Plastic Component Nonconforming Analysis Using FMEA and Fishbone Diagram

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Abstract

PT. X in Klaten is a company that produces Calcium Carbonate Masterbatch Compound (CaCO3 MB) with various grades according to customer demand. The resulting product is a component of plastic pellets that will be used by other companies to produce further products. This study aims to identify the cause of the mismatch and what solutions the company has taken. The study was conducted with Failure Mode and Effect Analysis (FMEA) to determine the value of the Risk Priority Number (RPN) with the highest value of 32 by product moisture mismatch, then the highest RPN value was analyzed using a fishbone diagram to determine the cause and effect of product mismatches. The results of the analysis are the human factor (man) who does not carry out the mixing procedure according to the instructions, the material factor, the raw material become humid and the inner being used is leaking, the method factor (method), mixing time does not match the maturity criteria and the inner process that does not tightly closed, the machine factor (machine) because the level of evaporation is different for each machine, environmental factors that can affect the humidity of raw materials and measurement factors, below standard boiler temperature.

Keywords

Quality Control, FMEA, Fishbone Diagram, Risk Priority Number, TQM

1. Introduction

PT. X is an industrial company that produces Calcium Carbonate Masterbatch Compound (CaCO3 MB) with various grades using raw materials in the form of resin, calcium and additives. In the process, a company has several factors needed to support production, such as humans, machines, the environment, or methods in the implementation of the production process. However, these factors can also be a constraint factor experienced both before, during the production process and after the production process.

Common problems that exist in PT. X can be categorized as problems that usually occur in similar companies such as noise, dust and smoke from production, engine damage during operation. However, after the measurements were made, all of these things were still in accordance with the standards so that they did not interfere with the production process. PT. X himself has taken preventive measures so that these things do not interfere with employee performance, namely by providing air plugs for workers to avoid noise, providing masks to avoid dust and smoke from the production process which had previously been filtered so as not to cause pollution to the environment. . PT. X also has a maintenance division for machinery parts so that inspections for engine parts are carried out regularly whether for maintenance, cleaning or repair when there is damage so that it can be immediately addressed when a disturbance occurs.

Based on observations made at PT. X the authors identify problems in the Quality Control (QC) division, which are related to the type of non-conformity in the manufactured product. There are several types of discrepancies that occur in manufactured products such as minor dispersion, major dispersion and moisture. This of course can be a problem because it allows consumer complaints and affects the quality of the products produced by the company so that the vision and mission of the company does not go well. Based on these problems, to be able to find out the root cause of product non-conformance, the Failure Mode and Effect Analysis (FMEA) method is used to identify what type of non-conformity occurred, its impact and mitigation before it arrives in the hands of the customer. Then further

analysis using the fishbone diagram method in order to know what factors affect the highest type of discrepancy based on the RPN value obtained in the FMEA method. With this analysis, it is hoped that it can help the productivity of work carried out during the production process, so that the types of non-conformities that occur can also be minimized and the quality of the products produced is maintained and meets consumer demand.

In the process towards an advanced company, the company must be able to run a good system. A good system is carried out to minimize the occurrence of risk because every company organization must have risks, Hanafi (2006: 18) defines risk management in the organization as a comprehensive risk management system faced by the organization for the purpose of increasing company value. A company can be said to be of high quality, if the company has a good production system and a controlled process. By carrying out quality control, the company is expected to be able to increase effectiveness and productivity in preventing the occurrence of failed or inappropriate products, so as to reduce the occurrence of waste both in terms of the use of materials, time and resources needed to produce one unit of product. PT. X in Klaten is a manufacturing company that produces Calcium Carbonate Masterbatch Compound (CaCO3 MB) which consists of several grades. This company is located in Blanceran Village, Karanganom District, Klaten Regency and produces CaCO3 MB with raw materials derived from calcium, resins and additives.

PT. X is committed to supplying products of good quality, which will ensure customer satisfaction by meeting requirements according to customer demands, delivering on time, and improving quality. To achieve this vision, they seek to fulfill its mission, there are improve customer satisfaction, reducing complaints from customers, improve delivery on time and increase productivity. The objectives from this research are aims to identify the factors that cause product non-conformance and analyze it further to be handled more seriously, calculate how much the RPN value from each cause of product non-conformance, to know the type of non-conformance of the product and the causes of the non-conformance, knowing the solutions that the company does in an effort to overcome the problems that occur.

2. Literature Review

Failure Mode and Effect Analysis (FMEA) is a technique used to define, identify and reduce failures, problems, potential faults of a system, design, process or service before reaching the consumer (Al Ghivaris, 2015). This method is used to identify the form of failure that might cause each malfunction and to ascertain the effect of the failure associated with each form of failure (Robin, 2010). The goals that can be achieved by companies with the application of FMEA are to identify failure modes, the consequences of failures that occur, and the causes of product failures, assist engineers in reducing product failures that occur, and prevent other product failure problems (Robin, 1995). Cause and effect diagrams, these diagrams are also called fishbone diagrams or Ishikawa diagrams, after the name of Kaoru Ishikawa from Japan who introduced the diagram. A cause-and-effect diagram is a structured approach that allows a detailed analysis to find the causes of a problem. This diagram is carried out by means of brainstorming to identify the causes of each category or main factor, which is then referred to as 4M + 1E (man, material, machine, method environment of work), (Ong Andre, 2015).

There are a lot of measure tools that includes everything from data collection to brainstorming methods and prioritising tools. Some of the most common tools are process description tools (value stream maps, process cycle effificiency, and time value analysis), focus/prioritisation tools (FMEA (failure mode and effects analysis), Pareto), data collection, and quantifying and describing variation (control charts). Failure mode and effects analysis (FMEA) – the use of FMEA is to identify in advance the factors that may cause function failure in the key process and llocate a risk priority number (RPN). Factors with a high RPN, usually defifined as greater than 125, will be selected and corrective actions will be recommended.

Identify vital few initial variables – in the Pareto diagram and FMEA as depicted in Figure 2 and Table 1. The project team concludes that the main problems in this project are: fifilling in all new account forms; the procedure of applying a new account; and checking procedures of supervisors. The vital few initial variables are (1) too much of the file needs to be filled in; (2) the file that needs to be filled in is unclear; (3) no notice customers; (4) no standard operational procedure for supervisor to check the documents; (5) no consistent operational standard for staff.

3. Methods

Research methodology is the steps used in solving a problem. In this study, the object of this research is the type of product discrepancy at PT. X in Klaten. The following are the stages carried out in this research:

1.Identify the problem

Based on the data obtained from the company, it can be seen that the product discrepancies that occur are minor dispersion, major dispersion and moisture. Therefore, a method is needed to reduce failures that occur in the company.

The method used is to find out the root cause of the problem, so that solutions can be found that can be done to reduce or even eliminate the problem of product incompatibility.
2. Literature study
A step is used to support the theory that will be used in this research, relating to matters concerning quality, quality control, quality control tools, namely Failure Mode and Effect Analysis (FMEA) and Fishbone Diagram.
3.Data collection
At this stage, data is needed that can be used to solve the problems identified earlier. The data needed in this study is data regarding production discrepancies, causes and solutions carried out by the company.
4.Data processing
This stage performs data processing using two methods, namely the Failure Mode And Effect Analysis (FMEA) method and Fishbone diagram, the following is an explanation of the data processing carried out the process of compiling the type of product nonconformity, its causes and solutions. Rating for Severity (S), Occurance (O) and Detection (D) values. Severity is a matter of identifying the potential impact of a failure by ranking failures according to their consequences. This value is the severity of the impact on consumers as well as on the continuity of the next process which is indirectly also detrimental. The severity value consists of a rating of 1-10. The more severe the effect, the higher the rating given. Occurance is the possibility that the cause can occur and result in a form of failure during the life of the product. This occurrence value is given for each cause of failure consisting of a rating of 1-10. The more often the cause of failure occurs, the higher the rating value given. Detection is a way, test, analysis to prevent failure in services, processes or customers. This value indicates how far the cause of failure can occur which consists of a rating of 1-10. The more often the cause of failure occurs, the higher the rating value given.
In this study, the root cause of the problem was searched and illustrated using the cause-and-effect diagram method (Fishbone Diagram). The benefit of this diagram is that it can help find the root cause of the problem in a user-friendly, user-friendly way (Purba, 2008). This diagram shows a relationship between causes (factors) that lead to something on quality. There are six main factors that need to be considered to identify the factors that influence or result in quality : man, working method/work method, machines/tools, environment, measurement and materials.

4. Data Collection

There are three kinds of raw materials to support the production process in the company namely CaCO3, resins and additives. These materials to be tested by quality control (QC) whether it is suitable or not for the production process. QC Pass and QC No Pass is a process where raw materials will be tested and then categorized into QC Pass if the raw material is in accordance with the standard production process, while QC no pass if the raw material does not meet the standard then the raw material will be quarantined to improve its quality. Raw materials that are categorized as QC pass will be put into the warehouse and then wait for the turn of production time. Order is a process where marketing gets requests from customers related to the number, type of product, and time for product delivery, then it is given to the production admin to make a production schedule. SPK is a process where the production admin makes a letter containing a work order to carry out the production process, the data obtained comes from customer requests submitted through marketing.

Addition is a process where the production department gets a work order from the production admin to start the production process starting with measuring the raw materials according to the specified formulation. Mixing is a process where all the raw materials that have been measured are put into the production machine and then mixed before being put into the extruder machine. Extrusion is a process in which raw materials that have been mixed will be made into lump-shaped dough by an extruder machine. Cutting is a process of cutting pellets or granules. Cooling is a process where the product will be selected to find oversize or undersize sizes, this process is also intended to cool pellets and remove dust from the rest of the previous production process. Packing is a process where the finished product will be packaged using sacks that have been previously lined with inner lining.

The QC Pass process is a process where the product is tested by the QC whether it is in accordance with the standard or not, categorized as a QC Pass because it is in accordance with the standard and then declared as goods that are ready to be sent to customers. The QC No Pass process is a process where the product is tested by the QC whether it is in accordance with the standard or not, categorized as QC No Pass because the product does not comply with the standard and then the product will be quarantined.

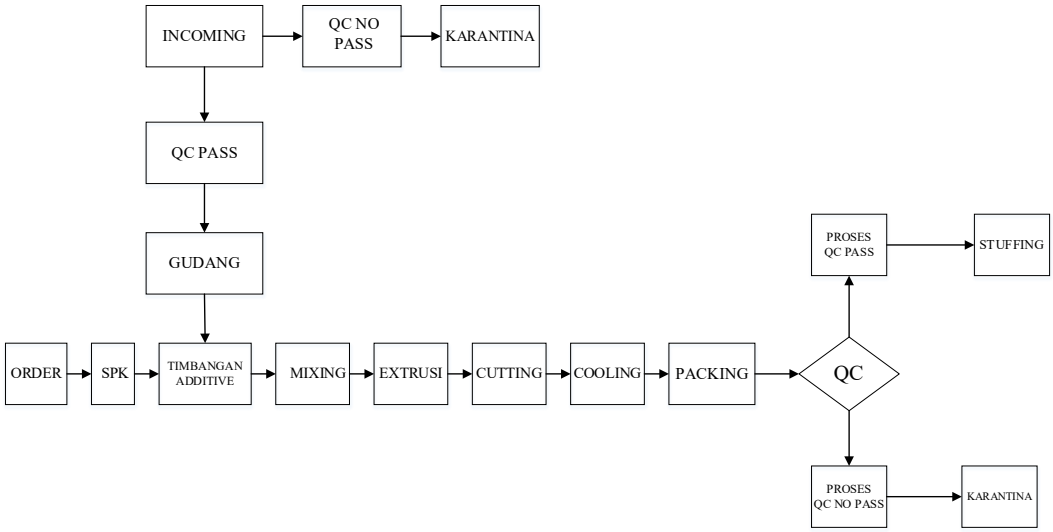

Figure 1. The Operation Process Chart

We can see the process flow chart from Figure 1, it describe the process from the beginning until the end, how the flow decision. also we can understand how the process runs, we can also identify processes that are at risk of defects and potentially fail.

5. Results and Discussion

Writing for the value of the Risk Priority Number (RPN), which is a measure used when assessing risk to help identify "critical failure modes" related to the design or process. RPN values range from 1 (absolute best) to 1000 (absolute worst) by multiplying the weights of severity, occurrence and detection.

RPN = (severity rating) x (frequency rating) x (probability of detection rating)
RPN = S x O x D

Sort the RPN values based on the highest value to determine the most detrimental effect to production process. Starting from the delay of the process until the process stops for one day. After finding the type of product discrepancy with the highest RPN value, it is further analyzed using a fishbone diagram.The data obtained comes from the results of observations and interviews, this is done to find out about the types of failures that occur in the company environment. Table 1 shows data on the types of process and the rating of severity,occurence, detection and the risk priority number, which are the multiplying of those three rating.

Table 1. RPN Value for Every Types of Process Failure

No.	TYPES OF PROCESS FAILURE	SEVERITY POINT(S)	OCCURRENCE POINT (O)	DETECTION POINT (D)	RPN (S x O x D)
1.	Minor dispersion	4	4	2	32
2.	Mayor dispersion	7	2	2	28
3.	Moisture	9	4	2	72

Table 2 describe the failures along with their effects, causes and solutions applied to overcome these failures. After calculating the RPN value, it was found that the potential cause of the product discrepancy with the highest RPN value was moisture, then further analysis was carried out regarding the cause of moisture using a fishbone diagram in figure 2.

Table 2. Process Failure Causes and Solutions

No.	TYPES OF PROCESS FAILURE	EFFECT	FAILURE CAUSES	SOLUTION
1.	Minor dispersion	Calcium spots appear on the application product	The raw materials don't united perfectly	The implementation of the 4M, namely: 1. Man = attention to the mixing, extrusion and packing procedures 2. Method = increased mixing time (lead time increases) 3. Material = 5R application of material and keep no dirt from entering the machine 4. Machine = make sure the temperature is according to the production standard
2.	Mayor dispersion	Calcium spots appear on the application product characterized by a rough surface on the application product when touched	The raw materials don't united perfectly	The implementation of the 4M, namely: 1. Man = attention to the mixing, extrusion and packing procedures 2. Method = increased mixing time (lead time increases) 3. Material = 5R application of material and keep no dirt from entering the machine 4. Machine = make sure the temperature is according to the production standardproduksi
3.	Moisture	Water spots appear on the application of the product	The water content of the raw material is high	The implementation of the 4M, namely: 1. Man = attention to the mixing, extrusion and packing procedures 2. Method = increased mixing time (lead time increases) 3. Material = 5R application of material and keep no dirt from entering the machine 4. Machine = make sure the temperature is according to the production standard

Fishbone diagram is a simple and useful tool to identify the main cause of defect or the other quality problem. This tool is found by Profesor Kaoru Ishikawa, a Japanese scientist.

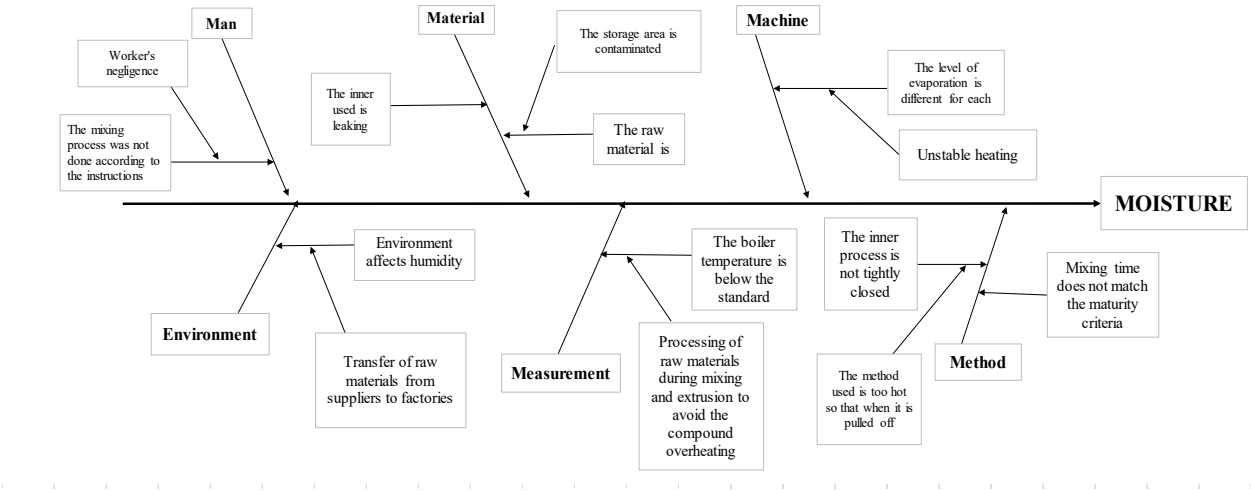

Figure 2. Fishbone Diagram for Moisture Product Defect Causes

Based on the fishbone diagram at figure 2, it can be seen that from the factors in the fishbone diagram there are several things that cause a mismatch of moisture products, including:

1.Working on the mixing process is not according to the instructions

The first factor of the cause of the mismatch of moisture in the product is the mixing process that is not according to the instructions due to the negligence of the workers in the production process. This can cause the production results are not in accordance with the specified formulation, giving rise to the type of product incompatibility such as moisture. Work on the mixing process that is not suitable is the reason behind the man factor which causes the product to be incompatible with moisture.

2.Inner used is leaking

The second factor of the cause of the mismatch of moisture in the product is the inner used in the packing process leaks because the method used to glue the inner is too hot so that when it is pulled it comes off. This can lead to the possibility of contamination and air entering the product so that moisture can occur in the product. The inner used is leaking to be the background of the material factor causing the incompatibility of moisture products.

3. Moist raw material

The third factor of the cause of the incompatibility of moisture in the product is raw materials that are moist or may have been contaminated with water because the storage area is not protected from things that can trigger contamination, considering that contamination can occur even before arriving at the factory, treatment from suppliers to raw materials can also lead to contamination. This can cause the raw materials to be produced are not protected from contamination and allow moisture to occur in the product. Moist raw material is one of the reasons behind the material factor causing the product to be incompatible with moisture.

4. Evaporation rate is different for each machine

The fourth factor of the cause of the mismatch of moisture in the product is the evaporation rate is different for each machine due to the unstable heating process due to the distance from the boiler to the machine so that it allows heating on the furthest machine to get the lowest heating content and the product is not fully cooked. This can cause the possibility of moisture in the product so that the evaporation rate is different for each machine.

5.Inner process is not tightly closed

The fifth factor of the cause of the incompatibility of moisture in the product is that the mixing time does not match the maturity criteria causing the packing process of the inner method to be too hot so that the packing is torn and causes contamination and moisture to enter so that the inner process is not tightly closed is one of the reasons behind the method factor causing product incompatibility. moisture.

6. Mixing time does not match the ripeness criteria

The sixth factor of the cause of the mismatch of moisture in the product is the mixing time does not match the maturity criteria due to negligence caused by the workers themselves. Of course this will affect the formulation of the product that has been determined and lead to discrepancies in the production results. Mixing time that does not match the maturity criteria is one of the reasons behind the method factor being the cause of the incompatibility of moisture products.

7. Boiler temperature below standard number

The seventh factor of the cause of the mismatch of moisture in the product is the boiler temperature below the standard number because the processing of raw materials must also be adjusted to the condition of the machine to achieve compound maturity and according to the standard temperature and condition of compound maturity. In addition, improper mixing and extrusion processing can cause the compound to overheat, which is the background of the measurement factor being the cause of product moisture incompatibility.

8.Environment affects humidity

The eighth factor of the cause of the incompatibility of moisture in the product is that the environment affects the humidity due to the mismatch of moisture in the product due to moisture contamination of the product either from raw materials or during the production process, it is very possible that a humid environment will have an impact on product incompatibility. The environment here is also not only in the factory environment but also in the environment when the raw materials are still at the supplier until they are sent to the factory so that the environment affects humidity, which is the background for environmental factors to cause incompatibility of moisture products.

6. Conclusion

Based on the results and discussion above, it can be concluded that:

1. The type of product discrepancy experienced by PT. X is the major dispersion, minor dispersion and also moisture.
2. The cause of the discrepancy, among others, minor dispersion and major dispersion is because the raw materials do not blend perfectly while moisture is caused by the water content in the raw material is quite high.
3. The highest RPN value of the type of product mismatch is moisture, which is 72.
4. The incompatibility of moisture products is caused by several factors, including human factors that do not carry out the mixing procedure according to the instructions, material factors, namely the raw material becomes moist and the inner used leaks, the method factor is the mixing time that does not match the maturity criteria and the inner process is not closed. meetings, machine factors due to different evaporation rates for each machine, environmental factors that can affect the humidity of raw materials and measurement factors, namely below standard boiler temperatures.

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Biography

Mila Faila Sufa is a lecture and researcher in Industrial Engineering Department of Muhammadiyah Surakarta University. Most of her research is in the field of quality engineering, supply chain management and lay out efficiency and optimization. She earned Bachelor of Engineering from Industrial Engineering study program of Institut Teknologi 10 November Surabaya and then got her Master from the same institution. She has published journal and conference papers and join some professional organization, she is member of IPOMS, ISLI and PEI.

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