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# Analysis of Wood Pallet Quality Control with Six Sigma and FMEA Methods

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## *ABSTRACT*

*This research was conducted at a logistics company engaged in warehousing and logistics services, or 3PL (third-party logistics service providers). Based on the results of the study, it is known that there are three types of product defects, the highest occurring during the last month, namely differences in pallet wood dimensions, cracks, and knots in pallet wood. From the FTA (Free Trade Agreement) diagram, it is known that the wood dimension product defect is a product defect that has the highest percentage of defects among other product defects, which is 62%. The processing results obtained an average DPMO value of 353.28 failures per one million, and the sigma level is around 3.33. Based on data analysis using Failure Mode and Effect Analysis, there are 3 product defects: dimensional differences, cracks, and knots on pallets. The main causes of product defects are checking goods from less careful suppliers, using damaged wooden pallets, and lacking lighting in the work area. Based on the analysis using SIX SIGMA and FMEA, quality improvement proposals for the company, namely conducting training and training so that employee knowledge and skills increase, selecting pallets that meet the standards, and adding lighting in the work area.*

***Keywords:*** *Defect, FTA, DPMO, Six Sigma, FMEA*

## Introduction

In the manufacturing industry, product quality is a key factor determining a company's competitiveness. Today's consumers demand high-quality, consistent products and compliance with international standards. Wooden pallets are a product widely used in logistics and distribution.[1]–[4]Wooden pallets must be strong, stable, and of proper dimensions to be used safely and efficiently.

CV. Mandiri Jaya is a company that produces wooden pallets for various industrial needs. In its operations, the company faces challenges in maintaining product quality due to production defects such as cracks, inappropriate sizes, and structural weaknesses. This impacts the increase in defective products, returns of goods, and decreased customer satisfaction.[5]–[7].

*Six sigma* is a statistical concept that measures a process related to defects at six (six) sigma, i.e., there are only 3.33 defects out of a million opportunities.[8]. Six Sigma is also a management philosophy that focuses on eliminating defects by emphasizing understanding, measuring, and improving processes. According to [9]FMEA is an analysis methodology used to ensure that potential problems in products and processes are considered and addressed thoroughly through process improvement.

The purpose of FMEA in identifying a problem is that it is very systematic, so issues that occur in processes and products can be prevented. [10] FMEA can be divided into two types: FMEA Design for use in a field and FMEA Process for use in a process.[11]–[14]. As with the possibility of failure in terms of strength, materials that are not suitable can be helped by the existence of FMEA Design.

## Method

In this chapter, the author tries to analyze the defects of wooden pallet products in CV. Mandiri Jaya uses Six Sigma and FMEA methods, collecting data from observation and interviews with related employees. The results of these observations and interviews are used to identify and classify the highest percentage of product defects. Data graph of defects in wooden pallet products. The following is a graph image of pallet product defects for one month from February 5 to March 3, 2024, at CV Mandiri Jaya.

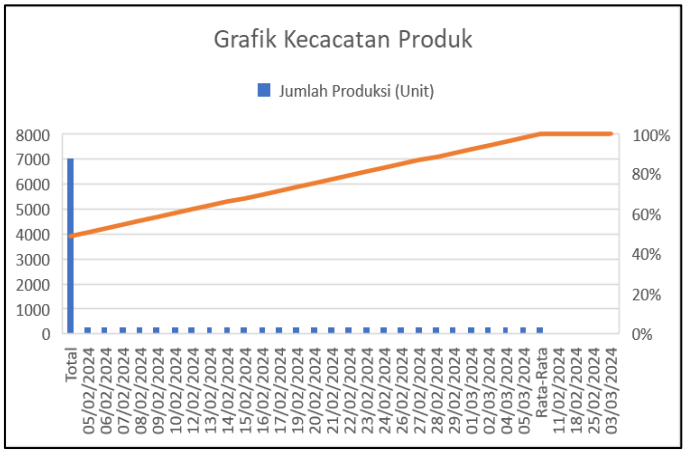


**Figure 1**. Product Defect Pareto Chart

Figure 1 shows that a total of 248 units of defect data were found. To overcome these problems, a systematic approach to quality control is needed. Six Sigma methods, especially the DMAIC (Define, Measure, Analyze, Improve, Control) approach, can identify, analyze, and improve production processes to reduce variations and defects. In addition, applying Failure Mode and Effect Analysis (FMEA) can help identify potential failures in the production process, assess their impact, and determine improvement priorities.[15]–[18].

Six Sigma is widely used in some cases, such as research conducted by [19] With the title "Quality Control Using Six Sigma and FMEA Methods to Reduce Reject Preform Materials in the Bottled Water Industry," research by [20] With the title "Quality Control Analysis Using the Six Sigma Method with DMAIC Stages to Reduce the Number of Defects in Vibrating Roller Compactor Products at Pt. Sakai Indonesia," as well as research by [21]. The title is Analysis of Product Quality Control X Using the Six Sigma Method (DMAIC) at PT. XYZ".

The analysis stages in Six Sigma use failure mode and effect analysis (FMEA) to analyze the root causes and dominant factors of the reject material performance problem in detail[22], [23].

## Results and Discussion

The following is the initial analysis of the *Define, Measure, Analyze, Improve, Control* (DMAIC) stage.[24]–[27].

**Define Stage**

At the definition stage, product defect data collection begins from February 05, 2024, to March 05, 2024. There are defects in wooden pallet products that researchers have identified as:

1. Dimensional difference of pallet board

If the difference in dimensions of wood raw materials is excessive, wood will have to be processed, hindering production. Conversely, if the difference is less than the standard of 120 cm, wood will be wasted because it cannot be processed.

2. Cracks in the pallet wood

Cracked or porous raw materials make the raw materials unusable, due to porous wood raw materials and loss of strength.

3. Wooden eyes on pallets

Wood blades will make it difficult to cut and smooth wood raw materials, affecting the wood's strength and the final appearance of the wood product.

The number of defect products in wooden pallet products for 1 month is 63 (pcs) in defects of difference in dimensions, 64 (pcs) in defects in cracks, 122 (pcs) in defects in timber, so that the total defect is 248 (pcs) out of a total production of 7,020 (pcs) or has a percentage defect value of 4%. In this define stage process, a sigma project team was formed to determine the problem for planning the next stage that will be worked on to reduce product defects.

There are four members in this sigma project team: 1 CV Owner, 2 Production Operators, and one driver at CV Mandiri Jaya. Each personnel member has their responsibilities and contributes to each other.

**Tahap Measure**

The researcher took data for 1 month and identified product defects into three defect criteria, while the data that the researcher has taken can be seen as follows:

**Table 1**. Product Defect Data

| Date | Production Quantity (Units) | Total Disability (Unique) | % Defect |
|---|---|---|---|
| 05/02/2024 | 270 | 6 | 2 |
| 06/02/2024 | 270 | 15 | 6 |
| 07/02/2024 | 270 | 12 | 4 |
| 08/02/2024 | 270 | 11 | 4 |
| 09/02/2024 | 270 | 13 | 5 |
| 10/02/2024 | 270 | 11 | 4 |
| 11/02/2024 | | **HOLIDAY** | |
| 12/02/2024 | 270 | 5 | 2 |
| 13/02/2024 | 270 | 11 | 4 |
| 14/02/2024 | 270 | 12 | 4 |
| 15/02/2024 | 270 | 12 | 4 |
| 16/02/2024 | 270 | 11 | 4 |
| 17/02/2024 | 270 | 6 | 2 |
| 18/02/2024 | | **HOLIDAY** | |
| 19/02/2024 | 270 | 9 | 3 |
| 20/02/2024 | 270 | 13 | 5 |
| 21/02/2024 | 270 | 6 | 2 |
| 22/02/2024 | 270 | 9 | 3 |
| 23/02/2024 | 270 | 13 | 5 |
| 24/02/2024 | 270 | 5 | 2 |
| 25/02/2024 | | **HOLIDAY** | |
| 26/02/2024 | 270 | 6 | 2 |
| 27/02/2024 | 270 | 11 | 4 |
| 28/02/2024 | 270 | 9 | 3 |
| 29/02/2024 | 270 | 10 | 4 |
| 01/03/2024 | 270 | 11 | 4 |
| 02/03/2024 | 270 | 8 | 3 |
| 03/03/2024 | | **HOLIDAY** | |
| 04/03/2024 | 270 | 7 | 3 |
| 05/03/2024 | 270 | 6 | 2 |
| **Total** | **7.020** | **248** | **92** |
| **Average** | **270** | **9,5** | **4** |

After the defect data is successfully identified, the next step is to measure the value of DPU (*Defect* per unit), DPMO (*Defect per million opportunities*), sigma level, UCL (*Upper control limit*), *mean*, and LCL (Lower *control limit*). In carrying out these measurements, data on the number of productions per day and the number of defective pallets are calculated per day from the three product defect criteria. Then, the results of the DPMO calculation are converted by looking at the six-sigma table so that the sigma value can be determined.

**Table 2**. Results of DPU, DPMO, and sigma value measurements

| Date | Production Quantity (Units) | Disability Criteria (Unit) | DPU | DPMO | Sigma Value | Mean (P) | UCL | LCL |
|---|---|---|---|---|---|---|---|---|
| 05/02/2024 | 270 | 6 | 0,02 | 22222 | 3,51 | 0,04 | | 0 |
| 06/02/2024 | 270 | 15 | 0,06 | 55556 | 3,09 | 0,04 | | 0 |
| 07/02/2024 | 270 | 12 | 0,04 | 44444 | 3,2 | 0,04 | | 0 |
| 08/02/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 09/02/2024 | 270 | 13 | 0,05 | 42142 | 3,16 | 0,04 | 0 |
| 10/02/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | 0 |
| 11/02/2024 | **HOLIDAY** | | | | | | |
| 12/02/2024 | 270 | 5 | 0,02 | 18519 | 3,59 | 0,04 | 0 |
| 13/02/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | 0 |
| 14/02/2024 | 270 | 12 | 0,04 | 44444 | 3,2 | 0,04 | 0 |
| 15/02/2024 | 270 | 12 | 0,04 | 44444 | 3,2 | 0,04 | 0 |
| 16/02/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | 0 |
| 17/02/2024 | 270 | 6 | 0,02 | 22222 | 3,51 | 0,04 | 0 |
| 18/02/2024 | **HOLIDAY** | | | | | | |
| 19/02/2024 | 270 | 9 | 0,03 | 33333 | 3,33 | 0,04 | 0 |
| 20/02/2024 | 270 | 13 | 0,05 | 48148 | 3,16 | 0,04 | 0 |
| 21/02/2024 | 270 | 6 | 0,02 | 22222 | 3,51 | 0,04 | 0 |
| 22/02/2024 | 270 | 9 | 0,03 | 33333 | 3,33 | 0,04 | 0 |
| 23/02/2024 | 270 | 13 | 0,05 | 48148 | 3,16 | 0,04 | 0 |
| 24/02/2024 | 270 | 5 | 0,02 | 18519 | 3,59 | 0,04 | 0 |
| 25/02/2024 | **HOLIDAY** | | | | | | |
| 26/02/2024 | 270 | 6 | 0,02 | 22222 | 3,51 | 0,04 | 0 |
| 27/02/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | 0 |
| 28/02/2024 | 270 | 9 | 0,03 | 33333 | 3,33 | 0,04 | 0 |
| 29/02/2024 | 270 | 10 | 0,04 | 37037 | 3,29 | 0,04 | 0 |
| 01/03/2024 | 270 | 11 | 0,04 | 40741 | 3,24 | 0,04 | 0 |
| 02/03/2024 | 270 | 8 | 0,03 | 29630 | 3,39 | 0,04 | 0 |
| 03/03/2024 | **HOLIDAY** | | | | | | |
| 04/03/2024 | 270 | 7 | 0,03 | 25926 | 3,44 | 0,04 | 0 |
| 05/03/2024 | 270 | 6 | 0,02 | 22222 | 3,51 | 0,04 | 0 |
| **TOTAL** | **7.020** | **248** | **0,92** | **91851** | **86** | **0,92** | |
| **AVERAGE** | **270** | **9,5** | **0,04** | **35,328** | **3,33** | **0,04** | |

Based on the calculations in Table 2 above, the company's pallets have a sigma level of 3.33. At the same time, the possible damage is 35,328 units per million productions. Therefore, steps must be taken to improve quality to reach the lowest average sigma level, 3.51 per million productions.

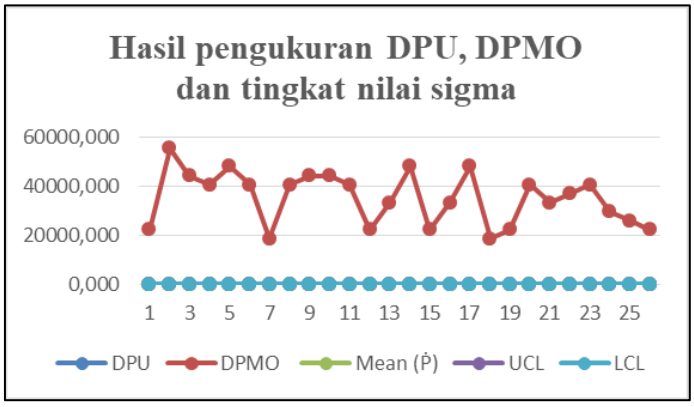


**Figure 2**. Control Map Graphics

**Tahap *Analyze***

The researcher took data from the previous measurement stage for 1 month and identified product defects based on three criteria. And the summary can be seen from Table 3 below:

**Table 3**. Total Disability Criteria

| No | Three Disability Criteria | Total Quantity (Units) |
|---|---|---|
| 1 | Difference in Pallet Wood Dimensions | 272 unit |
| 2 | Crack | 231 unit |
| 3 | There are wooden points on the pallet | 227 units |

Next, the evaluation of the problems of the three criteria will be analyzed, the cause and root cause, and then, after that, it will be analyzed, and corrective actions will be taken with the following decision tree diagram:

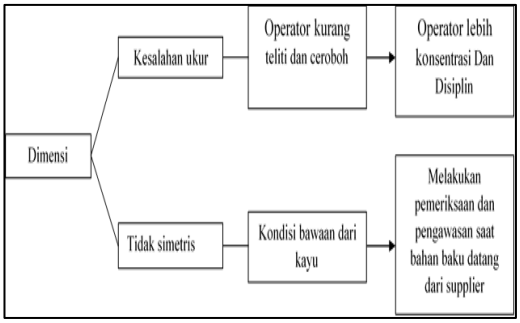


**Figure 3**. Control Map Graphics

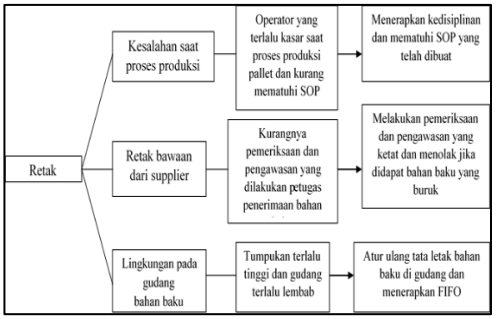


**Figure 4**. Tree Diagram of Causes of Wood Cracks

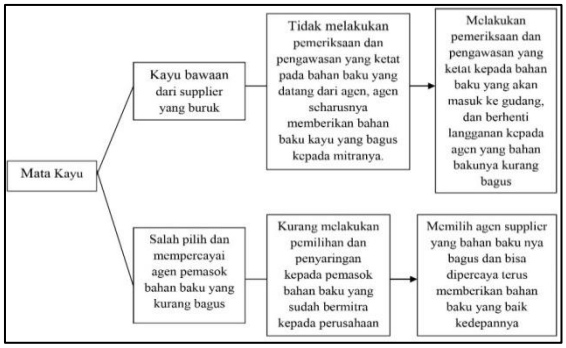


**Figure 5**. Tree Diagram of Tree Cause Wood Blade

For the next stage, a problem will be solved and recommendations will be made to improve the production process. The analysis results on pallet defects are based on the previous stages.

The following are the calculation results from the FMEA process. Then, suggestions or recommendations for improvement are given for the cause of the defect with the highest RPN value.

**Table 4**. RPN Calculation

| MK code failure | Failure Effect Analysis | SS | Potential Causes of Failure | OO | Proses Control | DD | RPN | Recommended Action |
|---|---|---|---|---|---|---|---|---|
| Difference in the dimensions of wooden pallets | Pallet durability decreases for non-standard products SOP | 44 | An asymmetrical wooden plank arena, a Lack of manpower, and precision | 77 | Visualize directly to the product | 99 | 2252 | Symmetrical Material Selection: Carefully check the quality of the results |
| Plot | Product Cacat Massa resistance is not optimal | 33 | Lack of manpower, prudence in material laying, Raw materials repair, and cracks from suppliers | 55 | Visual is direct and easily recognizable | 55 | 775 | Regular monitoring, tightening raw material standards for suppliers |
| Wooden Pallet Size | A fragile family, Indications of ticks on the material | 33 | Jamur on pallet wood, a Humid place | 55 | Visualize directly to the product | 33 | 445 | Check the quality of raw materials every day. Store in a dry place |

Table 4. The above is the result of the calculation of RPN (Risk Priority Number). Based on the table, the causes of product defects are known to be sorted from high to low values to determine the appropriate repair recommendations for each failure. The highest RPN value is in poor raw materials. Raw materials are one of the main factors that can affect product quality. Properly selecting and handling raw materials is expected to help reduce defective products.

**Tahap *Improve***

To produce an action plan for implementation to improve pallet production quality in the future, the SOPs for the production process, receipt of raw materials, and storage of raw materials in the warehouse must be redesigned and updated. This effort is made to reduce product errors and defects during the production process, after being analyzed at the previous analysis stage. The design of the new SOP is as follows:

1. Standard Operating Procedure:
   a. The head of production creates new rules and standards of operational procedures for production operators and evaluates or corrects any deficiencies found in the previous SOPs. Furthermore, the head of production conducts a briefing by informing all production operators of the new SOPs and rules.
   b. The production head must continue to supervise the pallet production process carried out by the operator more closely and assess whether the pallets made are in accordance with the company's criteria or there are still errors so that they can be repaired immediately.
   c. Operators must be more disciplined and meticulous when measuring and cutting wood. They must also be patient in carrying out their work, not in a hurry or too roughly, to minimize mistakes if they are not given a reprimand or punishment.
   d. When finding raw wood materials that are cracked by the agent's default or wood that is asymmetrical in shape, the operator should be wise not to use those raw materials and replace

them with better ones. And don't forget to immediately report to the company leader or other authorized employees to follow up on the poor raw materials.

2. Standard Operating Procedures for Receiving Raw Materials:
   a. Conduct inspections and supervise incoming raw materials, especially agents who supply any type of wood. Random wood allegedly has a lot of wood blades and traces of pest or insect attacks because any wood is obtained from fruit trees that grow wild around rural environments or residents' houses. Any wood differs from rambling wood, which comes from plantations and has a better appearance.
   b. Assess the raw materials that come and whether they are feasible and meet the criteria for producing pallets. If unsuitable raw materials are obtained, the factory must be firm about returning the wood to the agent or exchanging it for new wood.
   c. Make minutes for raw materials that have been received and provide reports to company leaders.
   d. Separating the level of wood, random wood is not always bad, even though it is often found with wood blades or traces of tree insect attacks. However, any wood has proven to have good strength, so it is suitable for pallet legs. Meanwhile, rambung wood is suitable for the upper part of the pallet, because rambung wood rarely has wood blades, and the appearance is also better and cleaner. Therefore, data collection must be carried out.

3. Standard Operating Procedures for Storing Raw Materials:
   a. The company must create new SOPs for authorized employees in the warehouse, and warehouse employees must continue supervising the agents supplying raw materials.
   b. Pay attention to the environment of the raw material warehouse, especially humidity, which can reduce the quality of the wood and make it easily attacked by pests or insects.
   c. c. Establish new rules and SOPs for arranging wood raw material piles by estimating a good height so the raw materials below it are not damaged.
   d. Apply FIFO (first in, first out) to warehouse management so that the raw materials that are the first to enter will be used for production to maintain the raw materials in good condition.

The researcher also attached data on suppliers who work together to supply raw materials to the company, which can be seen in the following table:

**Table 5**. Raw Material Supplier

| Agent Name | Types of Wood |
|---|---|
| Victory | Dutch teak |
| Amri | Squirt |
| Irwan | Dutch teak |

**Stage *Control***

The control stage is the last stage of the analysis of applying the six methods. Sigma. In the control stage, the Poka Yoke method is used. This Poka Yoke method avoids mistakes in production or work. The Poka Yoke concept was invented by Shigeo Shingo, an engineer at Matsushita Manufacturing, and is part of the Toyota Production System. Poka Yoke was originally referred to as Baka Yoke, but because it meant inappropriate, namely "avoiding stupidity", it was later changed to Poka Yoke. In general, Poka Yoke is defined as a quality management concept that avoids errors due to negligence by providing limitations in the operation of a tool or product, and it is related to the issue of defects. One of the approaches used for this Poke Yoke method is the Prevention Approach. Another term for this approach is Poka Yoke control. The prevention approach is to prevent errors from occurring and not allow errors to occur, because they have been prevented from entering the system. [3] The following are proposed preventive measures for several causative factors of defects in the base plate. Prevention proposals are as follows:

1. The company must make new SOPs for authorized employees in the warehouse, and the employees of the warehouse department must continue to supervise the agents who supply raw materials to the warehouse.
2. Record defective products for each production of each type of product defect.
3. Report the results of recording defective products to the supervisor so that faulty products can be analyzed every month, repairs can be made immediately, and faulty products can be minimized in the wood pallet production process in the future.

## Conclusion

Based on the calculation of a sigma value of 3.33 with a possible damage of 35,328 units per million productions, the company's pallet production defects can still be tolerated. The lowest mean sigma value, 3.51, was obtained from the analysis at the measure stage. At this stage, it was also found that the most common types of defects were the difference in the dimensions of wood as many as 63 units, cracks of 64 units, and wood pieces on pallets as many as 122 units, which shows that wood raw materials are the main source of problems and need to be the primary focus in repairs. Implementing the new standard operating procedures (SOP) will reduce the defect level to zero. Meanwhile, the results of the Risk Priority Number (RPN) calculation in the FMEA analysis showed that the type of defect with the highest repair priority was the difference in the dimensions of the pallet wood, which had an RPN value of 252 due to the selection of inappropriate raw materials. Therefore, it is recommended that coaching be conducted in selecting raw materials as a crucial improvement step.

## References

[1] C. Aidil Febri and A. Susilawati, "Productivity Improvement Based Systematic Layout Planning and 5S (Case Study: CV. Mutya, Indonesia)," *J. Ocean. Mech. Aerosp. -science Eng.*, vol. 66, no. 1, pp. 8–13, 2022, doi: 10.36842/jomase.v66i1.267.

[2] Y. T. Prasetyo and A.Fatih Fudhla, "Perbaikan Tata Letak Fasilitas Gudang Dengan Pendekatan Dedicated Storage Pada Gudang Distribusi Barang Jadi Industri Makanan Ringan," *ejournal.uin-suska.ac.id*, vol. 7, no. 1, p. 2021, Accessed: Jun.08, 2022. [Online]. Available: http://ejournal.uin-suska.ac.id/index.php/jti/article/view/11283

[3] E. R.Wijaya, N.Yulianti, andK.Padang, "Analisis Penyimpanan Pada Gudang Produk Jadi : Studi Kasus Pt . Abc Storage Analysis of Finished Product Warehouse : a Case Study of Company Abc," pp. 143–153, 2022.

[4] A.Haslindah, Andrie, S.Aryani, andF.Nurhidayat, "Penerapan Metode HAZOP Untuk Keselamatan Dan Kesehatan Kerja Pada Bagian Produksi Air Minum Dalam Kemasan Cup Pada PT. Tirta Sukses Perkasa (CLUB)," *journal-uim-makassar.ac.id*, vol. 1, no. 1, pp. 20–24, 2020, Accessed: Jun.25, 2022. [Online]. Available: http://journal-uim-makassar.ac.id/index.php/JUSTME/article/view/511

[5] D. A.Ferdiansyah, A.Suseno, andA. T.Septiansyah, "Review Sistematik : Analisis Kualitas Produk Kaki Pallet Menggunakan Basic Seven Tools," *J. Ilm. Wahana Pendidik. https//jurnal.unibrah.ac.id/index.php/JIWP*, vol. 7, no. 1, pp. 391–402, 2021, doi: 10.5281/zenodo.6301673.

[6] I.Kusumanto, "Analisis Kelayakan Usaha Particle Board Sebagai Pemanfaatan Limbah Kayu (Studi Kasus: CV. Riau Pallet)," *J. Tek. Ind. J. Has. Penelit. Dan Karya Ilm. Dalam Bid. Tek. Ind.*, vol. 2, no. 1, pp. 72–80, 2016.

[7] G. B. HM and N.-, "Usulan Perbaikan Postur Kerja Untuk Mengurangi Beban Kerja Proses Manual Material Handling Dengan Metode Rula Reba Qec (Studi Kasus Pengemasan Herbisida di PT. Petrokimia Kayaku Pabrik 3)," *J. Ilm. Tek. Ind.*, vol. 8, no. 3, p. 203, 2020, doi: 10.24912/jitiuntar.v8i3.7806.

[8] H.Sirine, E. P.Kurniawati, S.Pengajar, F.Ekonomika, D.Bisnis, andU.Salatiga, "Pengendalian Kualitas Menggunakan Metode Six Sigma (Studi Kasus pada PT Diras Concept Sukoharjo)," *AJIE-Asian J. Innov. Entrepreneur, vol.*. 02, no. 03, pp. 2477–3824, 2017.

[9] M. Rizki et al., "Maintenance of Raw Mill Machines Using Monte Carlo Simulation: A Case Study at Cement Company in Indonesia," in *the International Conference on Industrial Engineering and Operations Management*, 2022, pp. 1652–1664.

[10] C. A. G.Ulloa, "Design of a Preventive Maintenance Plan, ABC, Coding, Kanban System, FMEA and Forecasts to reduce costs in the metalworking company Ingenieros en Acción S.R.L.," *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, vol. 2021. 2021. doi: 10.18687/LACCEI2021.1.1.154.

[11] M.Rizki *et al.*, "Aplikasi End User Computing Satifaction pada Penggunaan E-Learning FST UIN SUSKA," *SITEKIN J. Sains, Teknol. Dan Ind.*., vol. 19, no. 2, pp. 154–159, 2022, Accessed: Jun.05, 2022. [Online]. Available: http://ejournal.uin-suska.ac.id/index.php/sitekin/article/view/14730

[12] V.Puspasari, K.Kunci, andK.Pelayanan, "Perbaikan Kualitas Toko Dunia Foto Dengan Metode Servqual, Zot (Zone Of Tolerance), Dan Siklus PDCA," *ejournal.uin-suska.ac.id*, vol. 19, no. 2,

pp. 178–185, 2022, Accessed: Jun.05, 2022. [Online]. Available: http://ejournal.uin-suska.ac.id/index.php/sitekin/article/view/9491

[13] T.Aprianto, I.Setiawan, andH. H.Purba, "Implementasi metode Failure Mode and Effect Analysis pada Industri di Asia – Kajian Literature," *Matrik*, vol. 21, no. 2, p. 165, 2021, doi: 10.30587/matrik.v21i2.2084.

[14] L. P. Hesti and A. E.Nugraha, "Analisis Komponen Kritis Mesin Bubut Underfloor Menggunakan Metode Failure Mode and Effect Analysis dan Fault Tree Analysis," *J. Serambi Eng.*, vol. 8, no. 3, pp. 6132–6138, 2023, doi: 10.32672/jse.v8i3.6103.

[15] J. Haekal, "Application of Six Sigma and KAIZEN Techniques to Non-Conformities: A Case Study of Pharmaceutical Companies," *Int. J. Sci. Acad. Res.*, vol. 3, no. 2, pp. 1–11, 2023, doi: 10.54756/ijsar.2023.v3.2.1.

[16] M. F. Afandi, D. Andesta, and Y. P.Negoro, "Upaya Perbaikan Kualitas pada Proses Pengemasan Kedelai di PT Sari Agrotama Persada Gresik Menggunakan Metode Failure Mode and Effect Analysis," *Serambi Eng.*, vol. VII, no. 3, pp. 3674–3684, 2022.

[17] Y. M. Fitriani, D. Andesta, and H.Hidayat, "Analisis Risiko Kerusakan Pada Mesin Las FCAW Dengan Pendekatan Metode Failure Mode And Effect Analysis (Studi Kasus : PT. Swadaya Graha)," *J. Serambi Eng.*, vol. 7, no. 4, 2022, doi: 10.32672/jse.v7i4.4663.

[18] Heru Winarno, Denny Kurnia, andMuhammad Fahmi, "Analisis Bullwhip Effect Dalam Sistem Rantai Pasok Pada Produk PTA di PT. Mitsubishi Chemical Indonesia," *J. Manuhara Pus. Penelit. Ilmu Manaj. dan Bisnis*, vol. 2, no. 1, pp. 11–22, 2023, doi: 10.61132/manuhara.v2i1.428.

[19] N. Alfarizi, S.Noya, and Y.Hadi, "Pengendalian Kualitas Menggunakan Metode Six Sigma dan FMEA untuk Mengurangi Reject Material Preform pada Industri AMDK," *J. Sains dan Apl. Keilmuan Tek. Ind.*, vol. 3, no. 1, pp. 01–12, 2023, doi: 10.33479/jtiumc.v3i1.41.

[20] A.Irwanto, D.Arifin, andM. M.Arifin, "Peningkatan Kualitas Produk Gearbox Dengan Pendekatan Dmaic Six Sigma Pada Pt. X, Y, Z," *J. Kalibr. Karya Lintas Ilmu Bid. Rekayasa Arsitektur, Sipil, Ind.*, vol. 3, no. 1, pp. 1–17, 2020.

[21] S. Suhartini and M.Ramadhan, "Analisis Pengendalian Kualitas Untuk Mengurangi Cacat Pada Produk Sepatu Menggunakan Metode Six Sigma dan Kaizen," *Matrik*, vol. 22, no. 1, p. 55, 2021, doi: 10.30587/matrik.v22i1.2517.

[22] D.Chandrahadinata andW.Nurdiana, "Analisis Pengendalian Kualitas Pada Crude Palm Oil untuk Meningkatkan Kualitas di PT. Condong Garut," *J. Kalibr.*, vol. 19, no. 1, pp. 43–52, 2022, doi: 10.33364/kalibrasi/v.19-1.1045.

[23] M. A. Nasir and D.Andesta, "Pendekatan Metode Failure Mode and Effect Analysis Dalam Analisis Risiko Kecelakaan Kerja Di Unit Fabrikasi Baja PT. XYZ," *J. Serambi Eng.*, vol. 7, no. 4, 2022, doi: 10.32672/jse.v7i4.4634.

[24] A. L. N.Falah, K.Arief, andR. S.Riginianto, "Analisis Pengendalian Kualitas Pada Tempe Menggunakan Metode Seven Tools Dan FMEA," *... Manaj. Ind. Terap.*, 2023, [Online]. Available: http://jurnal-tmit.com/index.php/home/article/view/264

[25] A. Wicaksono and F.Yuamita, "Pengendalian Kualitas Produksi Sarden Mengunakan Metode Failure Mode and Effect Analysis (FMEA) Untuk Meminimumkan Cacat Kaleng Di PT. Maya Food Industries," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, pp. 1–6, 2022, doi: https://doi.org/10.55826/tmit.v1iI.6.

[26] A. S. M. Absa and S.Suseno, "Analisis Pengendalian Kualitas Produk Eq Spacing Dengan Metode Statistic Quality Control (SQC) Dan Failure Mode And Effects Analysis (FMEA) Pada PT. Sinar Semesta," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. III, pp. 183–201, 2022.

[27] A. Wicaksono and F.Yuamita, "Pengendalian Kualitas Produksi Sarden Mengunakan Metode Failure Mode And Effect Analysis (FMEA) Dan Fault Tree Analysis (FTA) Untuk Meminimalkan Cacat Kaleng Di PT XYZ," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 1, no. III, pp. 145–154, 2022.