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PDCA Method Implementation to Reduce the Potential Product Defects in the Automotive Components Industry

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A B S T R A C T

The research aim to reduce the potential for product defects in the automotive component industry by implementing Plan-Do-Check-Action (PDCA). The application of the PDCA method was carried out in an automotive component manufacturing company in Indonesia which produced SLJ 91 parts as a research object. The causes of the high number of product defects are known at the Plan stage from setting the theme of improvement to the root cause by using a fishbone diagram and 5W+1H analysis. In the Do stage, system improvements are implemented from the solutions generated by the 5W+1H analysis. The improvement results are controlled to confirm the results of the improvement made. Based on the results of data processing, analysis, and comparison between before and after implementation, it was found that the defect rate for SLJ 91 products was reduced from 12.7 % to 8%, a reduction in the percentage of 4.7% so that the product reaches the quality target it should be. The results of the improvement had a direct impact on the type of dent defects, namely a decrease in the number of defects from 7.8% to 5.3%, so that there was a decrease of 2.5%. The results of the research are implemented and standardized in the action stage so that the improvements made can be maintained in the long term.

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1. INTRODUCTION

The increase in demand for automotive components caused by the growth of the automotive industry can be an opportunity for component manufacturers to increase production and attract more customers (McKinsey&Company, 2016). However, on the other hand, this has also increased pressure on manufacturers to produce high-quality products that can meet increasingly high market demands. The quality of automotive components is very important because these components are part of the vehicle system which must work properly for the vehicle to operate safely and efficiently (Kumar Singh et al., 2022; O'Connor et al., 2022). If these components are not of good quality, there is a possibility that problems will occur with the vehicle, such as engine damage to accidents caused by system failures.

Improving the quality of automotive

components can help reduce defective products in an automotive component manufacturing company (Muhazir et al., 2020; Sumasto et al., 2022; Sya'roni & Suliantoro, 2017). Defective products can occur due to errors in the production process or because the materials used do not meet established standards. To be able to improve product quality, companies can take corrective actions such as reducing the level of defective products produced to save production costs and increase customer satisfaction (Garza-Reyes et al., 2018; Rosa et al., 2017; Sumasto et al., 2022). Based on these problems, automotive component manufacturers must pay attention to the quality of the products they produce in each production process. This can be realized by using high-quality materials, following strict industry standards, and conducting tests and validations on the products produced.

When product quality does not meet the quality objectives, the manufacturing company must immediately take corrective action to improve product quality (Abubakar et al., 2022). This is important because the resulting defective product can cause problems with the vehicle, such as engine damage to accidents caused by system failures. Defective products can also result in decreased customer satisfaction and result in losses for the company. To improve product quality, manufacturing companies can use several tools and methods, such as DMAIC (Kulkarni et al., 2022; Ranade et al., 2020; Sumasto et al., 2022), PDCA (Khaerudin & Rahmatullah, 2020; Sunadi et al., 2020; Utami & Djamal, 2018; Wajdi & Wiguna, 2015), Quality Tools (Manojkumar & Kumar, 2021; Prasojo et al., 2020), and Statistical Process Control (SPC) (Godina et al., 2018; Madanhire & Mbohwa, 2016; Sunadi et al., 2020). These methods can help companies identify quality problems and develop appropriate problem solutions.

This research has taken one of the automotive components as the object of research. The automotive components that are the object of this research are parts for four-wheeled vehicles manufactured by PT Nusa Indah Jaya Utama. The company produces many automotive components, one of them. SLJ 91 is a component located under the L300 PickUp car which functions as a chassis container. SLJ 91 components are produced in a quantity of 3,000 – 3,500 units/month according to customer requests. The obstacle faced by the company is the high defect rate and exceeding the company's product defect tolerance of 10%. Based on this, this study aims to reduce the potential for product defects in automotive components at PT Nusa Indah Jaya Utama. In research using the PDCA method to reduce the potential for defects. PDCA was chosen because it has a sustainability scheme and improves quality because it ensures that the improvements made can be sustained in the long term (Permana et al., 2021; Sunadi et al., 2020). This method is also easy to follow because it has clear steps and can be done in stages.

2. LITERATURE REVIEW

Plan Do Check Action (PDCA) is a continuous management method used to improve business processes through four steps: planning (plan), implementation (do), checking (check), and corrective action (action). PDCA is very popular in the automotive industry because of its systematic and easy-to-apply process in the production of automotive components (Dahniar et al., 2022; Huang et al., 2022; Nabiilah et al., 2018; Permana et al., 2021; Sunadi et al., 2020; Zhou et al., 2021). Several studies have been conducted to test the effectiveness of PDCA in reducing defects in automotive component production. For example, Zhou et al. (2021) conducted research at an automotive factory in China and found that the continuous application of PDCA can help reduce the number of defects in the production of automotive components. The research also shows that PDCA can help improve product quality and production efficiency.

Another research conducted by Dahniar et al. (2022) at an automotive manufacturing company in Indonesia shows that the application of PDCA can help reduce the defect rate in the production of automotive components. This study used a quantitative approach by conducting statistical analysis of product quality data for a period of 6 months before and after the implementation of PDCA. The results show that after implementing PDCA, there was a significant reduction in the defect rate from 2397 pcs to 669 pcs. Another study conducted by Nabiilah et al. (2018) in the Malaysian automotive industry shows that the application of PDCA can help reduce the number of defects in the production of automotive components and improve product quality. This research used a qualitative approach by conducting a case study on an automotive company. The results show that the application of PDCA can help companies increase production effectiveness and reduce the number of defects in production.

In addition, another study conducted by Huang et al. (2022) in the SME industry in the automotive sector in China shows that the continuous application of PDCA can help improve product quality and production efficiency. The research used a quantitative approach by collecting data on product quality and production efficiency over a certain period. The results show that the application of PDCA can help improve product performance and reduce the number of defects in production. Based on previous studies, it can be seen that PDCA is a method that can be used to improve and reduce defect rates in a production system in the automotive industry.

3. RESEARCH METHOD

This research method uses an approach to the 7 Steps PDCA stage and data collection method by using primary data. The first stage is to determine the formulation of the problem in the production of automotive component companies. The determination of the problem is seen from the number of automotive components produced (Table 1). The production volume for clip 25 parts, clip 40 parts, and SLJ 91 parts from December 2021 to February 2022 reached 8,414 pcs.

Table 1. Number of production parts

Part Name	December	January	February	Total
Clip 25	2,315	2,323	3,200	7,839
Clip 40	2,315	2,710	3,000	8,026
SLJ 91	2,436	2,478	3,500	8,414

Inspection results on part clip 25, part clip 40, and part SLJ 91 from December 2021 to February 2022 show that the greatest frequency of defects is on the SLJ 91 part (Table 2.). The types of defects that exist on the SLJ 91 part are sliding holes (Fig. 1.) and dents (Fig. 2.). Table 3. shows the most defects in the SLJ 91 part are dents. The defect rate on the SLJ 91 part reached 12.7% and this already exceeded the tolerance limit set at 10%.

Table 2. Data on the number of product defects

Part Name	December	January	February	Total
Clip 25	250	215	220	685
Clip 40	215	225	220	660
SLJ 91	**342**	**351**	**375**	**1.068**

Fig. 1. Sliding hole defects

Fig. 2. Dented defects

Table 3. Number of defects in SLJ 91 parts

Type of defect	Numbers	Cumulative frequency	% Defect
Sliding hole	215	215	20,13%
Dented	853	1068	79,87%
Total	**1068**		

Based on Table 3., there are 2 types of defects in SLJ 91 parts, namely sliding hole defects and dents, and defects that often occur in SLJ 91 parts, namely dent defects. The second stage is to determine goals or objectives. This research will focus on reducing dented defective products on SLJ 91 parts. The third stage is the point of cause. Based on the results of field observations, variations or deviations that result in defects in the SLJ 91 product occur due to several factors, namely methods, machines, humans, materials, and the environment. Determining the root of the problem is done by conducting an analysis using a fishbone diagram obtained from the results of brainstorming with supervisors at the company. The results of the fishbone diagram are then processed and analyzed using the 5W+1H method to produce suggestions for improvement solutions. The first stage to the third stage is part of the plan stage in PDCA.

The fourth stage is the implementation of the solution. The action or solution obtained is derived from the results of the analysis of 5W + 1H and then implemented as a solution to the existing problem. The fourth stage is the do stage in PDCA. The results of the action will be controlled or checked and adjusted as a form of the fifth stage, namely, confirm the result. In this stage, the impact of the improvement is confirmed whether it has a positive impact and answers the goals. The fifth stage is the check stage at PDCA. The sixth stage is to standardize the implementation of the improvements made. The seventh stage is to reflect on the process which will then determine further improvements. The sixth and seventh stages are part of the action stage in PDCA.

4. RESULT AND DISCUSSION

The Plan Stage

The plan stage in the PDCA method is carried out to plan the initial stages at the improvement stage. Determination of a good improvement plan must be determined from the theme to be taken, research targets, cause and effect analysis, and making improvement plans. At the planning stage, 3 steps are carried out, namely: (i) Determine the theme: Based on the data that has been obtained, the problems that occur in the process of making SLJ 91 products have a high number of defects so that production per month is not achieved (Table 3), (ii) Determine the Root Cause of the Problem: Determination of the root cause of the problem is used to identify in detail related to the cause of the main problem by using a fishbone diagram, and (iii) Determine the improvement plan:

Determination of the next improvement plan is carried out by implementing the improvement plan using the 5W + 1H tool (What, Why, Where, How, When, Who) to minimize SLJ 91 parts that are considered defective. The improvement plan can be seen in Table 5.

From Table 3. it can be seen that the number of defects experienced by SLJ 91 products was 1,068 of the 8,414 produced. The level of defects in SLJ 91 products reached 12.7%, this exceeded the tolerance limit set by the company, which was 10%. Based on the problem of dent defects, it is necessary to see whether the product manufacturing process is well controlled or not, namely by making a control chart.

There are 22 data with different numbers of production and defects. Data on the proportion of dent defects on the SLJ 91 part can be seen in Table 4. The results of the proportion of defects are used to determine CL, UCL, and LCL on the P control chart (Fig. 3.). From the results of the P control chart, it can be seen that there are data that exceed the UCL limit. This is caused by variations that occur during the production of SLJ 91 parts. Variations or deviations that occur are caused by several factors, namely methods, machines, people, materials, and the environment.

Table 4. Data on the proportion of dent defective SLJ 91 parts

No	Date	Production (pcs)	Defects (pcs)	Proportion	CL	UCL	LCL
1	01/12/2021	360	20	0,0556	0,0780	0,1204	0,0356
2	06/12/2021	360	20	0,0556	0,0780	0,1204	0,0356
3	10/12/2021	360	20	0,0556	0,0780	0,1204	0,0356
4	14/12/2021	360	31	0,0861	0,0780	0,1204	0,0356
5	16/12/2021	360	25	0,0694	0,0780	0,1204	0,0356
6	20/12/2021	276	20	0,0725	0,0780	0,1264	0,0295
7	22/12/2021	360	24	0,0667	0,0780	0,1204	0,0356
8	04/01/2022	355	22	0,0620	0,0780	0,1207	0,0353
9	06/01/2022	357	30	0,0840	0,0780	0,1205	0,0354
10	09/01/2022	350	28	0,0800	0,0780	0,1210	0,0350
11	13/01/2022	354	20	0,0565	0,0780	0,1207	0,0352
12	15/01/2022	355	18	0,0507	0,0780	0,1207	0,0353
13	17/01/2022	355	29	0,0817	0,0780	0,1207	0,0353
14	22/01/2022	352	41	0,1165	0,0780	0,1208	0,0351
15	01/02/2022	437	42	0,0961	0,0780	0,1164	0,0395
16	03/02/2022	450	40	0,0889	0,0780	0,1159	0,0400
17	05/02/2022	434	38	0,0876	0,0780	0,1166	0,0394
18	07/02/2022	450	43	0,0956	0,0780	0,1159	0,0400
19	10/02/2022	432	35	0,0810	0,0780	0,1167	0,0393
20	13/02/2022	400	39	0,0975	0,0780	0,1182	0,0377
21	15/02/2022	457	36	0,0788	0,0780	0,1156	0,0403
22	17/02/2022	440	35	0,0795	0,0780	0,1163	0,0396
	TOTAL	8414	656	0,0780			

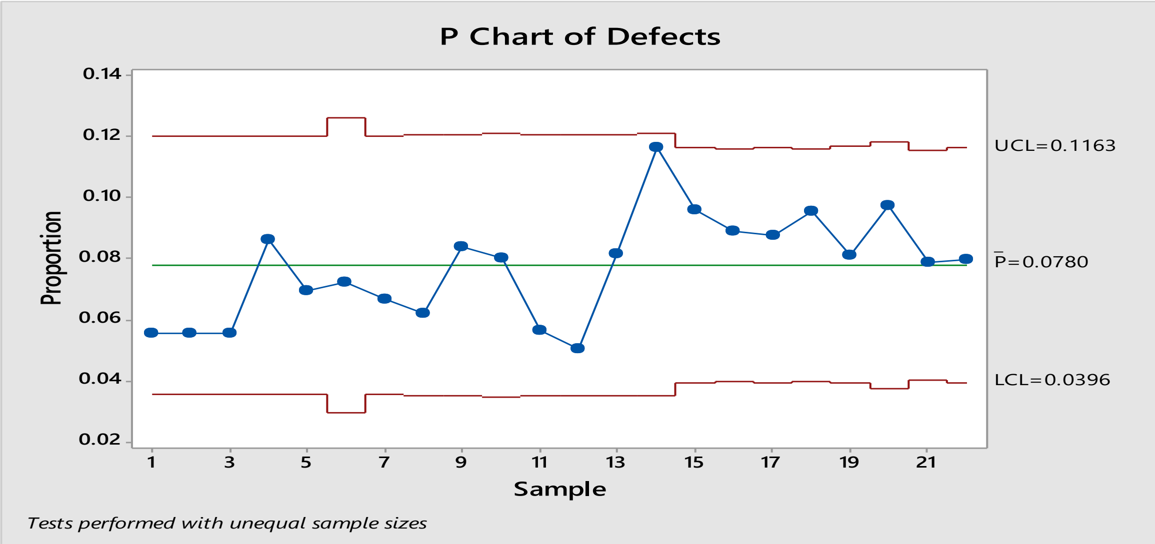

Fig. 3. P-control chart of SLJ 91 part before improvement

After knowing the types of defects and process control, the next step is to find the root cause of the problem. To find the factors that cause defects, a fishbone diagram is used to identify the possible causes of certain effects and then isolate the root causes (Figure 4). The problems that are mapped to the SLJ 91 part are human factors, methods, machines, and the environment.

The problems that are mapped to the SLJ 91 part are human factors, methods, machines, and the environment. (1) Human factor: Incorrect placement of the material is caused by not carrying out good work standards and the result of operators who are not careful, and insufficient lubrication of materials because operators are in a hurry and operators underestimate existing work procedures so that the parts produced are not following standards, (2) Method factor: Inappropriate dies placement is caused by dies being installed by inexperienced operators or new operators and the absence of dies installation work instructions so that the resulting parts do not comply with predetermined standards, (3) Machine factor: The lack of maintenance on the machine is caused because there being no maintenance schedule, (4) Environmental factor: Lack of lighting in a hot work environment and workspace. there are 11 areas namely Press Medium, Press PP, Welding, Handwork, Coating, PPC, MTC Dies, PPC, Maintenance, and Quality Control. The standard set for the Head office illuminance is a minimum of 300 Lux and the standard set for the site illuminance is a minimum of 200 Lux. However, the actual conditions that occur are that there are still several areas that do not meet predetermined standards such as the Press Medium area where the illuminance reaches 174 Lux, Press PP reaches 192 Lux, Coating reaches 138 Lux, and Quality Control reaches 174 Lux.

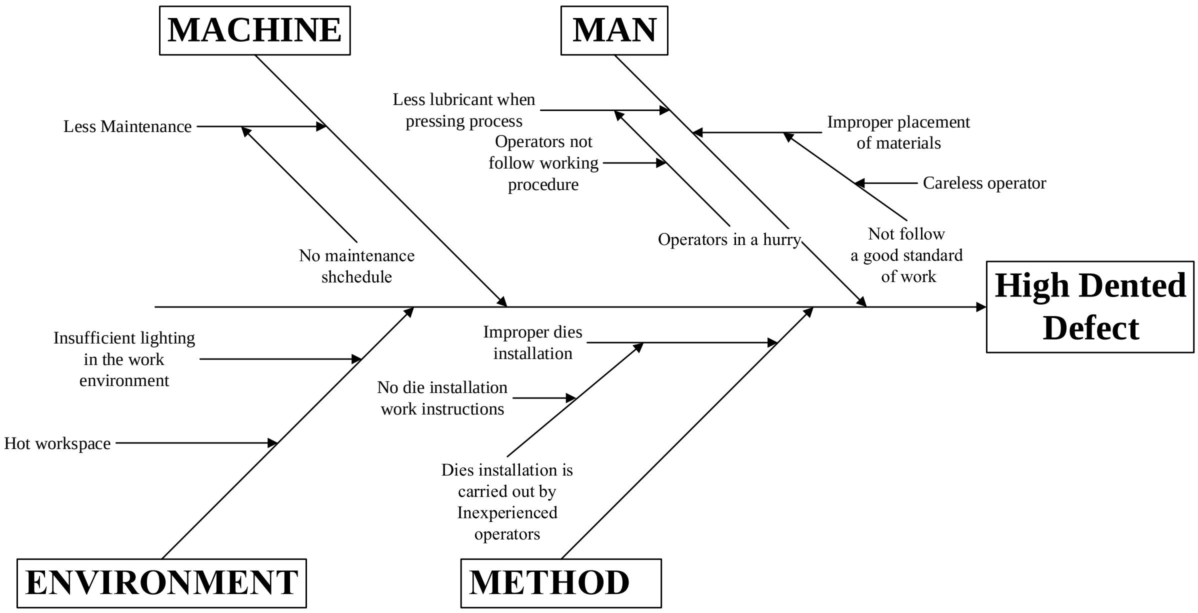

Fig. 4. Fishbone diagram of dented defect

Table 5. 5W+1H Analysis

Factor	*What*	*Why*	*How*	*Where*	*When*	*Who*
Human	Lubrication during operation	To avoid defects in the product	By creating work instructions	Production Line	During the production process	Production operator
	Material Placement	In order to produce products that comply with predetermined standards	By doing work instructions	Production Line	During the production process	Production operator
Method	Die installation	In order to produce products according to standards	Inexperienced operators are supervised who are trained in die installation	Production Line	Before the production process takes place	Production operator
Machine	Machine maintenanc e	The production process is not disturbed, so that the products produced are in accordance with standards and on time	Perform routine machine maintenance	Production Line	Before the production process takes place	Production operator
Environ ment	Production line lighting	The operators work optimally and produce products that meet standards	Examine the production environment	Production Line	Before the production process takes place	Maintenanc e Division
	High room temperature	The operators can work in a focused and comfortable manner, so as to produce products that meet standards	Examine the production environment	Production Line	Before the production process takes place	Maintenanc e Division

Implement an improvement plan using the 5W + 1H (What, Why, Where, How, When, Who) tools to minimize SLJ 91 parts that are considered defective (Table 5). The improvement plan that will be used to minimize the defects that occur in the SLJ 91 part is to make work instructions, make SOPs and provide supervision and training for dies installation to operators.

The Do Stage

In this Do stage, implementation steps are carried out to reduce defective products on the SLJ 91 part. In the Do stage, 4 stages are carried out, namely:

1. Making a Work Instruction for making SLJ 91 parts
   At this stage, work instructions for the SLJ 91 part for the Blank, Bending, Pierching, and Assy Nut processes were made.
2. Making Work Instructions for installing dies
   At this stage, work instructions are made for the installation of dies in the blank, bending, and dies piercing parts of SLJ 91.
3. Supervision and training for Operators
   This corrective action is carried out by conducting supervision and training of operators who are still in the training period to change dies for the production of new products.
4. Perform routine maintenance on the machine
   When carrying out routine machine maintenance, the operator is the person who has the influence to carry out routine maintenance in the production of new products. Especially when installing the machine, the operator must take preventive maintenance measures in the form of lubricants to clean and identify any abnormalities in the machine.

The Check Stage

At the check stage, the measurement of control limits and the percentage of defects is carried out again after making improvement. The data taken is data on the number of production and data on the number of defects in the SLJ 91 part products in April-June 2022. Control measures on the results of the improvement carried out resulted in a decrease in the number of defects in both sliding holes and dented (Table 6.).

Table 6. The number of defective SLJ 91 parts after the implementation of improvements

Type of defect	Number
Sliding hole	210
Dented	404
Total	614

At the check stage it is also necessary to calculate CL, UCL, and LCL to be able to see the results of the P control chart. Based on this, the 21 data for the number of production and defects used in the calculation are data from April – June 2022. Data on the proportion of dented defects after experiencing remedial action on the SLJ 91 part can be seen in Table 7.

The results of the calculations performed in Table 7. become input for making a P control chart (Figure 9.). Based on Figure 9. it can be seen that the proportion of defects is still within control limits and is more stable than before the implementation of improvements. The proportion of defects is more stable, it can prove that the actions taken can improve the quality of SLJ 91 products.

The Action Stage

In the action stage, quality control results are stored to prevent the recurrence of the same problem and minimize the number of failures in the future by setting standards for the company after improvement. Standardization of the manufacturing process is a regular corrective action to overcome/prevent problems with SLJ 91 products. Work standards are made based on the evaluation results of the check stage where work standardization is determined (Table 8.).

Table 7. Data on the proportion of dent defects after the implementation of improvements

No	Date	Production (pcs)	Defect (pcs)	Proportion	CL	UCL	LCL
1	01/04/2021	360	15	0,0417	0,0529	0,0884	0,0175
2	04/04/2021	360	21	0,0583	0,0529	0,0884	0,0175
3	05/04/2021	360	21	0,0583	0,0529	0,0884	0,0175
4	08/04/2021	360	21	0,0583	0,0529	0,0884	0,0175
5	11/04/2021	350	18	0,0514	0,0529	0,0889	0,0170
6	13/04/2021	358	22	0,0615	0,0529	0,0885	0,0174
7	10/05/2021	360	18	0,0500	0,0529	0,0884	0,0175
8	12/05/2021	251	21	0,0837	0,0529	0,0954	0,0105
9	17/05/2021	373	18	0,0483	0,0529	0,0877	0,0182
10	19/05/2022	342	19	0,0556	0,0529	0,0893	0,0166
11	23/05/2022	347	20	0,0576	0,0529	0,0890	0,0169
12	24/05/2022	370	20	0,0541	0,0529	0,0879	0,0180
13	30/05/2022	352	18	0,0511	0,0529	0,0888	0,0171
14	03/06/2022	364	20	0,0549	0,0529	0,0882	0,0177
15	07/06/2022	370	19	0,0514	0,0529	0,0879	0,0180
16	09/06/2022	400	18	0,0450	0,0529	0,0865	0,0194
17	13/06/2022	360	23	0,0639	0,0529	0,0884	0,0175
18	15/06/2022	372	20	0,0538	0,0529	0,0878	0,0181
19	17/06/2022	356	17	0,0478	0,0529	0,0886	0,0173
20	21/06/2022	450	18	0,0400	0,0529	0,0846	0,0213
21	22/06/2022	415	17	0,0410	0,0529	0,0859	0,0200
	TOTAL	**7630**	**404**	**0,0529**			

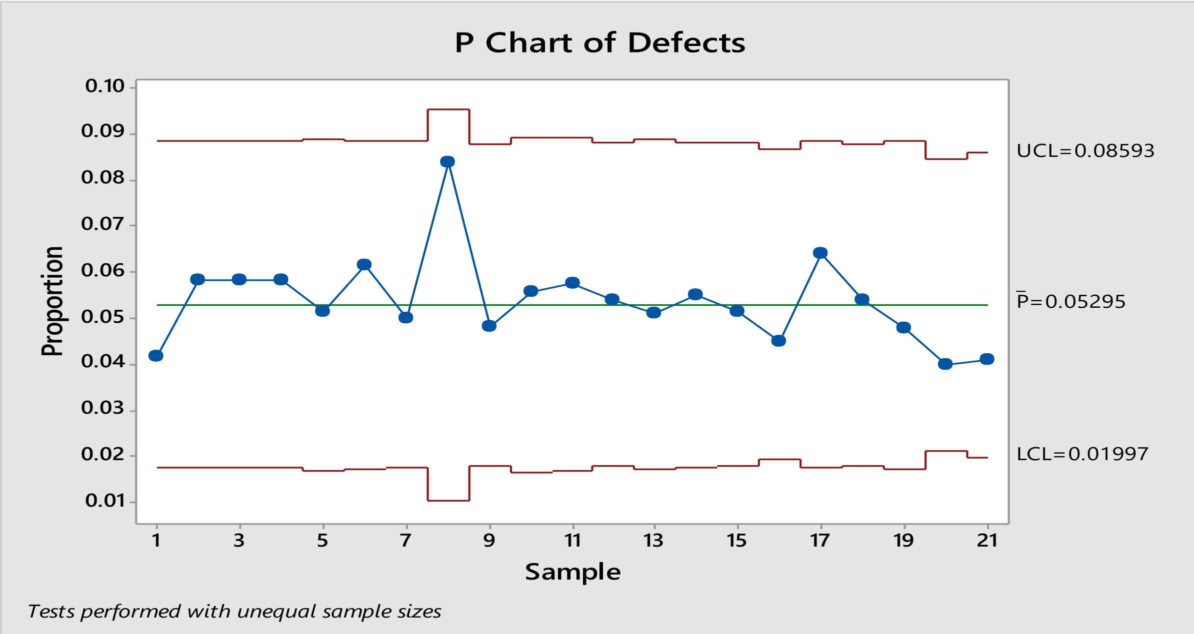

Fig. 5. P-control chart on the production of SLJ 91 parts after the implementation of improvements

Table 8. Standardization of the SLJ 91 part production process

No	Factor	Causes	Normal Standard	Company Standards After Making Improvement
1.	Human	Lack of lubrication in the production process	Create work instructions that operators must follow	Supervise to ensure work instructions are running properly
2.	Method	Improper installation of dies	Perform hands-on actions and training for die installation for inexperienced (new) operators	Create work standards regarding the installation of dies on each production line
3.	Machine	Lack of machine maintenance	Perform maintenance on production equipment	Perform maintenance on production equipment before damage occurs, and carry out checks before starting production
4.	Environment	Lack of lighting on the production line	The company makes a lamp replacement schedule	Check the lighting

Improvement Results Analysis

The results of improvements are measured to determine the level of success and results of improvements that have been made. Based on this, a comparison of the percentage of defects before and after improvement was carried out. Data before improvement of the number of products 8,414 pcs there are 1,068 pcs of defective products or 12.7%. Based on the results of the implemented improvements, there was a decrease in the number of defective products to 614 pcs from a total production of 7630 pcs or 8%. Decrease in the percentage of defects by 4.7% overall defective products. The results of the improvements implemented aim to reduce dented defective products. Based on the improvement data obtained, there were 404 pcs of defective products with dents a total of 7630 pcs or 5.3%. The percentage of dent defect reduction after the implementation of improvement is 2.5%. From the calculation results it can be shown that the corrective actions taken for the SLJ 91 product had a positive impact and reduced the percentage of defects on the SLJ 91 product. The improvement results also helped the company to be able to achieve its quality objectives. Based on findings of improvement impacts, future planning stage need to consider developing a standard operating procedure for company standards.

5. CONCLUSION

The results of the analysis carried out in the study resulted in the implementation of the PDCA Method having a positive impact on reducing the number of defective products in the automotive component industry. The biggest product defect identification result was in the SLJ 91 part product with 12.7% which exceeded the tolerance limit of 10%. The corrective actions taken were making work instructions for the SLJ 91 production process, dies installation work instructions, carrying out supervisory actions and dies installation training for inexperienced or new operators and carrying out routine machine maintenance. Based on the results of data processing, analysis, and comparison between before and after implementation, it was found that the defect rate for SLJ 91 products decreased from 12.7% to 8%, a decrease in the percentage of 4.7% so that the product reached the quality target it should be, and on the type of dent defect namely the decrease in the number of defects from 7.8% to 5.3%, so that there is a decrease of 2.5%. In this study it is still limited to automotive part product objects but cannot see operators as objects. Research can be developed by assessing or trying to calibrate the system using measurement system analysis (MSA) so that improvements can be more specific, especially on the method factor.

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