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IDENTIFICATION OF DEFECTS IN THE PRODUCING PROCESS OF INDUSTRIAL BREAD USING FMEA METHOD AND PARETO ANALYSIS

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Abstract

Preventive approach in quality control of production processes represents a new paradigm of quality assurance as a way to achieve production with zero defects or production with rarely present defects.

A critical limitation of the statistical quality control is ineffective in detecting and controlling defects, the dominant source of nonconformities in baking processes.

In these researches are implemented Failure Mode and Effects Analyses (FMEA analysis) for prediction of potential failure modes and for identification the reason of occurred defects, and Pareto analysis for determine the operations where appear the majority of defects in the production of industrial bread.

Contrary to the traditional quality control approach, which includes detection of poor quality based of evaluation and inspection, in this study are determinate the benefits of these techniques implementation: efficient variation and process stability monitoring, defects prediction, improvement of the baking process and production of high quality products at minimum costs, as the key to success of the organization.

Key words: *Quality, control, process, FMEA method, Pareto analyze, industrial bread.*

1. Introduction

Quality control in baking production process is conducted through inspection based on an assessment which provided detection of the poor quality of raw materials, half-products and products. In this business area what is missing is implementation of statistical process control as a prevention from non-conformities of final products that result in cost increase as of losses from the occurred defects (Чепујноска [1]). Within the production process of industrial bread on automatic production line with tunnel oven, a problem is being detected in variation of the final product weight, i.e. bread weight is beyond limits defined in the specification. As smaller the number of products with variation of the weight out the specification limits, as lower production costs.

According to (Калуѓерски and Филиповиќ [2]) as possible reasons are named certain factors: insufficient dosage of appropriate enzymes, imprecise parting of dough, suboptimal conditions of dough fermentation and water absorption, insufficient baking of the bread. The percent of non-conformities ranges between 13,0-14,0%. In order to identify the reason of occurred defects, the following is applied: Failure Mode and Effects Analyses (FMEA method) and Pareto analyses for number of defects during industrial bread production (Madison [3]). The results from the research are identifying and removal of the reason for weight variation of the industrial bread, as well as determining to the acceptable level (Clute [4] and Ušćebrka *et al*. [5]).

2. Materials and Methods

The research is made in Milling and Baking industry Zito Polog AD. FMEA method is applied in baking technological process, so the severity (SEV) of risk occurrence, the probability (OCC) of risk occurrence and the probability of risk detection (DET) are determined. All assessments are expressed by numerical values from 0-10, as shown in Table 1:

Table 1. Numerical values of severity, probability and risk detection

very small	small	medium	strong	very strong
1	2-3	4-5-6	7-8-9	10

By these numerical value can be calculated the value of Risk priority Number (RPN) with equitation (1):

$$RPN = O \times S \times D \quad (1)$$

The ranking of RPN is present in Table 2.

Table 2. General indication of risk

Value of RPN	Evaluation of risk
> 100	significant
10 < RPN < 100	less significant
< 10	negligible

Softver Statistica Six Sigma Release 7 has been used for FMEA procession. For FMEA worksheet creation, there have been used data from: Department for control and quality assurance, Maintenance department for equipment interventions, Production Department and IT department.

3. Results and Discussion

FMEA is made in each step of the production process of industrial bread, and there are determined some potential causes of failure function in separate phase (Stamatis [6]). In Table 3 is present FMEA Worksheet for the process of production of industrial bread, prepared on 10/15/2010.

FMEA analysis shows that RPN has higher value of 196 in the process of dough dividing, i.e. mayor "culpable" for defects in the production process of the industrial bread in the dough divider. The reason for this is the working principle, i.e. mechanical dough dividing, as well as the obsolesce of the divider (Ковачевиќ [7]). As the risk value priority is higher of 100, the risk in the sixth step (process of dough dividing) from the production process is considered as significant, while in the rest of the steps the value of the RPN ranges between 8-100. Therefore, it is considered as less significant or insignificant. If lower weight is determined during the control measurement of the dough parts weight, the same will be returned for re-procession of the initial dough. While in the other phases where the fault is obvious and the probability that the product with defects will be distributed is low (DET=1-2), within the phase of dough dividing there is a great probability for obtaining half product that weights beyond the specification limits, and small opportunity for detection, i.e. DET=7 (McDermott *et al*. [8]).

If the value of RPN shows Pareto diagram (Figure 1), it can be immediately concluded that the first bar of the diagram (step 6) is considerably higher in relation to the other phases.

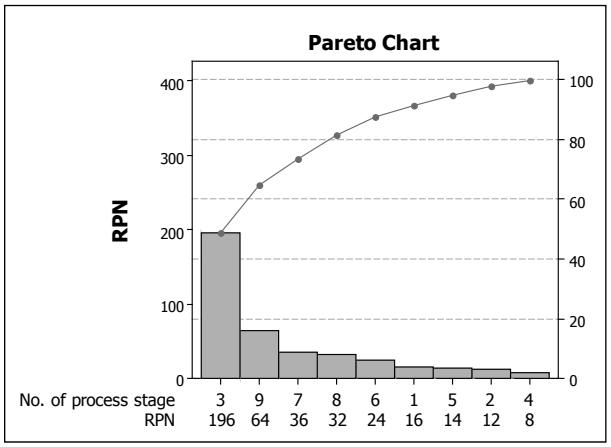

Figure 1. Pareto diagram for the RPN value before intervention

The concept of Pareto Analyzes is: "The vital few and the trivial many", which means the better improvement is achieved by reducing the highest bars of defects in the critical operation for a half, than reducing of any of the lower bars to zero (Чепујноска [1]).

The result of corrective action is being undertaken by replacement of the dough divider with a new one, is considerable increasing of the accurate of the final product weight. The accuracy of the new machine provides products with minimal weight variations, within the specification boundaries +/- 5%. RPN amounts to 28, risk detection from 7 decreases to 1. The percent of non-confirmative products amounts to 3, 6 %. After undertaking of corrective action, another calculation of RPN is being made, which is registered in table 4 with DFMEA functions.

Table 4. DFMEA functions

Ordinal number	Name of function (failure position)	Failure form	RPN before Corrective Action	RPN after Corrective Action	Corrective Action
6	Dividing of dough	The mass of dough is out of the specification limits	196	28	Replace-ment with a new machine for dividing dough

The RPN value after undertaking is present on Fugure 2, where it is concluded that the dough dividing operation (step 6) is the fifth bar.

Table 3. FMEA Worksheet: Process of production of bread on automatic baking process line

Operation	Problem description	Negative effects	SEV	Causes	OCC	Monitoring Control	DET	RPN	Corrective measures	PS	PO	PD	PRPN
1. Measurement of raw material	Disposal of reaching the recipe for raw materials.	Products with non-specific volume, deformed shape, irregular porous texture of bread, the presence of uncharacteristic flavor and taste.	4	Negligence of workers, improper measurement.	2	Accurate and calibrated measuring equipment. Technologist Control.	2	16	Removing of non-conforming product. Calibration of measuring equipment.	4	2	2	16
2. Kneading of dough	Inconsistent dough due to inadequate kneading process (speed and time).	Difficulties in processing and weakened dough strength; obtaining products with irregular shape, thin volume, cracked surface crust, poor elasticity, large holes in the middle of the bread, clots occurrence of salt, yeast, additive in the final product.	3	Kneading with wrong speed and time.	2	Technologist implements control of the given parameters of kneading.	2	12	Distribution of dough in small doses in the following configurations kneaded.	3	2	2	12
3. Dividing of dough	Mass of dough which is not in accordance with the value of the specified weight of the dough divider.	Obtaining the products with a weight that is outside from allowed interval of variation. Larger weight - increased production costs, mismatch with the intended consumption of raw materials. Lower weight - Customer dissatisfaction.	4	Imprecision of the machine sharing the dough. Irregular control the mass the dough from the operator.	7	A regular control of the accuracy of the machine for dividing dough - Technologist.	7	196	Products with different weight than the permitted are withdrawn as a non - conforming.	4	7	1	28
4. Moulding of dough	Distorted form of bread, no shiny and smooth surface of the crust.	Phenomenon of the blisters and cracks on the surface of the crust.	2	Too long processing of dough	2	Operation monitoring - Technologist, preventive maintaining.	2	8	Correction of dough molder- Maintenance.	2	2	2	16
5. Pre-ferment of dough	Resting the dough in chamber (dough proofer) in unsuitable conditions.	Disorders of the volume of the semi-products/final products. Difficulties in mechanical treatment of dough-forming a loaf.	7	Starting of the process with unrivaled working conditions (optimum temperature and moisture content).	2	Technologist - monitoring of the parameters.	1	14	Correction of the conditions before fermentation - Maintenance.	7	2	1	14
6. Fermentation of dough	Dough fermentation in inappropriate conditions.	Middle on bread is crumbly, is not achieved: optimal volume and shape of bread, color on bread crust is no specific.	8	Unsuitable and irregular controlled parameters (temperature and humidity).	3	Technologist - monitoring of the parameters.	1	24	Correction of the conditions for fermentation - Maintenance.	8	3	1	24
7. Baking the dough	Failure to reach the proper color of bread crust and appropriate structure in the middle of the bread.	Middle on the bread is sticky and crumbly. Appearance of cracks, blisters, burned, half-baked crust of bread. Getting the mold to final products before the expiration on shelf life.	9	Deranged preferences (temperature and time), lack on steam, inappropriate distribution of products on conveyor belt.	2	Monitoring on process preferences and quality on semi-products - Technologist. A suitable schedule of products.	2	36	Removing non - conforming products.	9	2	2	36
8. Cooling of the product	Incorrect conditions (time) of cooling.	Phenomenon of the wrinkled crust and drying up of the bread.	8	Inadequate cooling time.	4	Monitoring the cooling time of bread.	1	32	Adherence to the determined cooling time.	8	4	1	32
9. Packaging of finial product	Incomplete packaged product.	A potential possibility for contamination of the bread at further manipulation. Increased time for finalization.	8	Failure of the heater working temperature.	4	Monitoring on heater temperature.	2	64	Finishing of the products. Correction of the parameters - Maintenance.	8	4	2	64

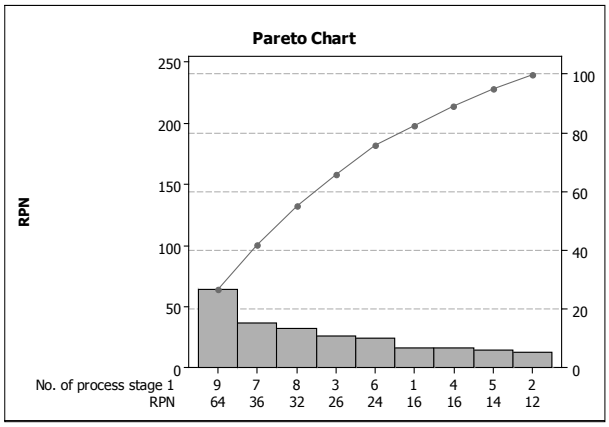

Figure 2. Pareto diagram of the of RPN values after corrective action

The percent of reduction of the non-conformities after corrective action from 13-14% annually to 3.6%, is shown by trend chart on Figure 3 (Чепујноска [1]).

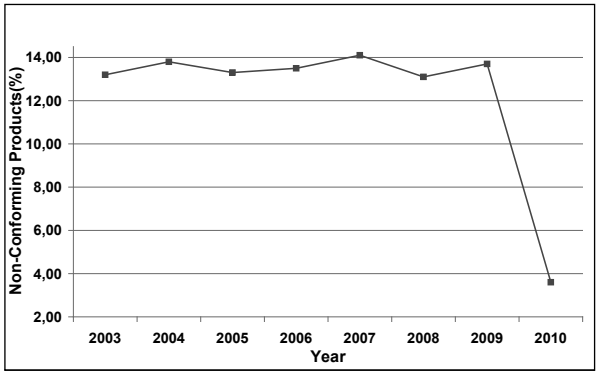

Figure 3. Diagram of the annual percentage of non-conformities

4. Conclusions

- The application of appropriate methods and techniques for monitoring and quality control in baking process, will allow managers scientific approach in the quality assurance and production of high quality products at minimum costs.
- Based on the results of FMEA and Pareto analysis, the source of poor quality is identified, the corrective action is taken and the required accuracy in bread making is achieved.
- Both methods are the excellent tools for organizations self assessment and tend to improve performance of bread making processes.

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5. References

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