REDUCING PRODUCTION COSTS BY MINIMIZING ERRORS IN THE OPERATIONAL PRODUCTION: A CASE STUDY OF COMPANY VENDOM

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Errors in operational production cannot be entirely eliminated, but they can be minimized to reduce their impact on production costs. These errors can affect several aspects, including increased material costs, waste generation, product quality, delivery delays, company reputation, and customer dissatisfaction. By identifying the root causes and applying various methods and techniques, it is possible to determine the most critical and frequent errors in operational production and develop effective corrective measures. The purpose of this study is to illustrate, through the example of the company Vendom, how to minimize costs arising from errors in the operational production, using the FMEA method for error identification. The results of the study is a proposed set of measures to reduce errors in operational production. These measures have a direct impact on reducing production costs.

Keywords:
production costs,
operational production errors,
product quality,
FMEA,
error reduction measures

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1 Introduction

Product quality is one of the main conditions for a company to participate in local, regional or global markets since a high-quality product can provide a company with a competitive advantage. Product quality refers to the specificity of a product or service that impacts its ability to meet customers' specific needs (Sun, 2011). According to (Kotler & Armstrong, 2010), product quality is the ability of a product to perform its functions, including overall durability, reliability, accuracy, ease of operation and repair, as well as other product attributes. The good or poor quality of a product depends on the company's ability and standards to continuously meet consumer perceptions. For consumers, quality depends on their expectations of how the product will behave during its use.

Given the greater availability of choices, customer expectations of the products that they purchase grow over time and lead to decreasing tolerance for any type of error. Even minor or seemingly negligible errors become increasingly unacceptable. Customers are not concerned with why a product is defective, they only care that it is defective (Vasiljević et al., 2024). For this reason, modern companies pay special attention to improving operational production processes and internal control of their products, aiming to produce the highest possible quality. Lazibat and Baković (2020) argue that quality control, as a key factor in a company's production results, can be simply defined as the process of ensuring compliance with standards by involving observing current performances, comparing them with the standards and taking appropriate actions if significant deviations are detected.

For a company striving to be competitive in the market, increasing demands are placed not only on the quality of products or services but also on the quality of production and business processes, as well as the reliability of the entire quality system (Kumar, Maiti & Gunasekaran, 2018). This is because achieving functional product quality contributes to increased sales (realization) due to customer satisfaction (user), cost reduction, increased production and the coordinated actions of all participants in a business system (Lazibat, 2003). Errors in operational production cannot be completely eliminated, but they can be minimized in a way that reduces their impact on increasing production costs. These errors can impact material costs, waste generation, product quality, delivery delays, company reputation and customer dissatisfaction. By identifying the root causes and applying various methods and techniques, it is possible to determine the most critical and frequent errors in operational production, as well as to design effective corrective measures. The first step in reducing production errors is identifying their root causes. Various methods are used for this purpose, such as Pareto Charts, 5 Whys, FMEA (Failure Mode and Effects Analysis), Six Sigma, Fishbone Diagrams and others. By identifying the root causes of errors, priorities can be set for addressing the most critical and frequent problems, that lead to the implementation of efficient corrective actions.

On the example of the Vendom company, this paper presents how minimization of errors in the operational production process, through the application of the FMEA method, can contribute to the reduction of production costs. The paper consists of four chapters. The first chapter provides introductory considerations related to the topic. The second chapter presents the theoretical concepts of the FMEA method, while the third chapter presents a case study of the company Vendom. The fourth chapter presents concluding remarks.

2 Failure Mode and Effects Analysis method

Errors made by humans are one of the main sources of failures in production operations and can arise due to various factors, such as lack of training, tiredness, distractions, stress, lack of concentration, poor communication and others. This type of error can impact the quality, reliability, safety and efficiency of products and processes, leading to customer dissatisfaction, increased waste, additional rework and even product recalls. To prevent or minimize human errors, manufacturers can use various methods, such as one of the most commonly applied, the systematic FMEA method, or analysis of operation modes and effects of failure/breakdown. FMEA is a proactive tool that identifies potential failures, their causes and consequences and prioritizes actions to reduce risks. By using the FMEA method, manufacturers can identify potential human errors that may occur in production operations and assess their impact and likelihood of occurrence (Demirkaya, 2022). The FMEA method can also help determine the root causes of human errors and suggest preventive or corrective measures to eliminate or reduce them.

In the manufacturing sector, FMEA has a crucial role in improving product quality and reliability, reducing waste and inefficiencies and ensuring customer satisfaction (Dobrović, Tadić, & Stanko, 2008). According to the same authors, by identifying potential failure modes and proactively implementing corrective measures, production facilities can prevent costly downtimes, rework and product recalls. The use of FMEA in the production process allows manufacturers to (Demirkaya, 2022):

- Identify and prioritize potential failures and their causes;
- Assess the effects of these failures on the overall production process;
- Develop and implement strategies to mitigate or eliminate these risks;
- Improve process control and product quality.

FMEA is a method that emerged in the 1950s, initially based on safety assessments of military systems in the United States. Due to its reliability, the use of this method quickly expanded not only within the US but also in France, where it was used to assess the safety of air traffic systems. Starting in the early 1960s, NASA adopted an updated version of the FMEA method due to the importance of safety and prevention of accidents in space projects (Stamatis, 2003). Later, in the 1980s, Germany implemented this method in its chemical and nuclear industries. In the second half of the 1980s, Ford's automotive manufacturing introduced the ISO 9000 quality standard to the US automotive industry by using this method, that has been applied worldwide in the automotive sector (Stamatis, 2003). The effectiveness of the FMEA method has also led to its adoption in healthcare centres to improve patient safety and emergency medical systems. Moreover, FMEA is widely used in electronics, chemicals and other manufacturing sectors to identify, prioritize, and address failures, deficiencies, and potential issues (Alizadeh, 2015).

The FMEA method is defined as a tool that prioritizes types of errors with the greatest impact on the entire system, rather than as a method for planning the identification of a large number of errors (Bahadır Ünal & Acar, 2016). The primary objectives of this method are to predict potential errors that may occur in a product or process, take preventive measures to avoid them and determine the degree of impact or criticality of individual types of errors.

In the literature (Mazlan, Yassin, & Kamaruddin, 2023), three types of FMEA are identified: DFMEA (Design FMEA), PFMEA (Process FMEA) and SFMEA (System FMEA). DFMEA primarily focuses on analyzing failure types related to design, helping companies identify and resolve design faults or weaknesses before the product enters production. PFMEA analyzes potential types of failures within the production or assembly process, aiming to prevent or reduce the likelihood of errors occurring during manufacturing. Finally, SFMEA evaluates potential types of failures in a system or subsystem, addressing issues related to component or subsystem integration and their overall functionality. Authors (Dobrović, Tadić, & Stanko, 2008) also mention a Service FMEA model, applying it to service analysis. Considering that the characteristics of services include intangibility, inseparability and the inability to store services, they are crucial in conducting this analysis before the requested service is provided to the user, ensuring the quality of the service and meeting end-user requirements (Dobrović, Tadic, & Stanko, 2008).

The implementation of FMEA in manufacturing involves several steps, where the first is identifying potential failure causes. This step includes identifying all potential factors that could lead to production process delays or defective products. These factors may include equipment failures, process disruptions, human errors and various other issues that can impact product quality. The outcome of FMEA analysis is the Risk Priority Number (RPN), a number calculated as the mathematical product of the values assigned to the Severity (S) of the consequences of a failure, the Probability of Occurrence (O) of the failure and the Detectability (D) of the failure. This calculation is presented by the following formula (1).

$$RPN = S \times O \times D \tag{1}$$

Table 1: Scale for Determining the Parameter S (Severity of Consequences)

Grade	Severity of Error Consequences
1-2	Can be neglected
3-4	Minor
5-6	Marginal
7-8	Major
9-10	Extremely significant

Source: Stamatis, 2003

For evaluating the parameters S, O and D are used scales, as shown in Tables 1–3. These scales may include descriptions for each score, depending on the author.

Table 2: Scale for Determining the Parameter O (Probability of Occurrence)

Grade	Probability of Occurrence
1-2	Very low
3-4	Minor
5-6	Medium
7-8	Major
9-10	Extremely significant

Source: Stamatis, 2003

Table 3: Scale for Determining the Parameter D (Detectability)

Grade	Detection Ability
1-2	Very Easy
3-4	Easy
5-6	Medium
7-8	Difficult
9-10	Very Difficult

Source: Stamatis, 2003

Taking into account the three given scales, the value of the RPN number is obtained, indicating the level of risk, whether is it necessary to respond and recommendations, as presented in Table 4.

Table 4: RPN Value and Corrective Actions

RPN Value	Reaction to RPN Value (Corrective Actions):
RPN < 10	No need for action
10 < RPN < 100	Greater adherence to prescribed procedures
100 < RPN < 250	Enhanced monitoring of the production process and introduction of certain corrections
250 < RPN < 400	Significant changes in the production process
RPN > 400	Excessive risk – termination of unprofitable production

Source: Stamatis, 2003

RPN values are listed from highest to lowest, according to the selected criteria. Higher RPN values have greater priority compared to lower to improve the production process, increase product quality and require faster and more efficient responses.

3 Case Study of the Company Vendom

This paper presents cost reduction in the production process through minimizing errors in operational production by applying the FMEA method, using the example of the company Vendom. Company Vendom produces a wide range of products in the metal industry. Real data from this company, collected during 2023, was used for the analysis.

3.1 Company Vendom

The company Vendom, Limited Liability Company (LLC), Laktasi was founded in 2003. It specializes in manufacturing metal products for both domestic and international markets, with a focus on the international market, primarily various types of waste disposal containers for the EU and South America. The company currently employs 200 workers and has an annual revenue exceeding 10 million euros. Vendom LLC, Laktasi is one of the largest exporters in the metal sector in Bosnia and Herzegovina. The most significant competitive advantages of the company are short delivery times, reliability and quality. The products of Vendom are distinguished by their design, innovation, and quality. The benefits of collaborating with this company for customers include responses to specific client requests and the uniqueness of the company's products, as well as product assembly, servicing and maintenance.

The product range of this renowned company includes industrial and residential fences, smaller steel structures up to 100 tons and demanding structures for industrial needs up to 1,000 tons. Within the Vendom product range, special emphasis is placed on underground and above-ground waste management systems, as well as cranes for container emptying. In addition, the company offers constructions, fences, steel moulds, underground and above-ground waste containers, cranes, steel structures for building construction and various products made of all types of steel manufactured according to customer requirements or solutions designed by the company's engineers.

In addition to its products, the company offers services to both domestic and international markets, including laser, plasma and gas sheet metal cutting, sheet metal bending, punching, welding, sandblasting, powder coating, assembly, repair, reconstruction, concept design, product design and development according to customer requirements or its conceptual solutions. The company annually produces over 2,500 above-ground and underground waste containers, 50 cranes, 100,000 various metal products and more than 30 steel structures (Vendom, 2025).

3.2 Identified Issues in the Production of Vendom Company

The company has a reputation as a responsible company delivering proven and recognizable product and service quality. Most errors in the production process that impacted product quality have been identified through internal controls, ensuring that customers, except in exceptionally rare cases, have not received products with quality defects.

In 2023, Vendom incurred total costs of 16,189 [€] due to operational production errors, specifically for repairing or replacing defective products. These costs are shown in Figure 1, with details about monthly expenses related to production errors.

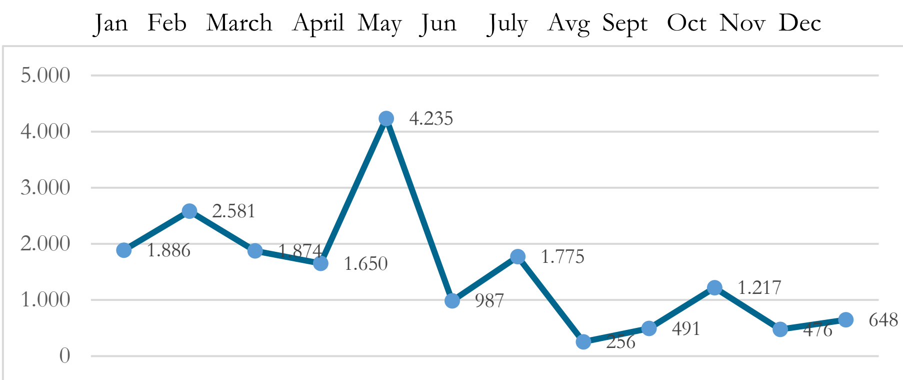

Figure 1: Vendom company's costs in 2023, due to operational production errors (in [€])

Source: (Vendom, 2025)

As shown in Figure 1, the highest costs for Vendom due to operational production errors occurred in May 2023. This was triggered by a customer complaint regarding poor joining of mouldings on platforms, resulting in a portion of the delivered platforms being returned for additional welding, leading to extra expenses. In this case, aside from the poorly executed welding operation, internal quality control of finished products also failed, as it did not detect the errors in question. In such cases, the role of internal quality control is particularly crucial, as it is far more important for the company to identify defects before delivery to the customer. Furthermore, delivered products with legitimate complaints negatively impact the company's positive reputation.

In February 2023, there was also a significant increase in costs due to operational production errors when approximately 200 components were mistakenly sent for galvanizing before welding operations for steel flats had been completed. This indicates a disruption in the sequence of production procedures. The internal quality control detected the error, which was eliminated by first removing the zinc layer through grinding, after which the welding operations were completed and the components were re-galvanized. Additionally, during that month, costs increased due to two platforms being damaged (warped) during transport, necessitating subsequent straightening.

A detailed analysis of production operations, conducted in 2023 using the FMEA method, determined that all operational production errors at the Vendom company, mostly attributed to human resources, could be categorized into five groups (with associated costs for 2023 shown in parentheses):

1. Errors during internal transport (4,582 [€]);
2. Errors in bending (3,968 [€]);
3. Errors in welding (3,192 [€]);
4. Errors in preparation: laser cutting, plasma cutting and others (2,326 [€]);
5. Errors in preparation: saw cutting, eccentric press (2,121 [€]).

Table 5 shows the most common errors, i.e., errors that contributed the most to the costs of the Vendom company, along with the RPN value for each error.

3.3 Discussion

Observing the obtained RPN values presented in Table 5, it can be concluded that for each error, the values range from 12 to 126. By applying the corrective actions recommended by the FMEA method, that correspond to the measured RPN parameter values, as shown in Table 4, the main recommendations for Vendom company to reduce errors in operational production, thereby reducing overall production costs, are to ensure greater adherence to prescribed procedures and intensify monitoring of the production process, introducing certain corrections.

Table 5: The most common errors and RPN values for each error

Internal transport errors	S	O	D	RPN
Warping and deformation of platforms during internal transport	3	4	1	12
Damage during internal transport	4	3	3	36
Errors during bending				
Reverse bending	4	2	5	40
Incorrect countersinking	4	3	7	84
Extremely poor bending leads to scrapping of materials	9	2	3	54
Welding errors				
Incomplete welding	4	4	7	112
Incorrect welding	5	3	6	90
Deformation during welding	5	3	3	45
Poor-quality welding	5	3	6	90
Corrosion due to poor welding	5	3	8	120
Welding instead of assembly	6	2	6	72
Errors in preparation: laser cutting, plasma cutting, etc.				
Warping of components during laser cutting	5	3	3	45
Incorrect countersinking	6	3	4	72
Errors in preparation: saw cutting, eccentric press				
Poorly cut pipes	8	3	2	48
Poorly finished container cladding	6	2	3	36
Incorrectly installed screws	6	3	7	126

To implement these FMEA recommendations and corrective measures, Vendom company introduced certain improvements to its operations. In its production cycle, the company uses state-of-the-art machines and tools, that were in the early stages of operation in 2023. However, the human factor was predominantly responsible for the errors and associated costs. To minimize such errors, the company conducted additional employee training on the operation of these machines and tools. There is a clear issue with internal transport, that significantly contributes to overall costs. During 2023, in the course of transporting finished products, not only the platforms were distorted and deformed, but the products also suffered significant damage. To address this issue and reduce these costs, the company has organized further training for employees responsible for transportation tasks and has invested in acquiring more suitable transport machinery for such products.

The most frequent bending errors arise from the human factor, such as reverse bending of components, incorrect countersinking and extremely poor bending, that rendered the product irreparable and needed to be scrapped. All these errors occurred due to non-compliance with clearly prescribed procedures, unskilled machine handling and a lack of concentration among employees. The recommendation is to further clarify each procedure to employees performing bending tasks to minimize these errors.

The majority of errors in the company occur during welding, typically involving incomplete, incorrect or poor-quality welding. Some errors result from failing to follow prescribed procedures, such as performing welding instead of assembly. The most easily noticeable errors of this type are deformations that occur during welding, while the most problematic are instances of corrosion caused by poor welding. Corrosion often becomes evident only after the product has been delivered, leading to higher costs. To address this, it is necessary to improve the skills of employees involved in welding to minimize such errors and to strengthen internal quality control to prevent the delivery of defective products.

Some errors occurred during the preparation phase, various types of cutting using lasers, plasma cutters, saws and eccentric press which latter being used for the quick forging of small-dimension objects. In these cases, common issues include warping of components during laser cutting, poorly cut pipes, poorly finished container cladding or the installation of incorrect screws. Errors that involve incorrect screws are the hardest to detect and are often only noticed when the product is already in use. In this situation, it is essential to frequently monitor compliance with prescribed procedures to reduce such occurrences to a minimum.

4 Conclusion

This paper presents the potential for reducing production costs by minimizing errors in the operational production process using the FMEA method in the company Vendom. Based on the obtained results and qualitative analysis of the RPN values for each error, it can be concluded that the company should implement stricter adherence to prescribed procedures, enhanced monitoring of the production process and introduce certain corrections, with internal quality control. The measures implemented based on the application of the FMEA method yielded results as early as the second half of 2023. This is evident shows a decrease in the company's average monthly costs related to product quality, i.e. costs fell below 1,000 [€].

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