CHAPTER IV

DATA COLLECTION AND PROCESSING

4.1 Data Collection

PT. Gula Putih Mataram (PT. GPM) is the national sugar industry that specializes in creating sugar cane-based products. The company produce a product, with the brand name of Gulaku, which is still their leading product in the market. PT. Gula Putih Mataram is state-owned company. This company has started its operation on September, 1987. PT. Gula Putih Mataram is located in Lampung Tengah. The research about product defect analysis in Gulaku department.

The first data obtained from the company is amount of production with the total defect that occur in each product type, the data is used to determine DPMO and sigma level on every product. The second data is the FMEA rating to get the FMEA criteria rating value and risk priority number on every defect type. The third data is the assessment of pairwise comparison to get the weight's comparison of initial AHP and weight's comparison of fuzzy AHP. The data of production amount and also the total defect are obtained from the historical data that given by Gulaku department. Then, the data of potential failure mode, potential causes of failure mode and current control are obtained from the expert, as well as the FMEA criteria rating, which are severity, occurrence, and detection that are obtained by interview with the expert. Next, the data of pairwise comparison are also obtained by interviewing the expert. The expert for this research is only the manager of Gulaku department in PT. GPM. The detailed data for this research will be shown below.

4.1.1 Product Type

PT. Gula Putih Mataram produces three types of product. There are 1 kg, ½ kg and 200 g of sugar. The production process is conducted every month for one production time.

4.1.2 Defect Type

There are four detected defects that recorded from one-year production period, which is from the 1st of October 2017 until 30th of September 2018. The defects are shown in the Table 4.1.

Table 4.1 Defect Type

Defect Type	Description
Sapon	Obtained from the scattered sugar sweep
Curah	Obtained from overflow vibrating, broken packaging from inside reject barrel and outside reject barrel, sugar from scrap bin and budpak
Dust	Obtained from dust collector (blower)
Production	Obtained from an outer reject barrel because of a deviation in the quality of sugar, off colour (brown sugar)

4.1.3 Production

There are different amounts of production for each product type in one production time. The data of production obtained from one production period, which is from the 1st of October 2017 until 30th of September 2018. The amount of production shown in Table 4.2.

Table 4.2 Amount of Production

Month	Production (Pcs)		
	1 kg	½ kg	200 g
October 2017	785712	7820	0
November 2017	1578672	111163	41256
December 2017	1740240	84280	0
January 2018	1192944	158560	34992
February 2018	1460208	249120	0
March 2018	1963944	0	0
April 2018	1746000	36160	6072
May 2018	4255752	0	0
June 2018	2021424	219460	31920
July 2018	2395704	241640	37944
August 2018	1559040	263660	27720
September 2018	2013984	196720	60108
Average	1892802	130715	20001

From the amount of production in a year production time, researcher could obtain the average number of production for each type of product, such as 1892802 pcs for 1 kg, 130715 pcs for ½ kg and 20001 pcs for 200 g.

4.1.4 Defect on Product

There are different amounts of defect for each product type in one production time. The data of defect were obtained from one production period, which is from the 1st of October 2017 until 30th of September 2018. The amounts of defects are shown in the Table 4.3.

Table 4.3 Amount of Defect

Month	Defect (Pcs)		
	1 kg	½ kg	200 g
October 2017	11498	287	0
November 2017	3827	5103	3827
December 2017	20323	3368	0
January 2018	24463	5507	4324
February 2018	19021	7862	0
March 2018	9608	0	0
April 2018	59358	2263	0
May 2018	61671	0	0
June 2018	7044	2819	0
July 2018	2395704	241640	37944
August 2018	11918	3843	4589
September 2018	26717	4893	4194
Average	220929	23132	4573

From the amount of defect in a year production time, researcher get the average number of defects for each type of product, such as 220929 pcs for 1 kg, 23132 pcs for ½ kg and 4573 pcs for 200 g.

4.1.5 Weight of Criteria Determination

To determine the pairwise comparison, the comparison of importance of the criteria will be written in a matrix of pairwise comparison in following Table 4.4. The data obtained from interviewing the expert.

Table 4.4 Pairwise Comparison Matrices between Criteria

Criteria	Severity	Occurrence	Detectability
Severity	1	1	7
Occurrence	1	1	5
Detectability	1/7	1/5	1

4.2 Data Processing

On data processing, the researcher applies six sigma implementation. There are 5 stages in this implementation, which are Define, Measure, Analyse, Improve, and Control that abbreviated with DMAIC, it will be used to measure the quality of products and services as well as to control their quality (Syukron & Kholil, 2012).

4.2.1 Stage of Define

Define is purposed to identify the production process and types of defects in industry (Purnama, et al., 2018). This stage aims to identify defects on Gulaku products based on historical data on Gulaku department. There are three detected defects that recorded from one production period, which is from the 1st of October 2017 until 30th of September 2018. Based on the historical data and interview by the expert, the defect that frequently occured are *sapon, curah,* dust, and production.

4.2.2 Stage of Measure

Measure is conducted by using defect per million opportunities (DPMO) to rate the recent company's performance, specifically in quality of management and to calculate sigma level from DPMO.

Below is the recapitulation of product defect data in one production time, recorded from the 1st of October 2017 until 30th of September 2018 as shown in the Table 4.5.

Table 4.5 Recapitulation of Product Defect Data

Batch	Type	Amount of Product	Amount of defect's possibility *Sapon*, *Curah*, Dush, Production	Total defect	DPO	DPMO	Six Sigma
1	1 kg	1892802	4	220929	0,029	29180	3,39
2	½ kg	130715	4	23132	0,044	44241	3,20
3	200 g	20001	4	4573	0,057	57160	3,08
			Average			43527	3,23

On every batch, DPMO and Sigma level can be calculated to get overall DPMO value and sigma level from average of 3 production batches. Hence, from average calculation, DPMO valued as 43527 and sigma level valued as 3.23. DPMO indicates that in one million chances of sugar production for each month or for one production time, there are 43527 possibilities of sugar for experiencing defects.

4.2.3 Stage of Analyse

Analyse stage is carried out to identify the cause of defect on sugar production. It was performed by involving Failure Mode and Effect Analyse (FMEA) to identify and assess the risk that turns to be the potential cause of failure (Vitho, et al., 2013). The result of FMEA analysis is shown in the Table 4.6.

Table 4.6 Failure Mode and Effect Analysis

Potential of failure mode	Potential effect of failure	Sev	Potential Causes of Failure	Occ	Current control	Det	*RPN*
Sapon	Sugar scattered on the floor	5	Torn packaging	4	Collect and clean the sugar	2	40
Curah	Grain size did not pass	6	Overflow vibrating	4	Enlarge screen size	4	96
Dust	Dust absorption is not optimal	6	Dust collector full of dust	3	Clean dust collector	2	36
Production	Sugar contain contaminants	7	Sensor of contaminant separator closed by huge sugar	8	Flip over and rip off the packaging to the barrel reject	2	112

Based on FMEA table above, it can be identified the occurred risk value and the effect based on the value of Risk Priority Number (RPN). The value of RPN is derived from the result of multiplication between rating severity (S), occurrence (C) and detectability (D). On the analysis of FMEA, the highest value of RPN with the value of 112 is recorded on production defect. The second one with the value of 96 is recorded on *curah* defect. The third one with the value of 40 is recorded on *sapon* defect. The last one is dust defect with the value of 36.

But, FMEA only considers 3 types of RPN's assessments, which are: severity, occurrence and detectability. In real case, the criteria of the risks are weighted differently (Aslani, 2014). Hence, it takes risk analysis criteria weighting by using Analytical Hierarchy Process (AHP) method. Coupled comparison on AHP will be more accurate if the comparison scale specified by expert applies Fuzzy AHP. It is assumed that AHP method includes high subjectivity. Fuzzy AHP effectively could reduce the human thoughts' unclarity by providing value's interval.

Calculate the weight of criteria, which are severity, occurrence, and detectability. Below are the steps of calculation on weighting the criteria.

Step 1: Add all the value of b_{ij} from each column of matrices pairwise comparison to normalize the matrix, which is shown in the Table 4.7.

Table 4.7 Pairwise Comparison Matrices between Criteria

Criteria	Severity	Occurrence	Detectability
Severity	1	1	7
Occurrence	1	1	5
Detectability	1/7	1/5	1

Step 2: Dividing b_{ij} with the total value of the column which resulted in normalized matrices of criteria which is shown in the Table 4.8.

Table 4.8 Normalized Matrices between Criteria

Criteria	Severity	Occurrence	Detectability
Severity	0.47	0.45	0.54
Occurrence	0.47	0.45	0.38
Detectability	0.07	0.09	0.08

Step 3: Sum up the lines to obtain the relative priority of the criteria or the eigen value which is shown in the Table 4.9.

Table 4.9 Calculation of Local Priority of Criteria

Criteria	Severity	Occurrence	Detectability	Eigen Value
Severity	0.47	0.45	0.54	0.49
Occurrence	0.47	0.45	0.38	0.44
Detectability	0.07	0.09	0.08	0.08

The result of calculation of the eigen value of each line is the local priority of calculation.

• Local priority of severity criteria = 0.49 (49%)

• Local priority of occurrence criteria = 0.44 (44%)

• Local priority of detectability criteria = 0.08 (8%)

The result above, shows weight's comparison of initial AHP.

After calculating the weight's comparison of initial AHP, the next step is to calculate weight's comparison of Fuzzy AHP.

Step 1: Convert the value on the pairwise comparison matrices between criteria table to the Fuzzy AHP pairwise comparison scale which is shown in the Table 4.10.

Table 4.10 Fuzzy AHP Pairwise Comparison Matrices between Criteria

Criteria	Severity	Occurrence	Detectability
Severity	(1,1,1)	(1,1,3)	(5,7,9)
Occurrence	(1,1,3)	(1,1,1)	(3,5,7)
Detectability	(1/9,1/7,1/5)	(1/7,1/5,1/3)	(1,1,1)

Step 2: Calculate the geometric mean of criteria, which are severity, occurrence, and detectability.

Table 4.11 Geometric Mean of Severity

Name	Value
Lower sev	1.71
Medium sev	1.91
Upper sev	3.00

The geometric mean of severity shows that lower severity with 1.71, medium severity with 1.91, and upper severity with 3.00.

Table 4.12 Geometric Mean of Occurrence

Name	Value
Lower occ	1.44
Medium occ	1.71
Upper occ	2.76

The geometric mean of occurrence shows that lower occurrence with 1.44, medium occurrence with 1.71, and upper occurrence with 2.76.

Table 4.13 Geometric Mean of Detectability

Name	Value
Lower det	0.25
Medium det	0.31
Upper det	0.41

The geometric mean of detectability shows lower detectability with 0.25, medium detectability with 1.31, and upper detectability with 0.41.

Table 4.14 Total Geometric Mean from all of Criteria

Name	Total Value
Total lower value	3.40
Total medium value	3.93
Total upper value	6.16

The geometric mean from all of criteria show total lower value with 3.40, total medium value with 3.93, and total upper value with 6.16.

Step 3: Calculate the normalization of each criteria using triangular fuzzy.

Table 4.15 Normalization of Severity

Name	Value
Lower	0.28
Medium	0.49
Upper	0.88

The normalization of severity shows lower with 0.28, medium with 0.49, and upper with 0.88.

Table 4.16 Normalization of Occurrence

Name	Value
Lower	0.23
Medium	0.44
Upper	0.81

The normalization of occurrence shows lower with 0.23, medium with 0.44, and upper with 0.81.

Table 4.17 Normalization of Detectability

Name	Value
Lower	0.04
Medium	0.08
Upper	0.12

The normalization of detectability shows lower with 0.04, medium with 0.08, and upper with 0.12.

Step 4: Calculate defuzzification of each criteria using $F = (1/2)(\alpha u + m + (1-\alpha)\, l)$

Table 4.18 Defuzzification of Severity

Normalization of Severity	Lower	0.28
	Medium	0.49
	Upper	0.88
Defuzzification of Severity	0.53	

The deffuzification value of severity is 0.53.

Table 4.19 Defuzzification of Occurrence

Normalization of Occurrence	Lower	0.23
	Medium	0.44
	Upper	0.81
Defuzzification of Occurrence	0.48	

The deffuzification value of occurrence is 0.48.

Table 4.20 Defuzzification of Detectability

Normalization of Detectability	Lower	0.04
	Medium	0.08
	Upper	0.12
Defuzzification of Detectability	0.08	

The deffuzification value of detectability is 0.08.

The result of Fuzzy AHP weight's comparison.

• Fuzzy AHP of severity criteria = 0.53 (53%)

• Fuzzy AHP of occurrence criteria = 0.48 (48%)

• Fuzzy AHP of detectability criteria = 0.08 (8 %)

The result above, shows weight's comparison of Fuzzy AHP.

After determining weight's comparison of initial AHP, weight's comparison of Fuzzy AHP also be determined. Hence, it has the difference value between both comparison, which shown in Table 4.21.

Table 4.21 The Result of Fuzzy AHP Weighting Comparison

Criteria	Weight's Comparison of Initial AHP	Weight's Comparison of Fuzzy AHP
Severity	0.49	0.53
Occurrence	0.44	0.48
Detectability	0.08	0.08

From table above, it shows that there is difference between weight's comparison of initial AHP and weight's comparison of Fuzzy AHP. Severity criteria increase from 0.49 to 0.53. Then, occurrence criteria increase from 0.44 to 0.48. The last is detectability criteria steady in 0.08. The result explains that Fuzzy AHP decrease human's unclarity, the weight's comparison of Fuzzy AHP is more valid or real than the initial AHP.

After calculating Fuzzy AHP weighting comparison, the next step is to calculate RPN value with the weighting of Fuzzy AHP. The following is the result of multiplication between relative weights with the value of severity, occurrence, and detectability which shows in the Table 4.22.

Table 4.22 The Result of RPN Calculation on Fuzzy AHP-FMEA

No	Defect Type	S	O	D	WS	WO	WD	RPN	Ranking
1	*Sapon*	5	4	2	0.53	0.48	0.08	4.73	4
2	*Curah*	6	4	4	0.53	0.48	0.08	5.42	2
3	Dust	6	3	2	0.53	0.48	0.08	4.78	3
4	Production	7	8	2	0.53	0.48	0.08	7.71	1

Based on RPN calculation by considering the weighting of Fuzzy AHP, hence it can be resumed the highest ranking of RPN with the value of 7.71 for production defect that caused by sensor of contaminant separator closed by the sugar, so the sensor does not work in a good performance to separate the contaminant from the sugar. The second one with the value of 5.42 for *curah* defect that caused by overflow vibrating, it makes the grain size does not pass the criteria. The third one with the value of 4.78 for dust defect that caused by full dust collector, it makes the dust absorption is not optimal. The last one with the value of 4.73 for *sapon* defect that caused by torn packaging that makes the sugar scattered on the floor. Therefore, it takes improvements to prevent possibility defect on product.

4.2.4 Stage of Improvement

After performing the observation towards the cause of defect, the next step is conducting the improvement by determining solution to prevent the defects on sugar. Improvement is applied for failure that has the highest RPN. The failure that has the highest RPN is production. Several actions that could be taken to overcome defects on product are illustrated by Table 4.23 below.

Table 4.23 Improvement on Production

Potential Failure on Production	Improvement
Sugar size less than mess 5 are passed	Vibrating screen checking
Some of black spots are passed	Magnetic separator checking
Dry and moist sugar are not separate well	The moist sugar in the sack is sew back

Based on the Table 4.23 above, it explains that each potential failure on the production has each improvement on action too. First, the sugar size less than mess 5 that are passed, should has vibrating screen checking as the improvement action. Second, some black spots are passed should has magnetic separator checking as the improvement action. Third, dry and moist sugar are not separated well has the moist sugar in the sack should be sew back as the improvement action. These improvements are to prevent the sugar defect.

After improvement actions are obtained, action effect analysis is needed to show the impact of each action to another action. The action effect analysis is shown in the Table 4.24.

Table 4.24 Action Effect Analysis

Action	Vibrating screen checking	Magnetic separator checking	Sew back the moist sugar in the sack
Vibrating screen checking		+	+
Magnetic separator checking	+		+
Sew back the moist sugar in the sack	+	+	

Based on the Table 4.24 above, it explains that if vibrating screen checking is applied, it will give positive impact to the magnetic separator checking action to result. Then, if vibrating screen checking is applied, it will give positive impact to sew back the moist sugar in the sack as action result. Next, if magnetic separator checking is applied, it will give positive impact to sew back the moist sugar in the sack as action result. All of the actions have the positive impact to other actions and vice versa.

4.2.5 Stage of Control

After developing the improvement action to prevent the product defect, the next step is conducting the control by determining person in charge (PIC). On every improvement action has its PIC to control the improvement as illustrated by Table 4.25 below.

Table 4.25 Control on Production

Improvement Action	Person In Charge (PIC)	Action Taken
Vibrating screen checking	Production officer, shift chief, vibrating screen operator	Shift 1, shift 2, shift 3

Improvement Action	Person In Charge (PIC)	Action Taken
Magnetic separator checking	Production officer, shift chief, magnetic separator operator	Shift 1, shift 2, shift 3
Sew back the moist sugar in the sack	Production officer, shift chief, *curah* operator	Shift 1, shift 2, shift 3

Based on the Table 4.25 above, it explains that every improvement action has each person in charge to handle the action when it is applied. Shift 1, shift 2, and shift 3 indicated the time of action.