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EXPERIMENTAL DESIGN MODEL TO REDUCE THE NUMBER OF EMULSION POLYMER PRODUCTS REJECT AT PT. AHP

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Abstract.
PT AHP is a chemical industry with the main product of emulsion polymer. The problem faced is the inconsistent product quality, especially the GP 31XXC product. PT AHP must immediately take action to reduce problem products, and increase productivity. The purposeof this study was to identify the cause of the problem, provide suggestions for improvement, and find out the decline in the no-good GP 31XXC product after repairs were made. This study uses an experimental design method, with SPSS17.0 statistical analysis. The results of the application of the experimental design show that the cause of the problem with the GP 31XXC product is the technical production process, namely, the cooling temperature parameters, feeding starting temperature, and inappropriate observation time. Proposed improvements made are changes to standardization and validation of temperature and time parameters. The cooling temperature is to 95°C - 96°C, the starting temperature is feeding on 80°C to 89°C, and the observation time is from 90 minutes - 120 minutes to a minimum of 93 minutes. The decline in the GP 31XXC no-good product after repairs were made was 90%, from 10 batches to 1 batch.

Keywords: *chemical industry, emulsion polymer, quality, experimental design.*

Introduction

PT AHP is a manufacturing industry whose main products are emulsion polymer, textile sizing powder, alkyd resins, acrylic resins, and car care products. To be able to produce consistent product quality can be achieved with a series of appropriate and effective process controls. Based on observations, it is known that there are still a large number of no-good products.

Table 1. *No-good product data 2019 – 2021*

No	Years	Reject Batch	GP31XXC Reject Batch	Percentage
1	2019	104	15	14%
2	2020	123	17	14%
3	2021	32	10	31%

Source: PT. AHP (2021)

Based on Table 1. GP 31XXC reject products have increased. In the period 2019 and 2020, GP 31XXC products accounted for 14% of the batch of total no-good products. Then the 2021production GP 31XXC accounted for 31% of the total batch of no-good products.

Table 2. *No-good batch measurement results*

Batch	%TS Initial (32.19-33.19)	%TS End of Aging (>=57)	%TS After P (>= 55)	%TS Final (55-57)	Particle size (0,210-0,235 µ)	Appearance	Status
876001	33.12	55.33	55.58	55.58	0.3170	White	NG
876002	32.83	56.96	56.30	56.08	0.2429	White	NG
876004	32.12	57.71	56.35	55.91	0.2487	White	NG
876005	31.89	56.98	57.57	56.34	0.2606	White	NG
876006	32.03	56.65	56.40	56.30	0.2603	White	NG
876007	32.18	57.68	56.33	55.74	0.2476	White	NG
876008	31.18	56.68	56.13	56.00	0.2487	White	NG

876010	30.74	56.60	55.62	55.77	0.2441	White	NG
876012	31.29	56.67	56.49	56.49	0.2545	White	NG

Based on table 1 and table 2, PT AHP should take quick action to deal with no-good products, and increase productivity. Corrective actions need to be taken because the target for no-good products in the last three years has fluctuated, so the improvements made do not take place continuously. To find out the root of the problem above, we need an appropriate methodto be able to find out the root of the problem caused by the appearance that is not up to standard, as well as looking for alternative actions to reduce the level of no-good products in this company so that the target for no-good products can be achieved with permanent and continuous improvements. continuously.

The type of problem that often occurs in GP 31XXC products is a mismatch in appearance,which is white while the standard is milky white to bluish. The appearance obtained is influenced by the particle size value, if the particle value is more than the standard, the appearance is not standard, namely white. If this problem occurs, it is necessary to carry out a rework process so that the product can be adjusted to the standard. For this reason, the author intends to implement improvements by applying the basic steps of experimental design at the stage of the GP 31XXC product process with the aim of reducing the level of no-good products and hoping that it will have a positive impact on the company.

The aims of this research is to Identify the biggest possible cause of the problem with the GP 31XXC product, Provide suggestions for improvement with the aim of reducing the level of no-good GP 31XXC products, and knowing the problem of the GP 31XXC product declineafter repairs were made with the experimental design method.

Results

This section describes the initial data collection of the GP 31XXC production process. Researchers took data on the production process carried out at PT AHP. The order of work, work steps, and how long the production process takes GP 31XXC. In the production process of the GP 31XXC, the process operator is provided with a work instruction sheet or generally called work instructions. Work instructions contain instructions and work steps and process parameters. Each production operator follows the instructions contained in the description of the work instructions and product formulas. However, in the production process, there are still process discrepancies or problems with the final product. The discrepancies found in the final product are viscosity, pH, appearance, product application, and product particle size.

The initial data collection of the suitable and unsuitable GP 31XXC production process was taken randomly to analyze the problem. This data will be used as a reference forcomparison of the actual process. GP 31XXC process data collection by searching for past data stored in the production and quality control data files. Looking to collect and summarize other data related to the production process of the no-good GP 31XXC.

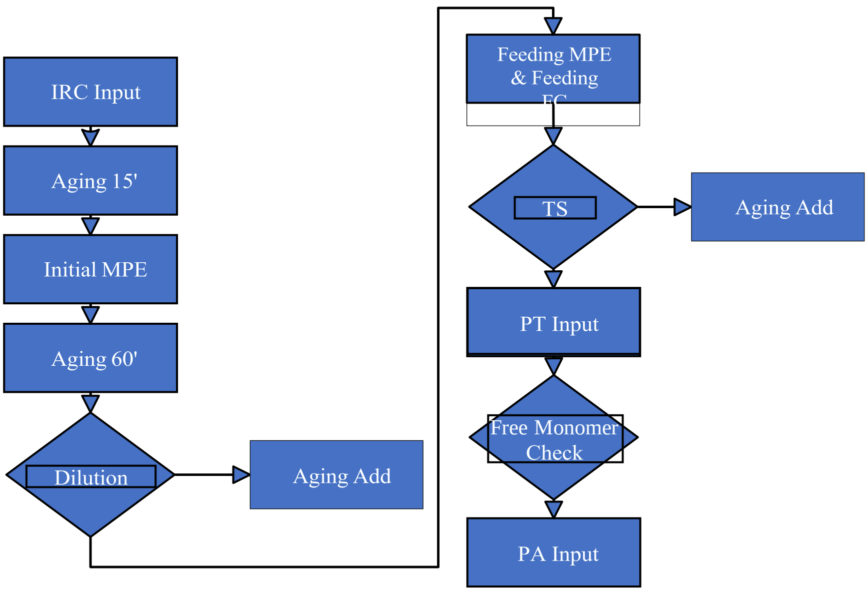

Figure 1. *GP 31XXC process flowchart*
Source: PT. AHP (2021)

Table 3. *Physical properties and aplication test*

Batch	Catalis Initial Temp(°C)	MPE Initial Temp(°C)	Feeding Start Tempt(°C)	*Cooling* Temp (°C)	Catalis Initial RPM	MPE Initial RPM	Feeding Start RPM	Catalis Initial Time (Minuts)	MPE Initial Time (Minutes)	Feeding Start Time (Minutes)
HA876001	79.3	78.7	89.6	93.0	23	27	23	10	12	93
HA876002	77.5	76.8	90.4	91.5	23	27	25	10	12	95
HA876004	77.6	77.2	85.0	93.8	23	25	25	10	12	94
HA876005	77.3	76.8	91.7	92.0	23	25	23	10	12	115
HA876006	77.1	76.9	79.9	92.0	23	27	23	10	12	98
HA876007	78.2	77.8	72.6	92.0	23	27	23	15	17	115
HA876008	77.7	77.6	85.9	93.0	23	27	23	10	12	98
HA876010	78.4	77.7	86.1	93.0	23	27	23	10	12	88
HA876012	76.0	75.7	88.2	90.2	23	27	23	10	12	93

Source: PT. AHP (2021)

a. GP 31XXC Problem Analysis

Analysis of the problem in this study was carried out using the 5 why method to find outthe causal relationship that became the root cause of the problem of product appearance discrepancies that emerged. The factors in table 4 are very influential on the results of the process. Based on the 5 why analysis that was reviewed, problems were found in the environment, machines, methods, and humans. However, the problems found can be resolved immediately, except for the method, namely the technical process method. So it is necessaryto take corrective action, namely validation and standardization of technical processes. However, to know in detail the technical parameters of the process that affect the problems that occur, further analysis is needed using failure mode and effect analysis (FMEA).

Table 4. *GP 31XXC Analysis problem*

Faktor	*Why*1	*Why*2	*Why*3	*Why*4	*Why*5	Action
Environment	Dirty reactor	Leftovers from previous products	Non-standard washing method	Non-standard cleaning tools	*Different cleaning operator skills*	Standardizationof cleaning methods, tools and operators
Machine	Reactor problem	Vibrating agitator	Mixing is not optimal	Unstable rpm rotation and noise	Teflon axle is thinning due to erosion	*Preventive Maintenance routine*
Method	Formula	Process technique is not detailed	Process parameters do not match	temperature and time	Improved temperature and time parameters	Validation and Standardization
Man	Not all operator process technical according to standard	Skills are not the same	Knowledge and not the same experience	Socialization of work instructions	Provided internal training	Operator assessment
Material	Main and supporting raw materials	No change in quality	No change in quality	No change in quality	No change in quality	No change in quality

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Table 5. *FMEA Analysis problem*

No	Process Parameter	Root Cause	Problem Effect	S	O	D	RPN	Rank
1	Catalyst initial temperature	Initial temperature is too high	Inappropriate polymerization reaction	7	6	1	42	7
		Initial temperature is too low	*Initial reactor catalyst failed*	7	5	1	35	11
2	MPE initial temperature (75°C - 78°C)	Exceeded the maximum initial temperature limit of MPE	*High initial solid total*	5	5	1	25	12
		Exceeds the minimum initial temperature limit of MPE	*Low initial solid total*	5	3	1	15	16
3	Feeding start temperature (80°C)	Low starting feedingtemperature	High viscosity and larger particle size	7	10	1	70	2
		High starting feeding temperature	Dilute viscosity	7	6	1	42	6
4	Cooling temperature (93°C - 95°C)	Cooling temperature too low	*Particle size is bigger*	7	10	1	70	1
		Cooling temperature too high	*Particle size is not standard*	7	6	1	42	5
5	Initial rpm of catalyst (23)	RPM too low	The polymerization reaction tends to be slow	7	1	1	7	20
		RPM too high	The emergence of fish eyes	7	3	1	21	15
6	MPE initialsRpm (27)	RPM too low	The accumulation of monomers	7	5	1	35	10
		RPM too high	*Foaming on the product*	7	3	1	21	14
7	Rpm start feeding (23)	Rpm feeding too low	The accumulation of monomers	7	5	1	35	9
		Rpm feeding too high	Dilute viscosity	7	2	1	14	19
8	Initial catalyst time (10 minutes)	Time is too fast	Polymerization reaction is not optimal	7	3	1	21	13
		Time is too long	The polymerization reaction tends to be slow	7	2	1	14	18
9	MPE initial time (12 minutes)	Time is too fast	Polymerization reaction is not optimal	7	5	1	35	8
		Time is too long	The polymerization reaction tends to be slow	7	2	1	14	17
10	Observation time (90 - 120 minutes)	Time is too fast	Total solid product low	7	6	1	42	4
		Time is too long	Particle size is bigger	7	9	1	63	3

Based on the results of the FMEA analysis in table 5, the technical parameters of the process that have a high RPN value are cooling temperature, feeding temperature, and observation time. The technical parameters of this process will be the main parameters in this research experiment.

b. Identification of Experimental Data

Recording of data material at the time of the experiment was carried out to find variables and to reduce the level of no-good GP 31XXC products as well as information as evidence that could identify the identity of the problem in the study. Evidence in the form of process batch record data. Information on the batch record process will be used as the basisfor processing research data which will be used as reference material for drawing conclusions.In the experiment using experimental materials as many as 8 process batches. Where each experimental process uses the same raw materials, process equipment, and test parameters. The test parameters of the experimental results are total solid, pH, viscosity, particle size, and appearance.

Table 6. *Experimental data atribute*

Cooling Temperature (°C)	Feeding Start Temperature (°C)	Observation Time (Minutes)
91	94	89
92	93	90
93	92	91
94	91	92
95	90	93
96	89	93

The fixed variable of the production process is that the quantity of raw material is 20200 kg and rpm according to the product formula. The independent variables that became the experimental parameters were the cooling temperature, the starting temperature for feeding, and the observation time.

c. GP 31XXC trial results

The results of the GP 31XXC production process use production process equipment that has been prepared by the production operator. The experimental results of GP 31XXC in this study were divided into two, namely, the results of the experimental parameters and the results of the experimental measurements. The results of the experimental parameters are the results of checking process parameters, namely temperature, rpm, and time. The results of the experimental measurements are measurements of the specifications of the GP 31XXC productin the laboratory, namely total solids, pH, viscosity, and particle size in accordance with standard product specifications.

Table 7. *Trial results*

No Trial	Feeding Start Temperature (°C)	Cooling Temperature(°C)	Observation Time (Minute)	*Particle size* (0,210-0,235 µ)
1	94	91	89	0.2446
	94	91	89	0.2461
2	93	92	90	0.2496
	93	92	90	0.2437
3	92	93	91	0.2639
	92	93	91	0.2579
4	91	94	92	0.2501
	91	94	92	0.2542
5	90	95	93	0.2220
	90	95	93	0.2175
6	89	96	93	0.2285
	89	96	93	0.2233

d. ANOVA test results

The ANOVA test was carried out to test whether the three process parameters had the same average. The ANOVA output is the end of the calculation that is used to determine the analysis of the hypothesis to be accepted or rejected. In this case, the hypotheses to be tested are the cooling temperature parameters, feeding temperature, and observation time which will be described in each parameter.

- **Cooling temperature**

  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of cooling temperature process parameters on theaverage particle size
  H1: There is a significant effect of cooling temperature process parameters on the averageparticle size

Table 8. *Anova single factor temperature cooling test*

Source of Variation	***Sum of Square***	***df***	***Mean of Square***	***Fcount***	***Ftable***	***Sig***
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	***Count***	***Sum***	***Average***	***Std Dev.***
Temperature *Cooling* 91 - 92°C	4	0.98404	0.24601	0.0026147
Temperature *Cooling* 93 - 94°C	4	1.02610	0.25653	0.0058585
Temperature *Cooling* 95 - 96°C	4	0.89130	0.22283	0.0045265

Based on table 8, the Fcount value is 57.870 and Ftable 4.26, so Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of cooling temperature process parameters on the average average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the cooling temperature parameter of 95°C - 96°C.

- **Feeding temperature**

  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of temperature feeding process parameters on theaverage particle size
  H1: There is a significant effect of the feeding temperature process parameter on theaverage particle size

Table 9. *Feeding temperature single factor anova test*

Source of Variation	*Sum of Square*	*df*	*Mean of Square*	*Fcount*	*Ftable*	*Sig*
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	*Count*	*Sum*	*Average*	*Std Dev.*
Temperature *feeding* 89 - 90°C	4	0.89130	0.22283	0.0045265
Temperature *feeding* 91 - 92°C	4	1.02610	0.25653	0.0058585
Temperature *feeding* 93 - 94°C	4	0.98404	0.24601	0.0026147

Based on table 9, the Fcount value is 57.870 and Ftable 4.26, so Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of temperature feeding process parameters on the average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the feeding temperature parameter of 89°C - 90°C.

- **Observation time**

  In this case the hypothesis to be tested is:
  Ho: There is no significant effect of the observation time process parameter on theaverage particle size hasil 50
  H1: There is a significant effect of the observation time process parameter on the averageparticle size result

Table 10. *Single factor anova test observation time*

Source of Variation	*Sum of Square*	*df*	*Mean of Square*	*Fcount*	*F table*	*Sig*
Between groups	0.002	2	0.001	57.87	4.26	0.000
Within groups	0.000	9	0.000			

Groups	*Count*	*Sum*	*Average*	*Std Dev.*
Observation time 89 - 90 minute	4	0.98404	0.24601	0.0026147
Observation time 91 - 92 minute	4	1.02610	0.25653	0.0058585

Observation time 93 minute	4	0.89130	0.22283	0.0045265

Based on table 10, the Fcount value is 57.870 and Ftable 4.26, then Fcount is greater than Ftable, meaning that H0 is rejected and H1 is accepted. While the significant value orprobability is 0.000 <0.05, meaning that H0 is rejected. These results indicate that there is a significant effect of the observation time process parameters on the average particle size results. The desired particle size standard is 0.210 - 0.235 , the average particle size value is 0.22283 at the observation time parameter of 93 minutes.

e. Effectiveness and Value of Deteriorating GP 31XXC Products

After carrying out a series of experiments and evidence using the SPSS17.0 statistical method, the researchers summarized the results of the GP 31XXC production process after repairs were made to determine the effectiveness and value of the GP 31XXC product with problems. The results are as follows:

***Table 11**. Troubled GP 31XXC Product drop*

Period	GP 31XX C Production Batch	GP 31XX C NG Batch
Nov 2021 - Jan 2022 (before improvement)	17 Batch	10 batch
Feb 2022 - April 2022 (after improvement)	39 Batch	1 batch

Conclusion

Based on the results of the analysis and discussion of the data, the authors obtain conclusions that can be drawn from research on Efforts to Reduce the Number of No-good GP31XXC Products Using Experimental Design Methods at PT AHP as follows:

1. The results of this study indicate that the cause of the no-good GP 31XXC product is the technical production process, namely the cooling temperature parameters, feeding starting temperature, and observation time. These parameters are variables that havethe most significant influence on product problems.
2. Proposed improvements with the aim of reducing the level of no-good GP 31XXC products at PT AHP are changes to standardization and validation of temperature and time parameters. The cooling temperature is from 93°C - 95°C to 95°C - 96°C, the starting temperature is feeding from 80°C to 89°C, and the observation time is from 90 minutes - 120 minutes to a minimum of 93 minutes.
3. The decrease in no-good GP 31XXC products after improvements were made with the experimental design method using SPSS17.0 was decreased by 90%, from 10 batches to 1 batch.

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