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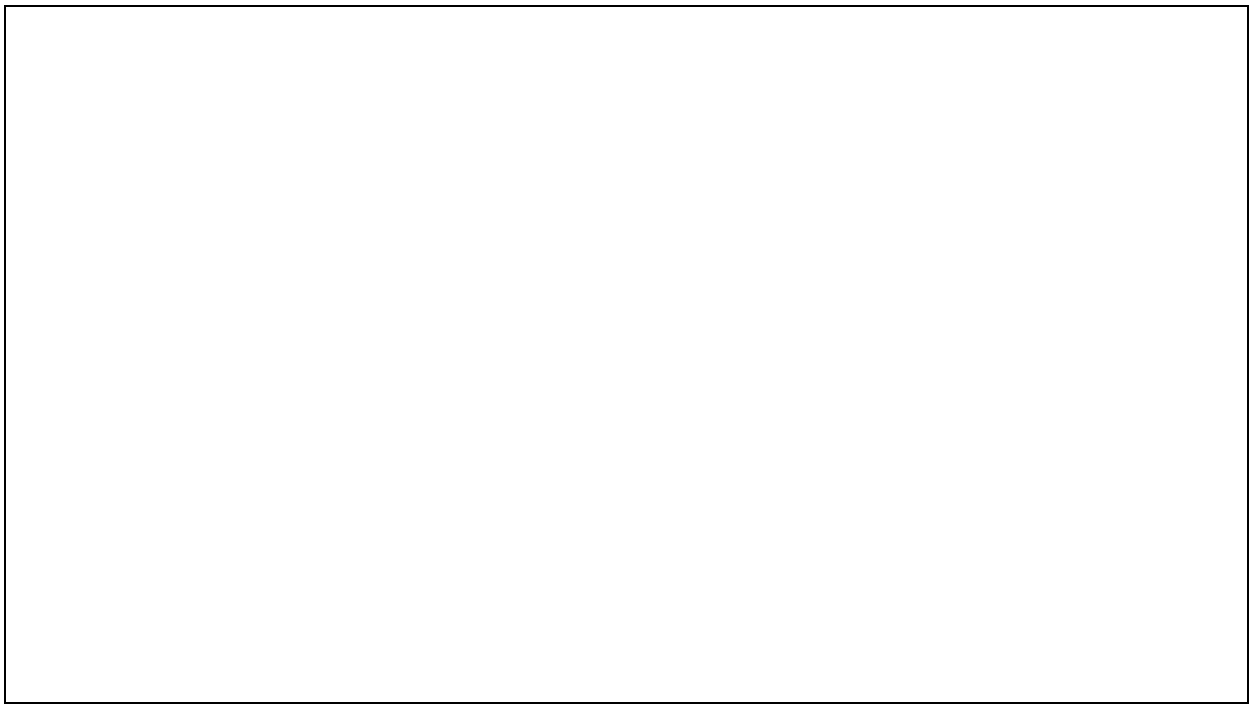

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Presenting Follow UP on Implemented pFMEA Methodology into Industrial Entity as a Quality Control Methodology used on a daily base

Ivo Kuzmanov[1] Silvana Angelevska[2] Roberto Pasic[3] and Ilios Vilos[4]

Abstract –**The paper presents only a segment from extensive done follow up on implemented pFMEA into industrial entity. The follow up was done at the beginning of the year 2018 after the implementation process at the industrial entity started at November 2016. The industrial entity is from the production industry - especially fire stoves production and it's the largest one in Macedonia but also one of the key players on the Balkan markets. The basic aim of the paper is to present the aimed results after the implemented FMEA methodology and the achieved benefits after a period of time (almost 2 years).**

Keywords –**FMEA, pFMEA, production system, Quality, Assurance, Quality Control, R. Macedonia.**

I. INTRODUCTION

The basic aim of the paper is to present a second follow up on a previously implemented FMEA into an industrial entity from Macedonia. The same one works into the metal cutting industry, or to be more precise the same one is maybe the largest producer of fireplaces for home use in R. Macedonia, and one of the key players on the Balkan market. Also what is more relevant is to say that the business entity is maybe one of the oldest ones in this area, or to be precise the same one has a constant production more than 60 years. Also the business entity has its unique capabilities – the largest one in this area according two main criteria's (production on a year base and the number of employees) but also has one of the most new and sophisticated and best lines among competitors. They use CNC machines in several production stages which makes the capacity maybe one of few in Macedonia with so many equipment doing precise things. On the other hand the papers presents only a small part from a second follow up on the effectivity of the implemented FMEA methodology and its benefits to the production stages and to the company itself. Also what is relevant to mention is to say that there were previously two published papers which reveals the details from the implementation (started at the year 2016) and the follow up of the same one. The first paper reveals the implementation stages, its problems, the first benefits, the changed mind of the managers after the implementation, the reducements of waste materials in production stages, the financial benefits etc. On the other hand the second published paper reveals the production stages after a while and the benefits they brought to the company. This paper presents an momentarily view, done as a fresh research at the same business entity, which presents the matrixes and it's real benefits after almost 2 years at the same business entity.

From this point of view the initial implementation brought the company a lot of reducements into the non conformities, problem solving technique implemented on a monthly level, some quality improvements, reducements of the production expenses etc. On the other hand the first review done showed up that the company had significant reducements of the waste materials, implemented problem solving technique on a daily base, significant quality improvements, and significant reducements of expenses, also bigger profits and ideas proposed from the internal workers.

So on this paper maybe the first hypothesis is to prove that the same one is still used on a daily or monthly base, than that the matrixes had maybe the same problems but with smaller RPN numbers in the same ones and finally that the level of quality in every stage is significantly improved.

Also what is relevant to say at this stage is to point that this is a third paper which is published, but as overview on the same entity from a different time sequence. At this point also what is relevant to mention is that the initial research and implementation was done by a multidisciplinary team (conducted from different persons – university professor, managers, different shift managers, workers from different work departments, workers from the warehouse and even an customer), but the follow up was done only as a monitoring to the work of the internal (business entity) team members. Also as the follow up, actually in this second follow up only a small part from the initial research is presented and shown up in this paper.

II. SHORT OVERVIEW OF THE FMEA METHODOLOGY

The presented methodology used at the initial research and used after the same one on a daily base (or in some cases used monthly) is the FMEA methodology. It's a worldwide known and recognized by companies as a method which will improve the quality, will reduce the problems, will deal with spotted

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problems but primarily is used for detection and analyses of potential non conformities. Also the same one is known as a method for systematic detection of potential errors but also a one that creates potential solutions for the spotted errors. Its full name is worldwide known as Failure Mode and Effect Analyses. It is most commonly used for:

- Detection of potential errors which has a significant influence to the system, to the quality, to the work effectiveness and to the system productivity
- Evaluating the potential and spotted effects of each error or non conformity and their influence to the system. But also the same one as a method evaluates the influence over the elements, production stages, functions, sub processes and subsystems.

On the other hand the most competitive thing of the FMEA method among other methodologies is that the same one is build up and based on a team work and that the same one is the most commonly used one for continuous improvements. The improvements could be spotted in all of the production stages from the raw material department try production stages till the final product, but also seen as an improvements spotted by the customers. It's a situation where the entity could spot all of the potential non-conformities, could evaluate the same ones, could divide the non-conformities to a priority or no priority for the system at the moment but also as process of actions which will reduce the influence of the same ones to the system.

The methodological approach of the same one is based on a team work, process of evaluation of the system, and after the same ones created tabular views which actually are a multiplied numbers from three relevant factors. The same ones are the following ones: the severity, the occurrence and the possibility for detection. Actually the multiplication brings the team the RPN number (Risk Priority Number) which could be aimed by the following formula:

$$RPN = S\ (severity) \times O\ (occurrence) \times D\ (detection)$$

Each of the main criteria's (the severity, the occurrence and the detection) could be in a scale from 1 to 10 and could be precisely read from generated tabular views. So that is the reason why the highest RPN number could be 1000. And the final thing worth full for mentioning is the solving approach. Actually every team could find another solution for maybe the same problem, but the priority of the tasks is according to the RPNs. A higher number means a preventive action which should be taken as soon as possible.

The implementation of the FMEA in real industrial entity actually means that the following steps should be taken:

- Team creation
- Defining TIME for implementation
- Defining place for implementation
- Creating a structural, functional and non-conformity analyses
- Defining RPNs for each problem
- Defining potential solutions for each problem
- Realization of the recommended steps for each problem
- Additional monitoring
- Continuous improvements
- Implementing PDCA cycle (plan-do-check-act)
- Monitoring of the process
- Doing thinks from the beginning so they could achieve smaller RPNs

III. PRESENTING THE BUSINESS ENTITY AND THE PRODUCTION STAGES OF THE SAME ONE

At this stage first of all we will present the industrial entity. As previously said the same one is one of the oldest in the Balkan area in the production of fireplaces for home use, but also one of the most competitive one. The same one is on the market more than 60 years, producing and selling in R. Macedonia but also in all of the Balkan countries. Since the beginning of the 90ties the same one from a state property was transformed to a private property and since then continuous improvements to the processes, to the knowledge, to the equipment are symbols of the same one. Now more than 150 people are employed by the same one and are working on automated and semi automated processes. Also the business entity has a lot of CNC machines which are used on a daily base for production. But still there are some older machines, older processes and older buildings that are in a constant use, and could be a thing to improve in the future.

On the other hand having in mind that this is a second follow up of the same industrial entity, researching the benefits from the implemented FMEA matrix, the first think to mention in this stage is to mention that there were two successful publications of papers from the previously done implementation and the first follow up. But just to present only a segment of the benefits the first think is to divide and to present the sub processes into the industrial entity. The same ones are the following:

- Consumption (process of buying) raw materials
- Quality control on the raw materials
- Placing the same ones in a warehouse
- Segmenting the raw materials
- Process of cutting (using small and large scissors)
- Quality control
- Making appropriate holes to the material
- Using hydraulic presses
- Delivering the final product (semi product) to another process

Generally this is only the first process into the industrial entity and according to the production plans the same ones are used for the production in production stages and then as final products are placed into the warehouses for final products before selling the same ones.

On other hand just to use the same approach to the follow up the following production characteristics are also taken under consideration:

- Methodology of work
- All of the documents used while planning the work
- Machines
- Raw materials and other materials used while production
- Human factors (employees)
- Measurement instruments
- Work conditions (in different shifts)
- Customer demands

Having in mind that there was already a follow up done on this project at the business entity, but also that they use the FMEA methodology on some cases on a daily base and on some on a monthly base, the mistake factor should be smaller and smaller. So the expectation was that the monitored processes and the RPNs of the same one from the first follow up should be lower than before. But in this case because still is a process where workers do their daily activities, enrolled on the machines and a process which enrols materials from different producers still there are some mistakes, there are some non-conformities and some problems. But seeing the same ones and comparing the same ones with the past the benefits are more than visible. In this stage we could freely say that the post FMEA era into the company is more successful than the pre FMEA era of the company. In this stage also a detail worth full for mentioning is that the producer especially in the last years has some problems on the market. The main reason is because some producers offer stoves on pallets and they are more and more used from customers and buyers. So in the general strategy of the company some considerations for swathing the productions are already are on.

IV. Presenting the Results

This is the segment where the results are presented. But before showing the same ones we should say that this part is only a segment from the extensive follow up. The same one was intended to see all of the processes, but because this paper is the third one dealing whit the FMEA in this paper only the process of Transferring done pieces to the warehouse is presented. Also this part could be compared to the firs follow up done in June 2017, from which if compared the three potential failures has been reduced even more. For example the first one in June was 18, the second one it was 40 and the third one was 8. And after more than 7 months in February we got the following results presented in the following tabular view.

Table I
Presenting one Process under FMEA

PROCESS	POTENTIAL FAILURE	NUS EFFECT
Transferring done pieces to warehouse	Damaged piece	Replacing time sequences which are long, but compared to previously far more faster
	Long time required for transferring	Production delay and free work force with nothing to do at the moment
	Non appropriate conditions into the warehouse	

And seeing the table the first thought is that we have some improvements into the first field, where the replacement time is shorter than before, but also if you see the third one you could see that there is nothing there. It's because the company now is aware that if they had such problems with the conditions in the warehouse they will have a lot of damaged products (row materials and final products) and that will cost money. So they invested in the warehouse and renovated the same one, so the damaged products now aren't such a problem, and the conditions in which the raw materials and the final products are placed are better. Also it's a situation in which the workers are more happy, because they are now working in a newer building. Still in some cases they have damaged pieces in the warehouse but the conditions are not the reason for the same one. Also in addition another tabular view is given in which the Reasons are given with the appropriate RPN numbers.

TABLE II
PRESENTING REASONS FOR MISTAKES AND RPNS

POTENTIAL FAILURE	NUS EFFECT	REASON	RPN
Damaged piece	Replacing time sequences which are long, but compared to previously far more faster	Mistakes made by workers while transferring the materials	10
Long time required for transferring	Production delay and free work force with nothing to do at the moment	Transport equipment which is old, but some of the same one is replaced with new ones	30
Non appropriate conditions into the warehouse		Old building which was renovated in the year 2017	6

Seeing the RPNs at the moment and comparing with the previous one (48,70,72) the results are visible. Also the results from the first follow up were 18,40,8 so it's more than clear that this method brings results for the processes and for the company as well. But still there are things to do. That is the reason why this method is based on continuous improvements. In this case things that should be done are the following:

- Training for the workers especially for the process of transferring
- Special two week training activities for the new employees in each case
- Quality check by the workers on the machines before they start using the raw material (piece by piece)
- Generating workers which will be the ones who will transfer the materials (to know which worker is the one in charged for such an activity)
- Buying new equipments for a safer and faster transfer of the materials
- Replacing the older transport equipments – the ones that they have at the moment
- Follow up after doing the same ones

In this case, step by step with the predicted actions the company will get benefits in future. There are still some investments that should be made and which will be a financial costs at first but seeing the final result it will be a long term benefit, and the same one will return. Also at this stage the company is considering to start a new project from which with the usage of SPSS method combined with the FMEA they will first get an exact numbers in percent with GANT charts and then they will analyze the problems try a process of FMEA. So in this case they will use two relevant methods which could bring results (visible ones). On the other hand because we previously mentioned the thing, because they have lost some of the market shares in some markets, at the moment there is a consideration to switch the production and to start a production of stoves for pallets as a fuel. That plan means problems at first so in that case those two methods (FMEA and SPSS) could be the right solutions to deal with the potential problems. On the other hand this kind of a situation could be a problem for the intended steps for improvements previously showed. In that case all of the financials will go to the new production lines or the new equipment and some of the previously mentioned activities will be momentarily stopped (training, equipment for raw material transfer etc.) But still we will have to see how thinks are maybe in the next months. That could be a good material for a new paper publication.

V. CONCLUSION

The paper presents only a segment from the done research regarding an industrial entity from Macedonia. The same one is actually a second follow up on an implemented FMEA or to be precise pFMEA in the same business entity, and actually presents the benefits which were aimed into the time frame year 2016 – 2018. Seeing the results the actual benefits could be seen such as: better commitment of the management, renovated building (warehouse), some of the equipment replaced, a multidisciplinary approach etc. But also the future steps such as: training for the employees than plans to buy even newer equipment but also to use another new method as SPSS, are good proofs that they got another way of doing things. Still there are some considerations for the future activities and plans that are interesting to be monitored in future. So, this paper is the third one, but also could be only a good starting point to another papers published in future.

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