Evaluation Of Instant Noodle Packaging Quality Using Failure Mode And Effect Analysis Method

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Abstract

Zero defect is the goal of the quality division of a company. Maintaining quality by eliminating wrong processes is a way to maintain business continuity. PT A is a prominent instant noodle producer in Indonesia. The quality division is experiencing problems with defects that are higher than the set target defect. This research aims to evaluate the defects in the instant noodle packaging process to find mitigation strategies to overcome these quality problems. Failure mode and effect analysis and cause-and-effect diagrams are used as approaches in solving quality problems. The study results show that the defects in the packaging noodles include non-standard packaging, incomplete seasoning components, missing and unprinted packaging Expiry date, and non-standard packaging weight. Recommendations due to non-standard packaging weight, namely the lack of proper setting of the mi crystal thickness, namely Providing proper and periodic training and working standards to all roll press operators

Keywords
FMEA, Defect, Packaging, Quality and Cause Effect

1 Introduction

Quality control is a significant activity through the manufacturing and service industry production line. One example of maintaining the market and expanding its market is improving quality control through production processes without wasting the opportunity to gain profits according to company goals (Chang et al., 2021). as one of Indonesia's prominent instant noodle producers, PT A has been maintaining continuous improvements method in terms of quality. This firm manages not only to provide domestic demands but also to organize and supply overseas demands. The stages of making noodles consist of mixing, roll-sheeting, slitting, steaming, cutting and folding, frying, cooling, and packaging. The first stage is mixing wheat flour and additional ingredients into the mixer. Once the dough cooks, then transmitted to the pressing process. Furthermore, the dough sheet with a thickness must be following thickness standards. The slitting process starts from a thin sheet cut by slitter machine and proceeds on the steaming process. The noodle then cut into pieces. Noodles are cut into specific sizes and weights using a conveyor then transferred to the frying machine. Furthermore, the fried noodles are cooled using a fan and a cooling machine. The cooled noodles are then packed into air-resistance, water-resistant and odor-resistant packaging. Primary packaging materials are polypropylene or polyethylene and then boxing on the carton box.
This firm is awarded international quality standard certification in terms of quality. Even though the company has obtained international standard HACCP and ISO certifications, there are many inefficiencies on the shop floor related to quality. The Quality Control Department challenges with existing problems in maintaining quality standards.

Furthermore, the number of product defects in the Packaging Department has been considered the highest defect compared to other noodle process departments. As a result, the output products in the packaging department have not met the standard target goods. Further evaluation is needed to identify the severity and frequency of defects and detect forms of failure that can cause product defects. Failure mode and effect analysis (FMEA) is an approach that is used to evaluate defects in both the manufacturing and service industries (Aized et al., 2020; Ostadi & Masouleh, 2019; Rislamy et al., 2020). This approach can be used to identify both the potential and effect of failure and the cause through the activity line and then identify current control and future recommendation action for better scenario improvement (Sharma & Srivastava, 2018). This study aims to identify the failure and causes of the failure of the instant noodle packaging process to provide better scenarios for improving the quality of the packaging process.

2 Literature Review

2.1 Quality, Quality Control, and Defect

Quality is one of the essential indicators in order to sustain customers loyalty. There are numbers in terms of quality definition provided by previous researchers. Overall, a quality definition based on previous research has a commonality in meeting the customers' needs. (Cristea & Constantinescu, 2017; Dejene & Gopal, 2021; Latinovic et al., 2020). According to (Lee et al., 2021; Oliveira et al., 2019), quality is a dynamic circumstance associated with a firm's stakeholders to meet the stakeholders' needs. The definition of quality categorizes into two dimensions: product quality and service quality (Pascu et al., 2020). Service quality is related to the relationship between producers and their customers. In addition, service quality is associated with the upstream and downstream production processes. (Shafiee et al., 2019).

Quality is an essential factor in maintaining business sustainability in the service industry sector and the goods industry. Product quality reflects the company's success in maintaining a business because it successfully fulfills consumer needs (Sharma & Srivastava, 2018). *Quality control* is an activity that essential be performed along the production line (Aized et al., 2020). On the one hand, consumers acknowledge that a company that cannot control quality throughout the production process will produce the poor quality of a product or service (Borković et al., 2017). On the other hand, consumers also acknowledge that a company has more value if it can produce good quality products. Continuous improvement is equally with quality control activities from raw materials, work in process to finished products, and then providing the goods to customers (Ostadi & Masouleh, 2019). Good quality control implementation is recognized to effectively reduce the number of defective products and the production process flow (Shafiee et al., 2019).

Product Defects are generally associated with a condition where the product or process fails to meet customer requirements. In addition, Reject is a condition in which a defective product is identified during the production process and inspection. Products in the defect category must be reworked or become scrap and waste, resulting in increased production costs (Pascu et al., 2020).

2.2 Failure Mode and Effect Analysis (FMEA)

FMEA is a significant tool to evaluate the foundations and root causes of a quality problem. FMEA utilizes a tabular method to assist the design process used in identifying major failure modes and effects that cause the failure (Ostadi & Masouleh, 2019). FMEA is a technique for evaluating the level of reliability of a system to determine the effect of the system's failure (Rislamy et al., 2020). In using the failure mode and analysis, the focus is on the current form of failure. Failure related to potential event cause failure throughout the system or process. The proper way to show the relationship and differences between the malfunctions is first, then note the form of the failure caused by the failure (Aized et al., 2020).

FMEA stages are started with identifying potential failure modes of the observed process. Identifying the potential effects caused by the potential failure mode is considered the second stage. Setting the severity (S) value assesses how profound the effect of the failure mode and. Identify the potential causes of the failure mode in the ongoing process as the five-stage stages. The next stage is setting the value of Occurrence (O). Occurrence shows the value of failure frequency that occurs due to a potential cause and then identifies the current process control, which describes the control to prevent the possibility of something causing the failure mode. The next stage is setting the detection value (D), where detection describes how capable the control process has been screened through the production process. The last stage is. Determine the value risk priority number (RPN) by multiplying the value of severity (S) occurrence (O), detection (D) (Cristea & Constantinescu, 2017).

In addition, The RPN value indicates the seriousness of the potential failure. The higher the RPN value, the more problematic it is. There is no RPN reference figure for making improvements. Severity is the first step to analyze risk, which is to calculate how much impact or intensity of events affect the output of the process. These impacts ranked on a scale of 1 to 10, where 10 is the worst impact. Occurrence related to failure frequency of process or production process occurs with scale range from 1 (rarely) to 10 (almost often). Detection is a measurement of the ability to detect or control failures that occur. Detection uses an assessment on a scale of 1 to 10 (Latinovic et al., 2020).

2.3 Fishbone Diagram

Fishbone diagrams will identify various potential causes of an effect or problem and analyze the problem through brainstorming sessions (Lee et al., 2021). Problems break down into several related categories, including people, materials, machines, procedures, policies. Each category has reasons that need to be explained through a brainstorming session (Lee et al., 2021). An action and corrective steps will be easier to do if the root cause of the problem has been found. Ishikawa diagrams are comprehensively accurate in detecting causes of significant problems, increasing productivity, and improving internal and external communication (Dejene & Gopal, 2021)

3 Methods

3.1 Instrument and Sample

The object of the research is on packaging noodle Division 2 of Company A. The data were obtained include packaging process system, production packaging output, and product defects. The data were obtained through walk through survey on the production floor. Data collection at this stage is then used for the next stage.

3.2 Research Stage

Two stages were conducted in this part, namely Ishikawa Diagram stage and FMEA stage. The first steps is related to the Ishikawa diagram. Fishbone Diagram stages are as follows (Oliveira et al., 2019; Pascu et al., 2020): 1. Define the problem is interpreted as a result. Everyone should clearly understand the nature of the problem and the process or product being discussed. 2. Determine the main cause categories. The causes of problems are grouped into main categories to determine the root causes of structured problems. In the manufacturing industry, generally using the 5M category, namely • Man: people related to the process • Methods: how the process is carried out and meets specifications • Machine: tools used during the process • Materials: raw materials and reagents used during the process • Environment: the surrounding conditions during the process 3. Identification of the causes of problems by brainstorming Each main category has causes that need to be described through brainstorming.
The second stage is calculating FMEA application procedures, including (Dejene & Gopal, 2021; Shafiee et al., 2019):

1. Identify the cause of the defect with the Fish Bone Diagram A tool used to help find the root cause of the problem currently being faced.
2. Setting the Severity Value Perform a severity assessment based on the severity of the defect
3. Setting the Occurrence Value Assess how often specific failures of a process occur
4. Setting the Detection Value. With the control system, records are made of the number of products or the number of potential failures that occur
5. Calculating the Risk Priority Number (RPN). The values of severity, Occurrence, and detection are used as data to calculate risk priority number (RPN) by multiplying the values of the severity (S), Occurrence (O), and detection (D).

4 Data Collection

Assessment of Severity, Occurrence, Detection and the final result in the form of a Risk Priority Number Severity is the first step to analyze how much impact the event has on the output of the process. These impacts are ranked on a scale of 1 as the lowest result to 10 is the worst impact. Occurrence is the frequency-specific failure cause. Occurrence value scale from a scale of 1 (rarely) to 10 (almost often) the level of Occurrence. Detection is a measurement of the ability to detect failures that occur. Detection score on a scale of 1 to 10, of which 10 is a potential failure with a

fragile detection ability. Severity, Occurrence, and Detection score obtained from the production supervisor, quality control supervisor, noodle packaging team head, and quality packaging team head.

5 Results and Discussion

Data defect illustrate in Diagram1. It shows defect of packaging process for 6 months from January to June 2021. The defect was classified into 6 category, namely leaky packaging, problem in seasoning, incomplete seasoning, problem with expiry date sign, problem with weight and etiquette.

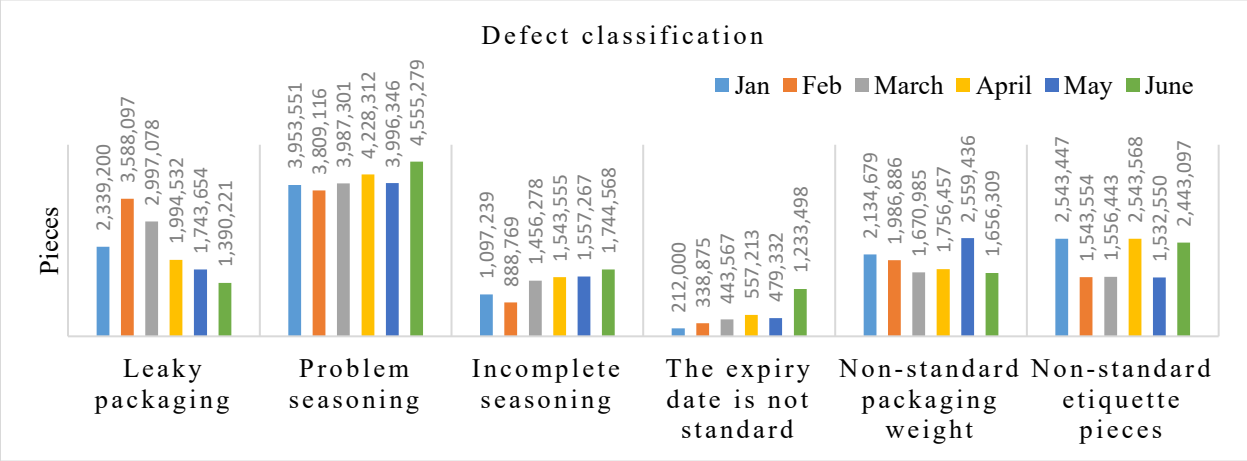

Figure 1. Defect of packaging process

It can be seen in Figure 1 that there was six defect classification during the packaging production process. Moreover, the highest defect with leaky category packaging counted 3,5 million pieces and the lowest in June with 1,3 million pieces. A problem in seasoning counted as the highest defect among six categories with an average defect of around 4 million pieces. Defect category on the expiry date is not standard counted as the lowest no goods product compared to six defect classification. Diagram 2 depicts target products and goods product. It shows that the goods product did not meet targets product for 6 months form January to June 2021.

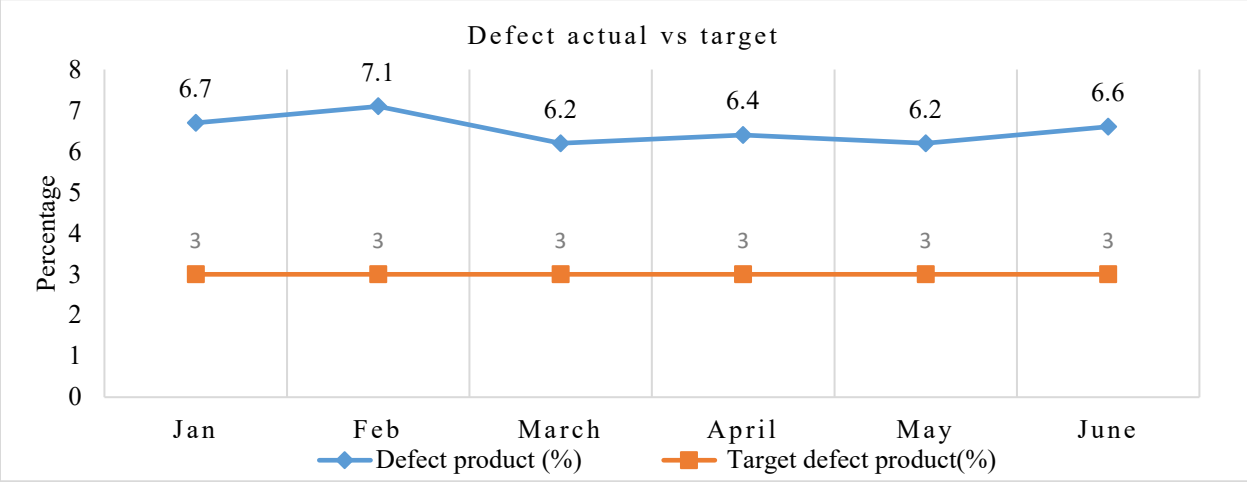

Figure 2. Target vs output goods product January to June 2021

Figure 2 shows that the Quality Control Department sets the maximum defect standard for the instant noodle packaging process at 3 percent. However, in reality, the defects that occur every month are more than double the standard set. Defects in the packaging process ranged from 6.2 percent to the highest value of 7.1 percent.

5.1 Identify root causes of defects

Ishikawa Diagram was used to identify deficiencies through the packaging production process. The data was obtained from expertise respondents, namely the packaging operator, the packaging production supervisor, and the quality control manager. The brainstorming results identified six defects: non-standard packaging, problematic seasoning, and the completeness of seasoning components. A non-standard expired date, non-standard packaging weight, and lastly, non-standard pieces of etiquette. Ishikawa Diagram is depicted in Figure 3.

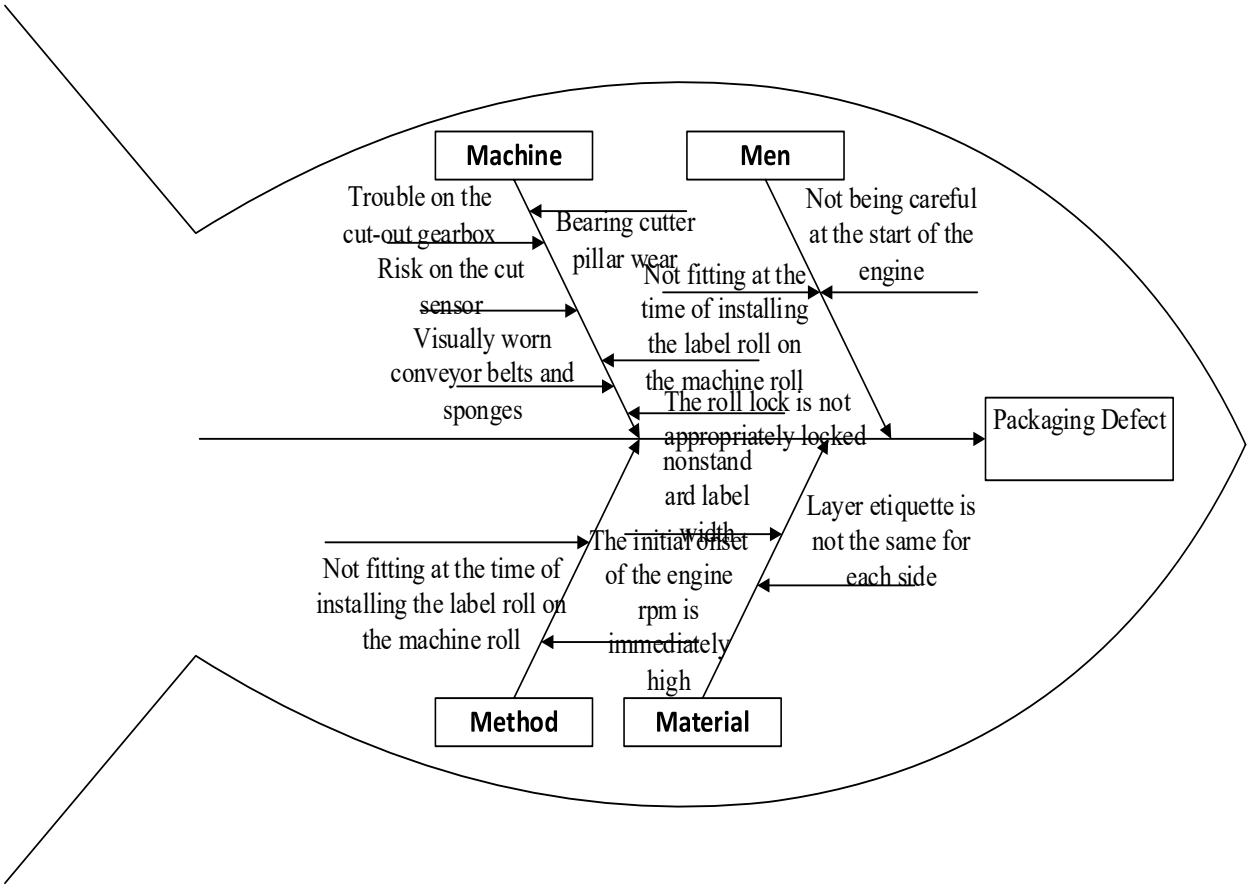

Figure 3. Ishikawa diagram of packaging defect

It can be seen in Figure 3. that the factors that cause defects in the noodle packaging process are men, machinery, materials, and methods.

5.2 Result of FMEA

This data shows how the control process is carried out in the production process of packaging noodles Assessment of Severity, Occurrence, Detection and the final result in the form of a Risk Priority Number Severity is the first step to analyze how much impact the event has on the output of the process. These impacts are ranked on a scale of 1 as the lowest result to 10 is the worst impact. Occurrence is the frequency-specific failure cause. Occurrence value scale from a scale of 1 (rarely) to 10 (almost often) the level of Occurrence. Detection is a measurement of the ability to detect failures that occur. Detection score on a scale of 1 to 10, of which 10 is a potential failure with a insubstantial detection ability. Severity, Occurrence, and Detection score obtained from the production supervisor, quality control supervisor, noodle packaging team head, and quality packaging team head. Table 1 depicts design of failure mode and effect analysis.

Table 1. Failure mode and effect analysis design

Potential Failure Mode(s)	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Occurrence	Current Design Controls	Detection	RPN	Recommended Action(s)
Nonstandard packaging (leaking)	Additional costs for product reprocessing	8	Dirty end sealer surface	8	Visual	2	**128**	
		8	Dirty long sealer surface	6	Visual	2	**96**	
		9	Dropout heaters	5	Visual	2	**90**	
		4	End sealer temperature is not steady	5	Further analysis	3	**60**	
		4	long sealer temperature is not steady	5	Further analysis	3	**60**	
		2	Display monitor error	4	Further analysis	2	**16**	
		2	Wrong temperature setting end sealer/long sealer	7	Further analysis	5	**70**	
		3	Not quite right when selecting the first temperature at the time of changing the label	5	Further analysis	4	**60**	
		1	The thickness of the brand is not standard	3	Visual	2	**6**	
		9	Broken thermocouple cable	4	Visual	7	**252**	Provides standard operating procedures regarding the scheduled replacement time of the thermocouple cable and checks the condition of the thermocouple cable periodically
Seasoning stuck in the cutting end sealer	Additional costs for product reprocessing	9	Gearbox Evinger install wear	3	Further analysis	6	**162**	Provide standard operating procedures regarding the timing of changing gearboxes regularly and checking the condition of the gearbox periodically
		2	The engine rpm is not standard.	3	Further analysis	3	**12**	
		5	The number of personnel installing spices is less	5	Visual	2	**20**	
		5	Lack of thoroughness of personnel installing spices	4	Further analysis	2	**40**	
		3	Slippery spice label packaging surface	5	Further analysis	4	**60**	
		4	Too many spice components	5	Visual	3	**60**	
		4	Faults in installing spices in the middle of noodles	4	Visual	4	**64**	
Incomplete seasoning components	Additional costs for product reprocessing	9	Spice sensor error	8	Further analysis	7	**504**	Provides standard operating procedures regarding scheduled seasoning sensor replacement times and periodic checking
		5	Engine rpm is not standard (too fast)	7	Further analysis	3	**105**	
		7	Lack of personnel in installing spices	6	Further analysis	2	**84**	
		6	The number of personnel is less	7	Visual	2	**84**	
		8	Late supply of herbs	2	Further analysis	2	**32**	
nonstandard packaging pieces of etiquette	Additional costs for product reprocessing	8	Bearing cutter pillar wear	6	Visual	7	**336**	
		9	Trouble on the cut-out gearbox	6	Further analysis	7	**378**	Provide standard operating procedures regarding changing gearboxes
		9	Risk on the cut sensor Further analysis	5	Further analysis	8	**360**	
		3	Worn conveyor belts and sponges	3	Visual	2	**18**	

		2	Not being careful at the start of the engine	3	Further analysis	2	**12**	
		2	High initial onset rpm	3	Further analysis	4	**24**	
		2	Nonstandard label width	1	Visual	2	**4**	
		2	Layer etiquette is not the same for each side	1	Visual	2	**4**	
		4	The roll lock is not appropriately locked	4	Further analysis	6	**96**	
		5	Not fitting at the time of installing the label roll on the machine roll	5	Further analysis	5	**125**	
Exp packaging is not printed or missing	Additional costs for product reprocessing	10	Sensor cable is broken	8	Visual	2	**160**	
		8	Print tech machine temperature overheat	10	Further analysis	3	**240**	paying attention to room temperature and repairs air conditioners
		7	Trouble Print sensor	5	Further analysis	6	**210**	
		7	Cartridge dirty	5	Further analysis	3	**105**	
		5	Not checked regularly	6	Further analysis	4	**120**	
		5	Poor ink quality	7	Visual	4	**140**	
		5	Out of ink	3	Visual	3	**45**	
		4	Mixing ink with additives is not balanced	7	Further analysis	5	**140**	
Non-standard packaging weight	Additional costs for product reprocessing	2	Problem packaging scales	2	Further analysis	3	**12**	
		9	Problem on roll press	9	Further analysis	4	**324**	
		5	QC operators does not check regularly	8	Further analysis	5	**200**	
		9	The insufficient setting of the thickness of the crystal noodles	9	Further analysis	5	**405**	Provides periodic training and work standards to all roll press operators.

5.3 Proposed Improvements

The critical root cause value is based on the highest Risk Priority Number score for each type of defect. Alternative recommendations to improve non-standard packaging is as follows. The current condition on the shop floor is that there is no preventive maintenance schedule to replace the thermocouple cable. The alternative recommendations made in table 1 are scheduling preventive maintenance by checking for two times in one work shift, namely at the beginning of the shift before production and during work breaks. If an unstable thermocouple condition has been found at checking, replacement is necessary.

Action recommendations in improving defects non-standard cutting end sealer are as follows. The current condition is that there is no preventive maintenance schedule for replacing the seasoning vinger gearbox. The alternative recommendations include scheduling preventive maintenance by checking two times before production and during work breaks in one working shift. Suppose the condition of the vinger gearbox is unstable at the time of checking. In that case, the seasoning is installed, and a replacement spare part is required.

The subsequent Alternative recommendations to minimize incomplete seasoning components are as follows. The current condition shows no preventive maintenance schedule for replacing the spice sensor. The alternative recommendations include scheduling preventive maintenance by checking at the beginning of the shift before production and during work breaks. Once the unstable condition of the spice sensor is found, replacement is needed so the spice sensor can function correctly.

Alternative recommendations to overcome non-standard packaging pieces defects are as follow. If the cut gearbox is unstable during an inspection, replacement or repair is needed to make the gearbox function optimally. The current condition is no preventive maintenance schedule to replace the cut gearbox. The alternative recommendations include scheduling preventive maintenance by checking for two times at the beginning of the shift before production and during work breaks.

Alternative recommendations to minimize packaging defects Expired lost or not printed. The current condition on the shop floor is the unstable room temperature. This problem is because the Air Conditioning cannot operate optimally. Moreover, one of the air conditioners is damaged but not repaired. This problem causes by the temperature inside the packaging area heating up. This problem impacts overheating the print tech machine, which is sensitive to hot

temperatures. The alternative recommendations include regular and preventive maintenance of the air conditioner on a scheduled basis so that there is no severe damage to the condition of the air conditioner.
The last Alternative recommendation is to overcome defects with Non-standard packaging weight. The current conditions are the lack of skill of the roll press operator when setting up the roll continue and the operator did not comply with standard operational procedure. The alternative recommendations include providing proper and periodic training to operators every six months and monitoring work standards and SOPs to roll press operators.

6 Conclusion

Defects that occur in noodle packaging are non-standard packaging, spices strained by the cutting end sealer, incomplete seasoning components, non-standard packaging pieces, missing or unprinted packaging Exp, non-standard packaging weight
The most critical causes of the Occurrence of each defect based on the Highest RPN Value are:
a. Non-standard packaging:
- Dirty end sealer surface.
- Dirty long sealer surface.
- Broken heater.
- End sealer temperature is not stable.
- Long sealer temperature is not stable.
- Display monitor error.
- Wrong end sealer and extended sealer temperature setting.
- Not quite right when setting the first temperature at the time of changing the label.
- The thickness of the label is not standard.
- The thermocouple cable is broken.

b. Seasoning wedges cutting end sealer:
- Gearbox vinger install worn seasoning.
- Non-standard engine rpm.
- The number of personnel installing spices is less.
- Lack thoroughness of personnel installing spices.
- Slippery etiquette packaging surface.
- Too many seasonings components.
- Not quite right during the process of installing spices in the middle of the noodles.

c. Incomplete seasoning components:
- Spice sensor error.
- Non-standard engine rpm.
- Lack thoroughness of personnel installing spices.
- The number of personnel installing spices is not enough.
- Late supply of spices.

d. Non-standard packaging pieces:
- Bearing cutter Plat worn.
- Trouble on gearbox pieces.
- Trouble on a cut sensor.
- Sponge and worn conveyor belt.
- Not being careful when starting the engine.
- The initial start of the engine rpm is immediately high.
- The label width is not standard.
- Layer etiquette is not the same on each side.
- Roll lock is not locked properly.
- Not fitting when installing the label roll on the machine roll.

e. Expiry packaging is lost or not printed:
- Sensor cable broke.
- The temperature of the print tech machine is overheating.
- Trouble with print tech sensor.
- Dirty printtech cutter.
- Poor ink quality.
- Out of ink.

- Not checked regularly.
- Mixing ink with unbalanced additives.

f. Non-standard packaging weight:

- Trouble on the spice packaging scales.
- Trouble on a roll press.
- Apr/QC does not check regularly.
- The setting of the thickness of the crystal noodles is not right.

There are six recommended solutions based on the highest RPN value for each defect, namely:

a. Non-standard packaging:
   Perform preventive maintenance by checking for two times in one work shift, namely at the beginning of the shift before production and during work breaks. If an unstable condition of the thermocouple is found at the time of checking, it is immediately replaced.
b. Seasoning wedges cutting end sealer
   Perform preventive maintenance scheduling by checking for two times in one work shift, namely at the beginning of the shift before production and during work breaks. If the condition of the vinger gearbox is found to be unstable at the time of checking, it will be replaced immediately.
c. Incomplete seasoning components
   Perform preventive maintenance scheduling by checking for two times in one work shift, namely at the beginning of the shift before production and during work breaks. Suppose an unstable condition of the spice sensor is found at the time of checking. In that case, immediate replacement/repair is carried out so that the spice sensor can function optimally.
d. Non-standard packaging pieces
   Perform preventive maintenance scheduling by checking for two times in one work shift, namely at the beginning of the shift before production and during work breaks. Suppose, at the time of checking, the condition of the cut gearbox is found to be unstable. In that case, spare part replacement needs in order to maintain the optimal function of the gearbox.
e. The expired packaging sign is not printed.
   Repair and check the sign machine to avoid overheating the temperature of the print tech machine.
f. Non-standard packaging weight
   Provide proper and periodic training to all roll press operators every six months and provide work standards and SOPs to roll press operators.

Recommendations for improvement given to Firm A that continuous improvement to be applied to reduce defects. In addition, the company should implement the FMEA finding to improve the noodle packaging process so that the packaging process can run more optimally. The firm is expected to compare and contrast before using the FMEA method and after applying the FMEA method. The QC department also should prioritize the types of defects that occur most often or those with the highest RPN value.

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