Analysis of Production Quality Control in Minimizing Product Defects with the Six Sigma Method (Case Study at PT. Jaykay Files Indonesia)

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Abstract - PT. JayKay Files Indonesia is a company engaged in the industry that produces files and drills. Where the products have been exported to various countries and the quality is well received by various overseas customers. PT. JayKay Files Indonesia is certified with ISO 9001:2008, OHSAS 18001:2007 and ISO 14001-2004 environmental management system. However, to maintain this quality, the company must control the existing defective products. Then the research was carried out using the Six Sigma DMAIC (Define Measure Analyze Improv Control) stage. And produced 4 (four) types of defects in the Define stage, with the calculation of the sigma value of 3.8 with 3.8% damage at the measure stage, then Analyze which occurs because there are several causes using a fishbone diagram, namely machine, human, method and environmental factors. At the improve stage, there are several recommendations for improvement so that for control, supervision is carried out at the dept. Quality control.

Keywords: Six sigma method, defect, production quality control

I. INTRODUCTION

In this industrial era 4.0, business movements are increasing rapidly. This has an impact on business competition that is getting higher and tighter in both the domestic market and the international market. Every business sector is required to always compete with other companies. One of the efforts to be able to excel in the competition or at least survive in the competition is to pay special attention to the quality of the products produced by the company.

According to Sofyan Assauri (in Hayu Kartika, 2013) control and supervision are activities carried out to ensure that production and operating activities are carried out in accordance with what was planned and if deviations occur, these deviations can be corrected so that what is expected can be achieved.

According to Bakhtiar et al (2013) quality control can be interpreted as "activities carried out to monitor activities and ensure actual performance".

Companies that implement quality control can be sure that the quality of the resulting production can also increase. Quality control can be interpreted as an effort made by the company to be able to reduce defective products in one production (Safrizal & Muhajir, 2016). One of the important criteria that must be considered by consumers in choosing a product is quality. A product is said to have high quality if it can meet the specifications desired by consumers without the slightest defect (Rimantho & Mariani, 2017).

According to Vincent Gasperz (2005:480), quality control is: "Quality control is the operational techniques and activities used to fulfill requirements for quality".

PT JayKay Files Indonesia is one of the stingy producers that still survives in this 4.0 industrial era. At this time PT JayKay Files Indonesia is faced with the problem of many defective products or there are many defects for slim taper products in the proving division. Until now PT JayKay Files Indonesia does not have the right solution to overcome the problem of defective products that occur. Therefore, PT JayKay Files Indonesia needs to improve quality control with the Six Sigma method, with the theme, "Analysis of Production Quality Control in Minimizing Product Defects with the Six Sigma Method".

II. RESEARCH METHODS

The implementation time of this practical work is from January to February 2020. The place where this research was carried out was at PT. JayKay Files Indonesia Semarang. The method used in the quality data processing process uses the Six Sigma method using the Six Sigma method (define, measure, analyze, and improve). is the theoretical basis in accordance with this research. The type of data used in this study is quantitative data which is data that can be calculated, namely data in the form of numbers and supporting information in the form of production cost data of PT JayKay Files Indonesia, which is primary data, namely data obtained from companies and interviews. directly with company employees who are considered related to this research.

III. RESULTS AND DISCUSSION

In the production of Slim Taper at PT. JayKay Files Indonesia found the following types of defects:

a. Forging Process (Broken Handle, Muntir Handle, Flat Handle)
b. Grinding (Hollow, Thick, Thin)
c. Cutting (chopping, Crooked, Not deep enough)
d. Proving (Seam/Laps, Broken Tang, Hollow, Size, Edge Damage, chopping, Level Out, Less Weight, Stamp NotVisible, Bend, Soft, Crack, Broken, Knocking, Dirty, Not Taking Prover, Pitting)

The next step is to determine the CTQ (Critical to Quality). The data used is the Quality Control Department data on the proving process which is the final stage before product packaging. Then determined and simplified CTQ in the proving process as Good Production and Reject. After determining the CTQ (Critical to Quality) then data is collected for 27 days in the proving process to determine the number of defects that occur in one day of the production process. Observations for 27 days can be seen in the table below.

Table 1. Production Results for January

Day	Production Quantity	Good condition		Reject Condition	
		Amount (Pcs)	%	Amount (Pcs)	%
1	20270	13058	64%	7212	36%
2	25721	21408	83%	4313	17%
3	17460	13951	80%	3509	20%
4	24436	21143	87%	3293	13%
5	23611	19481	83%	4130	17%
6	19776	15232	77%	4544	23%
7	21278	15843	74%	5435	26%
8	34221	29159	85%	5062	15%
9	37514	30433	81%	7081	19%
10	19878	15767	79%	4111	21%
11	25509	21455	84%	4054	16%
12	24698	20976	85%	3722	15%
13	33541	27862	83%	5679	17%
14	23101	18408	80%	4693	20%
15	19321	14934	77%	4387	23%
16	14532	12231	84%	2301	16%
17	12893	7314	57%	5579	43%
18	21440	16803	78%	4637	22%
19	36164	29843	83%	6321	17%
20	36195	29003	80%	7192	20%
21	22496	18826	84%	3670	16%
22	4266	3971	93%	295	7%
23	31044	25620	83%	5424	17%
24	34687	29219	84%	5468	16%
25	38296	28869	75%	9427	25%
26	30357	23536	78%	6821	22%
27	38948	34871	90%	4077	10%
total	691653	559216	80%	132437	20%

Source: Data Proving Slim Taper for January

Measure

At this stage, calculations are carried out to determine the value of DPMO and Sigma. Before that, a control chart is made by calculating the percentage of defects, CL (Control Limit), UCL (Upper Control Limit) and LCL (Lower Control Limit) using a p control chart.

P control chart has the benefit to help control the quality of production and can provide information about when and where the company should make quality improvements.

The steps for making the p control chart are:

a. Calculating Damage Percentage
   Description:
   np: the number of defects in the subgroup
   n: number of production in subgroup
   Subgroup: Day-
   Then the calculation of the data is as follows:
   Subgroup-1:
   Subgroup-2:
   Subgroup-3:
   Subgroup-4:
   Subgroup-5:
   Subgroup-6:
   And so on until the subgroup or day 27
b. Calculating the center line (CL)
c. Calculating the Upper Control Limit (UCL)
d. Calculating the Lower Control Limit (LCL)

The complete p control chart calculation results can be seen in the following table:

Table 2. Calculation of Control Limit P for January 2020 Periode

Day	Production Quantity	Number of Defects	Percentage of Disability (P)	CL	UCL	LCL
1	20270	7212	0,3558	0,1909	0,1998	0,1832
2	25721	4313	0,1677	0,1909	0,1988	0,1841
3	17460	3509	0,2007	0,1909	0,2004	0,1825

4	24436	3293	0,1347	0,1909	0,1990	0,1839
5	23611	4130	0,1749	0,1909	0,1992	0,1838
6	19776	4544	0,2283	0,1909	0,1999	0,1831
7	21278	5435	0,2544	0,1909	0,1996	0,1834
8	34221	5062	0,1479	0,1909	0,1979	0,1851
9	37514	7081	0,1883	0,1909	0,1976	0,1854
10	19878	4111	0,2068	0,1909	0,1999	0,1831
11	25509	4054	0,1589	0,1909	0,1989	0,1841
12	24698	3722	0,1507	0,1909	0,1990	0,1840
13	33541	5679	0,1522	0,1909	0,1979	0,1850
14	23101	4693	0,2032	0,1909	0,1992	0,1837
15	19321	4387	0,2271	0,1909	0,2000	0,1830
16	14532	2301	0,1568	0,1909	0,2013	0,1817
17	12893	5579	0,4328	0,1909	0,2019	0,1811
18	21440	4637	0,2336	0,1909	0,1995	0,1834
19	36164	6321	0,1751	0,1909	0,1977	0,1853
20	36195	7192	0,1987	0,1909	0,1977	0,1853
21	22496	3670	0,1631	0,1909	0,1993	0,1836
22	4266	295	0,0689	0,1909	0,2096	0,1734
23	31044	5424	0,1747	0,1909	0,1982	0,1848
24	34687	5468	0,1576	0,1909	0,1978	0,1851
25	38296	9427	0,2442	0,1909	0,1975	0,1854
26	30357	6821	0,2247	0,1909	0,1983	0,1847
27	38948	4077	0,1047	0,1909	0,1975	0,1855
total	691653	132436				
aver age	25617	4905			0,1994	0,1836

Source: Table of Calculation Results of the Control
Map Formula p

From the results of the calculation table above, Based on the table above, it is known that the highest probability of defects is on the 17th day of observation, which is 0.4328 and the lowest probability of defects is on the 22nd day, which is 0.0689. For the control limit, the result is 0.1915, the upper control limit is 0.1994 and the lower control limit is 0.1836. Next, a P Control Map is made which can be seen in the P control chart image on the next page.
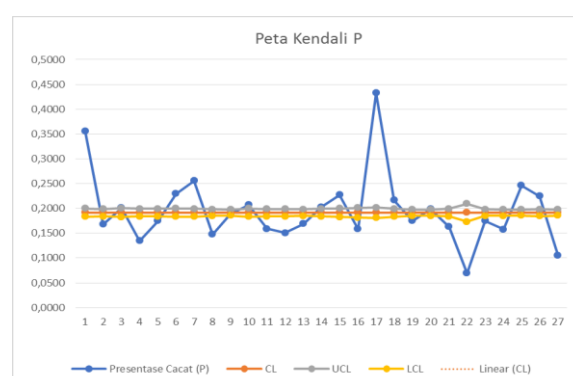

Figure 1. P Control Map

Based on the picture of the control chart p above, it can be seen that the data obtained are not entirely within the control limits that have been set, even many are out of the control limits, only 1 (one) point is within the control limits, so it can be said that the process is not under control. In the picture above, it can be seen that the 27 samples taken fall into the control limits. The highest value is on the 17th day and the lowest is on the 22nd day. This indicates that there is a high deviation. It states that quality control at PT. JayKay Files Indonesia needs improvement. Because there are very high and irregular fluctuating points which indicate that the production process is still experiencing deviations.

The next calculation is the measurement of sigma performance with the aim of knowing the current level of work (performance baseline). Performance baseline as a unit of measurement in Defect Per Million Opportunities (DPMO) or sigma capability level (Defrianto & Farida). The calculation stages start from DPO, DPMO, and Sigma Value. Defect Per Opportunities (DPO) is a measure of failure calculated in a six sigma quality improvement program which shows the number of defects or failures per opportunity.

$$Subgrup\text{-}1: DPO = \frac{7212}{20270 \times 16} = 0,022237$$

$$Subgrup\text{-}2: DPO = \frac{4313}{25721 \times 16} = 0,010480$$

$$Subgrup\text{-}3: DPO = \frac{3509}{17460 \times 16} = 0,012561$$

$$Subgrup\text{-}4: DPO = \frac{3293}{24436 \times 16} = 0,008423$$

$$Subgrup\text{-}5: DPO = \frac{4130}{23611 \times 16} = 0,010932$$

$$Subgrup\text{-}: DPO = \frac{4544}{19776 \times 16} = 0,014361$$

And so on until the 27th subgroup

Usually this DPO when associated with a constant of 1,000,000 will become DPMO (Defect Per Million Opportunities) with the formula:
DPMO = DPO x 1.000.000
The DPMO value is converted to a sigma value using Microsoft excel with the calculation formula:
DPMO Value Conversion =
NORMSINV((1,000,000-DPMO)/1,000,000)+1,5
The following is a table of the results of the calculation of DPO, DPMO and Sigma Value:

Table 3. Calculation of DPMO Value & Sigma Value

No	Production Quantity	Number of Defects	Probability of Disability (p)	DPO	DPMO	Sigma Value
1	20270	7212	0,3558	0,022237	22237	3,5
2	25721	4313	0,1677	0,010480	10480	3,8
3	17460	3509	0,2010	0,012561	12561	3,7
4	24436	3293	0,1348	0,008423	8423	3,9
5	23611	4130	0,1749	0,010932	10932	3,8
6	19776	4544	0,2298	0,014361	14361	3,7
7	21278	5435	0,2554	0,015964	15964	3,6
8	34221	5062	0,1479	0,009245	9245	3,9
9	37514	7081	0,1888	0,011797	11797	3,8
10	19878	4111	0,2068	0,012926	12926	3,7
11	25509	4054	0,1589	0,009933	9933	3,8
12	24698	3722	0,1507	0,009419	9419	3,8
13	33541	5679	0,1693	0,010582	10582	3,8
14	23101	4693	0,2032	0,012697	12697	3,7
15	19321	4387	0,2271	0,014191	14191	3,7
16	14532	2301	0,1583	0,009896	9896	3,8
17	12893	5579	0,4327	0,027045	27045	3,4
18	21440	4637	0,2163	0,013517	13517	3,7
19	36164	6321	0,1748	0,010924	10924	3,8
20	36195	7192	0,1987	0,012419	12419	3,7
21	22496	3670	0,1631	0,010196	10196	3,8
22	4266	295	0,0692	0,004322	4322	4,1
23	31044	5424	0,1747	0,010920	10920	3,8
24	34687	5468	0,1576	0,009852	9852	3,8
25	38296	9427	0,2462	0,015385	15385	3,7
26	30357	6821	0,2247	0,014043	14043	3,7
27	38948	4077	0,1047	0,006542	6542	4,0
Total	691653	132437	5,292977			
average	25617	4905	0,1960	0,0123	12252	3,8

In the table above, it can be seen that the production of Slim Taper at PT. JayKay Files Indonesia has an average production rate of 25617 pcs per day with an average defect or damage rate of 4905 Slim Tapers per day or a probability of 0.1960. The DPMO value is 12252, which means that the probability of damage per 1 million units is 12252. For the sigma value, the result is 3.8, which means that in each production process there will be no defects or damage of more than 3.8%. Based on these results it can be seen that PT. JayKay Files Indonesia needs to improve the production process so that the level of defects or damage can be minimized. The following is a table of the level of achievement of the sigma value.

Table 4. Level of Achievement of Sigma Nilai Value

Sigma Achievement Level	DPMO
1-Sigma	691.462
2-Sigma	308.538 (Indonesian industry average)
3-Sigma	66.807
4-Sigma	6.210 (USA industry average)
5-Sigma	233 (Japanese industrial average)
6-Sigma	3.4 (World class industry)

Analyze
This stage is carried out by analyzing Pareto diagrams based on data that has been processed to determine the percentage of types of defective products and the order of types of damage that occur from the lowest to the highest in the Slim Taper production process at PT. JayKay Files Indonesia. The following is a table for calculating the percentage of types of defects:

Table 5. Calculation of the Percentage of Types of Defects

Jenis Cacat		Frekuensi	Presentase	Akumulasi
Keterangan	Simbol			
Seam/Laps	A	54	0,04%	0,04%
Broken Tang	B	5934	4,48%	4,52%

Hollow	C	1073	0,81%	5,33%
Size	D	2581	1,95%	7,28%
Edging Damage	E	17094	12,91%	20,19%
Chopping	F	11113	8,39%	28,58%
Level Out	G	12727	9,61%	38,19%
Less Weigth	H	288	0,22%	38,41%
Stamp NotViasible	I	1662	1,25%	39,66%
Bend	J	7863	5,94%	45,60%
Soft	K	17995	13,59%	59,19%
Crack	L	28012	21,15%	80,34%
Broken Knocking	M	643	0,49%	80,82%
Dirty	N	14016	10,58%	91,41%
Not Taking Prover	O	4065	3,07%	94,48%
Pitting	P	7315	5,52%	100,00%
Total	16	132436	100,00%	

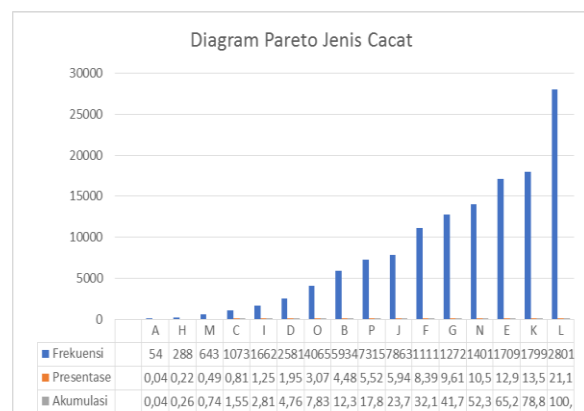Source: Results of proving data for January

Figure 2. Pareto Chart

From the Pareto diagram above, it can be seen that the type of defect L (Crack) is the type of defect with the highest percentage of 21.15%, the second is k (Soft) with a percentage of 13.59% and the third is E (Edging Damage) with a percentage of 12, 91% and so on as in the table above. After knowing the type of defect, the next step is to identify the cause of the type of defect using a fishbone.

There are four main causes of several types of defects that can occur due to machine, human, method and environmental factors. The following is an explanation of each of the factors that cause defects:

1. Machine
Machine factors that affect defective products are matters relating to the use of equipment or machines and their reusability such as the age of the machine which is no longer economical and the lack of maintenance for machine maintenance.

2. Man
Human factors are related to labor or personnel aspects such as lack of skills, lack of experience, and physical fatigue.

3. Method
Factors regarding work methods and procedures that can result in defective products include SOP errors and lack of training.

4. Environment
Work environment factors also affect the quality of the product. A good environment will make workers more comfortable and minimize defective products. Environmental factors that affect, among others, noise, and vibration.

Improve

At the improve stage, recommendations for improvement of each cause of defects that have been made through fishbone diagrams are given. The following are recommendations for improvements that can be made by PT. JayKay Files Indonesia in an effort to improve the quality of Slim Taper products:

Table 6.Recommendations for Improvement of each Cause of Disability

No	Causes of Defects	Recommendations Repair
1	Lack of training	Hold training activities or workshops related to the work to be carried out
2	SOP Error	Conduct regular evaluations if necessary changes or adjustments to SOPs
3	Fatigue	Optimal work and rest time planning
4	Less Skilled	Setting worker acceptance standards Do more intensive training
5	Lack of experience	
6	Machine Life	Carry out routine checks regarding machine effectiveness
7	Less Maintenance	Schedule maintenance on a regular basis
8	Noise	Using lighting standards according to the regulation of the Minister of Manpower No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment
9	vibration	

Control

The last stage is controlling the improvement recommendations that have been given. Supervision needs to be carried out to see if there are differences in the quality of Slim Taper before and after the implementation of several recommendations. PT. JayKay Files Indonesia, especially the Quality Control Department, tries to implement some of the

recommendations given so that the increase in sigma value can be achieved so that the quality of Slim Taper products at PT. JayKay Files Indonesia has increased and the percentage of defective products can be reduced.

IV. CONCLUSIONS AND SUGGESTIONS
Conclusion
1. The results of the calculation of the quality control of Slim Taper products at PT. JayKay Files Indonesia with the Six Sigma method:
   a. Based on the processed data, the results of the DPMO calculation are 12252, which means that there is a probability of a defective product of 12252 out of one million possibilities and a sigma value of 3.8 is obtained which means that in each production process there will be no defects or damage of more than 3 ,8%.
   b. The types of damage or defects that often occur in the production of Slim Taper PT. JayKay Files Indonesia is caused by Crack as much as 21.15%, the second is Soft with a percentage of 13.59% and the third is Edging Damage with a percentage of 12.91%.
2. The application of the six sigma method in calculating the quality control of Slim Taper products produces complete, precise and accurate data according to the data needs of the Quality Control department.

Suggestions
1. Companies need to use the six sigma method to be able to find out the types of damage that often occur and the factors that cause it. Thus the company can immediately take preventive action to reduce the occurrence of product defects.
2. Based on the analysis using the six sigma method that has been carried out, the company can make quality improvements by focusing on repairs to types of damage that have a large or dominant number in production, which are caused by factors such as; people, machines, methods, and the environment.

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