AUTOMATION SYSTEM DESIGN FOR STOPPER VALVE CHAMFERING PROCESS ON BENCH LATHE SD-32A MACHINE AT PT. DHARMA PRECISION PARTS

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Abstract

As the rapid development of technology, encourages manufacturing companies to be able to implement the technology into its production process, one of the technologies is automation that can improve the productivity. PT. Dharma Precision Parts is one of the manufacturing company that producing machining parts with various types of products, one of them is stopper valve.

The problems that arise in stopper valve production process is the manufacturing process still manual that rely on the operator's involvement and also the inability of the company to fulfill production targets. Automation system design using a Programmable Logic Controller (PLC) as the main controller in the process and pneumatic technology as driver is done in order to resolve the these problems and can be applied to the chamfering process of stopper valve part.

From research conducted it can be concluded that, automation system design for chamfering process stopper valve parts on Bench Lathe machine SD-32A at PT. Dharma Precision Parts has been completed and the new process time for chamfering process is around 5 seconds/parts. Using automation system in the stopper valve part production process is expected to increase production capacity and reduce the use of labor then provide a positive impact to the company.

Keywords: Automation, Programmable Logic Controller, PLC Programming, Pneumatic, Omron PLC

1. Introduction

PT. Dharma Precision Parts is one of the major local manufacturing companies in the country and is established in 1997. PT. Dharma Precision Parts is specialized in machinery manufacturing that produces metal components from machining process and also supplies it to several manufacturing companies operating in Indonesia. PT. Dharma Precision Parts is also as a supplier for OEM **(**Original Equipment Manufacturer) company from several types of manufacturing engaged in various fields such as automotive, medical equipment, to household equipment. The products produced by PT. Dharma Precision Parts also have a high quality, proven that PT. Dharma Precision Parts are trusted to supply a variety of components to foreign manufacturing companies operating in Indonesia.

As a major manufacturing company, PT. Dharma Precision Parts has a lot of machines and a wide range of products produced from the production process. One of the existing processes is chamfering stopper valve components, which was processed by CNC machines and Bench Lathe machines. The chamfering process begun by placing the stopper valve part that has been created by a CNC machine into the collet chuck which then will be locked and the spindle motor will rotate. The spindle will move into the part to running the chamfering process.

With an increase in competition and demand, the company must be able to fulfill the demand at the right time and with the best quality as well. The problem of the company faced on the production process for stopper valve is the process time to complete construction of a part which quite long so they had lost the demand. Currently the company was able to produce with the speed 6 pcs/min. If this condition was not immediately corrected by reducing the process time, the company would incur losses because the ability of supply does not match with the demand.

Table 1 Existing Production Condition

Parameter	Number
Average Process Time	9.92 seconds/pcs
Working hour	7 hours
Manpower Required	1 operator/shift
Average per shift production	2526 pcs

The number of operators required to operate this machine is one operator per shift.. Labor is one of main assets for the company because they performs kind of job in running the production. Labor also as the operator has a big rules in running production, productivity and company efficiency. The production number is still rely on operator ability in produce the product especially natural human factor such as fatigue that cannot be avoided.

Therefore, the reduction of the operator is one of the solutions to improve the efficiency of corporate expenditures. Reason for automation system is expected reducing labor cost and increase labor productivity with the reduction use of operators for the Bench Lathe machine, and also will improve the product quality, because the use automation also performs manufacturing process with greater uniformity and conformity to quality specification (Groover, 2001). In other word the use of automation will automatically reduce the defect in the product which is caused by human error factor.

One method which can be done to improve the productivity of the production process and the quality of products produced by Bench Lathe machine in producing stopper valve is to automate the process of chamfering using mechanical and electrical aspect. Automating this process can be done in two ways, first is to modify the electrical and mechanical process on Bench Lathe SD-32A machines which used for the production and the second is to build a new machine which is fully automated.

The reliability level of existing machine has been tested to perform chamfering process stopper valve. It will be different if they must build a new machine, so it will need higher investment, and the machine need more development time to make sure, it can produce the product with the same quality or above the existing machine and also faster. We conclude that the modification of the existing Bench Lathe machine can be the best alternative to increase production capacity and to maximize the machine utility.

The objective of this research is how to design the automation system and PLC program for controlling the chamfering process on Bench Lathe SD-32A machine in order to reduce process time for achieve the production target and increase efficiency?

2. System Design

Before make the system design, it begins with the conceptual model. Conceptual model is a way to create mindset in solving a problem in a research. It describe general overview of the research conducted.

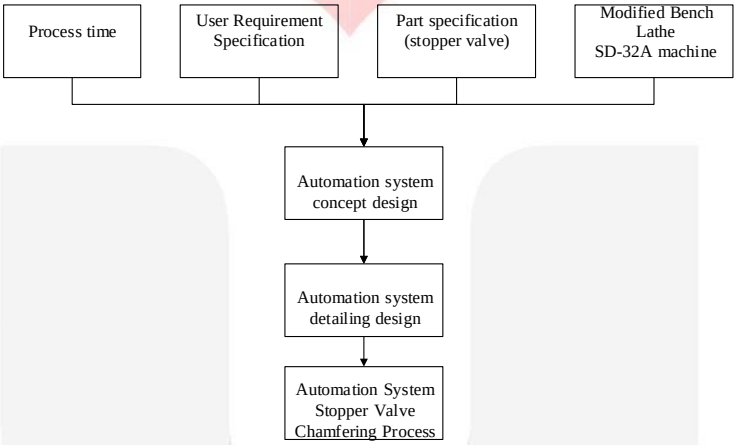

Figure 1 Conceptual Model

Problem that will discussed is how to make automation system stopper valve part chamfering process. On conceptual model can be seen that the input will be used is process time data, User Requirement Specification (URS), part specification, and modified Bench Lathe SD-32A machine. The problem solving done by made the automation system concept design then automation system detailing design. The detailing of automation system to make sure all of the process on the system is correct.

2.1 System Component Identification

In the system component identification, there are hardware and software requirement for supporting the system running properly. The hardware system input given by URS, then in here can identify the interconnection between each hardware and give the picture to configure it.

Beside hardware, the software requirement identification also need to make sure the component can be programmed with the system. The software that need in the system, such as :

1. Operation System Windows XP SP3
   The operation system that need for run and design the PLC program. This kind of operation system still need because some software still running well on Windows XP and does not support newer operation system yet.
2. CX-Programmer 9.4
   This software used for programming the logic on the OMRON PLC and some other function on PLC. CX-Programmer also used to monitor the activity which is run on the OMRON PLC.

3. Festo Fluidsim
   This software used to design and simulate the pneumatic and electro-pneumatic system that will be created. It is necessary to test the pneumatic system before it implement to the machine system to make sure the pneumatic design is has work properly.

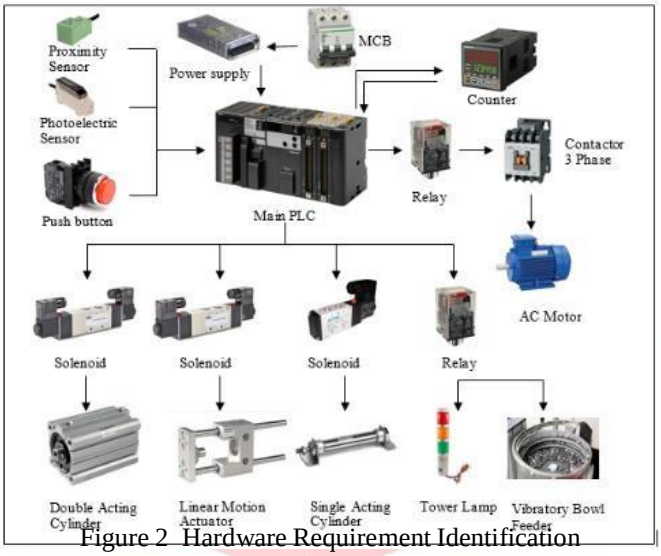

Figure 2 Hardware Requirement Identification

2.2 PLC Configuration

PLC used in this research is Omron CJ2M, where it is the modular PLC that consist of several difference modules which is connected to each other so it can work properly. Every module has its own function and connected using bus system. In the beginning it need to set-up the module configuration, to make the I/O addressing.

Table 2 PLC Module Configuration

Module Number	Module Type	Module Series	Address	Slot	Com
1	Input	ID211	0.00 - 0.15	16 slot	-
2	Input	ID211	1.00 - 1.15	16 slot	-
3	Input	ID211	2.00 - 2.15	16 slot	+
4	Output	OC211	3.00 - 3.15	16 slot	+
5	Output	OC211	4.00 - 4.15	16 slot	+

After determine the needs of input output modules for the system, then set-up the PLC module configuration on the CX-Programmer software to set the PLC setting match each I/O module types.

2.3 PLC Programming

Before make the PLC program, the important things is to know the process sequence of the process. There are two main process for the chamfering process :

a. Part Screening Process
   Hundreds of stopper valve are placed on the vibratory feeder. The feeder will vibrate to make part will move rotating the feeder in the line. In the first selection section, non-reject part will passes the trap and the reject parts will fall. Next, the non-reject from first selection will be checked again to differ the part which has had a hole and does not have. Before entering the checker, parts will queueing in the queue line. If the queueing part reaches 10 parts, the vibratory feeder will stop vibrating and wait until the remaining part is 5 parts to turn on again. The part which in the queue line will getting in to the checker one by one where controlled by a stopper. Sensor will detect and separate the reject with non-reject parts using a selector mechanism. The non-reject part from this section will continue to the slider.

b. Chamfering Processing
   After the part get into the slider, then the slider will move forward. When slider reach the maximum point detected by sensor, the part will positioned to the collet using part positioner cylinder. Then part will be locked in the collet after the clamping cylinder was trigger to retract forward. When the part has locked, slider will move backward to its beginning position and the chamfering process start when part rotate by the collet and the spindle at the tailstock move forward where controlled by drilling cylinder to drill the part. After that the clamp cylinder and drilling cylinder will move backward, then the part will detached from collet and get in to the box. Counter will count the number of successful processed part

Based on the PLC is used and the process scenario had create before, then the program language will use ladder diagram. Refer to the process scenario design, the program script will divide into two sections, they are section 1 called screening and section 2 called main process. The section 1 will describe program from part selection process in vibratory bowl feeder. And the section 2 will describe program from part refilling on slider, clamping, drilling, and finishing. Making the program in the PLC should be done in a structured or systematic, user friendly and flexible. It aims to facilitate the time of commissioning, maintenance and troubleshooting when problems occur. Sequential Function Chart (SFC) is using to easier translating from flowchart to PLC program and also easier to troubleshooting by another programmer. The SFC of chamfering process stopper valve part shown in Figure 3.

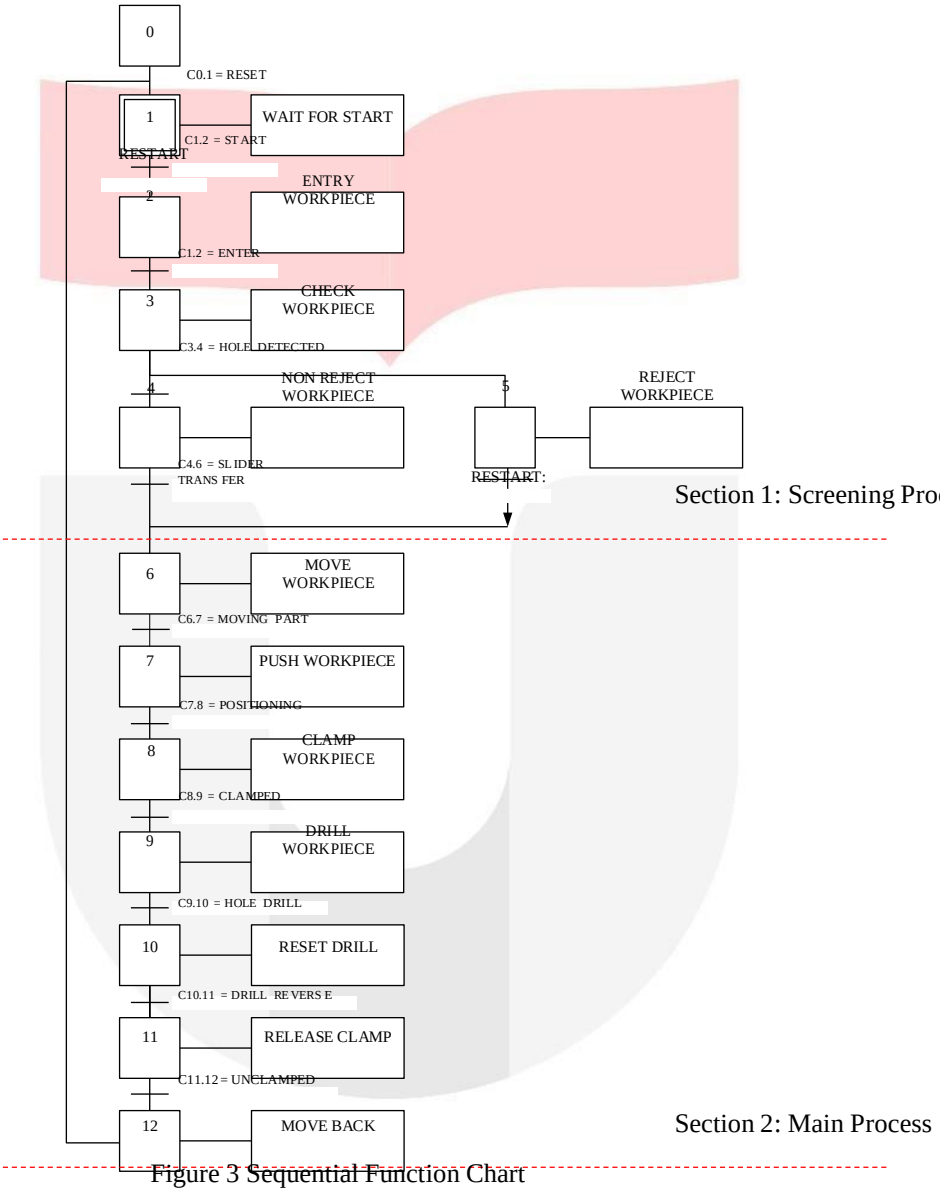

Figure 3 Sequential Function Chart

2.4 Hardware Setup

a. Panel Box Configuration

The panel box used for mounted the devices such as power supply, counter, PLC, relay, contactor, button, alarm and warning light. The panel box also used as control box, where almost all of the system can be controlled from here. The operator will easily control the process and maintain from the panel box. The panel box size consideration is based on the user requirement specification that has calculate the need of space depend on the device that will be placed on it

b. Pneumatic System Configuration

The pneumatic system also need precise configuration and connect to the automation controller device and the automation system work properly. Based on device list in user requirement specification the pneumatic and electro-pneumatic device needs are:

Table 3 Pneumatic Device

No	Device Name	Quantity
1	Pneumatic Double Acting Cylinder	3
2	Pneumatic Single Acting Cylinder	3
3	Pneumatic Linear Motion Cylinder	1
4	Double Coil Solenoid 5/2 Pneumatic Valve	3
5	Single Coil Solenoid 5/2 Pneumatic Valve	4
6	Single Coil Solenoid 3/2 Pneumatic Valve	1
7	Speed Control	6
8	Manifold	1
9	Air Service Unit	1

As it using pneumatic technology which is operate with pressured air, the consideration operating air pressure is 6 bar, refer to the calculation in the user requirement specification and the industrial standard of pressured air.

Figure 4 Flow of compressed air

The compressed air made on compressor, then it continue to master valve. Master valve will control the gate of pressured air on system, if there are any abnormal condition such as emergency or system failure it will automatically closed. Filter regulator will control the pressured air on the system and also make sure working pressure on the system is clear from moisture or water contained in the air from compressor and also lubricate the working pressured air for the cylinder needs. Manifold will distribute the compressed air to each solenoid valve that attached on it. Speed control will control the speed of cylinder in both direction, forward and backward based on the speed needed on each cylinder. And the last cylinder will actuate by the compressed air.

3. Discussion

3.1 Sequence of Process

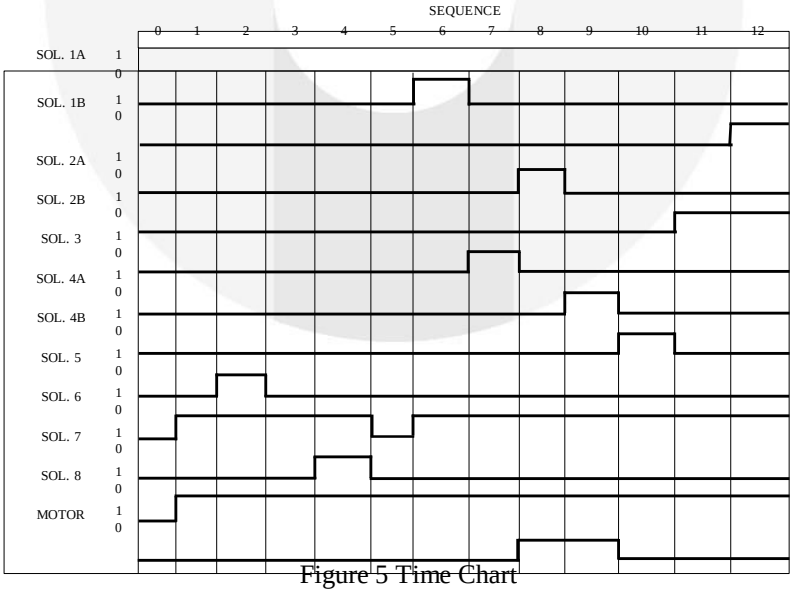

Figure 5 Time Chart

Time chart shows the devices or actuator active on each sequence. It will help to troubleshooting or configuring the devices by seen the chart. Time chart also represent the sequence of device work based on PLC program then it can easier to check what device is not working properly.

3.2 System Testing

To make sure the system will running well based on the process description there is need a testing. Testing also to find the opportunity error happen while the system running. Following table show the error on the system test :

Table 4 Testing Result

No	Error	Caused	Solving Method	Result
1	Part not completely clamped	The positioning cylinder not installed well	Fix the push cylinder position by adjust the bolt	Succeed
2	Part not completely clamped	The pressured air below 4 bar	Maintain the operating pressured air is above 4 bar	Succeed
3	Part not completely clamped	Program error	Fix the clamping program	Succeed

3.3 System Comparison

To make clearly understanding the differences between existing and proposed system, the following table will show the comparison between existing system and proposed system :

Table 5 System Comparison

No	Category	Existing System	Proposed System
1	Chamfering process	Perform manually using one operator to operate this machine	Chamfering process can be done automatically, where the operator just need to set up in the beginning and controlling the number of parts on feeder machine.
2	Chamfering Process	Process time around 7 – 10 seconds	Process time around 5 seconds.
3	Controlling system for tools usage	Check the tools manually	The drill bit tools usage or lifetime will know from the counter screen, then the replacement time can be forecast easier.
4	Operator need	Need one operator per shift to perform the chamfering process along the production time.	No operator need for perform along the production time, just need to start the process and controlling the machine.

The proposed system show the better performance than the existing system that shows in Figure 6 where the proposed system can produce faster than the existing chamfering process.

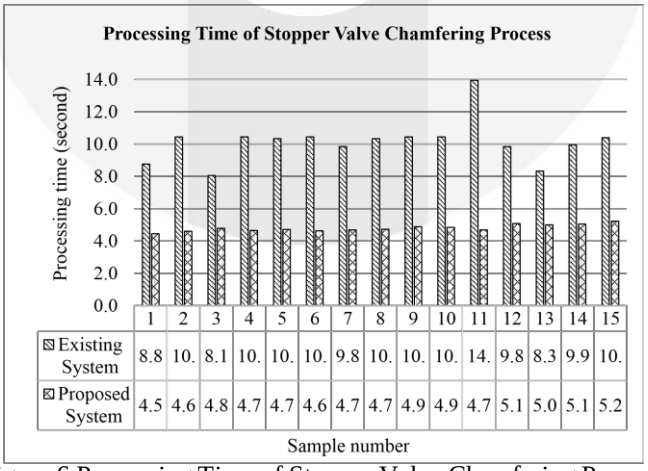

Figure 6 Processing Time of Stopper Valve Chamfering Process

From the economical aspect, the proposed system will give benefit for the company. With compare the existing production condition, the result of implement the proposed system will show in Table 6 :

Table 6 Comparison production condition

	Proposed System (Automation)	Existing system (Manual)
Working time/shift (seconds)	25200	25200
Shift per day	3	3
Production time (second/pcs)	5	9.92
Production per shift (pcs)	5.040	2.525
Production per day (pcs)	15.120	7.575
Production per year (pcs)	3.931.200	1.969.500
Revenue per year	Rp 393,120,000	Rp 196,950,000
Profit per year	Rp 78,624,000	Rp 39,390,000

$$Payback\ period\ (year) = \frac{Investment}{Profit\ per\ year}$$

$$Payback\ period\ (year) = \frac{43.842.000}{78.624.000}$$

$$Payback\ period = 0.6\ year$$

$$Payback\ period = 6.7\ months$$

It can concluded that with automation system can increase production capacity, profit, and also the payback period is only 6.7 months.

4. Conclusion and Suggestion

4.1 Conclusion

Based on the analysis result of the system that has been designed and implemented, was concluded as follows :

1. Automation system and PLC program design for controlling the chamfering process on Bench Lathe SD-32A machine in order to reduce process time for achieve the production target and increase efficiency has been succeed.
2. Programming and configuration of automation system design on Omron CJ2M PLC has succeeded then the control system and monitoring can be done based on the scenario.
3. Process time for chamfering stopper valve parts using automatic Bench Lathe SD-32A machine was reduced to around 5 seconds/part

4.2 Suggestion

1. In the next research discusses the monitoring of production in real time that can be controlled from a centralized control room.
2. Before determining the amount and type of PLC modules that will be used, it should be planned in more detail in order to efficiently use of I/O on the PLC.
3. In the next research discusses the collaboration between production scheduling and automation systems so obtained determine the level of production as scheduled.

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