Application of FMEA in an Automatic Component Insertion Equipment in an Electronic Industry

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ABSTRACT

One of the consequences of globalization was an increase in the response between companies. In this way, companies increasingly seek continuous improvement using various mechanisms and tools aimed at improving their processes, products, and services, thus making them more competitive. In this scenario, FMEA stands out as a unique tool for detecting and reducing failures in products and processes in order to improve their confidence. This article is the result of the study of the application of the FMEA in an equipment to the production process of insertion of components. For this, action research was carried out, where equipment failure data was collected. As a result, a 5W2H action plan was prepared with the support of a GUT matrix to apply the recommended improvements in the FMEA.

Keywords: Continuous Improvement, Failure, FMEA.

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I. INTRODUCTION

In the current globalized scenario, the industry is highly competitive, changeable, and demanding. In order to keep the industries competitive, it has used many mechanisms, quality and management tools, new technologies and collaborator qualification so that they can highlight themselves against their competitors.

Within this context, the maintenance sector of industries has become a means of cost reduction, process and products' quality improvement or services provided. Using the tools that focus on the better and continuous efficacy of maintenance plans, this sector has been gaining highlight within the process.

Within the tools that highlight the FMEA (Failure Mode and Effects), that translated would be the mode and effect of

failure analysis, created in the 50th decade for military purposes, although from the 80th decade started to be used in the industry to analyse processes and product's failure. The FMEA is the starting point to the reliability analysis of products, processes and systems aiming to identify, organize, correct, and prevent potential failures of them.

At last, this study has as the main objective, the application of FMEA in an automatic component insertion equipment. With the direct action inside of an electronic industry installed in Industrial Pole of Manaus, this article aims to demonstrate the improvements and possibilities that the FMEA provides to the company's productive process.

II. LITERATURE REVIEW

A. FMEA

According to Puente *et al.* (2002), around 1963, while the Apollo mission occurred, NASA had formulated a method to identify systematically the potential failures in systems, processes or, even, services before these eventual issues occurred. Therefore, it has been the beginning of the concept of Failure Mode and Effect Analysis (FMEA).

In an industry, the FMEA can be understood as a methodology that allows identifying potential failures within a certain system or process, with the purpose to discard or reduce the risks related, aiming to eliminate future failures. Thereby, putting an end in the failure modes.

To Stamatis (1995), the FMEA is a technique of product or process analysis used to detect all the possible potential failure modes and to see the effect of each one over the performance of the system, with basically deductive reasoning. Thus, a pattern analytical methodology to diagnose and eliminate potential issues of a complete and systematic mode.

In accordance with Palady (2004), the FMEA is one of the methods of low risk more efficiently to forestall issues and identify effective solutions in cost terms, seeking to prevent problems. Besides that, the FMEA has the duty to analyse the severity of the failures, the way that they can happen and, once they happen, how to detect and correct them.

According to Teles (2017), FMEA is a technique of qualitative analysis that shapes information into quantitative data. When the maintenance is elaborate, the FMEA is one of the most significant tools to be used, because of the following reasons:

- Failure mode determination: It can come from engineering or from the field. Data fields are more considerable, once they represent all the failures that a process can have.
- Risk analysis of each failure mode: the priority of which failure mode goes through three steps: failure severity determination (the scale of how bad it will be if it happens), failure occurrence determination (frequency of how much it happens) and failure detection probability determination (how easy it is to happen).
- RPN calculation (risk priority number): It is the calculation of multiplication of the occurrence values, severity and detection. It's a way to know which failure mode starts.

Teles (2017) complements that RPN stands for Risk Priority Number. The attention is defined by the result of Occurrence X Severity X Detection, the bigger the result, the bigger the priority ought to be to that point of the process. The three parameters presented can be attributed to punctuations from 1 to 10.

In accordance with Horita (2020), the FMEA utilization entails the minimization of the failure of the product or process, so, in the face of the methodology application. The reliability is contributed directly (Chhim *et al.*, 2019; Estorilio and Posso, 2010; Meng, 2011; Niu *et al.*, 2010; Pun *et al.*, 2002; Shafiee, 2015; Tian *et al.*, 2018).

FMEA methodology is applied in several areas of knowledge, resulting in significant improvements in processes, according to the work of different authors

(Rausand and Øien, 1996; Al-Hammad *et al.*, 2009; Irajpour *et al.*, 2014; Murthy *et al.*, 2002; Oliveira *et al.*, 2015; Oliveira *et al.*, 2012; Batista *et al.*, 2019).

B. 5W2H

According to [20] the 5W2H is a tool created by a Japanese automobility industry, which is an administrative tool that can have application in many business areas and in different contexts in an organization. The main purpose of 5W2H is to help plan the actions once it assists to clear doubts and free them from doubts about a certain issue.

From this, its use can generate benefits, such as adjust ideas and organize perspectives. The tool has been functioning similar to a checklist, in which it contains seven questions. The questions are: What? (What will be done?); Why? (Why will it be done?); Where? (Where it will be done?); When? (When it will be done?); Who? (By whom will it be done?); How? (How it will be done?) and How Much? (How much will it cost?) (Oliveira *et al.*, 2015).

C. 5W2H

Napoleão (2018) highlights that the GUT matrix is used by companies with the aim to define the prioritization of problems that need to be attacked by the management, such as discovering the priority of some activities that must be done or developed. The used tool, for example, in problem solving, developing projects, decision making, within others.

The acronym is formed by the words Gravity, Urgency and Tendency (Periard, 2011). The Gravity symbolizes the problem impact studied in case it happens. Urgency is defined by the deadline, the free or necessary time to resolution of the issue. Tendency portrays the potentiality of the problem growth, it is the probability of the problem growing according to time.

III. METHODOLOGY

It has used the research-action methodology taking into account that the research has been carried out in partnership with the industrial maintenance team of the company.

It is a qualitative and quantitative approach, once the study has as its aim the FMEA application, which approaches qualitatively and generates quantitative data, within an equipment to the insertion process of the company's compounds.

Initially, the choice of the equipment to apply to the FMEA. It has been chosen the CM-602 PANASONIC once it is an equipment of high quality in the productive lines of the company, with 14 units, also as being the chief of the insertion line of electronic compounds.

After it has been done, the subdivision of the equipment within systems, at this moment there has been the participation of the maintenance team of the company that supported the technical part of the study. After this division, it has been done the failure modes survey was already predefined by the manufacturer, according to the machine's manual.

Subsequently, there was the data collection from the maintenance manager, in which we filtered the CM-602 failure modes, where it has been verified the occurrences of it in the period of January to July of 2020, classifying each

failure mode according to its respective system within the equipment.

IV. RESULTS AND DISCUSSIONS

To the data analysis, it has been used some tools as spreadsheets, graphics, FMEA and GUT matrix. The following Table 1 shows the subdivision done in the equipment to better identification and localization of the failure modes.

TABLE I: EQUIPMENT SUBDIVISION

Machine Model	Structure
CM602 Panasonic	Head assembly
	Conveyor
	Vacuum system
	Linear guides
	Feed car
	Base camera
	Electronic system
	Nozzle change
	Electrical system
	Monitor
	Safety system
	Cutter

After that, it has been done the data collection of the failure's occurrence in each subsystem of the equipment. It has been used as a data bank of the company's maintenance team. The following graphic shows the quantity of failure modes of each subsystem.

During the data collection and definition of the modes and failures, it has been determined that the head of the CM-602 mounting is where the potential failures of the equipment occurred, followed by the Conveyor and the vacuum system. The three subsystems total 50% of the failure modes surveyed in the data collection during the evaluated period, as shown in Fig. 1.

Fig. 1. Quantity of Failures.

From the data survey, it has been done the FMEA elaboration, doing the failure analysis relating to its failure mode, effect, and possible cause, allocating by subsystem of the equipment.

Lastly, after the NPR calculation, it can be recommended preventive actions to each failure in the FMEA, taking into account the need and priority of each action. Based on the

information elaborated by the FMEA, it has been elaborated a starting action plan to be applied.

It has been used GUT matrix for the prioritization of the action of the maintenance team, taking into account that these actions must pass through a management analysis. The GUT matrix classification has been done by the PCM analyst according to the needs of the management.

Table II shows the action plan consolidated after the FMEA implementation study for the equipment.

V. CONCLUSION

Globalization had, among many consequences, increased competitiveness between companies. Through this way, the companies each time look more for continuous improvement using many mechanisms and tools that enhance its processes, products and services, becoming more competitive.

Then, the study consisted of FMEA application in automatic component insertion equipment of an IPM's company, with the aim to reduce equipment failures, provide data to the maintenance plan and be an example to be applied in another equipment.

Based on this information, it has been elaborated on the FMEA equipment and from it has been used the 5W2H methodology closely with the GUT matrix to propose an action plan based on the recommended actions in the study.

Although, there was a limitation of the action plan application, because the company's maintenance sector had changed the management. Therefore, it was not possible to compare the actions made before and after of the actions taken. At last, it is recommended the follow-up after the action is implemented and verification of the improvement occurred, thus it can be a model study to be replicated in the future in other companies' equipment giving this way a possibility of the reliability increase of the productive process.

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TABLE II: 5W2H ACTION PLAN

What to do?	Why to do?	Where will it be done?	When to do it?		Who will do it?	How to do this?	GUT Matrix			
Action	Reason/Consequence/Effect	Area	Expected start	Expected end	Responsible	How/Resources/Process	Grav.	Urg.	Tend.	Prior.
Survey the Part Numbers of the parts identified in the FMEA for registration in stock	Minimize machine downtime due to lack of parts	IAC Maintenance	25/01/2020	08/02/2020	Maintenance Technician	Using the equipment manual	3	4	5	12
Carry out the registration of parts for purchase and inclusion in stock	Minimize machine downtime due to lack of parts	IAC Maintenance	11/02/2020	12/02/2020	Maintenance Technician	Via registration spreadsheet sent to the registration sector	2	3	2	7
Inclusion of activities raised in MFMEA in the maintenance plan	Improved maintenance plan based on our MFMEA analysis	IAC Maintenance	24/01/2020	30/01/2020	Maintenance Technician	Add to the maintenance plan in the maintenance manager	3	3	2	8
Create troubleshooting based on defect analysis performed in MFMEA	Improvement in the maintenance stoppages made by the production	IAC Maintenance	17/01/2020	22/01/2020	Maintenance Technician	Using the data collected during the completion of the MFMEA	5	3	2	10
Perform HEAD Check programming with Panasonic to anticipate failures	Predictive maintenance of failures in HEADS	IAC Maintenance	25/01/2020	11/02/2020	Maintenance Technician	Conducting quotation process with Panasonic and closing the schedule according to equipment availability	5	3	2	10
Develop predictive maintenance in the company to implement predictive maintenance actions	Deployment of predictive maintenance in IAC	IAC Maintenance	25/01/2020	25/02/2020	Maintenance Technician	Conducting survey and development of suppliers	5	3	2	10
Development of a tensiometer for belt analysis	Minimize process stoppages due to broken belts and transport-related problems	IAC Maintenance	24/01/2020	22/02/2020	Maintenance Technician	Conducting survey and development of suppliers	5	3	2	10

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