

DEFECTIVE REDUCTION IN FROZEN PIE MANUFACTURING PROCESS

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Abstract. The frozen pie production has a lot of defects resulting in high production cost. Failure mode and effect analysis (FMEA) technique has been applied to improve the frozen pie process. Pareto chart is also used to determine the major defects of frozen pie. There are 3 main processes that cause the defects which are the 1st freezing to glazing process, the forming process, and the folding process. The Risk Priority Number (RPN) obtained from FMEA is analyzed to reduce the defects. If RPN of each cause exceeds 45, the process will be considered to be improved and selected for the corrective and preventive actions. The results showed that RPN values decreased after the correction. Therefore, the implementation of FMEA technique can help to improve the performance of frozen pie process and reduce the defects approximately 51.9%.

1. Introduction

Currently, the bakery manufacturing is growing rapidly with an highly competitive rate from domestic enterprises and foreign investors. Key success factors of production and quality are the customer satisfaction including cost reduction for maximum profit and higher competency. Cost reduction by controlling the quality of product can help to reduce the production time and increase the production rate without defects.

Hence, the case study of frozen pie production is conducted and the Failure Mode and Effect Analysis (FMEA) is applied to reduce the defects and wastes. In bakery company which manufacture various kinds of bakery to domestic and international customers, the frozen pie production is focused in this study. Since the highest number of defects (123,373 pieces) when comparing with other productions about 1,480,476 Baht per year.

Failure Mode and Effect Analysis (FMEA) technique is employed to define, identify, and eliminate the potential product failures from the process [1]. Hence, FMEA technique is utilized to analyze potential failure modes and prioritized according to how serious their consequences are, how frequently they occur and how simply they can be detected. The purpose of the FMEA is to take actions to reduce failures. Pareto analysis is used to determine the operations where appear the majority of failure modes in the frozen pie production [2].



2. Define phase of defect types in frozen pies production

This phase can help to define the rank of main defects according to the relative impact on the defective rate significantly. The historical data from April 2015 to March 2016 showed that the proportions of defects are classified as follows: cracked pies 27.10%, pleated pies 17.3%, twisted pies 14.12%, unfolded pies 11.20%, fissure pies 10.45% and other 19.83% shown in Fig. 1.

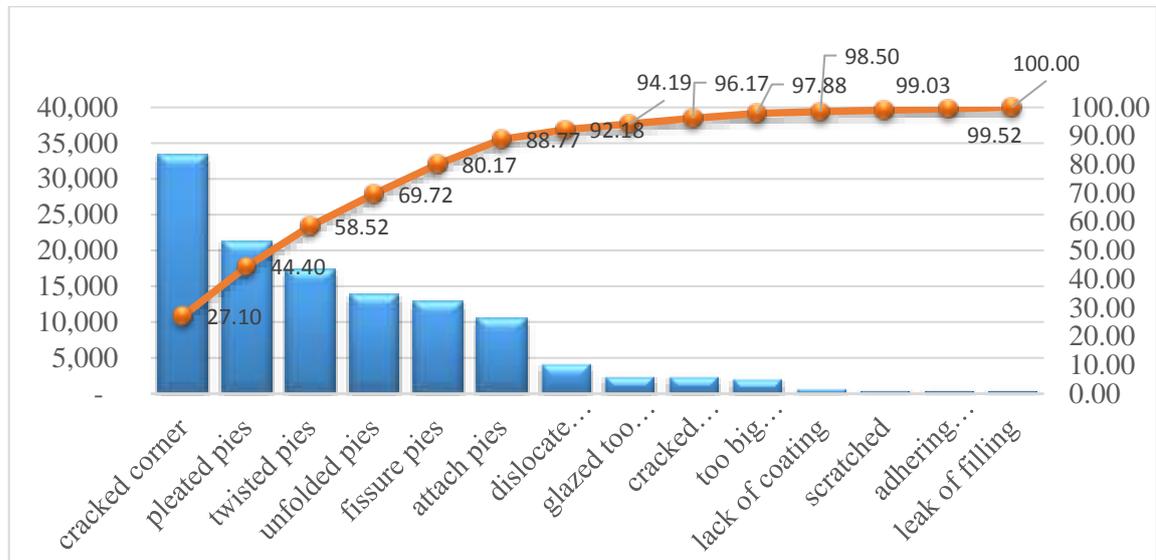


Figure 1. Pareto chart of defect (source: Production data of frozen pie from April 2015 to March 2016)

3. Root cause analysis of defects

Fishbone diagrams or the Cause and Effect diagrams are diagrams with 4M (Manpower, Machine, Material, and Method), to identify the factors causing an overall effect that may be part of the problem. These may be systems, equipment, materials, external forces, people involved with the problem. Fishbone diagrams or the Cause and Effect is applied to this process to indicate the root-causes of the defects [3]. Root causes of each type of defects can be summarized as shown in Table 4. There are 4 potential causes which are the lack of skills and expertise, the failure to check and control during process, the inappropriate equipment and improper method.

A brainstorming meeting by expert team who specializes in the frozen pie production is set to analyze and discuss the root-cause of the defects [4]. Hence, the failure modes of defects are determined by the cause-and-effect diagram as shown in Table 4.

4. FMEA in frozen pie production

FMEA is utilized to identify the potential process failure modes by ranking failures and helping to establish priorities according to the relative impact on the frozen pie. Implementing FMEA will help to identify the potential causes in order to reduce the occurrence and detect failure in frozen pie production.

The relative risk of a failure and its effects is determined by 3 factors which are Severity (S), Occurrence (O), Detection (D) [5] by multiplying the ranking for the three factors ($S \times O \times D$). A risk priority number (RPN) will be determined for each potential failure mode and effect [6]. Criteria for ranking of severity(S) occurrence (O) and detection (D) are selected and determined suitably by specialist in the frozen pies production as shown in Tables 1 to 3 [7]. The score of each parameter was recorded in FMEA table as shown in Table 4.

Table 1. Ranking of severity

| Effect | Severity of effect ranking | Ranking |
|---------------|---|----------------|
| Very high | Failure causes a high degree of customer dissatisfaction | 5 |
| High | Failure result in a primary function and becomes impacts the quality of the product | 4 |
| Moderate | Failure results in a partial malfunction of the product | 3 |
| Low | Failure creates enough of an effect to cause the customer to complain | 2 |
| Minor | No effect | 1 |

Table 2. Ranking for possible failure rates (Occurrence)

| Possibility of failure | Possible Failure Rates (Occurrence) | Ranking |
|-------------------------------|---|----------------|
| Very high | Extremely high; bound to occur (> 1 in 2) | 5 |
| High | High; occur frequently (1 in 10) | 4 |
| Moderate | Intermediate; occur occasionally (1 in 100) | 3 |
| Low | Low; occur rarely (1 in $1,000$) | 2 |
| Minor | Zero; never occur (< 1 in $100,000$) | 1 |

Table 3. Ranking of detection

| Detection | Criteria | Ranking |
|------------------|--|----------------|
| Very high | Uncontrolled process | 5 |
| High | Very low likelihood of detecting potential cause, failure mechanism | 4 |
| Moderate | Intermediate possibility of detecting potential cause, failure mechanism | 3 |
| Low | High possibility of detecting potential cause, failure mechanism | 2 |
| Minor | Virtual certainty of detecting potential cause, failure mechanism | 1 |

Table 4. Failure Mode and Effect Analysis in frozen pie production

| NO. | Failure Mode | Potential effects of Failure | S | Potential Cause(s) of Failure | O | Current Control, Prevention | D | R P N | Action Results | | | | |
|-----|---|------------------------------|---|--|---|---|---|-------------|--|---|---|---|-------------|
| | | | | | | | | | Action | S | O | D | R P N |
| 1 | Operators fold dough at inappropriate temperature | cracked pies | 3 | Failure to check temperature before folded | 3 | Observation of the operator usage | 5 | 45 | Dough temperature checking form was created | 3 | 2 | 3 | 18 |
| 2 | Folding Machine be in disrepair | fissure pies | 5 | Failure to check machine before folded | 2 | Observation and Checking of the machine | 5 | 50 | Maintenance , Upgrading and machine inspection form was created | 5 | 3 | 1 | 15 |
| 3 | Delay time of forming process | twisted pies | 5 | Failure to control delay time | 5 | Uncontrolled | 3 | 75 | Design new the conveyor process from convey on basket into belt directly | 5 | 1 | 2 | 10 |
| 4 | Operators trim edges over the edges | unfolded pies | 5 | Lack of skills and expertise | 3 | Observation of the operators | 3 | 45 | - Training and Informing of staff | 5 | 2 | 3 | 30 |
| 5 | Operators ruffle the sheet while forming | pleated pies | 5 | Lack of skills and expertise | 3 | Observation of the operators | 3 | 45 | - Created specified the defects on work Instruction and place on site | | | | |
| 6 | Operators spread sheet too tight | fissure pies | 5 | Lack of skills and expertise | 3 | Observation of the operators | 3 | 45 | | | | | |
| 7 | Gap between fringes of conveyor | cracked pies | 5 | Inappropriate equipment | 4 | Uncontrolled | 5 | 100 | Design new fringe of conveyor | 5 | 2 | 2 | 20 |
| 8 | Improper Method to bring pies out of basket | cracked pies | 5 | Not implemented for method | 5 | Uncontrolled | 5 | 125 | Design new the conveyor process from convey on basket into belt directly | 5 | 2 | 2 | 20 |

The Risk Priority Number (RPN) of different processes are found out. Eight causes of failure modes are selected and classified by Pareto diagram. The RPN values before and after corrective action are shown in Table 4. After applying all new corrective and preventive actions to the process, the RPN value is reduced approximately 60.08 %. Finally, FMEA analysis showed that the percentage of defects in the frozen pies production decreased by 51.9%.

5. Conclusions

In this study, FMEA is utilized to reduce the defects during the frozen pies production. The risk priority number (RPN) for the prioritization of failure modes of frozen pies is calculated. The results showed that RPN values of the 1st freezing to the glazing process, the forming and the folding process decreased by 33% to 87%. Furthermore, Pareto chart is applied firstly to elucidate which can help to find the main cause, the frequency and importance of the failures for each defects that may affect quality of frozen pie. An integration of PFMEA and Pareto chart to reduce the defects in the frozen pie production is proposed as these could be useful quality tools for improving the quality and the performance of the bakery manufacturing processes.

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