FMEA Study Proposal with Application in a White-Good Appliances Product

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ABSTRACT

One of the growing concerns in companies in developed countries and in Brazil is to look for new ways to stay in the market, increasing their productivity and improving the quality of their products. The FMEA methodology allows us to avoid, through the analysis of potential failures and proposals for improvement actions, failures in the design of the product or process occur, in order to increase reliability. The reliability of a product is the reflection of the number of failures it presents when subjected to stress tests, thus helping in the detection of problems, determining the time to be offered as a guarantee and helping in the prevention of new failures. The objective of this article is to present a proposal for the application of an FMEA in a white line company, where there is a product with a high failure rate, in which this issue will be analyzed and direct proposals for improvements, seeking to reduce its occurrence in the product.

Keywords: Continuous Improvement, Failure, FMEA, Reliability.

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I. INTRODUCTION

By acquiring a certain product, it is essential that it meets the expectations of its functionality and requests that were externalized by coming up with the buy interest. Although, it can cause damage through the useful life of it. Thinking of it, it is necessary that there is a parameter, which should be connected to the product's state related to time. To product verification and monitoring is very important that it is understood how it behaves through the years, by a constant daily use of its user. Having it in mind, it's inserted the processes' production reliability, such as the quality projection through time. Most of the products start their lives with low rates, and after they must present an increase at the end of the year's continuous use.

The Failure Mode Effects Analysis (FMEA) methodology is a tool that searches by the potential failure analysis and proposes actions to enhance, on projects or processes. The

failure processes are inevitable, although searching for methods and tools to reduce the failure numbers or even reach to zero, in specific periods, it is essential. A long time ago, it abandoned the concept that it is necessary to wait for the equipment to arrive to a huge number of failures so that it can create an action plan. However, once creating an action plan and classifying the failures that affect the most on the product process is something hard, putting failures in a decreasing way on a priority level. Then, it has caused an increase in the search by more efficient ways of doing the plan, in a way that the company is not focused on the potential failures. Aiming to improve the failures analysis, the FMEA has been a technique exclusively created for failure analysis, in 1949, it has been used by the American Army to identify possible failures on military systems.

Within this work, it has the aim to present a proposal of the FMEA application to a product belonging to a white-good application product. The techniques used for data collecting,

and information on the article are observation types in real life, where the data have been registered as far as they occurred. The data were collected on Final Test, which is done still on the production line to filter recurrent defects on the productive process.

With the study case method utilization, it is going to be done field research to obtain knowledge of an empiric knowledge within the context of the problem. Through qualitative and quantitative research in a field experiment, carried in August of 2020, it has been possible to collect data with the aim to measure behavior patterns and relation between the variables.

II. LITERATURE REVIEW

A. FMEA

Failure can be defined as the end of availability of an item to do its requested function. To Stamatis (1995), failure is the incapacity of any active do what its user wants it to do. The definition of reliability talks about “correct performance of an equipment or system”. The lack of correct performance compliance will be defined as failure. There are failures that can occur under some circumstances of the processes, which can be treated with naturally, for example, the burn of a vehicle intern light. On the other hand, in some cases, if the failure occurs, it can be crucial, for instance, airplanes flying, hospitals’ electricity and vehicles’ braking (Slack *et al.*, 2008).

The analysis of the type Failure Effect, known as FMEA is a systematic technique to recognize and evaluate potential failures and its causes. Identify actions that eliminate or reduce the probability of its occurrence (Toledo and Amaral, 2006). To make FMEA a product it is necessary to understand clearly how the process works, to monitor data cautiously and feed the table correctly.

The steps to feed the table are: Process/Product – step analyzed on FMEA; Function – It’s the aim of FMEA application; Failure Mode – How the failure presents itself; Failure Effect – Impacts caused by the failure; Failure Cause – What has brought about the component failure; Severity (S) – Impact on security failure; Occurrence (O) – Probability of failure mode to occur; Detection (D) – Probability of the failure be detected; RPN (Risk Priority Number) – Risk priority.

It must be given a value to each failure mode as shown: Severity (S): where 1 is “minimum” and 10 are “very high”. Occurrence (O): where 1 is “remote” and 10 is “very high”. Detection (D): starts with 1 and is “very huge” and 10 “very small”. After determining the degree of each failure mode. It’s necessary to calculate RPN (Risks), according to the formula:

$$RPN = S \times O \times D$$

Then scale the failure priority. The bigger the RPN, the more critic is that failure. It is on it that must be applied the preventive actions occurrence (Toledo and Amaral, 2006). Fill the second part of the table with the action plan that has some topics, such as:

- Recommended action: indicated by the manager of the team.
- Responsible: author of the action.
- Deadline: limited date to decision making.
- Actions Taken: what has been really done.

Later assign a value to each failure mode: severity, occurrence, and detection. It can be calculated a new RPN, with the aim to compare it to the previous number, and this way figures out if there has been some failure reduction. Applications of FMEA methodology are found in several areas, according to the work of different authors (Batista *et al.*, 2019; Braaksma *et al.*, 2013; Braaksma *et al.*, 2012).

B. Reliability

According to NPEN:13306 (2007), “Reliability is the ability of a good to accomplish a function requested under conditions during a period of time” (Moubray, 2000). According to Daneshio *et al.* (2014), “Reliability is the capacity of an item to perform under some specified conditions, during a period of time”. The reliability is applied in the beginning of the project, in the intermediate development phase, final development phase, initial production phase, and production after sales. Thus, it can be done through continuous enhancement over all the products made and creation process (Ming *et al.*, 2015; O’Connor, and Moleh, 2016; Un. and Huibin, 2012; Voinov *et al.*, 2016; Zio *et al.*, 2019).

With the absence of “right performance” of the product, it is defined as failure. According to Gulati and Smith (2009), the main application of reliability in Engineering is on failures’ prevention. The reliability of a certain item can be defined as its capacity of doing a certain requested function during a certain period, subjected to a certain mean, under the project’s condition (Pham, 2014). According to Oliveira (2017), reliability is the feature of an item eventually expressed through probability that it will fill a given function, under established conditions and for a certain period established. According to those definitions, the concept of reliability has four significant elements:

- Probability: the probability is the reliability; this characterizes the differences within equipment of the same nature and enables us to know how good the ability is to function without failures through certain periods of time.
- Given function: Before starting any study, it is necessary to define the performance of a function and to indicate what the function is about This function performance has a level established by the failure type that occurred, the failure’s types are: total or partial, catastrophic or parametric, dependent or independent of other failures, suddenly or gradually, and stable, temporary or intermittent.
- Defined conditions: it’s cautiously defined by the application type which will be used the equipment, and the reliability type that will be used. Those types are intrinsic (in testing banks, where the conditions are well controlled) and operational (in real conditions of use).
- Time: the products must work during a certain period of time intermittently or only once, and this parameter can be, according to the situation, a mission duration, a cycle

number or mileage. The products which the utilization also doesn't observe the time intervention (explosives).

III. METHODOLOGY

The study object is the Failure Effect Mode Analysis methodology. The FMEA analysis is essential because with it is possible to analyse failures that impact more in the productive process of the product, allowing the application of one or more enhancement proposals, to reduce or eliminate impacts occurred on the existent failure, using a weighted study according to the failure's critical degree, besides obtaining a catalogue of information about failures on product and process.

The FMEA model must have a well-defined scope and goals. With the realization of periodic meetings in the company, with all the members involved, similar to a project which must establish the steps evaluating its progress. In this way, the FMEA was applied following the steps of the Fig. 1.

IV. RESULTS AND DISCUSSIONS

The FMEA form is a document that enables an analysis of the failures historic of a product/item, since the frequent failures or even the future ones, which still can occur.

There are many models of FMEA forms that can be used according to the problem to be observed, and much specific software that can also do the confection of this form. In this work, the process FMEA model 2 has been used, with the aim to analyses an item of the production process of a white-good line product. The FMEA application proposal in a white-good product line is focused on the item "motor" which is an item that compound the final product.

The obtained data have been collected during the period of January to August of 2020, during eight months of observation in the model.

In Table I, it can be verified the failure "Motor noise" and the frequency in which it appears in the process, during the step "Final Test".

TABLE I: FAILURE FREQUENCY "MOTOR NOISE" FINAL TEST STEP

Failures of the Final Test step	Engine noise	Total step failures	Failure frequency (%)
Noisy engine	127	185	69%
Compressor does not start	17	185	9%
Engine does not start	10	185	5%
Panel - broken command	8	185	4%
Panel - exposed wiring	6	185	3%
Panel - fan does not turn on	6	185	3%
Panel does not turn on	5	185	3%
Crumpled cabinet	4	185	2%
Crushed fin	1	185	1%
Scratched cabinet	1	185	1%
Equivalence to total failures	185	185	100%

The failure motor noise has been equal to 69% of the present failures on the step, what makes necessary to an analysis of this item. It is also important to analysis failures on Fig. 1, in a way to visualize how much motor noise failure has a high index of occurrence.

Applying the FMEA in a product such as the item: "Engine with noise" as one of the highest indexes of failure, it was possible to take the following conclusions.

Fig. 1. Failure Final Test Graphic.

It is possible to verify in Fig. 2 that RPN reduced a lot after the application of some enhancements, almost trespassing the mark of 100% reduction. Through the actions made, it is possible to evaluate that there was a significant reduction of failures, with the FMEA application. The Table II shows this rate reduction. In other words, there is a significant reduction of failures in the FMEA application, and this shows how efficient FMEA analysis was, according to Fig. 3 and Fig. 4.

Fig. 2. Comparing to RPN after the FMEA application.

TABLE II: RPN REDUCTION PERCENTAGE POINTS

Failure	RPN before	RPN after	Failure reduction (%)
Warped snail	126	54	57%
Compressor does not break	192	48	75%
Engine propeller poorly fixed	120	30	75%
Burr on top curl	84	32	62%
Electric motor poorly fixed	90	30	67%
Locked propeller	105	30	71%
Crushed fin	45	18	60%
Decentralized turbine	48	16	67%

TABLE III: MOTOR FMEA PART I

FAILURE MODE AND EFFECT ANALISYS - FMEA													Revision: - Sheet: 1 Data: 15/02/2021			
PRODUCT/PROCESS: Engine / Final Test																
MODEL: QCI108BB					Responsible: Sheyla Cardoso / William Nicolas											
MATERIAL PROD/PROC.	FUNCTION	FAILURE MODE	FAILURE EFFECT	FAILURE CAUSE	S.	O.	D.	RPN	RECOMMENDED ACTION	RESPONSIBLE	ACTIONS TAKEN	S.	O.	D.	RPN	
Motor	Engine without noise	Engine with noise	Warped snail	Supplier process failure	6	7	3	126	Conduct visits to the supplier and request frequent reports of batch inspections	IQC Quality	Requested frequent reports of batch inspections	6	3	3	54	
				Storage when transporting					Conduct training for the correct transport and storage of products	Logistics	Training was carried out for the correct transport and storage of products					
			Compressor does not start	Poorly positioned snail	8	6	4	192	Perform daily checklist for critical parts	Production	Weekly checklist for critical parts	8	3	2	48	
				Strange item in the device					Track line for the most critical models and set SPEC for extraneous item identification	Process and Quality Engineering	Line tracking done for the most critical models and defined SPEC for extraneous item identification					
Motor	Engine without noise	Engine with noise	Engine propeller insecure	Operational failure	5	4	6	120	Apply Assembly Work Guide in the process for new operators; Update to existing ones	Process Engineering	Applied in-process assembly Work Guide for new operators; Updated existing ones	5	2	3	30	
				Poorly positioned snail					Conduct assembly training in the process Conduct assembly training in the process	Process Engineering	Assembly training carried out in the process					
				Turbine poorly fitted					Conduct assembly training in the process Conduct assembly training in the process	Process Engineering	Assembly training carried out in the process					
				Burr on top snail	Supplier process failed	4	3	7	84	Perform visits to the supplier and request frequent reports of part inspections	IQC Quality	Requested frequent reports of batch inspections	4	2	4	32

TABLE III: MOTOR FMEA PART II

FAILURE MODE AND EFFECT ANALISYS - FMEA													Revision: - Sheet: 1 Data: 15/02/2021			
PRODUCT/PROCESS: Engine / Final Test																
MODEL: QCI108BB					Responsible: Sheyla Cardoso / William Nicolas											
MATERIAL PROD/PROC.	FUNCTION	FAILURE MODE	FAILURE EFFECT	FAILURE CAUSE	S.	O.	D.	RPN	RECOMMENDED ACTION	RESPONSIBLE	ACTIONS TAKEN	S.	O.	D.	RPN	
Motor	Engine without noise	Engine with noise	Electric motor poorly fixed	Wrong screw	5	3	6	90	Apply attention to receiving material from suppliers	IQC Quality	Applied point of attention when receiving material from suppliers	5	2	3	30	
				Lack of threading					Request preventive maintenance report of the supplier's process machinery	IQC Quality	Requested preventive maintenance report of the supplier's process machinery					
				Burr on the thread					Request frequent reports of part inspections from the supplier	Quality Supervisor	Requested from the supplier frequent reports of inspections of the parts					
				Operational failure					Conduct assembly training in the process	Process Engineering	Assembly training carried out in the process					
Motor	Engine without noise	Engine with noise	Propeller locked	Wrong screw	5	3	7	105	Apply attention to receiving material from suppliers	IQC Quality	Applied point of attention when receiving material from suppliers	5	2	3	30	
				Lack of threading					Request preventive maintenance report of the supplier's process machinery	IQC Quality	Requested preventive maintenance report of the supplier's process machinery					
				Burr on the thread					Request frequent reports of part inspections from the supplier	Quality Supervisor	Requested from the supplier frequent reports of inspections of the parts					
				Propeller poorly fitted					Conduct assembly training in the process	Process Engineering	Assembly training carried out in the process					
Motor	Engine without noise	Engine with noise	Crushed fin	Incorrect storage	3	3	5	45	Conduct training for fin storage	Logistics	Training carried out for fin storage	3	2	3	18	
				Shipping failure					Checklist to verify the correct storage of the transport of fins	Logistics	Checklist carried out to verify the correct storage of the transport of fins					
				Operational failure					Conduct assembly training in the process	Process Engineering	Assembly training carried out in the process					
						Decentralized turbine	Misaligned hole	4	2	6	48	Request frequent reports of part inspections and keep the drawing updated with the supplier	Quality Supervisor and Product Engineering	Requested frequent reports of part inspections and updated drawing with the supplier	4	1

V. CONCLUSIONS

The aim of this work was to propose the FMEA application for a product belongs to a white-good line industry. It had been collected data related to the item, factors that influence directly on its functioning, listed the failure modes, and pondering in the way of which defined the priority degree (RPN) of each one. Subsequently, it has been simulated as an action plan, it has been pondered again each failure and obtained a new value to Risks, thus, reduced significantly almost trespassing the 100% reduction mark of failures.

In the critical item, it has been highlighted a considerable reduction of 72%, focusing on how important and efficient it is the utilization and proposal of FMEA.

Based on the FMEA application on the critical product, with focus on the failures of the item “motor”, it has been concluded that providing enhancement proposed will be highly important and will bring benefits to the process and product, once it will create a large-scale reduction to the previous failures. Leaving, this way, the FMEA application proposal as a suggestion of future studies.

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