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Improvement Quality of Normal Noodle Product using Six Sigma Fuzzy Failure Mode and Effect Analysis (FMEA) Methods

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Abstract PT Indofood CBP Sukses Makmur Tbk is a company engaged in food, which is producing instant noodles. Preliminary research shows that PT Indofood Tbk Suskes Makmur Tbk there are products that are not appropriate and formed the results of sampling the production process, sometimes even exceeding the standards set by the company. Based on production data obtained from PT Indofood CBP Sukses Makmur Tbk. known number of production in September 2018 amounted to 1,277,609 pcs in four production processes. The four production processes are cutting, frying, cooling and wrapping. In the four processes produced a number of different defective products, namely: In the process of cutting defective products produced as many as 30,586 pcs, in the frying process as many as 21,569 pcs, in the cooling process as many as 11,735 pcs and in the wrapping process as many as 42,000 pcs. % In improving the quality, the Six Sigma and Fuzzy FMEA methods are used from the results of calculations with fuzzy logic for FRPN values using MATLAB software have different results, where the highest FRPN value is failure mode 1 (F1) or the risk factor for product defects because many noodle blocks are tucked away, can result in wasteful material with a value of 150 as a rating of 1. This happens because with Fuzzy Logic it performs tools with the concept of expert systems to verify results to experts. With this method, it is expected that by using Six Sigma and Fuzzy FMEA methods the company can improve quality and reduce the percentage of defect risk in the production process.

Keywords Six Sigma, Fuzzy FMEA, 5W + 1H, Ishikawa

Introduction

In the modern era, as now, the needs of people for various kinds of food products are increasing. More and more food products with different levels of price, quality, and offer advantages. One of the advantages that a product usually shows is the ease of presentation offered. And one of those products is the normal noodle which is known for being practical and also having nutritional content of carbohydrates and calories. Every company that produces normal noodles must have several processes to make a noodle product that can be consumed by a consumer and give satisfaction to the consumer. One of the goals and efforts of the company is to improve products by reducing waste and scrap.

One of the efforts to improve food products can be done by eliminating various wastes and reducing the amount of scrap produced during the process and after the completion of the production process. One of the tools or methods that can be used to reduce waste can use the concept of green manufacturing [1]. This food company always tries to develop its products with a variety of interesting flavors and packaging. In the process of instant noodle production, there is a high enough obstacle to the scrap generated during the production process. Therefore an increase in productivity is needed. Good quality control will produce products according to consumer standards continuously [2]. One of them is by using the Six Sigma method to control and improve product quality.

Six Sigma is a new management tool used to replace Total Quality Management (TQM), which is very focused on quality control by exploring the company's overall production system. Six Sigma aims to eliminate production defects, reduce product manufacturing time, and eliminate costs. Six sigma is also called a comprehensive system, which means strategies, disciplines, and tools to achieve and support business success. Six Sigma is called a strategy because it focuses on increasing customer satisfaction, called disciplines because it follows the formal model, namely DMAIC (Define, Measure, Analyze, Improve, Control) and tools because it is used in conjunction with others, such as Pareto Charts and Histograms . Success in improving the quality and business performance, depends on the ability to identify and solve problems.

Six Sigma can be implemented with Fuzzy Failure Mode and Effect Analysis (FMEA). Fuzzy is an appropriate way to determine an input space into an output space. After obtaining the value of the Failure effect is severity (S), the probability of failure is Occurrence (O) and detection of failure (D) from the FMEA stage, the value is used as input in fuzzy calculations. The highest RPN fuzzy value will be used as a proposed corrective action. The use of the FMEA method itself will be able to identify potential failures that arise in the normal noodle production process with the aim of minimizing the risk of production failure. How serious is the condition that is caused if a failure occurs, the level of possibility of failure and what methods have been applied to anticipate the failure is the basis for determining important components for corrective action. From some corrective actions obtained from the processing of FMEA, then the FMEA method is integrated with the fuzzy method to get priority.

PT Indofood CBP Sukses Makmur Tbk is a company engaged in food producing instant noodles. Observations show that PT Indofood CBP Suskes Makmur Tbk sometimes produces products that exceed the raw material standards set by the company. This shows one of the defects in production that is the formation of scrap. Scrap is a noodle that does not pass at the end, namely packaging due to various things, namely dough scrap, wet noodles, HH (Fine Crushed) frying, dirty HH, clean HH, clean HP (Crushed). One method that can be used to suppress scrap on products is to approach the integration of Lean Six Sigma and Fuzzy FMEA concepts to identify potential causes of defects in order to reduce defect products. The following is the reject data when cutting, frying, and wrapping:

Table 1: The number of rejects in shifts 1 and 2 for 15 days in the process of cutting, frying, cooling, and wrapping

No	Production Process	Quantity Production	Quantity Reject
1.	Cutting	1.277.609	30.586
2.	Frying	1.277.609	21.659
3.	Cooling	1.277.609	11.735
4.	Wrapping	1.277.609	42.000

Source: PT Indofood CBP Sukses Makmur Tbk

According on these data there are still many rejects in the wrapping process, the researchers conducted research with the Six Sigma method, FMEA and fuzzy logic.

Material and Method

Material

Six Sigma

Six Sigma is a structured methodology for improving processes focused on efforts to reduce variations in processes while reducing defects in products by using statistical approaches and intensive problem solving tools [3]. Six sigma methodology namely; first, define clearly identify the problems faced; second, the measure bases and filters the problem, emphasizing two key questions namely what is the focus and extent of the problem and what key data can help narrow the problem; third, Analysis is the most unpredictable phase of DMAIC; fourth, Improve the phase of improving the process and eliminating the causes of defects; and fifth, Control helps reduce variability, monitor performance at all times, and allows the correction process to prevent rejection.

Fuzzy Logic

Fuzzy Logic is an appropriate introduction method to map an input space into an output space with unclear or unclear boundaries.

Failure Mode and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is a systematic approach that implements a labeling method to help the thought process used by engineers to identify potential failure modes and their effects.

Method

In this study the authors use the Observation method, which is by directly observing the production process flow in PT Indofood CBP Sukses Makmur Tbk., Especially on wrapping machines. In addition to direct observation, the authors also see the record of production results and the amount of reject that often occurs on machines in PT Indofood CBP Sukses Makmur Tbk.

In addition to observing and seeing company data, the authors also asked operators, production supervisors and field supervisors directly. Thus the writer gets the data needed to compile the seminar report, so the writer collects data related to the amount of reject on the wrapping machine, in order to analyze the quality of normal noodle products by using the six sigma, fuzzy logic, FMEA, and DMAIC methods.

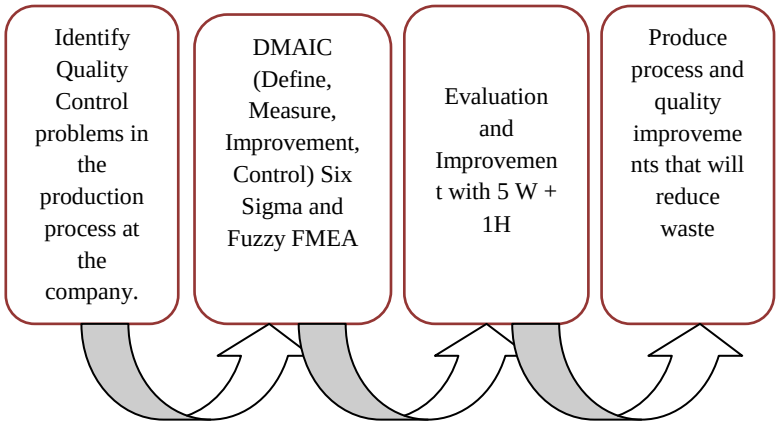

Figure 1: Research Framework

In accordance with Figure 1, researchers will design improvements to the process of making noodles by taking into account the quality of the products produced, so that in addition to the manufacturing process and guarantee of product quality will be more optimal.

Results and Discussion

The first step in data processing is Define Phase.

Define

At the data processing stage the first method is the SIPOC Diagram. This method is sorted by the process of making a normal noodle from supplier to customer. The following is Figure 2 SIPOC Diagram

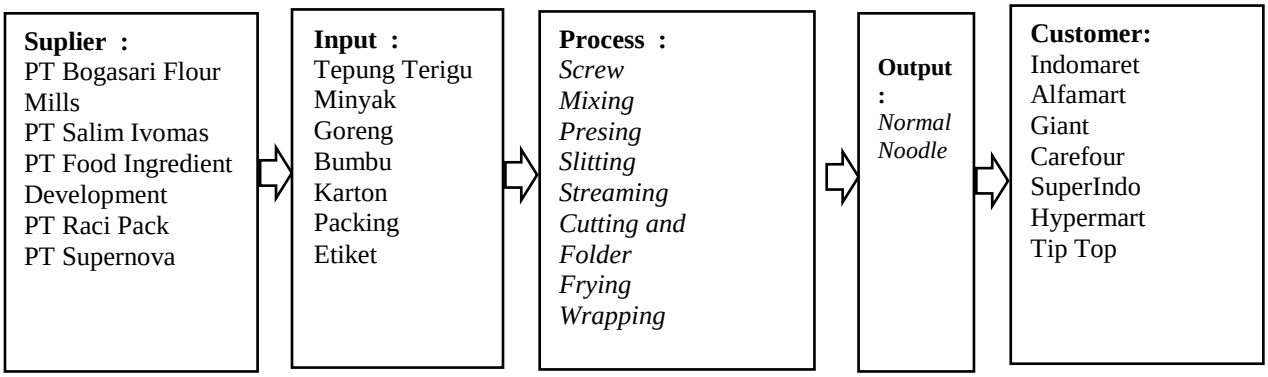

Figure 2: SIPOC diagram

Source: PT Indofood CBP Sukses Makmur Tbk

From the Diagram above, PT Indofood CBP ordered Normal Noodle Materials namely Wheat Flour, Cooking Oil, Spices, Packing Cartons and Etiquette to Suppliers of PT Bogasari Flour Mills, PT Salim Ivomas, PT Food Ingredient Development, PT Raci Pack and PT Supernova. And the targeted customers from PT Indofood are Indomaret, Alfamart, Carefour, Giant, SuperIndo, Hypermart and Tip Top.

a. Identification of defects in Normal Noodle

In the process of making Normal Noodle there are disability criteria in each production process. The following is Table 2 Characteristics of Production Process Disability

Table 2: Characteristics of Production Process Disabilities

	Quality Characteristics	Disability Criteria
Cutting	Cutting Noodles in Accordance with Standards	Wet Noodles
Frying	Noodle Frying that Appropriate with Shape and Standards	Fine Crushed Broken-Broken
Cooling	Cooling Noodles in Accordance with the Standards	Fine Crushed Broken-Broken
Wrapping	Standard Noodle Packing	Dirty Fine Crushed Clean Fine Crushed Crushed Dirty Broken Crushed Clean

Source: PT Indofood CBP Sukses Makmur

Measure

In carrying out statistical quality control, the first step that will be taken is to make a check sheet. Check sheets are useful to simplify the process of data collection and analysis. It is also useful to find out the problem areas based on the frequency of the type or cause and make a decision to make improvements or not. The following production data for September 2018:

Table 3: Report of Production and Product Defects in September 2018

No.	Process Production	Quantity Production	Quantity Defect	% Defect
1	Cutting	1,277,609	30,586	2.4%
2	Frying	1,277.,609	21,659	1.7%
3	Cooling	1,277,609	11,735	0.9%
4	Wrapping	1,277,609	42,000	3.3%
Total			105980	8.3%

From the table shown, it can be seen that the type of defect that often occurs is the wrapping production process with a total of 42,000 defects. The number of types of production process defects Cutting (cutting) as much as 30,586. Next is the type of production process of frying defects is 21,659.

In the measure stage, the measurement is divided into two stages:

a. Control Diagram Analysis (P-Chart)

Data is taken from PT Indofood CBP Sukses Makmur Tbk, which is quality control measured by the number of final products. Measurements were made using Statistical Quality Control type P-Chart of the final product in September 2018. The number of copies produced during September 2018 was 1,277,609, and defective products were found to be 105,980 copies. From these data p-charts control charts can be made.

Then p control chart can be made which can be seen in the following picture:

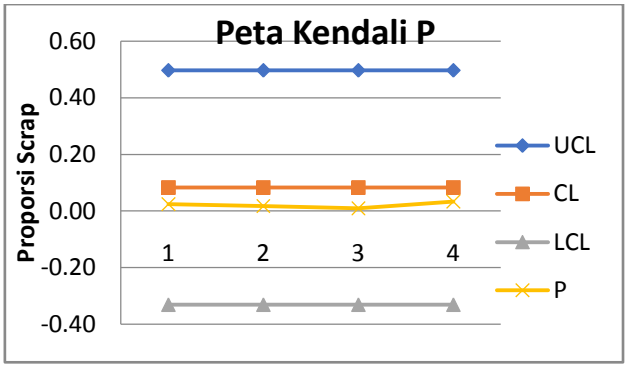

Figure 3: The highest normal noodle defect making process

Based on the control chart above, it can be seen that the data obtained is entirely within the established control limits. This shows that the control of damage is stable but still very high at around 3.3%. It also states that quality control at PT Indofood CBP Sukses Makmur Tbk requires improvements to reduce the level of disability so that it reaches a maximum value of 0%.

a. Phase measurement of Six Sigma and Defect Per Million Opportunities (DPMO) levels

To measure the level of Six Sigma from the production of the East Tribune Daily can be done in a way carried out by Gaspersz (2007: 42) [4] steps as follows:

1) Calculate DPU (Defect Per Unit) $\text{DPU} = \frac{Total\ Kerusakan}{Total\ Produksi}$

2) Calculate DPMO (Defect Per Million Opportunities)

$\text{DPMO} = \frac{Total\ Cacat\ Produksi}{Jumla\ h\ Produksi}$ x 1.000.000

3) Converting DPMO calculation results with Six Sigma tables to get sigma results.

Table 4: Measurement of Sigma and Defect Per Million Opportunities (DPMO) Levels for the September 2018 Period

Period	Production Output	Reject Number	DPO	DPMO	Sigma value
2	1,277,609	21,659	0.02	16952.76	3.62
3	1,277,609	11,735	0.01	9185.13	3.86
4	1,277,609	42,000	0.03	32873.91	3.34
Total		105980			
Rata-Rata			0.02	20737.96	3.57

From the results of calculations in table 4, the production division of PT Indofood CBP Sukses Makmur Tbk has a sigma level of 3.57 with the possibility of damage reaching 20737.96 for one million production. This is certainly a huge loss if not handled because more and more products fail in the production process will certainly cause an increase in production costs.

Analyze

a. Pareto diagram

The data is processed to find out the percentage of product types that are rejected. The calculation results can be illustrated in the Pareto diagram shown in the picture as follows:

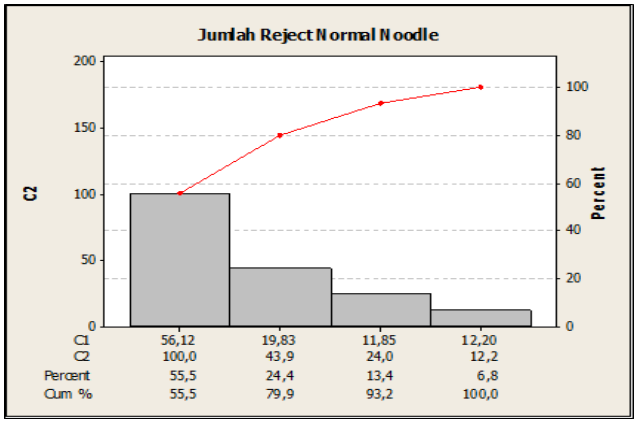

Figure 4: Pareto Number of Normal Noodle Rejects

From the pareto diagram above, there are 4 production processes that have a product defect level, namely Cutting, Frying, Cooling and Wrapping. The most important cause of disability is Wrapping with a percentage of total disability is 56.21%. So repairs can be done by focusing on one of the biggest causes of disability, namely the Wrapping process. This is because the process that often occurs disability at PT Indofood CBP Sukses Makmur Tbk in September 2018.

b. Cause and Effect Diagrams

Cause and effect diagrams show the relationship between the problem at hand and its possible causes and the factors that influence it. The factors that affect and cause product damage in general can be classified as follows:

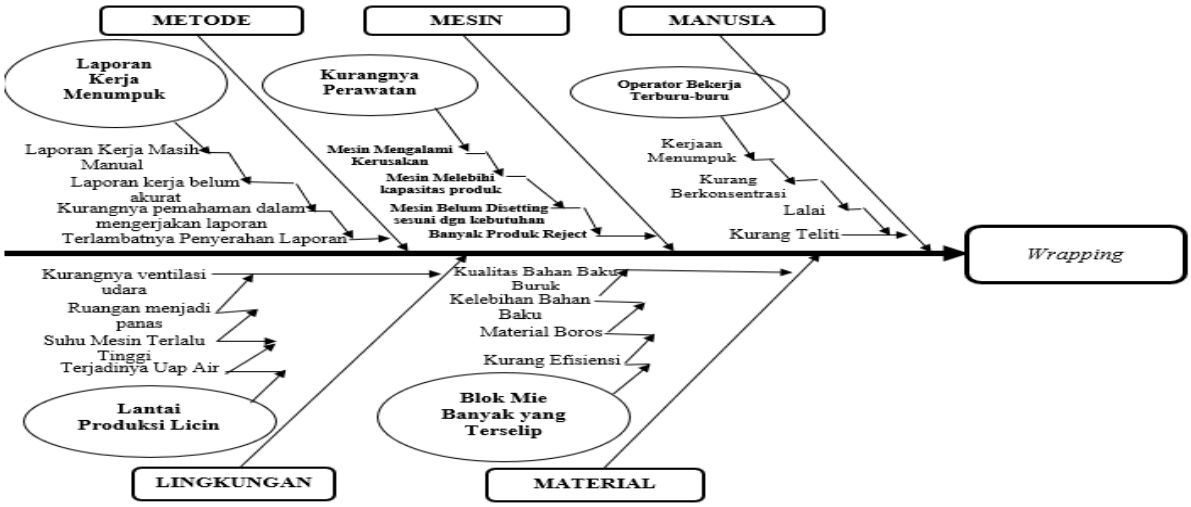

Figure 5: Fishbone

Once the types of defects are identified, PT Indofood CBP Sukses Makmur needs to take corrective steps to prevent similar damage. As a tool to find the cause of the damage, a causal diagram or fishbone chart is used. The use of cause and effect diagrams to trace the type of each disability that occurs.

Improve

It is an action plan for implementing Six Sigma quality improvement. After knowing the cause of disability on PT Indofood CBP Sukses Makmur Tbk products, a recommendation or recommendation for general improvement is made in an effort to reduce the level of product damage using Fuzzy FMEA and analysis of 5w + 1H. The first analysis used is FMEA. The following is a score table for FMEA analysis:

Coloum / Value	1	2	3	4	5	6	7	8	9	10
Frequency of Occurance	Hampir tidak pernah terjadi	Sangat jarang relatif sedikit (*low*)		Kadang-kadang terjadi (*moderat*)			Sering mungkin terjadi (*high*)		Sulit untuk dihindari (*very high*)	
Degree of Severity	Tidak berpengaruh (*minor*)	Sedikit berpengaruh, tidak terlalu kritis (*low*)		Cukup berpengaruh, cukup kritis (*moderat*)			Sangat berpengaruh, kritis (*high*)		Pasti berpengaruh, sangat mungkin, sangat kritis (*very high*)	
Chance of Detection	Pasti terdeteksi (*very high*)	Kemungkinan besar terdeteksi (*high*)		Mungkin terdeteksi (*moderat*)			Kemungkinan kecil terdeteksi (*low*)	Kemungkinan sangat kecil terdeteksi (*low*)	Mungkin tidak terdeteksi (*very low*)	Tidak terdeteksi (*none*)

Figure 6: FMEA score

Source: Book "Fuzzy Decision Making Techniques and Analysis in Supply Chain Management"

After FMEA analysis, the next step is Fuzzy analysis. The initial step for fuzzy work is identifying problems related to product quality in Normal Noodle. Collecting data related to product quality, including the parameters of risk of defects in products that are limited to severity and occurrence parameters. Besides the detection parameters are used as data to be processed further. Brainstorm with experts regarding the relationship of linkages to IF and THEN rules. Each parameter consists of 3 types as shown in table 5:

Table 5: Parameter Fuzzy (Source: Production Manager Expert)

No	Severity	Occurrence	Detection	Quality
1	Low [0, 2, 4] times	Low [0, 2, 4] times	Low [0, 2, 4] times	Poor [0, 45, 100]
2	Medium [3, 5, 7] times	Medium [3, 5, 7] times	Medium [3, 5, 7] times	Medium [99.99, 150, 200]
3	High [6, 8, 10] times	High [6, 8, 10] times	High [6, 8, 10] times	Good [200, 250, 300]

From Figure 5 above, Severity input is chosen to make the membership function more detailed, namely for the low, medium and high membership functions, all of which have a range between 0-10 times. For the low membership function the variable type is the triangle with parameters [0, 2, 4] times, while the membership function is the variable type is the triangle with the parameter [3, 5, 7] times and the variable membership type is the triangle variable with the parameter [6, 8, 10] times.

From the above results it can be concluded that the first rank that often occurs is in humans, machines and methods. And below this is according to experts from the Production Manager. The following is an SOD assessment from an expert production manager.

a. If (severity is low) and (occurrence is low) and (detection is high) than (quality is good)
b. If (severity is low) and (occurrence is medium) and (detection is medium) than (quality is medium)
c. If (severity is low) and (occurrence is high) and (detection is high) than (quality is good)
d. If (severity is medium) and (occurrence is low) and (detection is low) than (quality is less good)
e. If (severity is medium) and (occurrence is medium) and (detection is medium) than (quality is medium)
f. If (severity is high) and (occurrence is low) and (detection is low) than (quality is less good)
g. If (severity is high) and (occurrence is medium) and (detection is medium) than (quality is medium)
h. If (severity is high) and (occurrence is high) and (detection is high) than (quality is medium)
i. If (severity is low) and (occurrence is medium) and (detection is low) than (quality is medium)
j. If (severity is medium) and (occurrence is low) and (detection is medium) than (quality is medium)
k. If (severity is high) and (occurrence is medium) and (detection is high) than (quality is medium)
l. If (severity is high) and (occurrence is high) and (detection is low) than (quality is less good)
m. If (severity is low) and (occurrence is low) and (detection is low) than (quality is medium)
n. If (severity is low) and (occurrence is low) and (detection is medium) than (quality is good)
o. If (severity is medium) and (occurrence is low) and (detection is high) than (quality is good)
p. If (severity is high) and (occurrence is low) and (detection is medium) than (quality is less good)

q. If (severity is high) and (occurrence is medium) and (detection is high) than (quality is good)
r. If (severity is low) and (occurrence is medium) and (detection is high) than (quality is good)
s. If (severity is low) and (occurrence is high) and (detection is low) than (quality is less good)
t. If (severity is low) and (occurrence is high) and (detection is medium) than (quality is medium)
u. If (severity is medium) and (occurrence is high) and (detection is medium) than (quality is medium)
v. If (severity is medium) and (occurrence is high) and (detection is high) than (quality is medium)
w. If (severity is high) and (occurrence is medium) and (detection is low) than (quality is less good)
x. If (severity is high) and (occurrence is high) and (detection is medium) than (quality is less good)
y. If (severity is low) and (occurrence is low) and (detection is high) than (quality is good)
z. If (severity is medium) and (occurrence is medium) and (detection is high) than (quality is good)
aa. If (severity is medium) and (occurrence is medium) and (detection is low) than (quality is less good).

The results of optimization by assuming S, O and D for example 5, 5 and 5, then the risk of disability is needed with this decision making system is 150 where the risk of disability can be accepted. The results of the program are shown in Figure 7.

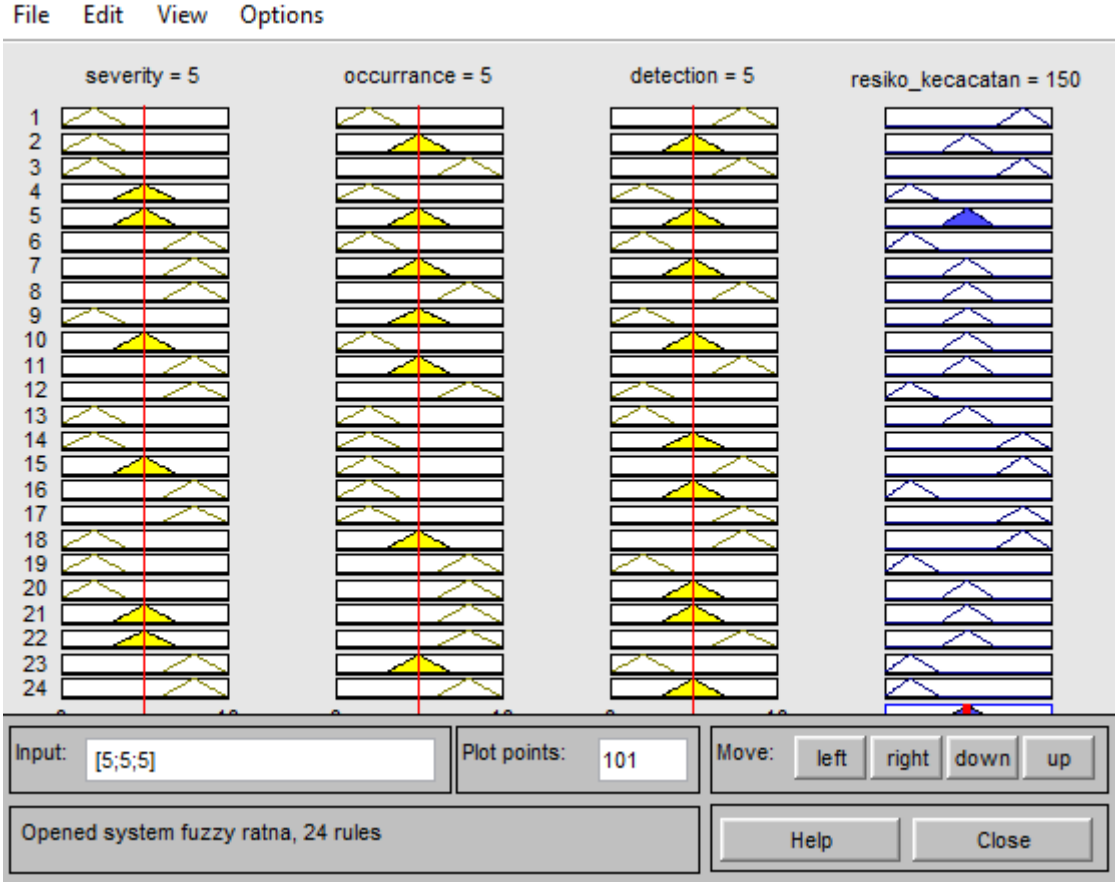

Figure 7: SOD Optimization Results

From the SOD above a calculation can be obtained for the FRPN value for the problem. Following is the FRPN value table.

Table 6: Fuzzy

1	2	3	4	5	6	7	8	9
Description	**Mode of Failure**	**Cause of Failure**	**Effect of Failure**	**Frequency of Occurrence**	**Degree of Severity**	**Chance of Detection**	**Fuzzy Risk Potential Number**	**Ranking**
Reducing Defects in Wrapping	Lack of Care	the engine is damaged	the number of defective products	4	3	1	48,9	4
	Work	default	less	6	3	3	150	1

	operators are too rushed		meticulous					
	Slippery Production Floor	water vapor from the engine	the engine temperature is too high	4	3	6	150	2
	Many Mie Blocks Tucked	less efficiency	material boros	4	3	3	48,9	3
	Stacking work reports	submission of reports	manual work reports	3	6	5	150	5

After the calculation is then analyzed from the calculation using the analysis of 5w + 1h. Following is the 5w + 1h table:

Table 7: 5W+1H

Root of the Problem (Human)	**Who (Siapa)**	**What (Apa)**	**Where (Dimana)**	**When (Kapan)**	**Why (Mengapa)**	**How (Bagaimana)**
Work operators are too rushed	Operators on Wrapping machines	Instruct operators to focus on working	On the Production Floor	During factory operational hours	So that the operator focuses on working	Conduct training for operators regarding the importance of concentrating on working
Lack of Care	Maintenance	Re-scheduling for engine maintenance	On the Production Floor	Four times in one month	So that during the production process the machine does not experience damage	Re-schedule engine maintenance
Stacking work reports	Production Section	Make SOPs and give strict sanctions on violations of the production process	On the Production Floor	Before the production process	So that reports on production run smoothly	Make SOPs and give strict sanctions on violations of the production process

Control Level

This is the final analysis phase of the Six Sigma project that emphasizes the documentation and dissemination of the actions taken including:

a. Perform regular machine maintenance and repair.

b. Supervise raw materials and employees of the production department so that the quality of goods produced is better.

c. Doing recording and weighing all products recorded every day of each type and machine, which is carried out by employees in the production process.

d. Report the results of weighing the defective product based on the product type, noting it to the supervisor.

Total defective products in one month period are listed in the montly manager. Scorecard for the production manager's accountability for general manager reporting.

Conclusion

The experience of conducting research at PT Indofood CBP Sukses Makmur Tbk is very valuable and beneficial for the writer. The author knows the world of work firsthand, starting from a basic understanding of quality management in theory to a basic understanding on the production floor. Professionalism, hard work, cooperation, accuracy, cohesiveness, to mutual respect also the authors see in the work environment in this company. From the research conducted at PT Indofood CBP Sukses Makmur Tbk, the author can find the problem and can give the following conclusions:

- Of the four production processes that often occur defects are cutting, frying, cooling and wrapping. In the four processes produced a number of different defective products, namely: In the process of cutting defective products produced as many as 30,586 pcs, in the frying process as many as 21,569 pcs, in the cooling process as many as 11,735 pcs and in the wrapping process as many as 42,000 pcs.
- From the calculation results with the conventional FMEA method it is obtained that having the highest RPN value is a product defect risk factor because the work operator is too in a hurry which can result in less accurate work with a value of 270 as rank 1. And from the calculation results with fuzzy logic for the value FRPN by using MATLAB software has the same results, where the highest FRPN value is a risk factor for disability because the work operator is too in a hurry which can result in less thorough work with a value of 150 as a rank 1.
- The root causes of problems in the production process are caused by humans, machines, methods, materials and the environment. Where is the root cause caused by humans because operators who work in a hurry, caused by machines due to lack of maintenance, due to methods due to work reports that accumulate, which is caused by the material due to many noodle blocks tucked, while due to the environment due to slippery production floors. The roots of this problem cause many defective products in every production process. Therefore, repair is done.
- Things that should be improved in humans by conducting training of operators to fund the importance of concentrating at work. Machine repairs should be done by re-scheduling the engine maintenance and methods for repairs done by making SOPs and giving strict sanctions on violations of the production process.

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