Risk Assessment of the Critical Production Process Using a New FMECA Approach: an Application in a Cooking Oil Production Company

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Abstract - This study attempted to apply the Failure Mode Effects and Criticality Analysis (FMECA) to improve the quality of a production system, especially on the production process of a cooking oil company. Since food processing safety is a worldwide issue, and the self management of a food company is more important than relying on government regulations, so the purpose of this study was to identify and to analyze the criticality of potential failure mode on the production process, then take corrective actions to minimize the probability of making the same failure mode and re-analyze its criticality. The results of corrective actions were compared with those before improvement conditions by testing the significance of the difference using two sample t-test. A final result that had been measured was the Criticality Priority Number (CPN), which represented to the severity category and the probability of making the same failure mode. The recommended actions that proposed on the part of FMECA gave less CPN significantly as compared to that before improvement, with 38.46% for the palm cooking oil case.

1. Introduction

Food processing is a very important worldwide issue. Processing may have either beneficial or detrimental effects on these different properties of food, so each of these factors must be taken into account in the design and preparation of complementary foods. Food quality is frequently associated with food safety. Food safety encompasses a whole series of processes and activities both within and outside the food processing plant that will ensure that the food is free of potential chemical, physical, and hazards. Quality within a food processing plant may also be related to the notion of quality control. In this regard, quality control has many objectives within a food processing plants, mainly being to maintain the nutritional value of the processed product, to protect customers from the dangers of contaminated food and associated food borne diseases, and to ensure that all food laws and regulations are met.

Quality assessment of processed food has become an emerging issue in the present era. The quality factor has broadened and covers all the aspects which satisfy consumer expectations. The terms “food quality” and “food safety” mean different things to different people. Quality has a vast number of meanings and can encompass parameters as diverse as organoleptic characteristic, physical and functional properties, nutrient content, and consumer protection from fraud. Safety is more straightforward, relating to the content of various chemical and microbiological elements in food. Clearly, food quality and safety issues need to be addressed along the entire food chain.

Food safety is the responsibility of everyone involved with the food chain from regulators to producers to consumers. A modern food safety system, with the new risk analysis approach has the ability to much sharper diagnose the problems and also to suggest focused interventions to properly deal with them.

A number of developing countries are already taking steps to improve and strengthen their systems for food safety management. Several are moving away from the traditional approach focused on end-product control toward a process and science-based approach. Malik et al. [1] provided one example of science-based activities is using of risk assessment to support food safety regulations. A science-based approach enhances the ability of food safety regulators to estimate the likelihood and magnitude of the resulting risks and impact on human health.

In contrast, there are many cases deal with violation objectives of quality control, especially in the case of protecting customers from the dangers of contaminated food. One of recently case happened is about food scandal involving edible oils. For sure, this issue is a worldwide problem, because it is related with trust damage in entire industry trying to rebuild its reputation. Besides that, not only in local area that affected from this case, but it also spread around the world because of trading process, export and import matter.

The objectives of this study are described as follows.

(i) Identify and analyze the criticality of potential failure mode on a system, especially on the production process of palm cooking oil.
(ii) Take corrective actions to minimize the probability of making the same failure mode and analyze its criticality.
(iii) Compare and test the significance of the difference between before and after improvement.

The final result leads to Criticality Priority Number (CPN), which contains severity category and probability of failure mode occurrence. All the objectives of this study are met through an application of industrial engineering tool called Failure Mode Effects and Criticality Analysis (FMECA).

2. Failure mode effects and criticality analysis

There are some findings related with FMECA. Bertolini et al. [2] pointed out an application in the pasta production plant. The results obtained through the application of the method proposed to the specific case study of a durum wheat pasta production process demonstrate that FMECA application to the analysis of the internal traceability system for food processing companies can grant valuable results. A valuable safety analysis tool should be efficiently used to analyze, improve and, if necessary, re-engineer a food product's internal traceability system. Braglia [3] noted that if reliable quantitative judgments are available for some criteria, they can easily be included in Analytic Hierarchy Process (AHP) analysis. This possibility means that Multi-attribute Failure Mode Analysis (MAFMA) can also eventually easily replace or integrate in a more complete manner FMECA studies already executed by maintenance staff.

The extension of FMECA using fuzzy logic is performed by Bowles and Pelaez [4]. Fuzzy logic provides a tool that can be used throughout the design process for performing a criticality analysis on a system design and prioritizing the failures identified in a FMECA for corrective actions. The result allows appropriate actions to correct or mitigate the effects of a failure to be prioritized. Bowles [5] also gave some comments of using the RPN methodology. The fundamental problem is that ordinal scales are used to rank the failure modes in terms of severity, occurrence, and detection, but the scales are treated as if numerical operations on them, most notably multiplication, are meaningful. Bowles [5] recommended if a cost could be associated with each failure effect, failures could be placed on a dollar scale (a ratio scale). Multiplying the cost of the failure effect and the probability of occurrence of the underlying failure mode could produce an "expected cost" of the failure. Finally, proposed design changes could then be evaluated by their effect on the expected cost.

3. Discussions

This study has used a concise and clear methodology on applying FMECA approach in an oil company. This approach begins with direct observation about the production process to make palm cooking oil, then map its flow process. Next is going into FMECA analysis, that describes the detail about critical process and perform criticality analysis for each of it. Recommended actions are proposed to have improvement on reducing the criticality risk. Evaluate recommended actions by performing criticality analysis as well as on the initialization step and compare its changes. At the end, recommended actions give better result significantly compare with before improvement. The result is related with safety improvement, which refers to lesser severity category and probability of making the same failure mode. Criticality priority number might be improved by 38.46% (from average CPN 3.25 to 2) on palm cooking oil case study.

As explained before, this study has succeeded to apply FMECA in an oil company case study. However, FMECA is not a tool that can only be applied in an oil company, but it's also feasible to apply in another field, such as use before design commences in order to influence the design and uncover design risk. FMECA can be applied in electricity component design, food industry, automotive industry, and even for daily needs industry related with customer satisfaction.

4. References

[1] Malik, A., Masood, F., Ahmad, S. Food processing: Strategies for quality assessment, a broad perspective. New York: Springer, 2014.

[2] Bertolini, M., Bevilacqua, M., Massini, R. FMECA approach to product traceability in the food industry. Food Control, vol. 17, no. 2, 2006, pp. 137-145.

[3] Braglia, M. MAFMA: multi-attribute failure mode analysis. International Journal of Quality & Reliability Management, vol. 17, no. 9, 2000, pp. 1017-1033.

[4] Bowles, J. B., Pelaez, C. E. Fuzzy logic prioritization of failures in a system failure mode, effects and criticality analysis. Reliability Engineering and System Safety, vol. 50, no. 2, 1995a, pp. 203-213.

[5] Bowles, J. B. An assessment of RPN prioritization in a failure modes effects and criticality analysis. Journal of Institute of Environmental Sciences & Technology, vol. 47, no. 1, 2004, pp. 51-56.