Increased Production Capacity of Semi-Automatic Lens Pressing Machine with Arduino Control Pneumatic Drive in the Type-045 Head Lamp Assembly Process

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Abstract: Pressing the lens of the Head Lamp 045 or HL-045 product manually using both hands of the operator may cause uneven compression. The manual process also often causes bottlenecks (time delays), also has an impact on "Not Good" products and the HL-045 product production planning target is not achieved in the Industry. The purpose of this research is to increase the productivity of the manufacture of HL-045 with the innovation of a semi-automatic lens pressing machine to press the upper jig. The research method used is RCA (root cause analyze) with the following stages: problem identification, problem determination, problem understanding, corrective action, and system monitoring. Lens pressing machine testing was carried out using 3 pressure parameters, namely 0.3, 0.4 and 0.5 MPa with 30 trials each to obtain data on the lens pressing process time. The test results show that the best test is at a pressure of 0.5 MPa with a lens pressing process time of about 3.63 seconds. The conclusion of this study is that the semi-automatic lens pressing machine that was made was able to increase production capacity by about 8.72% (initial 493 pcs/day to 536 pcs/day) and reduce the assembly process time of the HL-045 product by 7.98% (initial 109.33 seconds to 100.6 seconds).

1 INTRODUCTION

PT. Indonesia Stanley Electric (ISE) is a manufacturing company that produces lamps for the application of two-wheeled and four-wheeled motorized vehicles. The lamp parts produced include Housing, Reflector, Extension, Lens, and Inner Lens. The high demand from customers both in terms of quantity and quality, then PT. Indonesia Stanley Electric must implement good production management standards so that production targets can be achieved.

Based on the method, the assembly process of a product is divided into two, namely manual assembly and automatic assembly. Manual assembly is an assembly whose operation process is done conventionally without special tools. Automated assembly is an assembly that is done with automated systems such as automation and requires more specialized tools. (Ilyandi, 2015).

The implementation of the automation assembly system in the line-lamp-assy has not been carried out thoroughly. For example, the process of pressing the lens on the line-lamp-assy of the HL type 045 product is still done manually, see Figure 1. This makes it difficult for the operator during the manual lens pressing process and the pressure applied to the lens pressing process is uneven. This also resulted in "Not good" product quality and frequent bottlenecks or time delays that were not in accordance with the predetermined time standard so that the HL-045 production target was not achieved.

In addition, the HL-045 production plan has a production target in 1 working day of 540 parts/day. Meanwhile, the actual production of HL-045 was 493 parts/day or 97.22% of the predetermined target. Based on these data, it can be concluded that the production planning of HL-045 has a problem, namely a decrease in effectiveness and productivity. In order to solve these problems, solutions and innovations based on automation systems are needed, namely through the design of a semi-automatic lens pressing machine with a pneumatic drive based on Arduino control. Arduino IDE is sophisticated software and can be programmed using the C programming language (Barret, 2011).

This research describes a semi-automatic lens pressing machine system with pneumatic drive based on Arduino control (Croser et al., 2002; Darto et al.,

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2015; Dindorf et al., 2017; Gupta et al., 2013; Junaidi et al., 2018). This study also displays innovations based on automation systems to increase the effectiveness and productivity of HL-045 at PT. Indonesia Stanley Electric. The machine is then pressure tested to get the press time data.

Figure 1: Manual Lens Pressing Process.

The purpose of this research is to design and manufacture a semi-automatic lens pressing machine with a pneumatic drive based on Arduino control to increase production capacity in the HL-045 assembly process at PT. Indonesia Stanley Electric and to determine the performance of the lens pressing machine by comparing the differences in production results in the HL-045 assembly process before and after the design of the semi-automatic lens pressing machine.

2 MATERIAL AND METHOD

2.1 Method

Root Cause Analysis (RCA) is a method for finding a problem or non-conformity in order to get to the root cause of the problem. This method is used in order to fix or eliminate the cause of the problem and prevent the problem from recurring (Vorley, 2008).

Identification of root causes can be found by the process of making fishbone diagrams. Fishbone diagrams are a technique used for more complex RCAs. This type of diagram identifies all the processes and potential factors that can contribute to the problem. Fishbone diagram technique is used to describe the research process and to analyze the factors that influence the problem in the lens pressing process of the HL-045 line-lamp-assy product at PT. Indonesia Stanley Electric covers man, method, material, machine, money and environment.

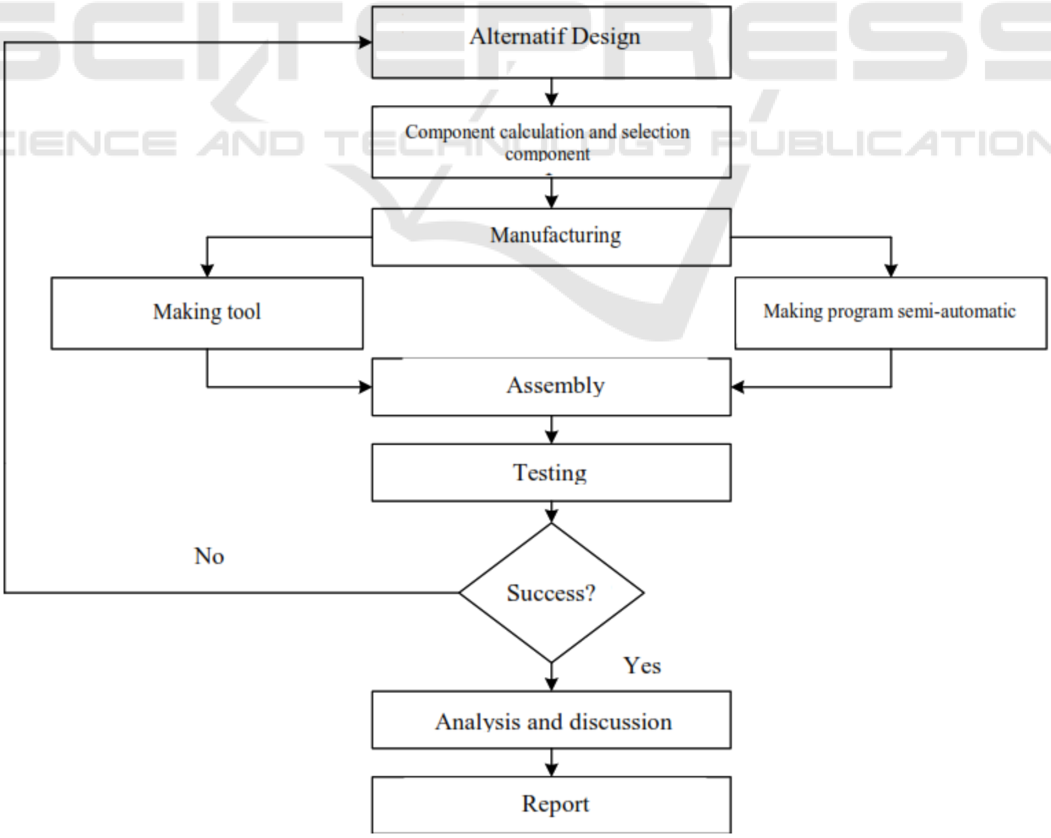

Figure 2: Flow chart of design product.

Corrective action that serves to realize the design concept that has been made into several alternative designs. Then one of the best designs is chosen from several alternative designs that have been made. The selected design is then analyzed with mathematical calculations on the material or components that will be used in the manufacture of the lens pressing machine. This design also adopted the process of design product by (Cross, et al. 2000). Figure 2 is a design flow diagram in the manufacture of a semi-automatic lens pressing machine.

2.2 Design

The first step in designing a semi-automatic lens pressing machine by using design software of Solidworks (**Dassault systems, 2015**) is to activate the vacuum ejector by turning the switch on first to attach the HL-045 lens product to the upper jig. A vacuum ejector is a device used to convert blowing power into suction by creating a vacuum, so that this allows the system to attract a desired workpiece (**Syahril, 2018**). After the vacuum ejector is active, the next step is to press the push button on the microcontroller box. When the push button is pressed, the reed switch sensor mounted on the upper pneumatic cylinder will detect the initial piston stroke, so that the piston will push the upper jig down until the piston step is detected by the reed switch sensor mounted on the bottom of the pneumatic cylinder.

When the piston stroke has been detected on the lower reed switch sensor, the lower reed switch sensor is automatically activated while the upper reed switch sensor and vacuum injector have been deactivated by the Arduino microcontroller command. When the lower reed switch sensor has detected the piston step will stop or delay for 1 second for the process of pressing the lens on the 045 reflector head lamp which is already installed on the lower jig. After the lens pressing process is complete, the piston will return to its initial position and activate the upper reed switch sensor and vacuum ejector.

The advantages of this alternative design I have several advantages, namely: it has a simple shape, does not require a lot of material, affordable manufacturing costs. As for the drawbacks, the upper jig only has 3 stays to place the lens when the lens pressing process takes place which is considered imperfect in the gripping process, and there is no retainer on the right and left sides so that the construction strength of the lens pressing machine is considered less strong.

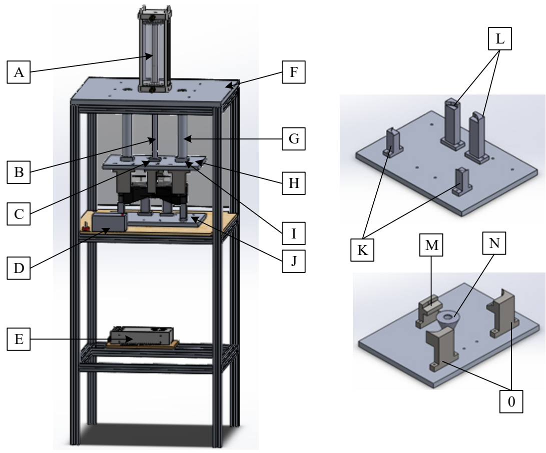

Figure 3: Alternatif design 1.

The work steps of alternative design II are the same as alternative designs I, namely the process of suppressing the semi-automatic lens is controlled through the Arduino microcontroller with the help of a reed switch sensor to detect the piston stroke. The advantage of alternative design II is that the machine construction is stronger because of the holder on the right and left side of the lens pressing machine, the process is easier and the vacuum gripping area is wider with the 4 stays on the upper jig. while the disadvantage of alternative design II is that it requires more material so that the manufacture becomes more expensive.

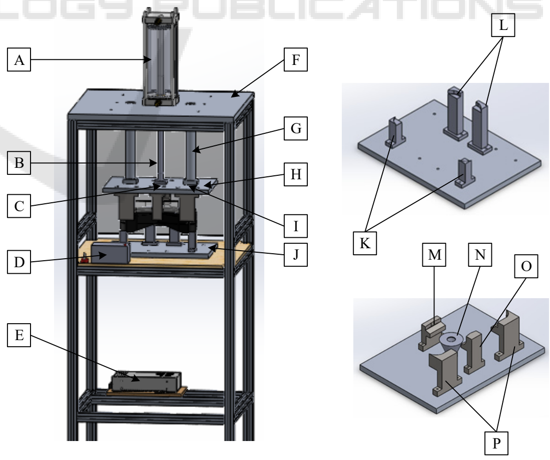

Figure 4: Alternatif desain 2.

The work steps of alternative design III are the same as alternative designs I and II, namely the process of suppressing the semi-automatic lens is controlled through the Arduino microcontroller with the help of a reed switch sensor to detect the piston stroke. The advantage of alternative design III is that the vacuum gripping area is wider with 4 stays on the upper jig so that it can grip the lens maximally and the machine manufacture is much cheaper because it uses ivony pipe material for the lens sealing machine frame. While the disadvantage of alternative design III is that the construction strength is less strong than alternative design II, but it is still safe to use on semi-automatic lens pressing machines and the process is more difficult than alternative design II.

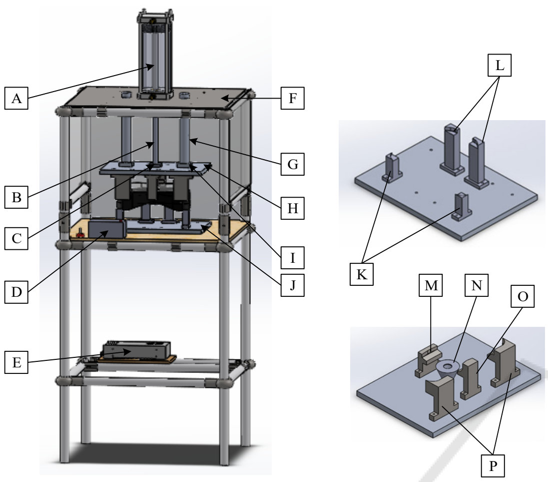

Figure 5: Alternatif desain 2.

2.3 Testing

The test was carried out using 3 pressure variations to determine the best pressure so that the lock on the 045 head lamp product could lock optimally and the semi-automatic lens suppressor cycle time test was carried out by observing the HL-045 assembly process.

This process is carried out by calculating the cycle time of the lens pressing process and the production capacity of the HL-045, then comparing before and after the semi-automatic lens pressing machine so that the success rate of the solution that has been implemented can be seen. After that, control of the tool needs to be done to determine the success rate of whether the solutions that have been implemented can solve the problem and do not cause new problems.

3 RESULT AND DISCUSSION

3.1 Mesin Penekan Lensa Semi Automatic

Based on the results of the analysis of the design and work processes carried out, a semi-automatic lens pressing machine with a pneumatic drive based on Arduino control is produced in the HL-045 assembly process which has dimensions of 550 mm x 580 mm x 1285 mm, see Figure 6. All of the machine element selection follows the text book of (Khurmi et al., 2005). This machine uses Pneumatic Solenoid valve 2/2 way: Airtac 1/8". DC 12V (Max Pressure 1.0 Mpa) and Solenoid valve 5/2 way: Airtac 1/8" Single Coil DC 12V (Max Pressure 1.2

Mpa). Pneumatic Cylinder: SMC 32 x 160 (Max Pressure 1.0 Mpa. Regulator / Pressure valve: SMC ARP 20 (Set Pressure 0.008 to 0.6 Mpa). Vacuum Ejector: Pamy CV 05 – HS 1/4" (Max Vacuum 87Kpa). Suction Cup: UT-SN-F20-TPU50-1/8AG/M5IG-FIL Microcontroller: Arduino Nano Atmega 168 (Work Voltage 5 volts).

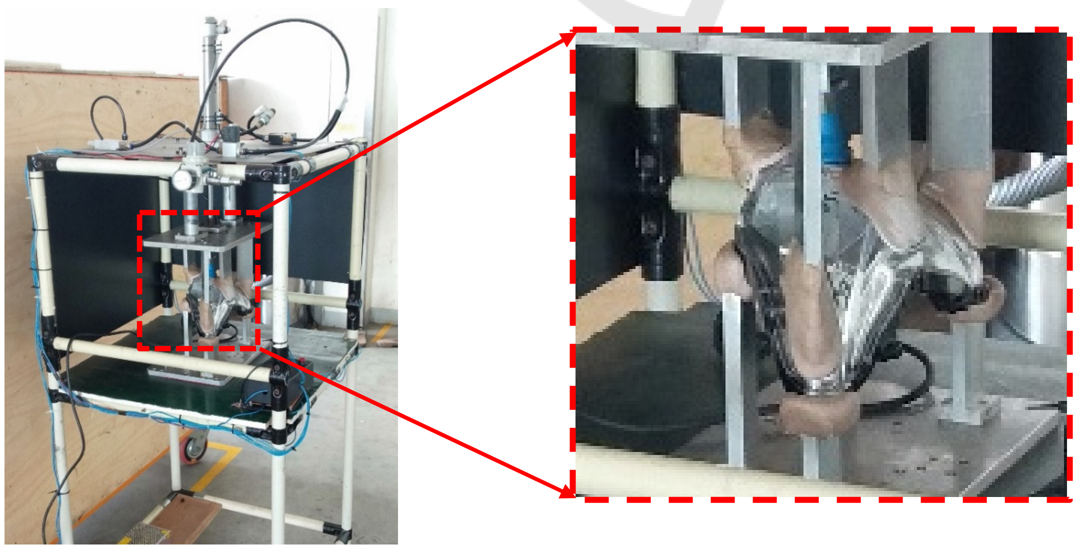

Figure 6: The prototype of of Semi-Automatic Lens Pressing Machine.

3.2 Pressure Testing

The semi-automatic lens pressing machine was tested with pressures of 0.3, 0.4, and 0.5 Mpa. The first test data obtained is shown in Figure 7. Based on the data obtained from the test results of 3 pressure variations where one pressure variation was carried out 30 times the lens suppression process experiment, then different time results were obtained based on the compressor pressure parameters that were working or applied. Tests with a pressure of 0.5 Mpa, namely the maximum safe pressure of the cylinder that is applied to be the fastest time and there is no Noot Good (NG) product compared to other pressures below it.

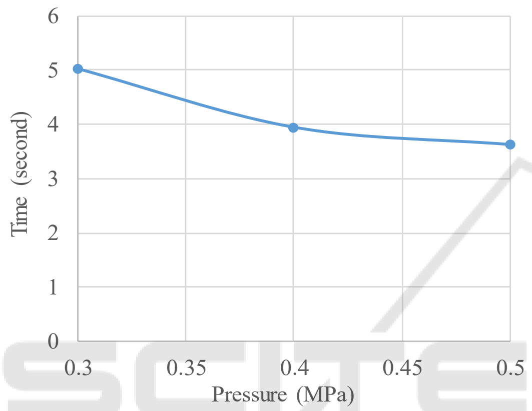

Figure 7: Alternatif desain 2.

3.3 Time Pressing after Impovement

The process of taking lens suppression data after the improvement is carried out using a stopwatch when the production process of the 045 type head lamp is in progress. Table 1 shows the data on the time of pressing the lens after the improvement obtained.

Table 1: Lens Pressure Time Data after Improvement.

No	Procces	Waktu
1	Installation of Qushion	3.64
2	*Houlder Caulking*	6.10
3	*Hotmelt*	25.86
4	*Lens Press*	10.05
5	Installaation of *SQ nut*	6.44
6	Installaation of *Bulb HL*	4.32
7	Installaation of *Cord Cp*	6.94
8	*Lighting Check*	22.56
9	*Stamping*	4.28
10	*Visual Check*	10.41
	Total	100.60

3.4 Comparison of Process Time Before and after Improvement

Lens compression time data after Improvement The research test of this semi-automatic lens pressing machine with a pneumatic drive based on Arduino control has been carried out using 3 pressure variations, namely 0.3 Mpa, 0.4 Mpa, and 0.5 Mpa. Testing with a pressure of 0.5 Mpa is the best test that produces the fastest time and there is no NG product compared to other pressures. Based on Figure 8 and Table 1 it can be seen that the comparison of the 045 type head lamp assembly process before the improvement activity was carried out with the assembly process after the improvement activity was carried out with the semi-automatic lens pressing machine as shown in the figure below.

Based on Figure 8, it can be done analysis of different work processes before and after improvement. The difference lies in the 4th working process, namely the lens suppression process which previously took 18.78 seconds and after modification it became 10.05 seconds. The graph shows that the semi-automatic lens pressing machine with an arduino-based pneumatic drive, in the 045 head lamp assembly process experienced a decrease in cycle time from 109.33 seconds to 100.6 seconds or 7.98%.

3.5 Productivity Cycle Time Calculation Before Improvement

Time Active working hours at PT. Indonesia Stanley Electric, which is Monday - Friday with an effective time of 8 hours a day. Meanwhile, Saturday and Sunday are taken to fill the overtime or overtime schedule to meet production targets that cannot be achieved with work activities. The following is the calculation of the actual production amount in the 045 type head lamp assembly process before the improvement is carried out by knowing the cycle time of the lens suppression process before the improvement is 109.33 seconds. The following is Table 2 comparison before and after the improvement of the manual lens pressing process.

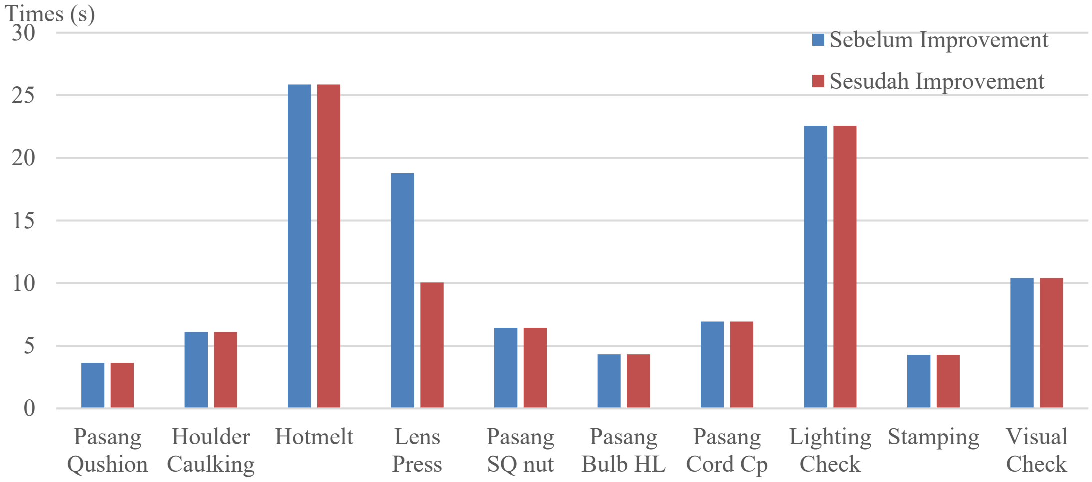

Figure 8: Comparison before and after Improvement.

Table 2: Comparison before and after Improvement.

	Shift (hours)	Production capacity	Average production time	Performance
Before *Improvement*	*Shift* 1 (8hour) *Shift* 2 (7hour) Total (15hour)	263 230 493	109.33	*baseline*
After *Improvement*	*Shift* 1 (8Jam) *Shift* 2 (7Jam) Total (15Jam)	286 250 536	100.6	*Cycle time* - 7.98 % *from actual* Produktivitas – 8,72 % *from actual*

Based on the data obtained from the test results of 3 pressure variations where one pressure variation was carried out 30 times the lens suppression process experiment, then different time results were obtained based on the compressor pressure parameters that were working or applied. Tests with a pressure of 0.5 Mpa, namely the maximum safe pressure of the cylinder that is applied to be the fastest time and there is no Not Good (NG) product compared to other pressures below it.

The failure to achieve production results was caused by obstacles in the assembly process of the HL-045 product. The obstacles that occurred were in the form of a bottleneck (time delay) in the assembly process, resulting in a significant difference between the actual time and the standard time set. Based on the study time that has been carried out on the HL-045 assembly process, it is known the cause of the obstacles that occur, namely the lens suppression process. The average time needed to carry out the pressing process is 12.56 seconds. This time is very different from the standard time that has been set, which is 3.55 seconds.

Based on the understanding of the problem, the potential sources that cause problems are man, material, method, money, machine and environment. Sources caused by the man factor itself arise due to the level of fatigue, work spirit and skills of each operator. The difference in assembly time that has been carried out by each operator is not too significant but there is a large enough time difference with the time set. Sources caused by material factors arise due to the presence of NG material produced by the plastic injection and evaporation division, resulting in material shortages in the lamp assy division. Therefore, there is a need for a double check process in the division before the lamp assy.

The process of pressing the lens which is still done manually results in bottlenecks (time delay) and an increase in cycle time so that it has an impact on not achieving the target production planning of the 045 head lamp. The manufacture of a semi-automatic lens pressing machine with pneumatic drive is the action taken to solve the existing problems. so that it can increase the cycle time and productivity of the HL-045. Environmental conditions can affect the morale of each operator, besides that the quality of product hygiene is also influenced by the existing production environment. Therefore, each operator is required to use special shoes in order to maintain the cleanliness of the existing production environment. Some of the proposed alternative designs are assessed based on the quality of the results, manufacturing costs, construction, ergonomics and workmanship. Based on the assessment that has been carried out, it is found that the three alternative designs have the highest rating, and the three alternative designs were chosen to be the design used. Calculation of material strength is carried out to determine material specifications that are safe to use on lens pressing machine components including: calculating axial forces on the lower jig, upper jig, pneumatic base, base table and calculating buckling that occurs in stay 1, 2, 3 and 4 lower jigs. Calculations of pneumatic cylinders, vacuum ejectors and bolt nuts are also carried out to determine the specifications of the three components used in semi-automatic lens pressing machines.

System monitoring is carried out to ensure that the improvements made have been running with the desired goals. System monitoring that has been carried out is to analyze and process test data for semi-automatic lens pressing machines using 3 pressure variations, namely 0.3, 0.4 and 0.5 Mpa. Data processing was carried out using bivariate analysis with the one way ANOVA method. The results of data processing show that the best lens pressing machine is tested at a pressure of 0.5 MPa with the fastest average processing time of 3.63 seconds. The final result of monitoring the system shows that the process time of pressing the 045 type head lamp lens after the semi-automatic lens pressing machine has decreased by 7.98% from 109.33 seconds to 100.6 seconds. This also affects the increase in productivity from 493 pcs/day to 536 pcs/day with an increase of 43 pcs or 8.72%.

4 CONCLUSIONS

Innovations and improvements made at PT. Indonesia Stanley Electric to provide problem solving solutions in the HL-045 assembly process, namely the design of a semi-automatic lens suppressor machine with an Arduino control pneumatic drive which is proven to be able to increase production capacity by 8.72% (initial 493 pcs/day to 536 pcs/day) and a decrease in cycle time of 7.98 % or 8.73 seconds (initial 109.33 seconds to 100.6 seconds). The semi-automatic lens pressing machine was tested using 3 pressure variations, namely 0.3, 0.4 and 0.5 Mpa. The test results show that the most optimal test results are at a pressure of 0.5 MPa with the fastest average lens pressing process time of 3.63 seconds.

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