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ANALYSIS OF QUALITY IMPROVEMENT TO IMPROVE PRODUCTIVITY OF PISTON RING PVD WITH SIX SIGMA (DMAIC) APPROACH

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ABSTRACT---*PT. NT Piston Ring Indonesia is a manufacturing company that engages in the automotive sector especially in motor vehicle engine components. One of the products produced is Piston Ring. The problem facing the company today is how to improve and maintain product quality in order to minimize defective products that can cause harm to companies, especially on a large scale. This study uses the Six Sigma method as an improvement approach that aims to find and eliminate the causes of defective products that often occur. The stages used are the stages of DMAIC (Define, Measure, Analyze, Improve and Control). At the define stage it is known that there are 15 types of CTQ on the GD-HIGH S. Piston Ring PVD product model. Then at the measure stage it is known that the highest pareto defect diagram is on the type of hakuri defect with a total defect reaching 32.1% with attribute data using a control chart p for which most data are still out of control. DPMO value was 21.888 and sigma value was 3.52. Then proceed to the analysis phase for analysis using a fishbone diagram and FMEA process. Now we know the root cause corrective suggestions made to improve and reduce the number of defects that occur in the product Piston Ring PVD-HIGH GD models S.*

Keywords---*Six Sigma, quality, piston ring, DMAIC, FMEA.*

I. INTRODUCTION

Background

PT. NT Piston Ring Indonesia as "one of the automotive component manufacturing industries is striving to make continuous product and quality improvements so that it can compete in the domestic and global markets. Minimizing defects is a business that must be carried out continuously in terms of increasing productivity and quality of a product, therefore it is very important for PT. NT Piston Ring Indonesia applies one of the quality improvement methods that can help reduce defects in producing piston rings, although in reality there are always products that do not meet the expected specifications so that forced rejections are product. The company's target of the percentage of piston ring A12G PVD group defects in 2018 is a maximum of 20.35%, but the actual percentage of defective products from January to December 2018 is an average of 26.88%, meaning that the percentage of defective products is still above that of targeted at 6.53%. (Source: production report data 2018)."

Formulation of the Problems

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Formulation of the problems raised in this study are:

1. What critical factors that influence the emergence of defects in the product produced by the piston ring type PVD so it does not fit the desired quality target.
2. How to improve the quality of the PVD piston ring product in an effort to increase company productivity with the Six Sigma approach.

Research Objectives

Objectives of this research are:

1. Determine the critical factors (CTQ = Critical to Quality) that influence the emergence of defects in the products produced.
2. Measuring the ability of the process to produce quality products that meet specifications with the Six Sigma approach to increasing company productivity.

II. LITERATURE REVIEW

Basic Concepts of Six Sigma Six Sigma

Definition: Sigma (18th Greek alphabet) is "a statistical term to indicate standard deviation, an indicator of the degree of variation in a set of measurements or processes." In its business use, the word indicates defects in the output of a process, and helps us understand the extent to which the process deviates" from perfection. While "Six Sigma is a statistical concept that measures a process related to defects or damage. Achieving six sigma means that a process produces only 3.4 defects per million opportunities, in other words that the process runs almost perfectly. The higher the value of sigma obtained, the more perfect the process carried out by the organization. It should be noted that the range of sigma values used is 1 to 6.

Table 1 Relationship between six sigma and DPMO

Sigma Levels	Defect Per Million
1 Sigma	690.000
2 Sigma	308.537
3 Sigma	66.807
4 Sigma	6.210
5 Sigma	233
6 Sigma	3,4 (world class)

Source: (Pande & Peter, 2003)

Six Sigma Methodology (DMAIC)

The sequence of phases of activities to be carried out in accordance with the Six Sigma approach (DMAIC) is as follows:

- **a.** **Define** is "the first operational step in thequality improvement program six sigma. Namely defining actions (action plan) that must be done to implement improvements from each stage of the key business processes."
- **b.** **Measure** is the "second operational step in the improvement program quality six sigma. How to get "DPMO and sigma level for sigma attribute data calculation is as follows:"
- **c.** **Analyze** is the third operational step in Six Sigma.
- **d.** **Improve**, aims to develop and implement improvements to reduce DPMO and increase six sigma
- **e.** **Control** There are three main things that must be done in the step control, namely:

1) Conduct validation of the measurement system.

2) Determine the process capabilities that have been achieved now.

3) Implement process control plans.

III. RESEARCH METHODOLOGY

Following is an overview of research flow diagrams that generally describe the methodology or steps in solving problems that occur in companies with the DMAIC approach (Define, Measure, Analyze, Improve and Control).

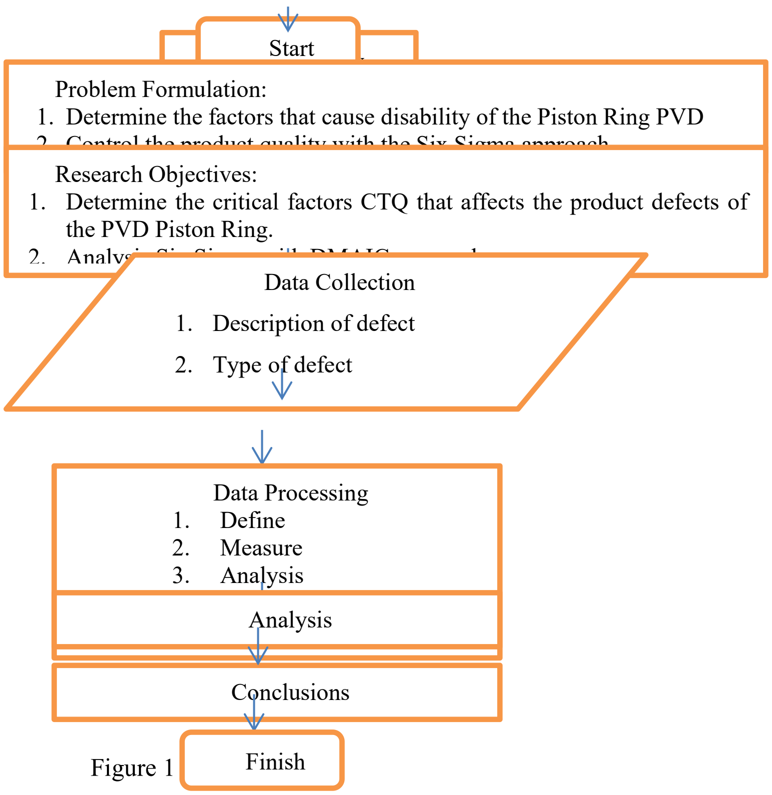

Figure 1

IV. RESULTS AND DISCUSSION

Define

In phase "define is also Key CTQ determinations are performed using Pareto diagrams. From the data obtained in the field in the achievement of the percentage of total defects (process defects + defects from inspection results) in 2018, the piston ring grouping A12G PVD is the grouping piston ring with the condition of achieving the worst percentage of defects in 2018 with an average defect value of 26, 9%."

Measure (Measurement)

At "this stage will be measured against the ability of the GD-High S piston ring production process. The steps taken are to measure the following process capability:"

1) Perhitungan Defect Per Unit (DPU).

$$DPU = \frac{\text{Total product defect}}{\text{Total product that is produce}} = \frac{129.979+90.050}{670.150}$$

2) Perhitungan Defect Per Oppotunity (DPO)

$$DPO = \frac{\text{Total product defect}}{} = \frac{220.029}{} = 0,02188$$

Total product x CTQ 670.150 x 15

3) Defect Per Million Oppotunity (DPMO)

DPMO = DPO x 1.000.000 = 0,02188 x 1.000.000 = 21.888

4) Mengkonversi nilai DPMO ke level sigma.

Konversi nilai DPMO ke level sigma dengan rumus pada MS excel :

Sigma score = **NORMSINV(1-DPMO/1.000.000)+1,5**

= NORMSINV(1-21.888/1.000.000)+1,5 **= 3,52 sigma**

Data Analyze Stage

1). Measurement of process stability

At "the define stage, it is known that the key CTQ is Hakuri defect, the next step is to measure the stability of the process by using the control chart for attribute data, namely the np-chart as follows:"

Determine UCL (upper limit) and LCL (lower limit),

$$S_p = \sqrt{\{P\ bar(1 - P\ bar)/n\}}$$

$$S_p = \sqrt{\{0{,}030\ (1 - 0{,}030)/8.544\}}$$

$$S_p = \sqrt{0{,}0291}/8.544 = 0{,}002$$

CL = P bar = 0,030

UCL = P bar + 3S_p = 0,030 + 3(0,002) = 0,030 + 0,006 = 0,036

LCL = P bar - 3S_p = 0,030 – 3(0,02) = 0,030 – 0,006 = 0,024

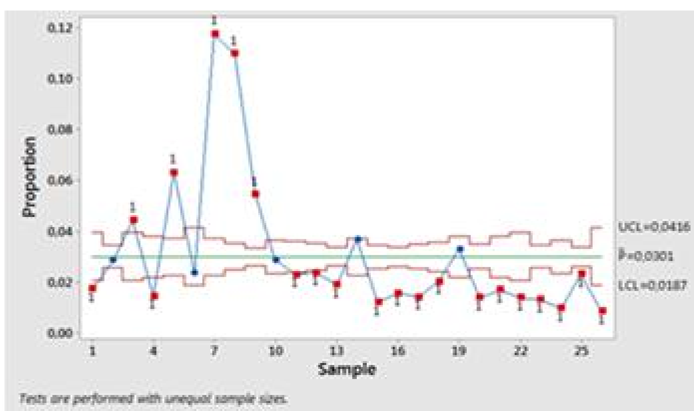

Figure 2 np-chart before stabilizing

Based on "Figure 2 above shows that the process is still not stable, then the next step is the process must be stabilized first by removing data that is out of control limits."

$$S_p = \sqrt{\{P\ bar(1 - P\ bar)/n\}}$$

$$S_p = \sqrt{\{0{,}0302\ (1 - 0{,}0302)/6.000\}}$$

$$S_p = \sqrt{0{,}0293}/6.000 = 0{,}0022$$

CL = P bar = 0,0302

UCL = P bar + 3S_p = 0,0302 + 3(0,0022) = 0,0302 + 0,0066 = 0,0368

LCL = P bar - $3S_p$ = 0,0302 – 3(0,022) = 0,0302 – 0,0066 = 0,0236

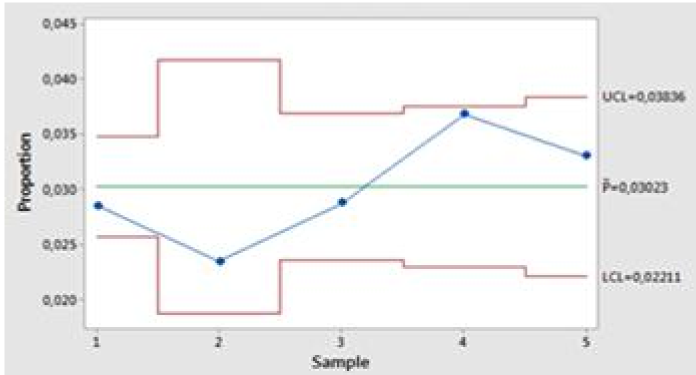

Figure 3 np-chart after stabilizing

From "the results of these calculations can be seen that the process is stable, then the next step is to calculate the capability of the process, to calculate the capability of the process in the attribute data there are 2 types of calculations namely the capability of the process used to measure the capability of the process of sigma based on the resulting process disability output (Cp) as well as the process capability index (Cpk) which is used to measure the ability of the process to determine the process capability index by using a conversion table using a process average shift approach of ± 1.5 sigma as presented in the table below. "

Table 2 Conversion of sigma levels

Level Sigma	Pergeseran proses ± 1.5 σ	
	Cpk	DPMO
3	0,5	66.807
4	0,833	6.210
5	1,167	233
6	1,5	3,4

Source: Mc Fadden, 1993[13]

The calculation of "process capability" is:

Cp = 1 - p bar = 1 - 0.30 = 0.70

The calculation "Process capability index (Cpk) is obtained from the results of the interpolation (equation) from table 2 sigma level conversion by referring to the sigma value which is at 3.52 sigma level."

$$\frac{3,52-3}{4-3} = \frac{x-0,5}{0,833-0,5}$$

$$\frac{0,52}{1} = \frac{x-0,5}{0,333}$$

x = (0,52x0,333)+0,5 = 0,67316

From the above Cpk value of 0.67316 it can be concluded that the ability of the GD-High S piston ring process is still less capable because the Cpk value is still <1.5, it is necessary to make efforts to improve quality towards the target expected by the company.

Analysis of Cause Effect Diagrams

The next step is to analyze the cause of the Hakuri flaw problem with a cause effect diagram analysis of the process that causes the Hakuri flaw. To find out what processes are related to the coating process (PVD coating) and cause the emergence of this hakuri defect, the following is the flow of the GD-High S PVD piston Ring production process. "

V. RECOMMENDATION

1) **Improvement of Fishbone Diagram Analysis**

Based on the results of "fishbone diagram analysis, several have been identified issues that need to be followed up by ensuring that problems that occur related to material factors, machinery, humans and methods must be improved to minimize the appearance of defects hakuri that occurs in the PVD process

2) **FMEA Improvement Process**

From the results of "FMEA analysis obtained the value of the level of importance of the RPN (Risk Priority Number) the highest which indicates that a failure mode is increasingly important to be addressed immediately, in this case there are three failures the mode that becomes the main priority is the process of DH (dry Honing), Washing and Sorting, while the level of importance is small shows that the level of a failure mode is not a priority for problem solving. Of the three main priorities that arise then corrective action that must be done is to review the effectiveness of the current SOP (Standard Operating Procedure) run and make the check sheet process in accordance with the standards the quality expected. "

3) **Control Stage**

At this stage "it is explained how to control improvements has been made in the improvement stage so that defects occur in the process making piston rings GD-HIGH S PVD can be minimized. As for control carried out more towards the control of the Machine, Material and working methodsHumans, here are the controls that need to be done: "

a. Implementation of Maintenance of PVD Coating machines including machinery its supporters are carried out according to a periodic engine maintenance schedule (preventive and predictive maintenance). The form of control that is carried out is monitoring the implementation of machine maintenance by making engine maintenance checksheet and engine failure history, controllinginventory of engine parts in accordance with the needs and age of life (life time spare parts) by making a spare parts checklist and control its inventory.
b. Review of SOP (Standard Operating Procedure) in one PVD process series including supporting processes: Dry Honing,Washing, Setting table, Coating, Unloading and Buffing process, for ensure the effectiveness of this SOP for preventing the onset of defects hakuri in the production process.
c. Ensuring that the process checksheet in the field is oriented quality control, controlled by the addition of critical check points on processes related to CTQ such as the Dry Honing process,wash and PVD Coating.
d. Clean the table set and jig the PVD process before usage, controlled with a cleaning aid and checksheet checked by the direct supervisor in the field.
e. Maintaining the quality conditions of tools and chemicals used in good quality conditions, controlled by examination aids and check sheets periodic chemical check sheets (daily/weekly/monthly) accordingly with an estimated life time (life time) from tools or chemicals the.

VI. CONCLUSION

Based on research conducted at PT. NT Piston Ring Indonesia concerning Quality improvement analysis to increase the productivity of PVD piston rings with the Six Sigma approach (DMAIC), the following conclusions can be drawn:

1) Based on the results of data processing and analysis found that there are fifteen critical quality characteristics (CTQ), all types of defects can be measured and the results can be seen in the pareto diagram showing the number of defects of each characteristic with the percentage of disability as follows: Hakuri 31,994 with a disability of 4 , 77%, Menokori 29,452 or 4.39%, Atari 22,452 or 3.35%, Kake 16,368 or 2.44%, Kizu 9,422 or 1.41% and other defects namely Sabi, Droplate, Sagari, kandai, henkei, ore , pinhore, katagiri, megawari and sonota of 20,341 or an average of 0.28% of the total total sample of 670,150 pcs GD-HIGH S piston rings during the 4-month period. From the results of the Pareto diagram and the importance rating, the key CTQ results obtained are Hakuri defects that have the highest level of product defects compared to other defects.
2) Based on the results of CTQ Hakuri analysis with causes effect analysis, it can be seen that the potential causes of GD-High S piston ring disability caused by several factors are as follows:
   a. Engine: lack of engine maintenance, high engine loading, less engine cleanliness, engine spare parts not available.
   b. Material: dirty processed goods, broken aids still in use, dirty aids, cleaning chemicals less suitable to use.
   c. Method: dry honing process is not perfect, washing is not clean, ring setting is not good, PVD coating occurs abnormally.
   d. Humans: The ability of operator skills is not the same, operators do not work according to SOP, fatigue or lack of concentration, lack of quality awareness level.

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