

Research about using the Failure Mode and Effects Analysis method for improving the quality process performance

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Abstract. Failure Mode and Effects Analysis (FMEA) is a method of analysing potential failures of a product or process, in order to plan the necessary measures to prevent their occurrence. Being a critical analysis method, FMEA has extremely precise objectives: determining the weak points of a technical system; searching for the initiating causes of component dysfunction; determining the needs of technology upgrading and modernization of production; increasing the level of communication between work compartments, people, hierarchical levels; analysis of the consequences on the environment, the safety of operation, the value of the product; providing corrective actions to remove the causes of defects; providing a plan to improve product quality and maintenance. The FMEA must be used from the design phase before the product is made. This paper describes a study about the improving the quality process for an axis for packaging using FMEA method. The potential causes of the defects have been studied and improvement measures have been proposed. Among these we mention: implementation and monitoring of the preventive maintenance program; providing specific compliance; self-control, flow or sample control; periodic training and retraining; upgrading existing equipment, acquisition of more advanced software.

1. Introduction

Worldwide due to customer expectations coupled with the continuing increase in the complexity of products, declining design and launch periods have necessitated systematic quality planning [1].

The premise of traditional quality assurance, based on the detection and elimination of defective products, is no longer relevant, the argument being extremely simple and intuitive: defects that can be avoided before launching the product, do not need to be corrected later [2]. Modern methods of systemic quality design are answers to new quality requirements, they must allow the analysis and elimination of potential defects from the design and implementation stage [3], so that more and more often the notion of "quality design" is encountered [4]. One of these methods that has become increasingly used in recent decades is the FMEA [5,6]. Failure Modes, Effects & Analysis (FMEA) is a systematic method of determining and preventing errors, defects and risks that may occur, applicable to a process, product or machine used in the process [7,8]. This method consists in detecting possible defects, inventorying the causes that could cause these failures, demerits effects on users in order to plan the necessary measures to prevent their occurrence [9]. This method was originally developed in 1949 by the US military, thus the military procedure MIL-P 1629 entitled "Procedures for Performing a Failure Mode, Effects and

Criticality Analysis" having applicability to projects aimed at ensuring maximum availability of strategic military equipment [10]. The first notable applications of FMEA techniques (acronym AMDEC in French) are related to NASA (60's) and later in the 90's by the 3 major US car manufacturers: GM, Ford and Chrysler by including them in the prescriptions of the quality standard QS 9000, figure 1 [11-13].

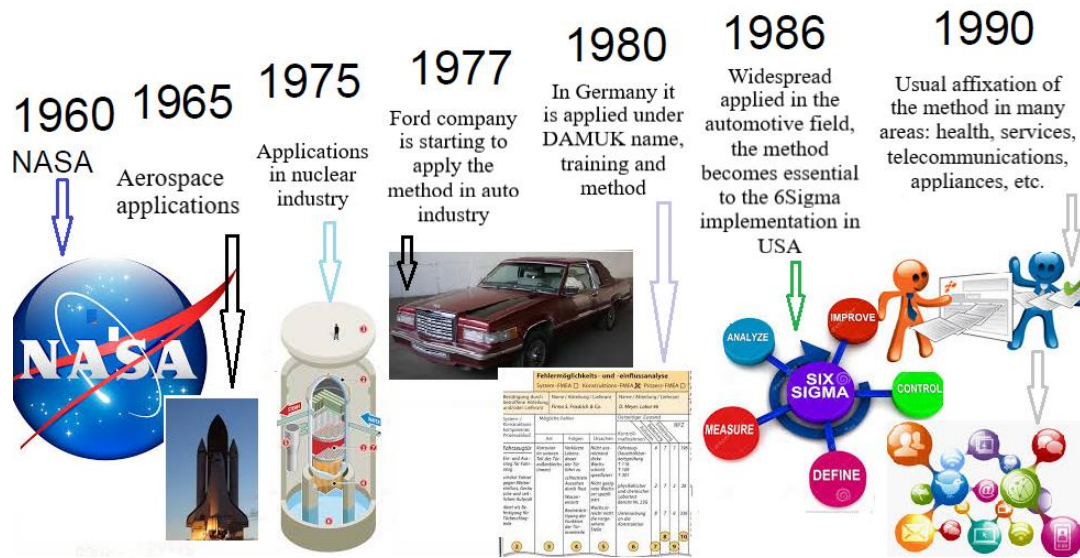


Figure 1. Time evolution of the FMEA workability.

There are two main types of FMEA [14]: product development (design), DFMEA and process development, PFMEA. In addition to the two types of FMEA listed above (DFMEA and PFMEA), the following are also known and used: FMEA system (system) focused on the study of the functions of the components of the subsystem, machine–or technological equipment; FMEA service that is used to analyze the functions of the service; FMEA software focused on the study of software functions and computer components [15].

2. Methodical Basics for FMEA Analysis

The methodology for applying the FMEA method was presented in [16, 17]. The application of the process FMEA involves, in a first stage, the description of the process functions. Starting from these functions, the potential faults are identified and the critical stages of the process are highlighted. The necessary corrective measures shall be taken to prevent the occurrence of defects.

The designated team of specialists evaluates the defects in terms of two criteria: probability of occurrence (Occ) and probability of detection (Det), which are expressed using the same notation scale with marks from 1 to 10. The quantification of these probabilities depends on the type of product or the analyzed process. Severity (Sev) means the value that characterizes how serious is the effect established for the failure mode and how it affects the customer, in terms of product / process failure / failure, their effects and grading being achieved by grades given from 1 at 10.

The assessment of the importance of defects is done using the notation scale based on probabilities of occurrence (Occ) and detection (Det), and occurrence (Occ), the RPN risk index coefficient is determined by the relation:

$$RPN = Sev \times Det \times Occ \quad (1)$$

The estimations of the analysis are written in tabular form, similar to the one described in figure 2.

Potential Failure Mode and Effects Analysis (Process FMEA)																
Item:						Process Responsibility:										
Type of component:						Key Date:					Rev.					
Core team:																
Process Step Function	Requirement	Potential failure mode	Potential Effect(s) of Failure	S E V	C L A S S	Potential Cause(s) of Failure	Current Process				R P N	Responsibility & Target Completion Date	Action Results			
							Curent Process Controls Prevention	O C C	Current Process Controls Detection	D E T			Action taker	S E V	O C C	D E T

Figure 2. The table header used for FMEA analysis [18]

The RPN coefficient has values between 0 and 1000. It is generally considered that measures are needed to prevent potential failures when the CR risk coefficient is greater than 100.

3. FMEA process Analysis for a Packing Shaft

Figure 3 shows the packing axis for which the process FMEA analysis was performed.



Figure 3. Packing shaft

The operations and stages necessary for the obtaining of the component in the chronological order of their development, are: qualitative inspection - reception of materials; semi-finished cutting; milling and centering; turning 1; milling and drilling; turning 2; grinding; final adjustment.

After the application of the FMEA, it was found that there are operations that lead to serious disturbances of the technological process, having a high RPN, of over 100 points, these being the following: when cutting the semi-finished product, when the semi-finished product shows arrow curvature due to deviation from misalignment due to large successive temperature variations (severity - score 5, occurrence - score 3, detection - score 10), RPN value of 150, certificate of material from the supplier; when cutting the semi-finished product, when the documents are incorrectly completed or incomplete, having as affect the mounting of the shaft with material of different specification due to the filling error at the material suppliers (severity - point 9, occurrence - point 4, detection - point 3), RPN with a value of 108, certification and control of material from the supplier is recommended; when cutting the semi-finished product, when the cut semi-finished product is longer than necessary, it may have the effect of affecting the on time delivery (OTD) due to non-compliance with the working instructions (severity - score 10, occurrence - score 4, detection - score 3), RPN value of 120, training, periodic retraining and flow self-monitoring are recommended; at turning operation 1 when the milled

and drilled shaft is not in accordance with the documentation may cause rejection of the shaft or its reclassification due to human error, respectively operator is trained but does not comply with the manufacturing process (severity - point 10, occurrence - point 5, detection - point 4), RPN with a value of 200, standard working instructions describing the process steps are recommended. At the turning operation 1 when the overhaul is exceeded, the shaft may be reshaped, reclassified or rejected due to the delayed launch by the design, respectively the operator is trained but does not respect the manufacturing process (severity - score 10, occurrence - score 3, detection - score 4), RPN with a value of 120, the following modification sheet is recommended, audit.

The RPN values in order of their appearance are presented in the diagram in the figure 4.

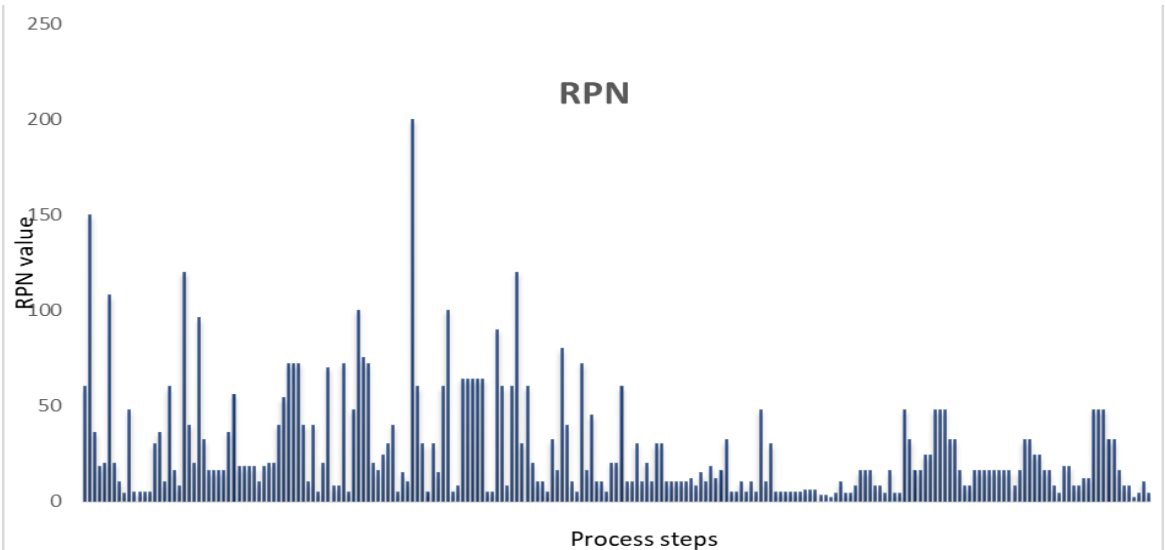


Figure 4. The RPN values in order of their appearance.

In figure 5 the RPN values in descending order of parts subjected to FMEA analysis is represented. After taking the necessary measures to implement the recommendations for each operation with a high RPN, it decreased to zero, leading to finished products with "zero defects".

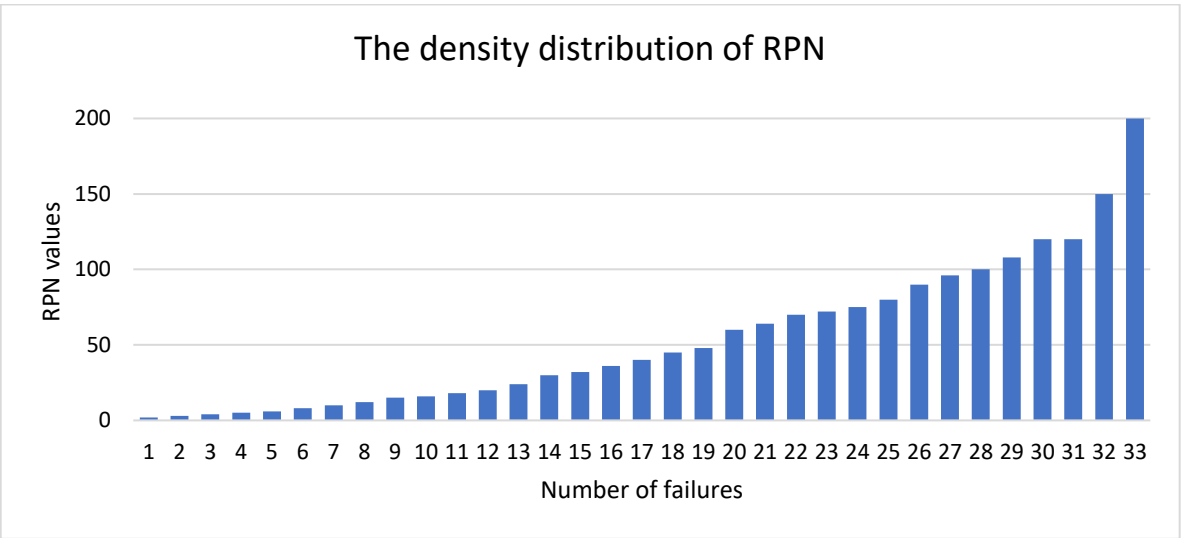


Figure 5. Diagram of RPN distribution

4. Conclusions

Timely use of FMEA - Process analysis can avoid costly changes to the technological process of making the product "packaging tree" by identifying potential defects, avoiding them and assessing the risks and potential consequences of defects and obtaining "zero defects" as target products.

The main potential defects analysed are: misalignment due to large successive temperature variations, shaft mounting with different specification material, milled and drilled shaft is not in accordance with the documentation, reshaping, reclassifying or rejecting the shaft, damage affecting the dimensions on the part. The potential causes of the defects have been studied and improvement actions have been proposed. Among these we mention:

- implementation and monitoring of the preventive maintenance program;
- modernization of the existing milling machine;
- revamping of the numerically controlled lathe on which the turning operations are performed;
- update for the software of the processing program - introduced in the program, with the processing and revision of the drawings;
- acquisition of a program for simulating the turning operation, periodic testing of the program in production;
- standard work instructions that describe the process steps;
- monitoring of operators through actions to observe operators' non-conformities and their regular training;
- periodical trainings and annual audits.

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