Design control system of auto air remaining machine based on programmable logic controller in the automotive manufacturing industry

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Abstract. This research was conducted in one of automotive manufacturing industry of shock absorber. Air remaining is the process of preparing Shock Absorber to achieve ideal conditions i.e. ready to test the quality of its damping power. The trick is to remove the gas fluid contained in the cylinder so that the fluid remaining in the cylinder is just the oil fluid. If there is still a gas fluid left in the cylinder at the moment of the damping test, the Shock Absorber will experience momentary loss of power and this will greatly affect the quality of the Shock Absorber. The high frequency of repetition in the process of testing the quality of the damping power Shock Absorber on the Damping Force Tester machine due to not ideally Shock Absorber condition. This condition is one of them caused by the error of method in previous process that is air remaining process. Based on the above problems, then we research and design of new methods of operation of auto air remaining machine and design the control system. The method used is to utilize the gravity and the density of the two types of fluid, namely oil and gas to optimize the elimination process in Auto Air Remaining machine. The gas fluid can be perfectly eliminated. Control system design using Programmable Logic Controller (PLC). The Input and Output of PLC has used are 19 of inputs and 19 outputs. This method ensures the removal of the remaining air process.

1 Introduction

Shock absorber is produced on line shock absorber assembly. Shock absorber assembly line is the line where all components of shock absorber parts are assembled. In shock absorber assembly line, there are line 1 to line 9, where on each line produce shock absorber with different type and model. Shock absorber assembly line 9 produces shock absorber type of gas and oil type. In shock absorber assembly line 9 there are various processes including: table assembly, auto tightening Hi-Spin-Caulking, BVC press, roll closing, inserting plug, Oil & Gas filling, air remaining, damping force tester, Projection welding lower eye, Projection welding boss, Rotary reinforce welding boss, Reinforce welding eye, Cover press, 4-Spot welding cover, rubber bushing press, Sensor bracket welding, and Hose bracket welding.

Among the assembly process is often a problem in the damping force tester process, which is the repetition of the testing process due to the shock absorber function graph that does not meet the test standard of damping force tester. With further research it is found that the failure is due to a momentary loss of power when the functional testing process is, in other words, caused by a gas that has not been completely eliminated from within the cylinder by the existing Air Remaining machine.

The process problem that occurs in the air remaining machine is not able to achieve the standard function, which is to eliminate or remove the entire gas fluid from inside the cylinder. This causes conditions that are not yet ready to enter the function testing process on the damping force tester machine. Therefore, the target of our research is redesigned the Auto Air Remaining machine with a new method that can achieve standard functionality, and will eliminate the repeatability testing process on the damping force tester machine.

To redesign auto air remaining machine, we need to know the order of processes on this machine. The air remaining machine has a working process sequence that is: the operator placed shock absorber in the lower jig, press start the button, pneumatic cylinder start pressing the shock absorber from above as much as 3 times. With such a process method, there is often an alarm during the next process of testing the function on the damping force tester machine; we conclude that the cause of the alarm is due to gas that has not been eliminated perfectly from the cylinder. With these events, in addition to affecting the quality results when testing the damping force tester, it can also affect the cycle time of the damping force tester and the achievement of its daily targets [1, 2, 3, 4, 5].

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2 Methodologies and design

2.1 Input and output design

To meet the needs of the machine control, then we designed a concept of auto air remaining machine control system. Automation of auto air remaining control system using PLC, where there are several Input and

Output devices, so that the devices are available for the control system. PLC-based control systems are well suited for most automation problems in the Manufacturing Industry [6, 7, 8, 9].

Fig. 1 shows the diagram of the auto air remaining machine control system using PLC & HMI (Human Machine Interface) with its input and output components.

Fig. 1. The diagram of the auto air remaining machine control system using PLC & HMI.

The components of input and output are: emergency stop; push button with indicator; proximity sensor; photoelectric sensor; reed switch; area sensor; HMI; PLC CJ2M-CPU33; relay; valve double solenoid; indicator lamp; tower lamp; driver motor; and servo motor.

2.2 Flow chart and programing design

Fig. 2 shows the flow chart of the process of auto air remaining machine.

Fig. 2. The flow chart of the process of auto air remaining machine.

When the start button is pressed, the photoelectric sensor will detect whether there is a workpiece on the jig o / shell clamp. If it does not exist then the machine

cannot operate until there is a workpiece. If there is a workpiece then the cylinder o / shell clamp will be on. After that, the piston rod clamp will be on the end of the

piston rod. Then the servo motor will on forward press the piston rod to the position of L-Min or full stroke. When it comes to the maximum position of emphasis, the proximity sensor will detect the presence of the piston rod clamp. Once there is already detection, next the cylinder for rotate will be on. Then the servo motor will be on backward and pull the piston rod up to the L-Max position or until full stroke. Once it has reached L-Max, the piston rod cylinder clamp will be off. Then the o / shell clamp cylinder will be off. The workpiece has been completed in the process, and the operator picks up the workpiece. The sensor area and part detection sensors will detect the absence of the workpiece, so that the rotate cylinder will be off and restore the rotate section position at the starting position. The process can be resumed by putting the workpiece and pressing the start button.

2.3 PLC programming design

After all Input and Output devices are installed and a flow chart is created, and then next is the creation of a PLC program. This PLC program is to adjust the parameters of the servo motor to determine the length of the stroke of each shock absorber which has different length and different models. In this case, a special PLC program of servo motors is used @ PLS2 instruction where this instruction is used for pulse control of the servo motor.

With the @ PLS2 function on the PLC then the user can control the motor by entering some memory data that will be used to set acceleration, deceleration, starting frequency, and so forth. Furthermore, memory data is required to enter the desired servo motor data movement. Fig. 3 shows some of the PLC programs for servo motor control.

Fig. 3. The PLC programs for servo motor control.

In the @ PLS2 instruction on the PLC there is some memory data needed to serve as a reference for the movement of the servo motor which will be described in Table 1 that shows the motor control settings.

Table 1. The motor control settings.

Memory Data	Description	Used
S1	Acceleration Rate	500 pps (pulse per second)
S1+1	Deceleration Rate	500 pps
S1+2	Lower Target Frequency	500 kpps
S1+3	Upper Target Frequency	
S1+4	Output Pulse	as per the desired rotation
S1+5	Output Pulse	

From the explanation of Data D1000-D1005 can generate motor movement as required. Here the content of the D1000 is acceleration rate of 500pps, so the motor will rotate as much as 500 pulses per second until it reaches the maximum set pulse on D1004. In data D1004 contains data D400, that is data pulse required in accordance with product parameter inputted in program setting parameter. In D1006 known starting frequency is 200 pps will start up to the maximum speed limit that is adjusted from D1002 500kpps.

Fig. 4. Instructions to set parameters based on models that have different shock absorber lengths.

3 Research and discussion

This stage is the testing phase and the end result obtained from the design and manufacture of auto air remaining machine control system. At this stage, it will be shown the movement of the control system that has been designed. Fig. 5 shows the movement of the auto air remaining machine [10, 11].

The new auto air remaining machine movement is as follows:

Step 1: The operator will insert shock absorber in the upside position, this is so that the gas having a smaller density can be in close proximity to the valve, since the valve is the fluid inlet from the cylinder to the outer shell and vice versa

Step 2: when the operator presses the start button which means the process starts, the outer shell clamp cylinder will go on and clamp the work piece.

Step 3: after outer shell clamp is finished clamp process, cylinder on piston rod clamp will on and clamp piston rod.

Step 4: after that the servo motor will be on and push the piston rod to the maximum. It is used to remove the

gas from the cylinder through the base valve case and the oil will enter through the hole in the oil seal.

Step 5: After the motor is finished pressing the piston rod, the cylinder on the back plate will be on and rotate section rotate until 1800.

Step 6: then the motor will come back on

Step 7: The motor will pull the piston rod back to the starting position. This should be done in a rotated Shock Absorber position which is useful for sucking the oil from the outer shell entering the cylinder through the base valve case.

Step 8: After pulling the piston rod to the maximum, the cylinder on the piston rod clamp will off and release the piston rod.

Step 9: After completion on piston rod cylinder clamp, followed by outer shell cylinder clamp off release Shock Absorber. And the remaining water process for gas elimination has been completed.

Step 10: The operator will take a shock absorber that is tinny after being processed

Step 11: after the shock absorber is taken, the cylinder to rotate the plate will be off and rotate the rotate section back to the starting position.

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Fig. 5. The movement of the auto air remaining machine.

Fig. 6 shows the comparison of air remaining machine process results with the auto air remaining process. From this it can be seen that no gas fluid is left in the cylinder. The left image shows that the output generated by the air remaining machine. While the right image shows the output which generated by auto air remaining machine with a new control system design.

Fig. 6. Comparison of process results between air remaining machine (before modification) and auto air remaining machine.

4 Conclusions

In this paper we have discussed the research on design control system of auto air remaining machine based on Programmable Logic Controller in the automotive manufacturing industry. The design of this method has

utilized the mass of the two types of fluid, namely oil and gas. Changes in auto air remaining machine process method by reversing dampers in section called rotate section using cylinder and rack and pinion. This is so that rotation section rotation gets mechanical help from gear, so bearing becomes lighter. That way the gas fluid can be perfectly eliminated. Design the control system is built using PLC Omron CJ2M-CPU33 with CJ1W-ID261 input module and CJ1W-OD261 output module. Input and Output used are 19 inputs and 19 outputs. In addition, a special module is used CJ1W-NC113 module, with the help of MR-JE-70A servo amplifier to control the servo motor. The Auto Air Remaining machine is only designed to process one damper model. To increase the scope of production, other parameters can be made so that one machine can be used to process various models of damper products.

References

1. Ardi S, Ginarto R, and Putro AP, *Journal of Engineering and Applied Sciences*, Volume: **12** Issue: 8 Page No.: 2148-2153, (2017)
2. Ardi, S., D Ardyansyah, *IOP Conference Series: Materials Science and Engineering*, **306** (1), 012112, (2018)
3. Ardi, S., A Ponco, RA Latief, *IEEE Xplore*, 187 – 191, (2017)
4. Ardi, S., H Abdurrahman, *IEEE Xplore*, 192 – 196, (2017)
5. Alphonsus, E.R., Abdullah, M.O., *Renewable and Sustainable Energy Reviews*, **60**, 1185-1205, (2016)
6. Gökhan Gelena, Murat Uzamb, *J of Manufacturing Systems*, **33**, 535–550, (2014)
7. Ardi, S., Al-Rasyid, A., *Advanced Science Letters*, 22(7), pp. 1813-1816, (2016)
8. Ardi, S., Jimmy, M., Agustono, R., *Proceeding International Conference on QiR 2015*, University Indonesia, (2015)
9. Ponco, A., Ardi, S., *IOP Conference Series: Materials Science and Engineering*, 288 (1), 012028, (2018)
10. Alexander Fay, et.all, *The J of Syst and Software*, 101 221–235. (2015)
11. Milik, A., *IFAC-PapersOnLine*, 48-4 354-361. (2015)