pressure, the total process cycle time was obtained for 59.27 seconds.

If averaged for every one cycle in the pick & place station when using 4 bar pressure, the time is obtained for:

$$\bar{X} = \frac{\Sigma\, cycle\ time}{10\ expeiments} = \frac{64\ sec}{10} = 6.4\ sec \quad \text{......(3)}$$

While for an average for every one cycle in the pick & place station when using 4 bar pressure, the time is obtained for:

$$\bar{X} = \frac{\Sigma\, cycle\ time}{10\ experiments} = \frac{59.27\ sec}{10} = 5.93\ sec \quad \text{......(4)}$$

Table 3. Accuracy process for 4 bar air pressure

| Experiment (4 bar) | Accuracy Process | |
|---|---|---|
| | Distribution | Pick & Place |
| 1 | OK | OK |
| 2 | Not OK | OK |
| 3 | OK | OK |
| 4 | OK | Not OK |
| 5 | OK | OK |
| 6 | OK | OK |
| 7 | Not OK | OK |
| 8 | OK | OK |
| 9 | OK | Not OK |
| 10 | Not OK | OK |
| Total Fail | 3 | 2 |

From 10 times experiments using a pressure of 4 bar, there were three process failures at the distribution station. Meanwhile, the pick & place station experienced two failures. So that the percentage of the accuracy value of the success of the process can be obtained:

Distribution Station:

$$Accuracy\ (\%) = \frac{experiment\ success}{Total\ experiment} \times 100\% = \frac{7}{10} \times 100\% = 70\% \quad \text{......(5)}$$

Pick & Place Station:

$$Accuracy\ (\%) = \frac{experiment\ success}{Total\ experiment} \times 100\% = \frac{8}{10} \times 100\% = 80\% \quad \text{......(6)}$$

Table 4. Accuracy process for 6 bar air pressure

| Experiment (6 bar) | Accuracy Process | |
|---|---|---|
| | Distribution | Pick & Place |
| 1 | OK | OK |
| 2 | OK | OK |
| 3 | OK | OK |
| 4 | OK | Not OK |
| 5 | OK | OK |
| 6 | OK | OK |
| 7 | OK | OK |
| 8 | Not OK | OK |
| 9 | OK | OK |
| 10 | Not OK | OK |
| Total Fail | 2 | 1 |

From 10 times experiments using a pressure of 4 bar, there were three process failures at the distribution station. Meanwhile, the pick & place station experienced two failures. So that the percentage of the accuracy value of the success of the process can be obtained:
Distribution Station:

$$Accuracy\ (\%) = \frac{experiment\ success}{Total\ experiment} \times 100\% = \frac{8}{10} \times 100\% = 80\% \qquad (7)$$

Pick & Place Station:

$$Accuracy\ (\%) = \frac{experiment\ success}{Total\ experiment} \times 100\% = \frac{9}{10} \times 100\% = 90\% \qquad (8)$$

## 4. CONCLUSIONS

Based on the results of 10 experiments carried out at MPS distribution stations and pick & place stations using 4 bar and 6 bar pressures, it can be seen that the cycle time of 6 bar pressure is faster than that of 4 bar pressure. Process failures that occur are also less when using a pressure of 6 bar compared to 4 bar pressure. The pressure of 6 bar has a higher level of accuracy than the pressure of 4 bar. This makes the 6 bar pressure more effective and efficient in carrying out work processes. So it is more advisable to use a pressure of 6 bar to carry out the work process.

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## REFERENCES

[1] Badarudin, R. (2022). *VIRTUAL DISTRIBUTING STATION SEBAGAI SARANA MEDIA*. *06*(02), 75–84.

[2] Kridoputro, A. A., Putramala, A., Isdawimah, M., Industri, O. L., Elektro, T., Jakarta, P. N., & Siwabessy, J. P. G. A. (2020). *Pemrograman Prototype Modular Production System Handling Menggunakan Bahasa Sequential Function Chart Prosiding Seminar Nasional Teknik Elektro Volume 5 Tahun 2020*. *5*, 158–162.

[3] Chen, J. Y., Tai, K. C., & Chen, G. C. (2017). Application of Programmable Logic Controller to Build-up an Intelligent Industry 4.0 Platform. *Procedia CIRP*, *63*, 150–155. https://doi.org/10.1016/j.procir.2017.03.116

[4] Ganesh, S., & Gurunathan, S. K. (2017). Evolutionary Algorithms for Programming Pneumatic Sequential Circuit Controllers. *Procedia Manufacturing*, *11*(June), 1726–1734. https://doi.org/10.1016/j.promfg.2017.07.299

[5] Mayer, B., Rabel, B., & Sorko, S. R. (2017). Modular Smart Production Lab. *Procedia Manufacturing*, *9*, 361–368. https://doi.org/10.1016/j.promfg.2017.04.025

[6] Müller, R., Hörauf, L., Vette-Steinkamp, M., Kanso, A., & Koch, J. (2020). The Assist-by-X system: Calibration and application of a modular production equipment for visual assistance. *Procedia CIRP*, *86*(March), 179–184. https://doi.org/10.1016/j.procir.2020.01.021

[7] Systems, M., & Training, M. (2018). Learning Systems Modular Systems for Mechatronics Training Automation Training with MPS : Modular Production Systems. *Create an Effective Learning Environment*.

[8] Wrede, S., Beyer, O., Dreyer, C., Wojtynek, M., & Steil, J. (2016). Vertical Integration and Service Orchestration for Modular Production Systems Using Business Process Models.

*Procedia Technology*, *26*, 259–266. https://doi.org/10.1016/j.protcy.2016.08.035
[9] Sartika, E. M., Sarjono, T. R., & Christian, K. (2021). Modular Production System Control Using Supervisory Control Theory Method. *Journal of Physics: Conference Series*, *1858*(1). https://doi.org/10.1088/1742-6596/1858/1/012095
[10] *Pengertian MPS*. (n.d.). Retrieved April 1, 2023, from https://www.coursehero.com/file/91951353/Pengertian-MPSdocx/
[11] Yusuf, M., Riyanto, S. D., & Susanti, H. (2022). Design and Build Miniature Production System (MPS) on Handling Station and Sort Station Using Cascade Controller. *Elkha*, *14*(1), 15. https://doi.org/10.26418/elkha.v14i1.49747
[12] Swastika. (2019). *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699.
[13] *Pengantar PLC/Programmable Logic Controller*. (n.d.). Retrieved April 1, 2023, from https://plc.mipa.ugm.ac.id/pengantar-plc/
[14] Fanica, I. S. P. (2019). *Optimasi Modul Handling dan Assembly Menggunakan Programmable Logic Controller FEC 640*.
[15] Zhang, P. (2010). *Advanced Industrial Control Technology British Library Cataloguing in Publication Data*.