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PRODUCTION ENGINEERING ARCHIVES 23 (2019) 12-17

PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN2353-7779 (online)

Exist since 4th quarter 2013
Available online at www.pea-journal.eu

Problems of use of FMEA method in industrial enterprise

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Article history
Received 08.04.2019
Accepted 09.05.2019
Available online 04.07.2019

Keywords
FMEA
Failure Mode and Effect Analysis
Quality planning
quality improvement
quality methods

Abstract
Presented paper concentrate on problems connected with FMEA method usage in industrial enterprise. There is in the paper a description of the basic rules of FMEA method and competition between FMEA analysis and gap analysis. The analysis of defects has been done to find recommendations how to eliminate or restrain them. On the basis of conducted research we found that selection of staff to the team is very important factor in the FMEA analysis undertaking process. The staff should have appropriate level of knowledge about FMEA method methodology and other tools which are indispensable in the process of implementing this method within the company.

DOI: 10.30657/pea.2019.23.02 JEL: L23, M11

1. Introduction

FMEA method name is short for the English full name, the Failure Mode and Effects Analysis, which when translated means the analysis of the causes and effects Wad. It can be described as a structured series of activities aimed at (Hys, 2014; Wolniak, 2018):

- identify and analyze potential defects in the product or the production process and their possible effects,
- identify actions that could eliminate or reduce the risk of potential defects• Document all analysis.

The analysis of FMEA is particularly recommended in the development and production of a new product, as it allows identification of potential defects in time that they can be eliminated by the use of preventive measures before the start of production. The method can be applied not only to analyze the causes of defects already identified, but also in order to prevent defects that are likely to occur in the product (Jain, 2017).

Application of FMEA is one of the requirements of ISO / TS 16949:2002, where in the section on design and development states that (Kowalik, 2018):

- the organization should use an interdisciplinary approach in the preparation of product realization, including among others, the development and review of FMEA, including measures to reduce the potential risk of defects in the manufacturing process,
- preparing the draft of a new product should be an analysis of FMEA,
- the design of the production process of a new product should be performed FMEA analysis.

FMEA document is a document that "live", meaning that it needs to be reviewed and adjusted, if necessary, even when problems occur already during production. However, any changes corrective actions should be implemented immediately by the selected person to be responsible for it, and progress in their implementation should be monitored by the quality department manager (Wolniak and Skotnicka, 2011; Wolniak and Skotnicka-Zasadzień, 2014).

FMEA method can be used in both the design process and in the production process of the product. In the example discussed later in this publication focuses on the implementation of the FMEA process of production.

FMEA allows the manufacturing process to identify problems and inconsistencies that may occur during the course of the manufacturing process. The main advantage of this method is that a very early stage - still in the planning stage of the production process can be sufficiently in advance (Kowalik, 2018):

- decide on the suitability of the production process,
- detect the weaknesses and problems that may occur during the production process,
- take appropriate measures, which may occur during the production process,

- create a list of hazards during the production process and identify them according to their impact on the quality of the product.

FMEA analysis of the production process assumes that the product is designed and corresponds to the intended project. Therefore, it is not changing the design of the product, so as to overcome the weakness occurring in the manufacturing process. But takes int+- account the characteristics of the product design or manufacture of the planned assembly process to ensure as far as possible that the resulting product meets customer needs and expectations (Krynek et al., 2014; Łuczak and Matuszak-Flejszman, 2007; Łuczak and Wolniak, 2015; Wolniak, 2017; Zasadzień, 2011).

The course of the analysis is for both FMEA same, differing only in the analyzed issues. In the case of product FMEA are evaluated designed constructional features of the product, whereas in the case of the production process FMEA analyzes the production process of the product, the solutions and technologies in order to reduce the formation of defective elements (Sęp and Pacana A., 2001; Skotnicka-Zasadzień et al., 2017).

The most common method to assist in determining the types of defects that can occur is brainstorming all the team members and other persons using information related to production using their experience. After specifying the defect occurring in the manufacturing process, you should determine the consequences of their occurrence, ie what will be the impact on product manufactured especially for the customer. On this basis, determines the significance of the defect, according to the method adopted in the enterprise.

The importance of product "Zn" or in English "S" (severity) is defined by assigning the defect number from 1-10, where 1 - no significant defects, 10 - faults of the highest importance.In a further step should be to determine the potential cause of the defect and give the expected frequency of their occurrence. They syllable means "Sun" or the English "F" (frequency), and assigns the value of 1 - 10, with 1 - defect in general does not happen because of the cause, and 10 - the cause is often a cause of defects .

Then, it is Determined how often a defect is detected in the production process. This parameter is defined as in the previous cases on a scale of 1 - 10, with 1 - defect is detected in 100% and 10 - do not defect is detected, and is Determined by the syllable "O" or the english "D" (detection).

On the basis of these three values is determined by the risk level of the coefficient of error "WPR" (English or "RPN" - Risk Priority Number), which is equal to the product of the probability of occurrence, importance and difficulty of a defect (Mangla and Lutha, 2018; Michalska, 2007; Vinodh and Santhosh, 2012).

$$WPR = Zn \times Cz \times Wy \quad (RPN = S \times F \times D) \qquad (1)$$

This ratio can range from 1 to 1000, but it is assumed a certain limit (eg, 100), above which corrective actions should be introduced to reduce the risk of error. It is best to sort these values from the largest to the smallest, so that we can more easily see which errors are most important and should be addressed first.

Action to be taken in order to reduce the value of the CAP (RPN) include:

- reduce the incidence of such defects by modifying the manufacturing process or improve production tools,
- enhancing the detectability of defects created by improving the control system,
- reducing the size of the defect by agreeing with clients such as the derogation from the design or modification of the project. It is difficult to carry out an action which is usually impossible, because often it is not taken into account.

The document produced by the FMEA should be written all the preventive measures, together with information who is responsible for them and the deadline for when they should be implemented. These records shall be kept up to date, and their implementation monitored by the chairman of the conducting analysis (Pacana et al., 2014; Paciarotti et al., 2014).

However, even before the implementation of the proposed preventive measures should be recalculated CAP rate (RPN) for new meanings of, and detection frequencies. If the value has not been reduced enough to be consider additional preventive measures.

Yes, the analysis should eliminate possible defects that occur during the production of the product and ensure lower risk of defective products to a minimum.

2. FMEA analysis and gap analysis - a comparison of results

The test is performed only organization FMEA process, because the company is engaged in product design, but gets ready projects on the product from the customer. Therefore the method is carried out immediately after the fixing of the production schedule, ie, the order of administration of the manufacturing operations are carried out (process) starting from the acceptance of the material on the device, and ending with the finished product shipment to the customer. Then, during the implementation of the following components of the product quality planning analysis is modified and supplemented. Ultimately, it is the stage of completion of dispatch of documentation for the manufacturing process to the customer, but it also often serves to improve mass production, when there are any errors not included before.

They are then supplemented the documentation FMEA method, so that in the future could serve as a basis for training aimed at improving the experience of the employees in the performance of subsequent FMEA analysis and planning of production of newly introduced products.

Application of FMEA production planning is a requirement of ISO / TS 16949 and automotive customers. Therefore, the company realized it investigated thoroughly, and the final document is approved by each customer the item. The study carried out in selected FMEA method for the production element of the front wheel hub (the hub of the front wheel and the company produced in the test part of the front wheel hubs are shown in Figures 1 and 2). This item is manufactured using processes that Figure 3 shows the schematic

Fig. 1. Front wheel hub

Fig. 2. Part of the front wheel hub

The FMEA include all elements of the manufacturing process for the element hub of the front wheel, because the product is a safety element mounted on vehicles, which requires a special accuracy. Each of the sub-processes of production may be affected by faults that may have an impact on the final product. Therefore, the individual operations of the production process are listed as follows to a possible defect:

1. First Adoption of the material and the unloading and storage - defects that may appear herein are the differences in the required technical documentation, acceptance of wrong material, different alloy number, the differences in the number of bars, the differences in the determination of the stored material, the lack of labels on the bundles, the lack of labels on bars, surface burrs, bent rods. For instance most of these defects is possible to produce an item from the wrong material, which would lead to the rejection of the entire batch.
2. Second Cutting - can appear here defects such as: allowing the material in the machine, bad fit the required material, different radius, different alloy number, wrong labels on the bars or bundles, weight cut material beyond the requirements of (too much or too little material), burrs off tolerance, wrong size, fracture, mixing rod ends.
3. Blasting - the remaining material in the machine, a high rust.
4. Forging - the remaining material in the machine, mixing bars, the material does not meet the specifications, the radius bars bad, bad weight bars for low temperature heating, the heating temperature is too high, insufficient material after forging, cracks, bad height, bad radius, the extrudate, scratches, dents, bead.
5. Blasting - the remaining material in the machine, a high rust.
6. Final inspection - other parts of the machine, to see surface defects during inspection.
7. Delivery - broken pallet, wrong number of parts, no labels delivery, delay in delivery, delivery in the wrong direction.

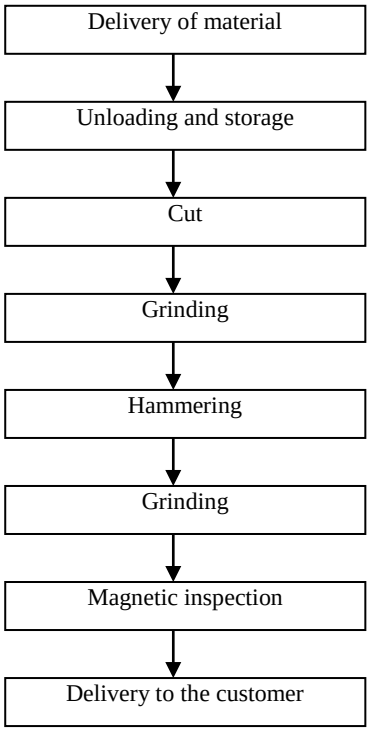

Fig. 3. Schematic of the manufacturing process of the front wheel hub component

The results of the FMEA method can be compared with the amount of claims submitted by the client, which appeared in the mass production and the amount of internal defects that occur during the manufacturing process. On this basis it is possible to examine whether specific levels of prevalence data and detect defects have been well accepted or emerging issues were not taken into account by the team conducting the analysis of FMEA (or their importance has been underestimated).

The test element was introduced into mass production in October 2008. From now until the end of March 2009 was sent to the customer ready to 494,734 items, of which only

1,619 were advertised, or about 0.33%. The most common cause of complaint was the lack of material for manufactured parts, the wrong size provided the item (1039 units). Other causes of complaint were already a lot less important, since in the stamping advertised 95 elements and because of the cracks only 26 pieces.

If the number of internal defects is 14.95% of all the manufactured components of the front wheel hub. Among these, by far the biggest problem in the production turned out to be wrong size provided the item whose share in the total number of defects is predominant, as illustrated in Figure 4 Other causes are much less important because the total of the share is 27%.

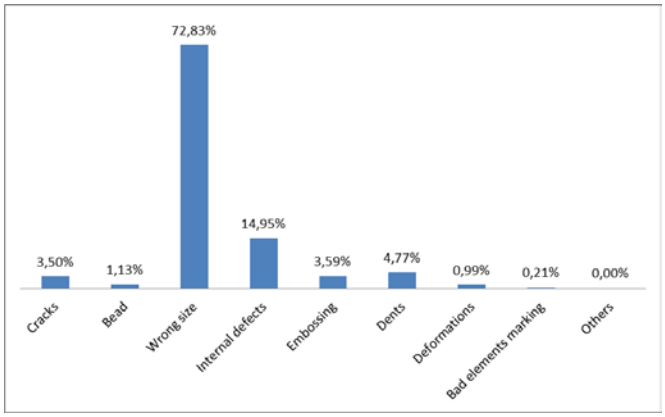

Fig. 4. Chart percentage causes of internal defects in the production of the front wheel hub component produced in Kotani

The most important cause of the manufacturing defects are wrong size elements. This issue has been taken into account in the analysis of FMEA in the forging process, where the importance of a material having a bad dimensions after forging was evaluated at 8, while the highest incidence of potential causes, which is bad for both cooling and lubrication settings and inadequate transport were assessed at 7, but this was reduced after the introduction of corrective measures to 4.

With the proposed corrective action is selected and implemented new design tools for cooling and lubrication, which was designed to reduce the frequency of occurrence of the problem, which is sticking to the hot steel as hot tools by which the product has been distorted, and its dimensions comply with the specification. Also changed settings control method of cooling and lubrication of data stored on a computer to make cards and instructions for inspection and lubrication cooling, as well as increased monitoring of workers implementing the machine settings. As for the inadequate transport to press for hot forging is properly adapted to the transport element of the front wheel hub. To make sure that you have eliminated all possible causes of the evil of cooling and lubrication chart shows them Ishikawa.

The diagram shows that the causes of poor cooling and lubrication setup is a lot, so would be introducing corrective actions to eliminate all of them. However, those highlighted in the analysis do not take into account the possibility of FMEA damage the cooling temperature sensor and / or the level of grease which can be a very big problem, which has not been corrected control of corrective actions. It was not also considered the possibility of overheating of the material, but because it has been treated as a separate defect that can occur when the heating temperature is too high.

The research shows that the greatest value of the RPN, the most affected by the risks of the method have been carried out FMEA dents and embossing material. These defects were not eliminated by the end of the corrective actions implemented, but it was not for the production of such a large problem, as the share of dents in the amount of all deficiencies amounted to only 4.35% and 3.68% stamping.

The data presented in the table shows that the incidence of defects formed in the estimated FMEA method does not coincide with the actual frequency. The highest incidence according to the method FMEA (value 4) occurs in the event of a defect, "the dimensions of evil," which agrees with reality (70.89% defects), but the same frequency (value 4) assigned wypływce whose occurrence is much rarer (only 1.03% of defects). The second most frequently occurring defects - defects of the internal (share 13.64%) was the lowest-rated FMEA method (score 2), ie, the time underestimated the importance of this issue. This could be the result of lack of experience performing analysis of FMEA team, or omission of possible causes of these defects.

Corrective actions have been introduced to four potential drawbacks, namely for bad material dimensions, dents, burrs, and for surface defects detected during the inspection, or cracks. Despite the corrective action taken all these problems came up again or not been fully removed, only reduced the risk of their occurrence. The problem was also that corrective action is not so significant drawbacks related to internal defects, deformation, or send to the client rusted parts.

The first of these problems (wrong size material) is very difficult to detect, since each of the elements would have to go a very long testing laboratory, which is not cost-effective and time-feasible. Therefore, this research is subjected to only a sample of the finished products manufactured from the party. Typically, it is 30 units, but the client can request that a different amount.

Internal defects in the second after a bad size of the material in terms of the validity of the defect. They arise most often when forging temperature is too low, or has been used for the production of alloy steel other than required. These reasons were included in the analysis FMEA, but the degree of risk of their occurrence was so low that they were not in this case, the required corrective action. It is recognized that it is cheaper to produce defective parts, rather than the introduction of corrective measures that would be very expensive but not necessarily effective. Another disadvantage, in the case of which have not been directly introduced corrective actions are deformed. This defect is very rare (0.9%), but there is in mass production. Also not taken into account in the analysis of FMEA as a separate problem. In the case of the drawbacks was that the introduction of additional corrective action is too expensive, and with the consent of the client accepted this condition.

Table 1. Comparison of the incidence of defects according to the FMEA method and by the percentage

	Material wrong size	Internal defects	Dents	Embo-ssing	Cracks	Beads	Deforma-tions	Bad ele-ments mar-	Others)
The frequency of defects by FMEA	4	2	3	3	2	4	3	2	2
The actual incidence of defects [%]	70.89%	13.64%	4.35%	3.68%	3.35%	1.03%	0.90%	0.20%	1.96%

The situation is similar with the drawback of "designation wrong element", as a result of forging bad batch or a different number, not in accordance with label delivery. This causes problems with the identification of parts or batch number. This problem is only partially included in the FMEA. It has been incorrectly assessed because they do not take into account that the number of forged parts may be unreadable, which proved to be a problem emerging with mass production. However, this is a problem that occurs very rarely (0.2%), there is no need in this case the use of corrective action.

Another problem that has not been taken up by the company, and all the items were placed in the customer's defective, it is rust. This defect does not detected at all with the result that a certain level of detection at level 3 has been underestimated, due to the lack of experience of the company's employees in the performance of FMEA.

3. FMEA analysis to evaluate the effectiveness of a company

Summarize the analysis performed corrective actions can be concluded that most of the defects actually occurring in mass production has been taken into account during the planning and measures were taken to prevent them. You can, however, be noted that not all of the precautions taken have been effective.

Especially this is the case when it comes to bad material dimensions, where he initially underestimated the effectiveness of the action taken. It turns out that in practice the only way to reduce the level of defects in replacement parts are forging press, which requires significant financial resources, which the company does not have. So the only thing you can offer is to increase the control hollowed elements by preventing the supply of defective parts to customers.

Throughout this analysis, FMEA can see errors resulting, inter alia, not to use it for performing interdisciplinary team any additional tools to support the method. For example, the use of so-called seven "old" instead of quality management tools used only brainstorming could allow for greater accuracy of the analysis.

Based on the analyzes it can be concluded that, although presented in a publication such as the application of the FMEA method proved ineffective, however, he pointed right course of action that should be taken. Problems have arisen in the implementation of corrective actions that have been poorly implemented, also overestimated their performance.

4. Conclusion

Experience with FMEA analysis in the present, an industrial company suggest that this method is only effective if it is carried out by experienced staff with extensive knowledge about the production process and the use of technology and are able to use additional tools to support the implementation of quality management methods. Based on the research it can be concluded that the FMEA analysis carried out by the company were unsuccessful. This was associated with significant costs also.

Any industrial company wanting to use the method of FMEA should pay close attention to the selection of staff to the team undertaking the analysis. Only the presence of staff with a good knowledge production process will help ensure that the analysis was done correctly and properly assessed and taken into account all aspects of the processes of production. It is also important that employees are properly trained in the use of appropriate tools useful in implementing FMEA methods. The same basic knowledge of FMEA methodology is not enough to support the execution of the other tools such as the seven "old" tools of quality management, statistical methods, etc. In another case, the results are not reliable.

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工业企业使用 FMEA 方法存在的问题

關鍵詞
FMEA
质量策划
质量改进
质量方法

摘要
提出的论文集中于与工业企业中 FMEA 方法使用相关的问题。 本文描述了 FMEA 方法的基本规则以及 FMEA 分析和差距分析之间的竞争。 对缺陷的分析已经提出了如何消除或限制它们的建议。