Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri

Vol. 10, No. 1, 2024

Analysis Of Defect Outside Diameter (+) Moveable Spring Type Driven Using the Seven Tools Method

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ABSTRACT

PT. ISP is a manufacturing company that focuses on producing springs for vehicles in the industrial sector. The products include leaf and snail springs, produced via cold and hot processing. PT. ISP collaborates with Mitsubishi Steel Manufacturing, Japan, using a license from that company. One is Moveable Driven, a spiral spring produced through a cold process. PT. ISPs face challenges related to defects that arise during the production process. This research aims to assess the level of defects, identify factors that contribute to product defects, and suggest improvements. Seven tools are used to identify factors that cause defects in products. The research results based on the Pareto diagram show that the most dominant type of defect is outside diameter (+), with a total of 3,197 pcs and a percentage of 44.9%. Hence, defects need to be the main focus for improvement. On the P Chart, 1 data is out of control below the Lower Control Limit/LCL limit in the 9th data. After revision 1, there was no data that was out of control. In this way, the factors causing Outside Diameter (+) defects using fishbone include the Man Factor, Measurement Factor, Machine Factor, Process Capability, and Method Factor. The condition of internal defects is still within control limits. So, improvements need to be made so that defects meet the targets set.

Keywords: *Defect, Quality Control, Spring*

Introduction

As time passes, progress in the manufacturing and service industry continues to increase rapidly. Therefore, every industry player must be prepared to compete and take appropriate steps, especially in maintaining product quality. This is important so that companies can remain competitive with similar competitors and support the sustainability of their operations. Each component in the company carries out quality control, a monitoring activity that aims to increase and sustain production levels to comply with predetermined quality standards. Product quality is suitability for using the product (fitness for use) to meet customer needs and satisfaction. [1]This effort minimizes errors in the production process, ensuring that the desired level of product quality is consistently met to meet customer expectations. [2]

Previous studies examined quality control by applying the Seven tools method, one of which was research. [3] Quality Control Using the Seven Tools Method to Minimize Consumer Returns at PT. XYZ research results show that tools such as Check Sheets, Control Charts, and Fishbone Diagrams can be used to identify product defects that may be caused by various factors, such as machines, humans, climate conditions, or storage methods, causing a decrease in quality that occurs in the company. Similar findings were also found in research in the MSME food industry sector. [4]This method was chosen because it is closely connected to quality control in the manufacturing process. It considers various factors to reduce the number of defective bread products and increase competitiveness in the local market.

Thus, previous research results can support the benefits of using the Seven Tools method in all aspects to control product quality and identify and determine the factors that cause defects for the company. A defect is a product that does not meet specifications and is of low quality, causing rework to be carried out. [5].

Based on the previous research explained above, the gap between this research and the research above is the addition of machine indicators and measurements. These indicators are necessary because this research is closely related to the results of measuring products produced by production machines. Product measurement results can also be used as a reference to determine a production machine's capabilities.

The approach to this research uses a combination of quantitative and qualitative methods. This research prioritizes data analysis and direct observation. Applying the seven tools method is an effective way to manage product quality. Seven tools are basic statistical techniques that can be used as a practical solution to problems and proposed improvements for process improvement.[6]. The simplicity and accessibility of the seven tools method make it applicable to businesses in all industries because the technique, skill requirements, objectives, and mechanisms are easy to understand regardless of educational background.

This research's contribution is expected to provide new insights and knowledge or understanding of the steps in using the seven tools method for all related sectors so that it can help solve the problems faced by companies, significantly improve the quality control process, reduce the factors that cause defects, and help improve a company's performance.

Research Methods

This research was conducted at PT. ISPs. This company operates in the manufacturing sector and produces spring and brake components, a technique for collecting production data and coil spring defect data from July to September 2023. Data was collected through various methods, including interviews, direct observation, and literature research [7]. The data analysis technique uses tools from seven tools, namely:

Check Sheet

A check sheet is an essential tool used to collect and record data efficiently and consistently whenever it is found during an incident. [4], [8], [9].

Stratification

Data stratification refers to dividing and grouping data into smaller categories, considering similar characteristics in each group. [10]

Pareto Chart (Pareto Chart)

The Pareto diagram is used to identify defects that dominate a product.[11]. This graph sorts data classifications from left to right based on the highest to lowest ranking order. It can help identify the most critical problems to be resolved immediately and those that do not need to be resolved immediately. [12].

Histograms

Histograms are often used as a visual aid to illustrate common defect categories.[13] Effectively.

Scatter Diagrams

Scatter diagrams, also known as scatter plots, were created to visually show the relationship between the number of defective products and the number of products produced. [14]–[16]

P Chart / P Control Map

P Control Chart, or Control Chart, is a quality control tool shaped like a line graph. This chart includes upper and lower control limits, as well as a center line, to assist in identifying trends that describe data over a certain period. [17].

Cause and Effect Diagram (Fishbone Diagram)

A cause-and-effect diagram, better known as a fishbone diagram, is a tool for identifying the relationship between a problem and the possible causes and factors that influence it. [18].

Results and Discussion

Research Result

Moveable Driven is a coil spring product from PT. ISPs. It functions to regulate the tension of the rear pulley of two-wheeled automatic vehicles. Defects are still found in the process of making movable-driven type spring products, which reduces product quality. To reduce defective product errors, analysis was carried out using the seven-tools approach. Production and coil spring defect data for July to September 2023 were retrieved. The table data is as follows.

Table 1. Coil Spring Production Defect Data for the period July to September 2023

	Months			Total	Output	Defect
Type	July	August	Sept	(Pcs)	13 Months)	Percentage (%)
Moveable Driven	2636	2470	2019	7124	1874940	0.38%
Compression Spring	1979	2126	2925	6139	1751000	0.35%
Tension Spring	2110	1868	2112	6090	1964060	0,31%
Wire Ring	188	207	176	571	1265000	0.05%
Total	6912	6671	6332	19915	6855000	0.29%

Source: PT. ISP

From Table 1, the defect percentage data for three months is 0.29%, still exceeding the standard set by management, namely 0.22%. The highest defect is the Moveable Driven Spring type, with a total defect reaching 7124 pcs per three-month period and a percentage of 0.38%. Based on this data, the movable-driven spring type needs further analysis to determine what defects occur. , by analyzing the highest types of defects. Based on the table data above, the seven tools method analyzes Moveable Driven Spring type defects.

Checksheet (Check Sheet)

A checksheet is a tool for collecting data in a structured and orderly way to facilitate analysis and assessment. The information recorded in the checksheet can be quantitative or qualitative, depending on the specific data collection needs.[19] In the Moveable Driven Spring type production process at PT. ISP has implemented a check sheet for defective products. Then, the check sheet is recapped for 90 days with the results as below, shown in the following table.

Table 2. Moveable Driven Defect Checksheet for the period July to September 2023

	Type of Defect							
Period e	Square eness (+)	Free Height (+)	Free Height (-)	Outside Diameter (+)	Cutting Cip	Total	Output	Percentage
W-1 Jul 23	63	183	50	277	15	588	156245	0,38%
W-2 Jul 23	79	202	35	297	33	657	156815	0,42%
W-3 Jul 23	85	130	100	351	51	717	179620	0,40%
W-4 Jul 23	67	155	98	329	24	673	176295	0,38%
W-1 Ags 23	26	166	145	326	18	681	166675	0,41%
W-2 Ags 23	31	193	101	285	22	632	160150	0,39%
W-3 Ags 23	14	177	95	239	31	556	150600	0,37%
W-4 Ags 23	28	182	65	288	26	589	151295	0.39%
W-1 Sep 23	33	187	78	190	41	529	156015	0,34%
W-2 Sep 23	41	164	80	222	23	530	148815	0,36%
W-3 Sep 23	24	169	91	200	29	513	138660	0,37%
W-4 Sep 23	36	142	56	193	32	459	133755	0,34%
Total (pcs)	527	2050	994	3197	356	7124	1874940	0,38%

Source. PT. ISPs

Based on data from Table 2, there are 7124 defects with 5 types of defects as follows.
1. Defect Squareness (+), The results of measuring the spring slope (squareness) exceed the specified standard limits
2. Defect Free Height (-), The spring height measurement result is less than the specified standard limit
3. Defect Free Height (+), The spring height measurement results exceed the specified standard limits
4. Outside Diameter (+), The results of measuring the outer spring diameter exceed the specified standard limits
5. Cutting chip, visually the cut at the end of the spring is uneven

Stratification

Based on data on the type of defect and the number of defects in the production output of the Moveable-Driven Spring type, this data can be classified as a group analysis of one type with clearer data presentation. [20]. The stratification of the types of defects that occur in production output for the spring movable-driven type is as follows.

Table 3. Stratification

No	Type of Defect	Defect Total (pcs)	Percentage
1	Squareness (+)	527	7,40%
2	Free Height (+)	2050	28,78%
3	Free Height(-)	994	13,95%
4	Outside	3197	44,88%
5	Diameter (+) Cutting Cip	356	5,00%
	Total	7124	100,00%

Source: PT. ISPs

Based on Table 3. Stratification above, the type of defect with the highest percentage is the Outside Diameter (+) defect type, 3197 pcs, with a rate of 44.88%, and the lowest is the chip cutting defect type, 356 pcs, with a rate of 5.00%.

Pareto Chart (Pareto Chart)

From the data processing results in Table 3, the Pareto diagram determines the sequence of defect-type problems based on the number of defects. [21], from the highest number of defect frequencies to the lowest number of defect frequencies. Making Paretto diagrams is assisted by using Minitab software. The following is a Pareto diagram of the spring movable driven type defects.

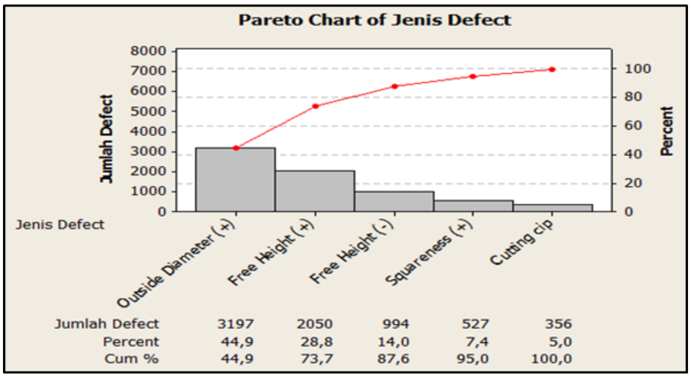

Figure 1. Pareto Chart of Type of Defect

Figure 1 shows that the Outside Diameter (+) defect type has the highest number of defects, at 3197 pcs. Based on this table, the Outside Diameter (+) defect type is the main priority in analyzing the causes of problems and minimizing defects in the spring moveable driven type.

Histograms

Minitab software assists in creating histograms. The histogram displays the size of the Defect Outside Diameter (+). The X-axis shows the shape of the number of defects per week. The Y axis depicts the frequency of defects. Figure 3 shows that the distribution of different types of defects is not normal, indicating that the frequency of defects is not concentrated around the mean and shows more significant variability.

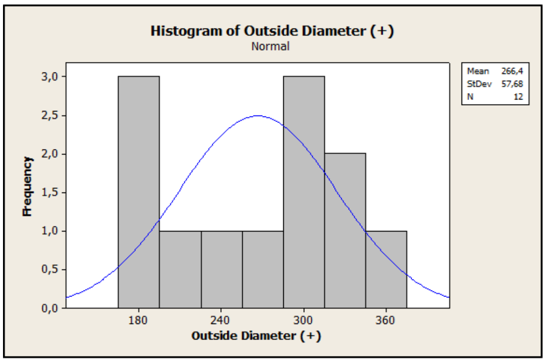

Figure 2. Histogram

The histogram graphic output in Figure 3 shows a distribution pattern resembling a bell curve, which shows that the data follows a normal distribution. The normal distribution is an essential statistical tool for assessing data distribution and performing hypothesis testing because it assumes the normality of data. The role of the normal distribution allows for testing and estimating hypotheses based on data.

Scatter Diagrams

The diagram illustrates the possible relationship or correlation between two types of variables. This diagram visualizes the level of closeness of the relationship between these two variables, which is often measured or represented as a correlation coefficient. The diagram to find out whether there is a correlation between Outside Diameter (+) (X) and the amount of production (Y) is depicted in a Scatter diagram. The following is an image of a scatterplot diagram processed using Minitab.

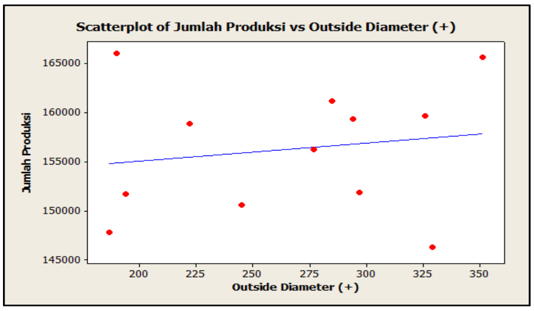

Figure 3. Scatter Diagram

Based on the Minitab analysis, the scatter diagram pattern shown above shows the distribution of scattered points, which shows a potential positive correlation between production quantity and the number of moveable driven type defects. In Figure 4, the diagram pattern shows the relationship between the higher production quantity of the spring moveable driven type, which can influence the number of defects that occur in the spring moveable driven type.

P Chart / P Control Map

A Control Chart is an effective quality control tool in the form of a line graph. It consists of a lower control limit (LCL), upper control limit (UCL), and center line (CL), which helps identify trends in data over a certain period. The primary purpose of the P control chart is to assess whether the defective product is within the specified limits. [22][23], [24]. Using a graphical representation of attribute data, the defect status in the defect outside diameter (+) data can be determined as follows.

Table 4. P Chart Outside Diameter (+) for the Period July to September 2023

Period	Production Total (Pcs)	Defect Total (Pcs)
W-1 Jul 23	156245	277
W-2 Jul 23	156815	297

W-3 Jul 23	179620	351
W-4 Jul 23	176295	329
W-1 Aust 23	166675	326
W-2 Aust 23	160150	285
W-3 Aust 23	150600	239
W-4 Aust 23	151295	288
W-1 Sept 23	156015	190
W-2 Sept 23	148815	222
W-3 Sept 23	138660	200
W-4 Sept 23	133755	193
Total	1874940	3197
Average	156,245	266

Source: PT. ISPs

From the data in Table 4. to find the control chart, proportions are calculated: CL (Center Line), UCL (Upper Control Limit), and LCL (Lower Control Limit). With the following calculations:

Center Line (CL),
CL = number of defects/number of production

Upper Control Limit (UCL),
$UCL = \overline{P} + {}^{3}\sqrt{\overline{P}(1-\overline{P})}$

Lower Control Limit (LCL),
$LCL = \overline{P} - {}^{3}\sqrt{\overline{P}(1-\overline{P})}$

From this calculation method, a control limit table is created as follows:

Table 5. Control Limits for Number of Defects Outside Diameter (+)

Period	**Production Result (pcs)**	**Defect Product (pcs)**	**Proportion %**	**CL Center Line %**	**UCL Upper Control Limit %**	**LCL Lower Control Limit %**
W-1 Jul 23	156245	277	0,177	0,171	0,202	0,139
W-2 Jul 23	156815	297	0,189	0,171	0,202	0,139
W-3 Jul 23	179620	351	0,195	0,171	0,200	0,141
W-4 Jul 23	176295	329	0,187	0,171	0,200	0,141
W-1 Aust 23	166675	326	0,196	0,171	0,201	0,140
W-2 Aust 23	160150	285	0,178	0,171	0,201	0,140
W-3 Aust 23	150600	239	0,151	0,171	0,202	0,139
W-4 Aust 23	151295	288	0,194	0,171	0,202	0,139
W-1 Sep 23	156015	190	0,122	0,171	0,202	0,139
W-2 Sep 23	148815	222	0,149	0,171	0,203	0,138
W-3 Sep 23	138660	200	0,152	0,171	0,204	0,137
W-4 Sep 23	133755	193	0,140	0,171	0,204	0,137
Total (pcs)	1874940	3197				
Average	122.912	266	0,16916	0,1705	0,2019	0,1391

Source: PT. ISPs

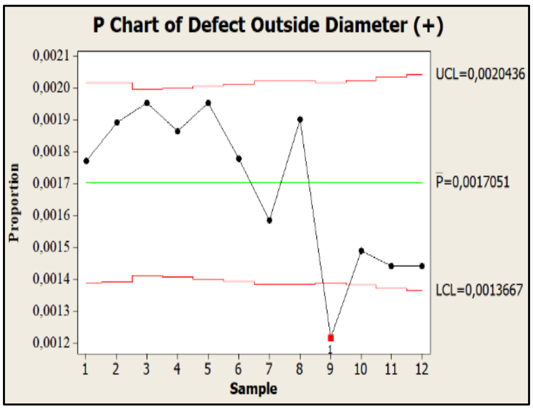

Figure 4. . P Chart Outside Diameter (+)

Based on the results obtained in Figure 4 above, the P-Chart defect contains data that is out of control. Namely, the 9th data set is below the LCL limit. This shows the need for improvements in quality control. Due to deviant data, it is necessary to establish new control limits for the data being checked by eliminating data outside the previous control limits and recalculating as appropriate. So, after the p-control chart was revised, the CL value was adjusted to 0.17493%.

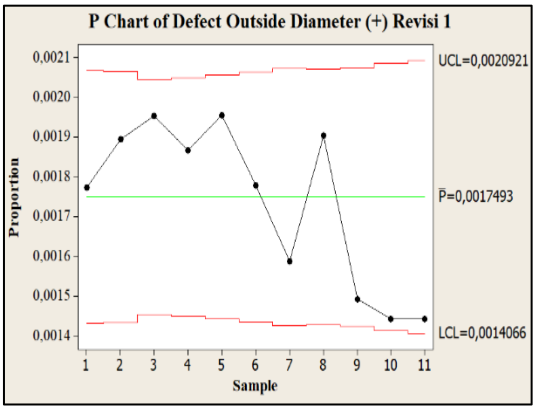

Figure 5. P Chart Outside Diameter (+) Revision 1

Cause and Effect Diagram (Fishbone Diagram)

The cause-and-effect diagram shows that the Pareto diagram was created from the results of Figure 2; it is known that the Outside Diameter (+) type of defect has the highest number among the other types of defects. This diagram, also called a fishbone diagram, can be used to analyze the possible causes of problems or actual conditions during the production process. [25]The benefits of the cause-and-effect diagram can be used in actual conditions to improve product or service quality, use resources more efficiently, and reduce costs.

These various problems are then analyzed to obtain recommendations for improvement. The findings of the issues were then analyzed to find solutions for improvement efforts. The Fishbone Diagram Outside Diameter (+) is as follows.

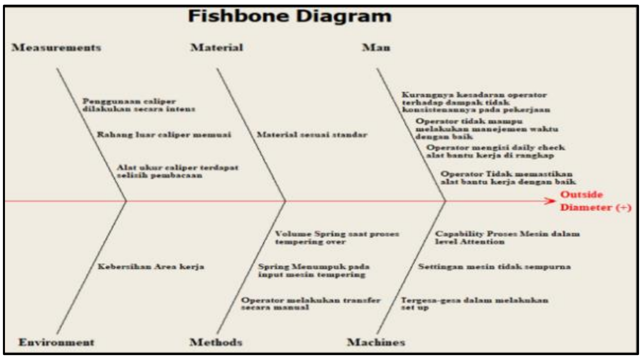

Figure 6. P Chart Outside Diameter (+) Revision 1

Based on the Fishbone diagram in Figure 7, the causes of Outside Diameter (+) defects consist of various aspects such as Measurement, Material, Man, Machine, Methods, and Environment. After identifying defects that occur in the Outside Diameter (+) production process, the cause of the defect is known. Then, further analysis is carried out to reduce the number of defects, and suggestions for improvement are as follows.

Table 6. Analysis of the Root Causes of the Problem and Suggestions for Repairing Defect Outside Diameter (+) Out spec

Factor	Findings	The root of The Problem	Improvement Suggestions
Man	The operator does not ensure that tools work properly	Lack of operator awareness of the impact of inconsistencies on work	Training and outreach to all operators regarding consistency in work
Material	Material according to standards	-	Consistency ensures material suitability.
Machine	Machine Process Capability at the Attention level	Haste in setting up	Reviewed set-up time targets and carried out optimal standardization
Measurement	The caliper measuring instrument has a difference in readings	The use of the caliper is done intensively	A measuring tool or poka-yoke was created to reduce the use of calipers
Method	Spring Volume during the tempering over the process	The operator makes the transfer manually	Conveyor manufacture from coiling machine to tempering machine
Environment	Cleanliness of the work area	-	Consistently carry out 5S in the work area.

Conclusion

Based on the analysis of the results and discussion of the Pareto diagram, the most dominant type of defect is Outside Diameter (+) with a total of 3,197 pcs with a percentage of 44.9%, so this defect needs to be the main focus in improvement efforts. In the P chart, there is 1 data set that is out of control below the Lower Control Limit / LCL limit in the 9th data set, which then needs to be corrected. After revision 1, there was no data that was out of control. The findings of factors that cause Outside Diameter (+) defects are analyzed using a fishbone diagram to find the root of the problem. Factors that cause defects include the human factor, which is why the operator cannot ensure the tools work correctly. Measurement Factor: The caliper measuring instrument differs in readings: machine Factors, Capability Machine processes at the Attention level. Method factors include spring volume during the over-tempering process.

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