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PROPOSED QUALITY IMPROVEMENT OF ACRYLIC RESIN PRODUCTS WITH *SIX SIGMA* (AT PT. XYZ)

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ABSTRACT

PT. XYZ is a manufacturing company that produces various types of resins. One of them is acrylic resin, acrylic resin is the raw material for loading solvent base paints such as those used in the automotive paint manufacturing process. In acrylic resin, defects are usually found such as dirty resin, yellow resin color and rust drum. This study aims to determine the value of the sigma level on acrylic resin products before repair, analyze the factors that cause defects in acrylic resin products and provide suggestions for improvements with the Six Sigma approach. So that defects that occur in acrylic products can be reduced or even eliminated, With a six sigma approach in analyzing and calculating data using the DMAIC concept (define, measure, analyze, improve and control), the total acrylic resin defects in the last six months have an average by 8.94% with a type of gross resin defect of 89.88%, drum rust of 95.80% and yellow resin color of 100.00%. While the average sigma value on acrylic resin before repair was 3.15 with DPMO damage of 81,636 for a million productions. Based on the fishbone diagram, the causes of dirty resin defects, yellow resin color, rust drums are from human factors, materials, machines, methods and the environment. Based on the 5W + 1H method, suggestions can be given to companies in the form of periodic checks on machines, making a schedule for cleaning the production area, holding training or training for employees and carrying out supervision from superiors.

Keywords: Quality Control, Six Sigma, DMAIC, and 5W+1H

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1. INTRODUCTION

PT. XYZ was founded in 2011 which is located in Cikande Modern Industrial Estate, Serang Banten. PT. XYZ is a company that produces resins for *coatings* (paint raw materials). Resin is a polymer made from chemicals and a series of reactors that use high temperatures and pressures, for the formulation the use of resin in a paint can reach 10 to 50 percent. In the manufacture of resin PT. XYZ produces four types of resins, namely alkyd resins, amino resins, acrylic resins and modified resins. This research is focused on acrylic resin where the acrylic process itself produces defective products such as dirty, rust drum and yellow resin color. This reduces the targeted process results and makes customers wait for the requested product. To improve the quality of PT. XYZ uses the Six Sigma with the DMAIC concept (Define, Measure, Analyze, Improve, Control). Six Sigma is a structured method used to improve processes and is focused on reducing defective products beyond specifications using statistics and problem solving tools intensive

PT. XYZ has a policy that every product that has been processed by production will be checked by the Quality Control with standard parameters, namely checking non volatile, viscosity, acid value, color and appearance .'s request criteria customer For this reason, supervision and action are needed so that the production process runs well without any defects that are produced.

2. METHODS

As described in the introduction, this study uses a Six Sigma approach with data analysis techniques using the define-measure analyze-improve-control (DMAIC) stage. In the DMAIC stage, the quality of the process is improved by following a structured method in the steps that have been defined. The following steps are carried out as follows:

A. Define Phase

At this stage the identification of the overall production process at PT. ZYX. Identification is done by looking directly at the situation in the field plus interviews with the head of production and the quality control (QC) department. This identification is illustrated using a supplier-input-process output-customers (SIPOC) diagram which is a process map to identify important aspects of the existing process (Borror, 2009).

B. Measure

Stage This measurement stage is the stage of measuring the level of defect and performance level by measuring the DPMO value and sigma value in the acrylic resin product.

C. Analyze

Stage The analysis stage is the stage of finding and determining the cause of all defects in acrylic resin products. The initial step taken at this stage is to create a Pareto diagram to show the cumulative percentage of all types of defects in order to facilitate the analysis process.

D. Improve Stage

In the improve stage which is a follow-up to the analyze stage. At this stage is the provision of solutions or recommendations for improvement to PT. XYZ to the problems that have been identified and analyzed from problems that have occurred in the company. The improvements carried out occurred on dirty resin, rust drums and yellow resin color using the 5W+1H (What, Why, Where, When, Who, and How) design stages.

3. RESULTS AND DISCUSSION

3.1. Findings

In this study, the data collection used was primary data and secondary data. Primary data is obtained from company history for the period July to December 2021. While secondary data is obtained from interviews, observations and documentation in the field. The following is the

acrylic resin production data along with the defect data *listed* in the table below.

Table. 1

No.	Products Acrylic	Total Production (kg)	Total Defects (kg)	% Defects
1	36X1	111.124	12.992	11,69
2	36X2	26.244	400	1,52
3	36X3	2.345	0,0	0,0
4	36X4	5.078	278	5,5
5	36X5	1.112	0,0	0,0
6	36X6	625	0	0,0
7	36X7	614	0	0,0
8	35X1	5.643	106	1,88
9	35X2	2.124	0	0,0
10	35X3	1.161	0	0,0
11	34X1	6.551	992	15,1
12	34X2	616	0	0,0
Total		163.237	14.768	

Acrylic Resin Production Data and Defect Data for the Period July – December 2021

In the table above is the number of defects in acrylic resin products from July to December 2021 in certain defect categories to the total number of defective products. In the next stage, data processing is carried out using a six sigma approach with DMAIC analysis techniques. The first stage is the define stage where the definition of the production process of PT. XYZ. The following is a SIPOC diagram of the acrylic resin production process.

4.2.1.4 SIPOC diagram of acrylic resin manufacture.

Table 2.

S Supplier	I Input	P Process	O Output	C Customer
Supplier Manufacturing Warehouse	Material A Material B Material C Material D Material E	Heating Dropping Holding Cooling Adjustment Packaging	Acrylic resin	paint factory Solvent base

Based on observations, defective products were obtained such as: dirty resin, rust drum and yellow resin color, which often occurs during resin processing and packaging carried out by production.

The next stage of the measure stage is to measure the level of defect and the level of performance by measuring the value of DPMO and sigma values on the results of acrylic resin products.

Table 3.

No.	Month	Total Production (kg)	Total Defects (kg)	% Defects
1	July	33.054	1.854	5,61
2	August	27.211	8.770	32,23
3	September	36.337	1.783	4,91
4	October	32.535	885	2,72
5	November	2.781	105	3,78
6	December	31.360	1.371	4,37
Total		163.278	14.768	53,61
Average		27.213	2.461	8,94

Monthly Total Production Data and Acrylic Resin Defect Data for the Period July – December 2021.

From the data above, the P control chart is used to measure the proportion of defects and continues to calculate the CL value, LCL and UCL. After the calculations are carried out starting from July to December 2021, the table can be compiled as follows:

Table 4.

Month	Amount Production (kg)	Amount Defect (kg)	P	CL	LCL	UCL
July	33.054	1.854	0,056	0,0904	-0,02608	0,04041
August	27.211	8.770	0,322	0,0904	-0,02608	0,04041
September	36.337	1.783	0,049	0,0904	-0,02608	0,04041
October	32.535	885	0,027	0,0904	-0,02608	0,04041
November	27.81	105	0,038	0,0904	-0,02608	0,04041
December	31.360	1.371	0,044	0,0904	-0,02608	0,04041
Total	16.3278	14.768				

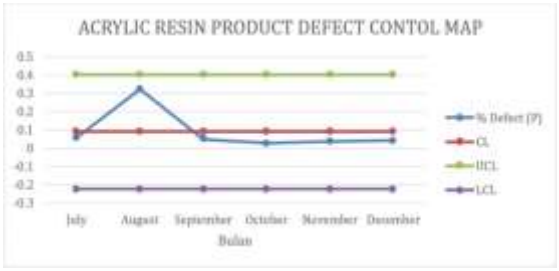

Figure 1. Chart P Control Map Data Defect Acrylic Resin Producrs (Source: Processing Data, 2022)

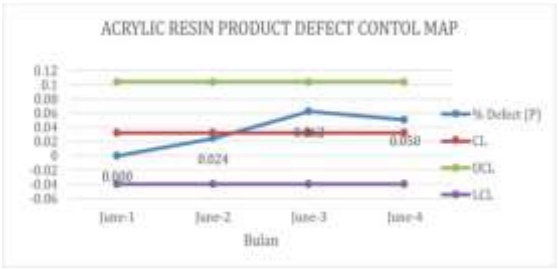

Figure 2. Chart of Controlled P Map Acrylic Resin Products (Source: Processing Data, 2022)

The following is an example of the calculation of control maps P, CL, LCL, and UCL as follows:

- Determine the value of P

$$P = \frac{\sum np}{\sum n}$$

$$PJuly = \frac{\sum np(july)}{\sum n\,(july)}$$

$$PJuly = \frac{1.854}{33.054} = 0{,}056$$

- Central Line of Central Limit (CL)

$$Cl = \frac{\sum np}{\sum n}$$

$$ClTotal = \frac{\sum np(total)}{\sum n\,(total)}$$

$$ClTotal = \frac{14.768}{163.237} = 0{,}090$$

- Lower control limit, is the lower boundary line on the control map

$$LCLJuly = CL - 3\sqrt{\frac{CL(1-CL)}{n(1,2,3,\ldots(n))}}$$

$$LCLJuly = 0{,}090 - 3\sqrt{\frac{0{,}090\ (1-0{,}090)}{33.054}} = -0{,}223$$

-Upper control limit, is the upper boundary line on the control map

$$UCLJuly = CL + 3\sqrt{\frac{CL(1-CL)}{n(1,2,3,\ldots(n))}}$$

$$UCLJuly = 0{,}090 + 3\sqrt{\frac{0{,}090\ (1-0{,}090)}{33.054}} = 0{,}4041$$

Measurement of Sigma Level and DPMO Calculation

The steps to calculate the velue of the DPU, DPMO, and Sigma value in the process of acrylic production.

- Calculate the value of defect/units (DPU) with the following calculations.

$$DPU = \frac{Total\ Defect}{Total\ Production}$$

$$DPU = \frac{1.854}{33.054} = 0{,}056$$

- The proceed with the calculation of the DPMO value as follows.

$$DPMO = \frac{Total\ Defect}{Total\ Production\ x\ CTQ}\,x1.000.000$$

$$DPMO\ July = \frac{1.854}{33.054 \times 1}\,x1.000.000$$

$$DPMO\ July = 56.090$$

Table 5.

Month	Total Production (kg)	Total Defects (kg)	CTQ	DPU	DPMO	Sigma
July	33,054	1,854	1	0,056	56,090	3.09
August	27,211	8,770	1	0,322	322,296	1 ,96
September	36,337	1,783	3	0.049	16,356	3.64
October	32,535	885	2	0.027	13,601	3.71
November	2,781	105	1	37,756	31,360	3.28
December	43,718	1,371	1	0.044	27,213	3.21
Average	81,636	2,461	1.50	0.09	0.038	3.15

Table 6.

Type of Defect	Amount (kg)	Frequency Cumulative	of Defect (%)	Percentage Cumulative
Gross	13,273	13,723	89,88%	89,88%
Drum Rust	874	14,597	%	95.80%
Yellow	621	15,218	4.21%	100.00%
Total	14,768			

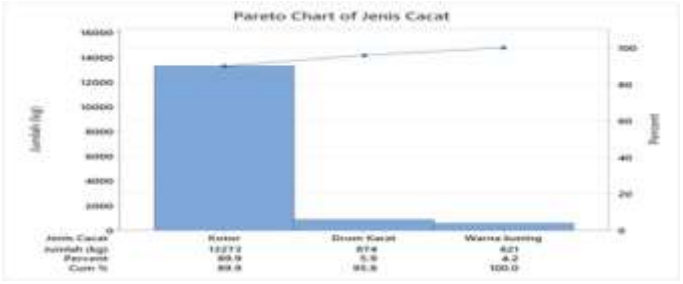

Figure 2. Pareto Diagram of Defects in Acrylic Resin

Based on Pareto dabove, it can be seen that the types of defects that often occur in each acrylic

resin process are 13,273 kg of dirty resin with 89,9% defect percentage, 874 kg of rust drum with 5,9% defect percentage, 621 kg yellow resin color with 4 defects percentage, 2% after making a pareto diagram, then proceed with making a fishbone facilitate the analysis process in determining the cause of acrylic resin product defects. Based on interviews that have been conducted with the Head of Production and production operators, the causes of defects in acrylic resin products can be identified as follows:

1. Dirty Resin

Figure 3. Fishbone Dirty Resin Defects (Source: Data Processing, 2022)

2. Resin color yellow

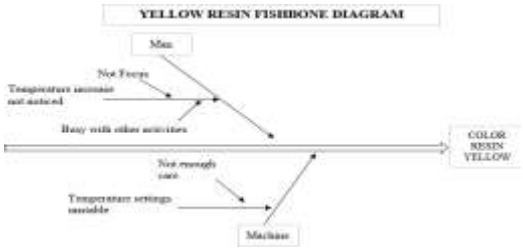

Figure 4. Fishbone Defective Yellow Resin (Source: Data Processing, 2022)

3. Drum Rust

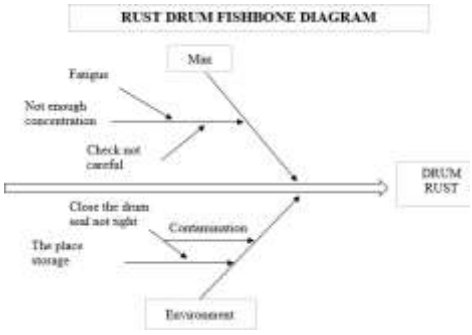

Figure 5. Fishbone Defective Drum Rust (Source: Data Processing, 2020)

- Improve

Planning at the repair stage can use the following steps: Designed the 5W+1H Method (*What, Why, Where, Who, and How)*. The following table describes the plan for repairing defects in the form of dirty resin using the 5W+1H Method.

4. CONCLUSION

Based on data processing and analysis that has been carried out If done, the following conclusions can be drawn:

Table 7.

Periode	Type of defect	Amount (kg)	Cumulative percentage	Defect avarage	Avarage DPMO	Avarage Six sigma
Juli - December 2021	Dirty	13.273	89.88	8,94	81.636	3,15
	Rust drum	621	95.80			
	Resin color yellow	874	100.00			
June 2022	Dirty	1.400	9.48	0,80	28.081	3,41

1. The table above describes a change in defective products, where before repairs were made, the value of acrylic resin production defects in the July-December 2021 period had an average of 8,94% with the most types of defects, namely dirty resin as much as 13,273 kg with a percentage of 89.99%, yellow resin with a percentage of 874 kg with a percentage of 5.92% and drum rust with a percentage of 621 kg with a percentage of 4.21%. While the average value of sigma before repair is

3.15 with a possible damage (DPMO) of 81,636 for a million productions. The results of the improvements that have been made with the proposed target that have been given can be applied by the company with a sigma value of 3.41 and the DPMO result of 28,081, showing that acrylic resin products have met the standard criteria applied by the company.

2. The causes of defects in acrylic resin products in the form of dirty resin are caused by human factors, machine factors, method factors, and environmental factors, yellow resin color defects are caused by human factors, material factors, and machine factors, while drum rust defects are caused by human factors and environmental factors. Proposed improvements that can be made in an effort to reduce the occurrence of

defects in acrylic resin products such as dirty resin defects, namely replacing filters, carrying out routine maintenance, using study lamps so that when making sure the resin is clean or still dirty

1. Plans for Repairing Dirty Resin Defects

Table 8.

No.	Causative Factor	What	Why	Where	When	Who	How
1	Man	Checkingg clarity not optimal	There is not SOP yet	Packing area	While doing filtration process and packaging	Production operator	Checking clarity every 15 minutes before the packaging
		Lack of supervision				Leader or head of production	Accompanied or ask directly to the leader or head of the from impurities
2	Machine	Lights in the area lack packing bright	There isn't any additional lights	Packing area	While doing filtration process and packaging	Production operator	The existance of LED lights at packaging area
		Filter is broken	Lack of care				Procurement of filters when the packaging takes place with the filter mess
3	Method	There is not SOP yet	Only depend on feeling	Packing area	While doing filtration process and packaging	Production operator	Make soup and give the training to employees so that the SOP is carried out
4	Environment	Dirty packaging area	Evety time you finish the process, you rarely clean up	Packing area	While doing filtration process and packaging	Production operator and office boy	Make a cleaning schedule for OB on duty in the production area
		OB rarely clean in production					

2. Yellow Resin Color Defect Improvement Plan

Table 9.

No.	Causative Factor	What	Why	Where	When	Who	How
1	Man	Temperature increase not noticed	Busy with other activities	Process area	During the process take place	Production operator	Record and monitor each recognize the temperature that occurs during the process
2	Machine	Temperature settings unstable	Direct used when process	Process area	From the beginning of the process until the	Production operator	Before use calibration first

3. Drum Rust Defect Repair Plan

Table 10.

No.	Causative Factor	What	Why	Where	When	Who	How
1	Man	Check is not careful	Fatigue	Production area	When drum already filled with resin packaging results	Production operator	Before the drum is filled with the resin another check by the package operator
2	Environment	Storage place	Contamination	Production area	During the warehouse prepare drum for pack	Production and warehouse operator	Each warehouse prepares drums for packaging, cover the drum seal in a tight state
		Drum seal close is not tight					

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