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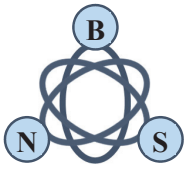

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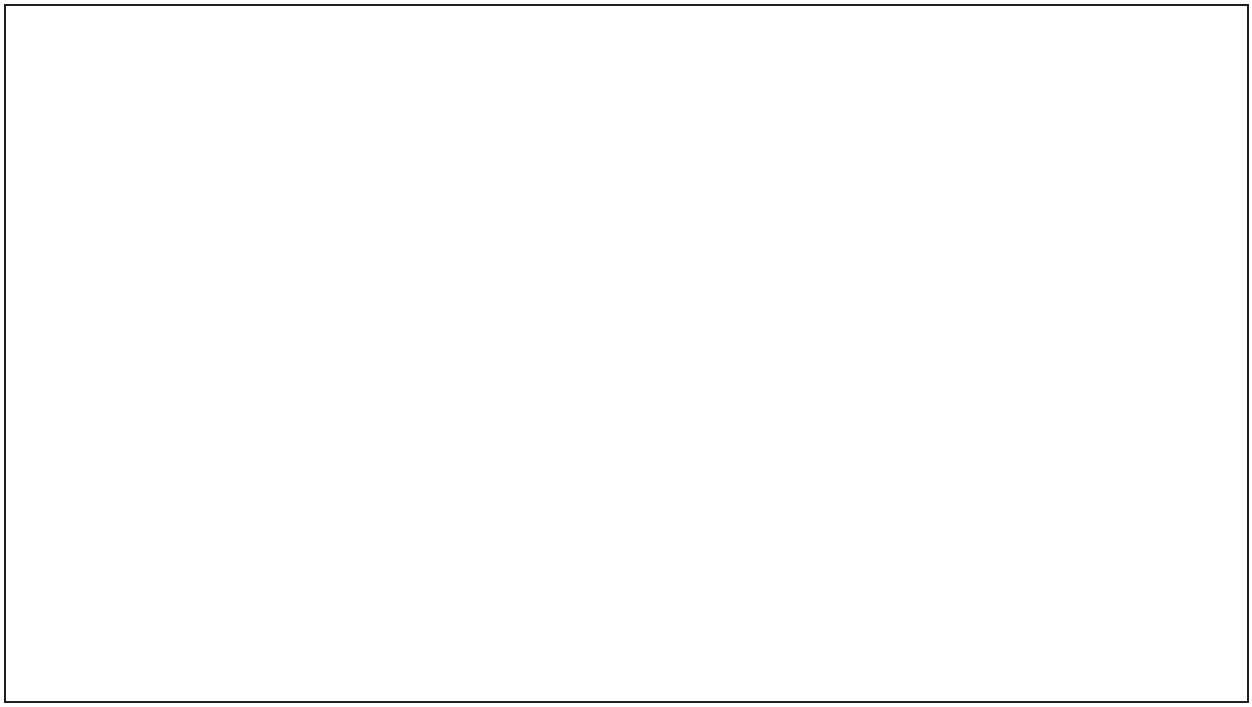

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Real Overview on Implemented p-FMEA Methodology in a Real Industrial Entity after a Year from the last Follow Up

Ivo Kuzmanov[1], Roberto Pasic[2], Zore Angelevski[3], Ilios Vilos[4]

Abstract –**This paper presents only a part from a real overview which presents an implemented p-FMEA into industrial entity after a year of its real implementation and usage on a daily base. The entity is a key player into the production of hot stoves in the country and one of the key players into the Balkans. The reason of this research is because of the extensive application research and also an implementation effort made, over the year which gave a real productive and profit benefit to the industrial entity. So, the data presented into previous papers presents the real benefit from the implementation into the years 2017-2018, and this paper is an overview which presents what happened with the company and the implementation process after a year since the last follow up, when the expert influence was done. The main aim of the paper is to present the real benefits of the p-FMEA as a method, but also to present what really happens with companies when the collaboration with an expert is done, or when the company doesn't understand the real benefit from the same one as a key method for quality improvements.**

Keywords – ***p*-FMEA, production system, Quality Assurance, Quality Control, overview.**

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 North Macedonia. The same one works into the metal cutting industry, or to be more precise the same one is one of the largest producer of hot stoves and fireplaces for home use in R. North Macedonia, but on the same hand one of the key players in the Balkan market for years. One of the key elements which presents in best light the industrial entity, is the fact that this one is one of the key players in the market of fireplace and hot stove production in the Balkan area since the 90ties, and has a constant production more than 60 years with a small stagnation of production processes during the period of 90ties. At this stage the company has made a real investment into the machinery over the past 10 years and became one of the key players into the market, but on the other hand has seen the bad side from the concurrency which produces stoves which work on pallets. Still one of the key points that represent this company as a real market player is that the same one has a tradition over 60 years, and has a constant production on new products (fancy ones) for the market. On the other hand the industrial entity has unique capability – to produce as much as the market demands because of its machinery investment and also because of the market role and cooperation with raw material producers. One of the key positive points at this stage is the number of produced pieces and the number of employees for this kind of producer which makes the company one of the key player into the Balkans, maybe even more – because there is a situation in which some companies buy products from this company and then sell them to foreign markets. When we are talking about the benefits or the positive sides from the company we must say that they use several CNC machines in several key production stages which bring the company real production benefits and a competitive advantage, but also a productivity which is quite bigger than the competitors.

But, so far we just present the positive side of the company. Now the market is changing from minute to minute, so the production of hot stoves and fireplaces is fearing a worldwide change – at first the demand of governments and regulative to influence on reduction of pollution, but also to compete with producers which produce stoves that use pallets as a fuel (trend at the market at the moment). So the company is facing real market turbulence and all of the efforts are up to the line to solve or to find a new product or a new market which will save the company profits. This is the main reason why this research was done and why the same one is at this stage.

So, in this point the main important thing is that the real implementation of the FMEA method was made and the real benefits into the year 2018 were with the following benefits: less waste materials in production stages, financial benefits, mind change, real management commitment, significant reducement of non conformities, implemented problem solving techniques on a week level, less production expenses etc. As well as the FMEA was implemented on a daily and month stage also significant reduce of waste materials were detected, significant quality improvements were detected, significant reducements of expenses were detected, but also bigger profits and ideas from the internal workers were spotted.

But the market had some significant changes during the year 2017 – 2019 and now the company is facing some problems such as: global market is changing from a day to day, there are some demands from the authority about the pollution, the mindset of the customers is changed and everybody is looking for inverters (as electricity heating) or stoves that work with pallets (as a less pollution and easier way of heating). So, the company and its management is in a

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situation where they are facing a change management solutions and the FMEA method is not on the top management strategic key points.

That is way the papers is done, as a result of an extensive research done into the same entity, just to see what really happened with the implemented FMEA method from one hand, but also to see what happened with the company when they face change management. So, the starting hypothesis from this point of view is that there will be some bigger RPNs on the same criteria's and that the level of quality of the final products will be not on such high level as into the year 2018 regarding that the company is facing some problems.

At the end of this part it's more than important to say that there were several papers published previously, but also the team is working on several similar project in different stages, from implementation, to follow up, to the stage where the same one has no benefits due to several issues.

And another key point at this stage is that from the beginning phase of the implementation there was a multidisciplinary team which was working on this project (conducted from different persons – university professor, managers, different shift managers, workers from different work departments, workers from the warehouse and even an customer), then the first follow up into the year 2018 was done only based on a daily work from internal team members from the company when the same one was still a part from the strategic plans of the company, and now at the end we have a situation where there is a second follow up or an overview when the team should be working with this method but we will see the results in the following paper.

II. Short overview of the FMEA methodology – What is it and why the same one should be used

The presented method used at the initial research and used after the same one on a daily base (or in some cases used monthly) was the FMEA methodology. We should consider at this stage it is a thing that must be presented, so the readers could get a real picture about the method which was implemented and was a part of the daily activities in a large period of time (since 2016 till the end of the year 2018). On the other hand the same one was used as a p-FMEA or so called process oriented Failure Method Effective Analysis. So that really means that the method was used to specific process. At this stage it is more than important to present the same one and its real meaning so that we could see what are the real benefits of the same one, what was achieved in the past period into the company and at the end because of some reasons (market and customer ones) what is the situation in the moment. But at first in the following part of the paper the basic information of the FMEA are presented at first.

FMEA as a quality control and quality improvement oriented method is a worldwide known and recognized by companies as a method which will improve the quality, will reduce the problems, will deal with spotted 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 production problems, non-conformities and errors, but also as a method that creates potential solutions for the spotted production problems (related with raw materials, production, machinery, people, documents flow etc.). So the full method name is worldwide known as Failure Mode Effect Analyses. There are some modifications depending on the stage the same one is used as: p-FMEA or product / process FMEA, d-FMEA or design FMEA. But the general idea of the same one regarding in which stage is used is for:

- Detection of potential design or production problems which has a significant influence to the system, to the quality, to the work effectiveness and in total to the overall system productivity,
- Evaluating the potential and spotted problems and effects of each spotted and even detected problem /error or non conformity and their real or potential 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.

So in this stage we could conclude that the people that deal with quality and productivity will consider the implementation of a huge amount of methods such as: QFD, FMEA, FMECA, OEE, SPSS, SPC, ABC, KANBAN, KAIZEN, JUST in TIME and several other methods. But, 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 (although several other are as well) and that the same one is the most commonly used one for continuous improvements based on a constant usage of the same method. The improvements could be spotted in all of the production stages from the raw material department, try pre-production stages, try production stages on each machine, till the final product and post selling processes, seen as improvements spotted by the customers as well. It's a situation where the entity (the team which is working on the same one, but also every other employee) could spot all of the potential non-conformities, could evaluate the same ones, could divide the non-conformities to a priority or no priority ones at that stage for the system, but also could provide a process of several alternative actions which could reduce the influence of the same ones to the system. The provided alternative actions are also a thing that will be evaluated during the future FMEA processes and evaluations so the team could see if the same one brought a real effect to the process.

The implementation and the working approach of the FMEA method is based on a team work, process of evaluation of the system (but a real one – regarding how bad is it in that stage), and after the same ones (as activities) process of creation of real tabular views which actually are a multiplied numbers from three relevant factors. At this stage this tabular views are maybe one of the key elements why companies use this method, because the same one presents a real overview of the problems related to the production stages.

So, the key elements (factors) 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) x O (occurrence) x 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. At this stage, at first a worker with a real understanding and a real experience is a must have as a person to the FMEA team so that a real benefit is aimed from the method.

The multiplication of the three key factors could give the team a highest RPN number up to the number of 1000 (which is a situation that nobody wants). So, the final thing that is worth to mention is the solving approach, which is also one of the key things why companies choose this method. 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 company and the production stages into the same one

At this stage because it is a company that has more than 3 year experience (at first non formal – only as a pilot project, but at the end as a real method used into the same one) it is more than important to present in short term the same one, it capabilities and also to present only a small part from the production stages. So, the same one is a company that has a market share and experience in the hot stove and fireplace production more than 60 years, and has been to different stages. From state one till 100 % private one. But during the period especially in the period from the late 80ties till the middle of the 90ties it has a significant reducement of the production and had a period when even the same one has been under a key. Then since the same one changed the property from state to a private one, and since the market demands were to get a quality hot stove that will last, it has a process of transformation and after a lot of investments especially into the CNC machines and automated processes, has became one of the key players on the market, as well as into the Balkan's. Now there is a situation in which more than 150 employees are a part of the production processes, with more than 20 different products on the sale line.

But what is more than relevant in this key stage (year 2019), and because of the regulations and customer changed demands, the company has a "bad period". This is a situation mainly because of the upraising demand for pallet stoves and inverter technology as a new way of heating. Even in some parts a gas heaters are a main heating during the winter period. So in that situation the company is facing a situation in which the demand is reducing, so all of the activities are on a different level. Even there is a consideration to reduce the number of employees. So that situation is mainly interesting, because at the stage 2017-2018 the company was using FMEA and was enjoying the benefits from the same one. On the other hand now we have a situation in which the company's strategic goals are completely different. So, that was also one of the main points why this paper is written.

And before we present what really happened in the past when the FMEA was used, and what is happening now, we should have a real picture about the sub processes into the production stages of the company. So 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 here into the overview as into the follow up and the first implementation of the p-FMEA into the production stage the same production characteristics were also taken under consideration. So everything is the same just in a mater to get a real picture what is happening. The following characteristics were taken into considerations:

- Methodology of work
- Documents used for planning the work (work orders, customer demands)
- Machines – same ones as before

- Raw materials and other materials used while production (same raw material producers)
- Human factors (employees) – with some changes (some of them from before are retired, some are gone – or find another job, but also we have some new employees)
- Measurement instruments (some of them aren't calibrated at the moment and at this stage is a problem that was seen immediately)
- Work conditions (in different shifts) – there are some modifications as well regarding the new employees
- Customer demands (some are the same, some are new, and also there are customers which are trying to get a lot of discount because of the previous mentioned things)

So, having in mind that all the same characteristics were taken under considerations, but changes were spotted immediately, even ones which will have a bad influence to the production stages, at first we get an impression that the FMEA will have worse RPNs then before. In this stage especially human factor and measurement instruments were the first thing that we spotted and that could or should be a part of the new FMEA. But this time, the time necessary and given for creation of FMEA matrix was quite shorter especially because the management was considering getting more and more products at same time (shift) so they could get a lower price of the product. That was one thing more that was a problem.

Also during the last FMEA there was a company consideration to switch a part of the production processes so that they could produce pallet stoves, but over a year, nothing happened. And at the end we had a situation where it will be a must do for a shorter period of time. That is also a problem.

At the end the first impression is that we had a company where in a year period of time, a lot of problems accrues, and maybe the FMEA method could provide solutions if it is used again.

IV. Presenting the Results from the Overview

This is the main part from the overview and the presented paper. In this part of the paper we should once more present that this paper presents a small segment from an extensive research done in several parts since the year 2016 till 2019. So in the first period of time we had a situation where the subject was working on a daily base but without FMEA method, then a part when the subject started to use the method, then a part where the subject used FMEA on a daily base, and now finally when the same one is not used. So, previous published papers represents the real situation in each stage, but this paper takes into consideration the last tabular views (in a moment of active use of the p-FMEA on a daily base) and the real situation at the moment (February 2019) when the subject due to various reasons is not using the same one.

So, we could get a real picture about the situation and the real benefit from the FMEA method as a quality control method, but also a strategic one, we have done also a FMEA process in the present time so we could compare what happened.

Also on other hand so that we get a real comparison, regarding the subject, we used the same process as before (in which in the past FMEA was used). We took under consideration the process – Transferring done pieces to warehouse, as a sub process which is quite important for the production and even for some processes is the final process. So we could compare things we have shown two tabular views. The first one is also presented into previous published papers but is a starting point from which we could get a real picture what really happens when the process is under p-FMEA. Also this tabular view num. 1, shows us that even then some side effect happened.

TABLE I
PRESENTING ONE PROCESS UNDER FMEA

FOLLOW UP POINT IN YEAR 2018

PROCESS	POTENTIAL FAILURE	NUS EFFECT	RPN
Transferring done pieces to warehouse	Damaged piece	Replacing time sequences which are long, but compared to previously far more faster	10
	Long time required for transferring	Production delay and free work force with nothing to do at the moment	30
	Conditions which are not appropriate for the product into the warehouse	Damaged piece which has passed all of the production stages	6

Seeing this tabular view, we could say at first that although FMEA is used, some mistakes are spotted, but if compared with previous we could say that the benefits were seen in reduce which was more than 50%.

On the other hand, after the overview we made another table which is presented as following in which we could see that there are a lot of mistakes (more even than the past) in a moment when the company decided not to use the FMEA anymore. So, we present the table as well and if seen and

compared with previous we could conclude that the real implementation of the p-FMEA on a daily use brought a lot of benefits to the company in the past. Now we have a new situation and if we see the tabular view num. 2 we could conclude that a lot more problems we have in present time. Also if we compare that situation with the situation in which the company is in the moment, we could say that the company is not facing only market problems, but also internal problems that could be seen as loss of raw materials, loss of final pieces-produced ones, loss of quality (non conformities) and finally loss of money (loss of profit). Now, before we could present even more, first let's see the tabular view num. 2.

TABLE II
PRESENTING FAILURES AND REASONS WITH APPROPRIATE RPNS

PRESENT TIME – YEAR 2019

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	80
Long time required for transferring	Production delay and free work force with nothing to do at the moment	Transport equipment which is old, OR THERE ISNT ANY Workers who are only standing and not doing anything	120
Conditions which are not appropriate for the product into the warehouse	Damaged piece which has passed all of the production stages	Old building which was renovated in the past, but not as they should be renovated	100
Workers who do not what to do even when they are at working places	Damaged pieces in production processes	Not enough training for the workers, or no team leader appointed	40
New employees – almost every week there are new employees	Damaged pieces in production processes	Not enough training for the workers, or no team leader appointed	60

If we compare both tabular views presented, we could immediately conclude that there are a lot more problems than before in present time. On other hand because FMEA matrix was really done but in short time, just to compare the things and to present a real picture (how was in the past – how is now), and if we just compare the RPNs we could see the problems. Here we must say that maybe some of the problems which occurred are not presented, because the lack of time to do a real matrix again – It was a rush up, regarding the management decision that they should produce regarding to spend time for such activities. But, if we just see the RPN numbers, we could conclude that things happen more often, with a larger influence to the system and to the processes. On other hand there is a situation where nobody is taking care if these kinds of things could be prevented. And some of them really can be prevented.

Also another relevant information from before is or to be more precise are the previous activities which were just an idea how things could get better. This data are also presented in past papers. Having in mind that some activities were selected as a real must do for the entity, and a lot of time was invested into that process, we could conclude that there are a lot real problems in this subject at this stage. But first to get a clear view, let's see the previous things which were selected as a must do (in the year 2018 for the following period). They were done in a better time, a time when the company used the FMEA on a daily base. So here they are:

- Training for the workers especially for the process of transferring
- Special two week training activities for the new employees in each case
- Quality check done by workers on direct machines as a pre-process, actually before they start to use raw material (piece by piece)
- Generating workers which will be responsible for the transfer of 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 (forklifts etc.)
- Replacing the older transport equipments – the ones that they have at the moment (not automated processes)
- Follow up after doing the same ones

So if we see just the things presented previous and see what is happening at the moment there are some things which should be done, so the company could have a significant improvement into processes such as:

- Special training activities for new employees (each worker depending the job position to have different training)
- Creating a model for cooperation with workers - which will keep the workers into the company
- Showing what is happening into processes (gathering data which will be really analyzed by the managers and some actions will be taken)

- Buying new (or used, but in good condition) transport equipment (especially forklifts – electrical, on fuel and hand forklifts)
- Quality check in each stage (worker will be the first check point before and after work activities)
- Improving for workers – in term to get a higher and better paid work positions – as a general motivation to keep them into the company
- Creating a short term strategy with to do activities, deadlines and responsible persons
- Creating a strategy which will transfer the production into some new and more attractive for the market (stoves which will work on pallets – especially because the company has the equipment and the potential for such a big step)
- Repairing a part of the warehouse and using the same one for the done pieces (creating small modern warehouse)
- Creating a work flow without a warehouse
- Generating PDCA cycle in each production stage

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 significant financial cost at first, but seeing the final result it will be a long term benefit, and the same one will return as a profit on long term base. Maybe the first things to do are: to get a new or used but in good condition equipment (especially forklifts), to find a way to keep the workers and to motivate them, to create a work flow without a warehouse and to make quality check in each stage so the non conformity is less and less in stages.

This will be a something that hopefully will be followed into the future, and some future possible publications could be prepared as well. It's quite interesting to see what really will happen.

V. Conclusion

This paper is only a small segment from a real overview into industrial entity which had a real benefit from the implementation of the p-FMEA as a method and now due to several reasons has a situation where not only the same one has not significant benefits, but also is in a situation where the same one should consider its future. So, because the paper is only a small part from what was really seen, researched and really done into the company, maybe in the future some other publications will come from this paper and the overview done. But the main point of the paper is to present that the implementation of FMEA as a method in a full production stage and a real market share with customer demand is more than real, and also with real benefits. At this stage we could say that the entity had benefits is several different ways: from production savings in a matter of raw material, till effective production, till maximization of profits made as a benefits, till enrollment of worker ideas in every production stage, etc. But only one moment (changes into the regulations, market changes and also customer needs changes) could influence on the implemented p-FMEA and also on the key strategy for the future. So that situation could turn over the "management eyes" to a complete new way of seeing things, and change the company way of doing things from a company where "future methods" are everyday activity to a situation where the company is considering only about the company's future and cares only about profits (if any).

So, this is one good example (maybe a bad one in practice) of how a real implemented FMEA method with benefits could be set as a non relevant method at the moment, regarding market changes. But on the other hand there is also the moment where the company should buy new equipment and where the company should change the main products if they want to have a market share, so the FMEA method from implemented will come to a stage non relevant, and again (hopefully) in future maybe will come to a situation where it will have a key role in industrial processes. That is maybe a thing that should and could be followed up, and from which several new papers could be published in future.

At this stage, from this example, we could conclude that the FMEA method and its implementation and benefits are a thing that is complementary with the way of doing things for the company, but also with the market share at the time. So, when the company has a real market share and incomes, methods could be implemented, but when there is a situation in which the company has market share problems, the future of the company and the profits are the priority things – so that is everything that is talked about in future. At the very end of the paper, a future research into the subject could get us to new similar publications.

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