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Failure Analysis and Priority Determination of Maintenance of Raffia Rope Extrusion Machine Using the FMEA Method

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ABSTRACT

CV. ABC is a manufacturing company engaged in the production of woven mats made of raffia rope through the extrusion process. In the implementation of its production, the company experienced obstacles in the form of high levels of damage to the extrusion machine and the length of downtime, which had an impact on the achievement of production targets not optimally. In the period from August 2025 to January 2026, there was a difference between the target and the realization of production of 900 - 1,400 pcs, with a total of 145 maintenance activities and a total downtime of 162 hours. In addition, defective products in the form of raffia rope were found to be 75 kg per day or around 3.57% of total production. This study aims to identify the types of failures that have the highest level of risk through the Failure Mode and Effects Analysis (FMEA) method and formulate the right machine maintenance strategy with the Reliability Centered Maintenance (RCM) approach. The results of the FMEA evaluation identified Filters/Filters, Die, Screws, Thrust Bearings, and Hoppers as critical components based on the highest Risk Priority Number (RPN) values. Meanwhile, the RCM analysis resulted in preventive maintenance recommendations with Mean Time To Failure (MTTF) values of 11.44 days for Filters/Filters, 20.25 days for Die, 20.29 days for Screws, and 33.25 days for Thrust Bearings. The implementation of the preventive maintenance schedule planned for the July-December 2026 period is expected to improve engine reliability, minimize downtime, and maintain a smooth production process, with an estimated total maintenance cost of IDR 53,500,000.

INTRODUCTION

The development of the manufacturing industry requires companies to maintain the effectiveness and continuity of the production process in order to be able to compete competitively. One of the important factors that affect the smooth running of production is the condition and reliability of production machines. Machines that often suffer from breakdowns can cause increased downtime, disruption of the production process, decreased product quality, and increased maintenance costs. Therefore, an analysis method is needed that is able to systematically identify potential engine failures so that companies can take appropriate preventive measures. The Failure Mode and Effects Analysis (FMEA) method is one of the methods widely used to identify failure modes, causes of failures, and the impact caused on the production system through Severity,

Occurrence, and Detection assessments to obtain a Risk Priority Number (RPN) value [1].

CV. ABC is a company engaged in the production of woven mats made from raffia rope. In the production process, the extrusion machine has an important role because it is used to produce raffia rope as the main raw material. The extrusion machine works continuously so that it is susceptible to damage to some machine components. The high frequency of breakdowns leads to increased downtime, slowed production processes, and increased product defects. This condition shows that the maintenance system implemented has not been optimal in identifying potential engine failures early, so a failure risk analysis of the extrusion machine is needed to determine a more effective repair priority [2].

Several previous studies have discussed the application of the FMEA method in the failure analysis of production machines. Research by [1], explains that the FMEA method is able to identify failure modes in CNC Plate Cutting machines and determine repair priorities based on RPN values. Research [2], shows that the FMEA method is effectively used to analyze the risk of failure on UV digital printing machines so that companies can determine critical components that require special attention. Research [3], also shows that FMEA is able to assist companies in determining the priority of lathes maintenance strategies to reduce production downtime. In addition, research by [4], shows that the FMEA method can be used to identify the causes of failures in the production process so that companies can determine repair priorities to reduce defects and increase the effectiveness of the production process.

Another study by [5] states that FMEA is an important method in maintenance engineering to systematically identify potential equipment failures. [6] explained that ineffective maintenance can cause unplanned downtime and reduce the reliability of production machines. [7] It also states that the identification of machine failures is an important part of improving the effectiveness of modern industrial maintenance systems. Research [8] shows that the combination of availability analysis and FMEA can help companies understand the level of risk of production machine damage.

In addition, research by [9], explains that the Failure Mode and Effects Analysis (FMEA) method can be used to identify the engine components that have the highest level of failure risk through the analysis of Severity, Occurrence, and Detection values. The results of the study show that the implementation of FMEA is able to help companies in determining repair priorities and maintenance actions more effectively so that machine downtime can be reduced and production operational effectiveness can be increased. A similar study was also conducted by [10], which explained that failure risk analysis using FMEA is able to help companies in determining priority repairs to critical components of production machinery.

Although much research related to FMEA has been conducted, most previous research has focused on common production machines such as CNC machines and digital printing machines. Research on the application of FMEA to raffia rope extrusion machines in the weaving mat industry is still relatively limited. In addition, previous studies have generally focused only on the identification of failure modes and the determination of RPN values without discussing the association between extrusion machine failure and increased raffia rope production defects and disruption of weaving mat production continuity. This condition shows that there is a research gap which is the basis for further research on the failure analysis of raffia rope extrusion machines using the FMEA method [1].

Based on the research gap, this study was conducted to analyze the failure mode in raffia rope extrusion machines using the FMEA method with a focus on identifying the cause of damage, the impact of failure, and determining risk priorities based on RPN values. This research is expected to contribute to the development of science in the field of maintenance and reliability of production machines, especially in the raffia rope-based weaving mat industry. The novelty of this research lies in the object of research that focuses on raffia rope extrusion machines as well as the analysis of the relationship between failure mode, downtime, and raffia rope production defects that have not been widely discussed in previous studies. Thus, the results of the research are expected to be able to be the basis for determining the priorities for machine repair more effectively to improve the stability and effectiveness of the production process.

MATERIALS AND METHODS

Research Methods

This study uses the Failure Mode and Effects Analysis (FMEA) method to identify potential failures, analyze the causes and impacts of damage, and determine the priority of machine maintenance actions based on the Risk Priority Number (RPN) value. According to [11], the FMEA method can be used to identify and evaluate potential failures in the production system as a basis for determining the priority of repair actions. Based on this approach, the research stages are systematically arranged. The research stages are shown in Figure 1.

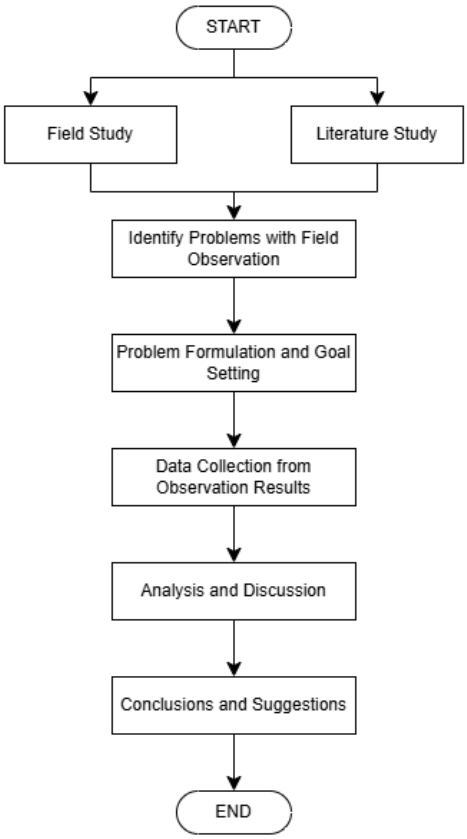

Figure 1. Research Flowchart

Based on the flowchart in Figure 1, the study began by identifying damage and downtime problems in the raffia rope extrusion machine at CV Elresas Abadi Sejahtera.

Furthermore, data were collected related to the frequency of damage, downtime, maintenance history, and the impact of failures on the production process. The data was used to identify the types of failures, causes, and impacts caused by each machine component. The next stage was to determine the values of Severity (S), Occurrence (O), and Detection (D), then calculate the RPN value to determine the priority of failure risk. The results of the analysis were used as a basis for determining critical components and formulating recommendations for maintenance actions to reduce downtime and maintain a smooth production process.

Research Location

The research was conducted at CV. ABC which is engaged in the production of woven mats made of raffia rope. The object of research is focused on raffia rope extrusion machines because the machine has the highest rate of breakdown frequency and downtime compared to other production machines. The high frequency of damage to the extrusion machine causes disruption of the production process and an increase in the number of defective products.

According to [12], the research object in the Failure Mode and Effects Analysis (FMEA) method is generally focused on components or machines that have the highest level of failure risk so that companies can determine the priority of maintenance and risk control actions more effectively to reduce production process disruptions.

Research Variables

The research variables used consisted of the main parameters in the FMEA method, namely Severity (S), Occurrence (O), and Detection (D). Severity is used to assess the extent of the failure impact on the production process and product quality. Occurrence is used to determine the frequency of damage to engine components. Detection is used to determine the system's ability to detect damage before it causes a larger disturbance.

These three parameters are used to determine the Risk Priority Number (RPN) value which is used as the basis for determining the risk of failure in the raffia rope extrusion machine. The RPN value is calculated using the following equation:

$$RPN=S\times O\times D$$

According to [13], the Severity, Occurrence, and Detection assessment method in FMEA is used to evaluate the level of failure risk so that the company can determine the priority of corrective actions on critical components of production machinery.

Data Collection Techniques

The data collection techniques in this study were conducted through observation, interviews, and documentation to obtain accurate and comprehensive data related to the condition of the raffia rope extrusion machine and the maintenance activities carried out by the company. These techniques were used to support the Failure Mode and Effects Analysis (FMEA) process in identifying potential failures, determining the causes of damage, and analyzing their impact on the production process.

Observation was conducted directly in the production area by monitoring the operation of the extrusion machine and the raffia rope production process. Through observation, the researcher identified machine components that frequently experienced failures, production disruptions, machine downtime, and defects in raffia rope products.

This process also helped determine the actual operating conditions of the machine and the effectiveness of the existing maintenance system.

Interviews were conducted with production operators and maintenance technicians to obtain detailed information regarding the causes of machine failures, the frequency of breakdowns, the impact of damage on production activities, and maintenance actions implemented by the company. Information from interviews was used to support the assessment of machine conditions and to strengthen the results obtained from direct observations.

In addition, documentation techniques were used to collect company data such as machine downtime records, component damage history, maintenance reports, and production interruption data during the research period. These data were analyzed to identify critical machine components and determine the frequency and impact of failures on the production process.

The combination of observation, interviews, and documentation provided both qualitative and quantitative data needed in the FMEA analysis. According to [14], these data collection techniques are effective in providing complete information regarding operational conditions and potential failures, thereby supporting the identification of risks and the determination of maintenance priorities more effectively.

Data Analysis Techniques

The data analysis process in this study was carried out using the Failure Mode and Effects Analysis (FMEA) method to identify potential machine failures, analyze the causes and impacts of failures, and determine maintenance priorities for the raffia rope extrusion machine.

The first stage involved identifying failure modes in each machine component based on the results of observations, interviews, and company documentation. After identifying the types of failures, the causes of damage and the effects of failures on the production process were analyzed. Failures in the extrusion machine were found to cause production delays, increased downtime, unstable machine performance, and defects in raffia rope products.

The next stage involved assigning Severity (S), Occurrence (O), and Detection (D) values to each identified failure mode. The Severity value indicated the level of impact caused by the failure, Occurrence represented the frequency of damage, and Detection showed the ability of the system to detect failures before larger disruptions occurred. The assessment process was based on operational data, maintenance records, and information obtained from operators and technicians.

After the assessment process, the Risk Priority Number (RPN) value was determined to identify the level of failure risk in each machine component. Components with the highest RPN values were categorized as critical components that required priority maintenance and corrective actions because they had the greatest impact on production continuity and machine reliability.

The results of the FMEA analysis were then used as the basis for proposing corrective and preventive maintenance actions such as routine inspections, scheduled component replacement, machine monitoring, and preventive maintenance implementation. According to [15], the FMEA method is effective in systematically identifying and prioritizing failure risks so that companies can determine appropriate corrective actions to reduce machine downtime and improve production effectiveness.

RESULTS AND DISCUSSIONS

Results

1. Frequency and Downtime

Based on the results of data collection on the raffia rope extrusion machine at CV Elresas Abadi Sejahtera, data on the frequency of damage and machine downtime during the research period were obtained. Data shows that extrusion machines suffer several types of damage that have an impact on the disruption of the production process and the increase in defects in raffia rope products. High downtime indicates that some engine components have a high enough risk of failure that further analysis needs to be carried out using the Failure Mode and Effects Analysis (FMEA) method.

Table 1. Frequency Data and Downtime Data

Machine	Frequency	Downtime
Oven	25	14
Extrusion	145	162
Boom	14	10
Mat Knitting	16	22
Cutting	17	6
Sewing	79	38

Based on data on the frequency of breakdowns and downtime of production machines, it is known that the Extrusion Machine has the highest level of disruption with a frequency of breakdowns of 145 times and a total downtime of 162 hours. This shows that the Extrusion Machine is the most critical machine that experiences the most frequent disruptions and has the greatest impact on the production process.

In addition, the Sewing Machine also has a fairly high frequency of damage, which is 79 times with a downtime of 38 hours. Meanwhile, other machines such as Plastic Seed Oven Machine, Boom Machine, Mat Knitting Machine, and Cutting Machine, Sewing Machine have a relatively lower breakdown rate and downtime. The data shows that the priority of repair and maintenance needs to be focused on the Extrusion Machine because it has the largest downtime contribution that can hinder the smooth production process of raffia rope.

Descriptive statistical analysis was carried out to find out the engine components that were damaged the most often and had the highest downtime. Based on the observation results, the components of the heater barrel, screw extruder, and gearbox are the components that are most often disrupted during the production process. Damage to these components causes the extrusion process of raffia material to become unstable so that product quality decreases and production is delayed.

In addition to the frequency of damage, an analysis of the total downtime of each engine component is also carried out. The results of the analysis show that components with a high frequency of damage tend to have a large downtime, which has a direct impact on the effectiveness of the company's production process. This condition shows that the maintenance system implemented is still corrective maintenance so that repair actions are carried out after engine damage occurs.

2. Risk Priority Number (RPN)

Based on the results of the Failure Mode and Effects Analysis (FMEA), it is known that raffia rope extrusion machines have several components with a fairly high level of

failure risk. The analysis was carried out by identifying the failure mode, the cause of failure, the impact of failure, and calculating the Severity (S), Occurrence (O), and Detection (D) values to obtain the Risk Priority Number (RPN) value. The results of the RPN calculation are used to determine the priority of repairs on the engine components that are most critical to the production process.

Table 2. Failure Mode and Effects Analysis (FMEA)

No	Engine	Types of Damage	Impact	Cause	S	O	D	RPN	Recommended Actions
1	Extrusion	Clogged/dirty filter	Material flow is disrupted, raffia quality is defective, machine stops	Build-up of dirt on the material	**9**	**8**	**8**	**576**	Regular filter cleaning, installation of filter replacement schedules, and screening of raw materials before entering the machine
2	Extrusion	Screw off	Inconsistent output	Constant friction	9	6	7	378	Routine inspections and replacements based on service life
3	Extrusion	Unstable heater	The quality of raffia is not suitable	Damaged heating element	8	7	6	336	Temperature calibration and heater replacement
4	Extrusion	Motor damage	Engine stop	Overload	9	5	6	270	Load monitoring and maintenance of the motor
5	Extrusion	Broken needles	Woven defects	Wear and tear	7	7	6	294	Periodic replacement
6	Oven	Uneven temperature	Decreased quality	Faulty sensor	7	5	5	175	Sensor calibration
7	Boom	Broken thread	Disrupted process	Unstable voltage	6	6	5	180	Voltage setting
8	Cutting	Blunt knives	Untidy results	Rarely honed	5	6	4	120	Routine sharpening
9	Sewing	Engine jammed	Production halted	Less lubrication	6	5	5	150	Routine lubrication

Based on the results of the Failure Mode and Effects Analysis (FMEA) conducted on the production machines, it can be identified that the most critical failure occurs in the extrusion machine, specifically in the form of a clogged or dirty filter, which obtained the highest Risk Priority Number (RPN) value of 576. This failure is primarily caused by the accumulation of dirt and impurities in the raw material entering the machine. As a result, the material flow becomes obstructed, causing disruptions in the production process, defects in the quality of raffia products, and even machine stoppages. Such conditions significantly affect production efficiency and may increase downtime and operational costs. Therefore, several corrective and preventive actions are recommended,

including routine filter cleaning, scheduled filter replacement, and the implementation of raw material screening before the material enters the extrusion machine. These actions are expected to reduce contamination and maintain stable machine performance during operation.

Another critical failure identified in the extrusion machine is screw wear, which has an RPN value of 378. This damage is mainly caused by continuous friction between machine components during long-term operation. The worn screw results in inconsistent production output, which directly affects the uniformity and quality of the raffia products produced. If not handled properly, this failure can lead to increased production defects and decreased machine reliability. To minimize the risk, routine inspections and component replacement based on the service life of the screw are strongly recommended. Preventive monitoring of machine conditions can also help detect early signs of wear before severe damage occurs.

In addition, the unstable heater failure in the extrusion machine also shows a relatively high RPN value of 336. The main cause of this problem is damage to the heating element, which affects the machine's ability to maintain stable operating temperatures. Since the extrusion process is highly dependent on temperature consistency, unstable heating can cause the raffia products to fail to meet quality standards. Variations in temperature may lead to defects such as uneven texture, poor product strength, or inconsistent product dimensions. Recommended actions for this failure include periodic temperature calibration and replacement of damaged heating elements to ensure optimal machine performance and product quality consistency.

The analysis also indicates that other production machines experience failures with moderate RPN values. For example, broken needles in the weaving machine have an RPN value of 294 and are mainly caused by wear and tear during continuous operation. This failure results in defects in the woven raffia products and disrupts the weaving process. Preventive actions such as periodic needle replacement are necessary to maintain product quality and reduce machine downtime. Furthermore, motor damage in the extrusion machine has an RPN value of 270, caused by excessive load during operation. This failure can stop the entire production process and potentially damage other machine components if not addressed immediately. Therefore, load monitoring and regular motor maintenance are recommended to prevent overload conditions and extend motor lifespan.

Meanwhile, failures occurring in the oven, boom, cutting, and sewing machines have relatively lower RPN values compared to the extrusion machine. Uneven temperature in the oven machine, with an RPN value of 175, is caused by faulty sensors and affects product quality due to inconsistent heating. Broken thread in the boom machine has an RPN value of 180 and occurs due to unstable voltage, leading to process interruptions. In the cutting machine, blunt knives produce untidy cutting results with an RPN value of 120, while engine jams in the sewing machine have an RPN value of 150 due to insufficient lubrication, resulting in production stoppages. Although these failures are categorized as lower risk, they still require regular maintenance actions such as sensor calibration, voltage stabilization, routine sharpening, and lubrication to avoid more serious damage and ensure smooth production activities.

Overall, the FMEA results indicate that the extrusion machine is the most critical machine in the production line because it has several failure modes with high RPN values. This condition demonstrates that the extrusion machine should become the main priority in maintenance planning and improvement programs. By implementing a structured preventive maintenance system, the company can reduce the frequency of

machine failures, minimize downtime, improve product quality, and maintain production continuity effectively. In addition, the application of regular inspections, scheduled component replacements, and proper monitoring systems will help increase machine reliability and support the achievement of optimal production performance in the long term.

Discussions

Based on the results of the Failure Mode and Effects Analysis (FMEA), it is known that some extrusion machine components have a high level of failure risk so that they require priority in maintenance activities. Priority components include Filters, Die, Screws, Thrust Bearings, and Hoppers. The determination of these priorities is the basis for preparing preventive maintenance recommendations by considering the need for component replacement and maintenance frequency. To determine the potential cost efficiency of the implementation of these recommendations, a comparative analysis of maintenance costs before and after maintenance planning is carried out. The results of the comparative analysis of maintenance costs on critical components of the extrusion machine are presented in Table 3.

Table 1. Before and After Cost Analysis

Components	Price	Freq	Total	Freq	Total
Filters	250.000	20	5.000.000	16	4.000.000
Die	1.500.000	12	18.000.000	9	13.500.000
Screw	3.500.000	13	45.500.000	9	31.500.000
Thrust Bearing	450.000	8	3.600.000	5	2.250.000
Hopper	750.000	5	3.750.000	3	2.250.000
Total			75.850.000		53.500.000

Based on Table 3, the total maintenance cost before the preventive maintenance plan is IDR 75.850.000, while after the maintenance planning the cost is estimated to be IDR 53.500.000. The comparison results show a potential cost savings of IDR 22.350.000 or around 29,46%. The cost reduction is obtained from the reduction in the frequency of maintenance or replacement of critical components, namely Filter/Filter, Die, Screw, Thrust Bearing, and Hopper. The Screw component contributes the largest savings, which is IDR 14.000.000, followed by the Die component of IDR 4.500.000. Meanwhile, the savings in Filters/Filters, Thrust Bearings, and Hoppers are IDR 1.000.000, IDR 1.350.000, and IDR 1.500.000, respectively.

These results show that preventive maintenance planning has the potential to increase maintenance cost efficiency through more planned regulation of component replacement frequency. Determining maintenance schedules based on failure risk priorities can help companies allocate costs more effectively while reducing the likelihood of damage that disrupts the production process. Thus, the implementation of maintenance recommendations is expected not only to reduce maintenance costs, but also to support the improvement of extrusion machine reliability and the continuity of raffia rope production. However, the value of these savings is still in the form of an estimate based on maintenance planning so it needs to be further evaluated through actual implementation and monitoring in the company.

CONCLUSION

Based on the results of the analysis using the Failure Mode and Effects Analysis (FMEA) method on the raffia rope extrusion machine at CV Elresas Abadi Sejahtera, the extrusion machine was identified as the production machine with the highest frequency of damage and downtime, which was 145 times damage with a total downtime of 162 hours. The results of the FMEA analysis showed that clogging or accumulation of dirt in the filter was the type of failure with the highest priority, with a Risk Priority Number (RPN) value of 576. Furthermore, failures in the form of screw wear had an RPN value of 378, while heater performance instability had an RPN value of 336. These results show that maintenance activities need to be prioritized on critical components that have the potential to disrupt the smooth production process and reduce product quality.

The results of the cost analysis show that the implementation of the proposed maintenance has the potential to reduce maintenance costs from IDR 75.850.000 to IDR 53.500.000, resulting in potential savings of IDR 22.350.000 or around 29,46%. However, these savings are still in the form of estimates based on the proposed maintenance plan and have not been validated through direct implementation. Therefore, further monitoring and evaluation are needed to determine the effectiveness of the proposed maintenance schedule in reducing the frequency of damage, minimizing downtime, increasing machine reliability, and maintaining the quality of raffia rope production.

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REFERENCES

[1] I. N. Gusniar and A. Triawan, “Analisis Maintenance pada Mesin AMG CNC Plate Cutting Menggunakan Metode Failure Mode and Effect Analysis (FMEA),” Aug. 2021.

[2] Tri Wibowo, Novi Purnama Sari, and Hb Rudi Kusumantoro, “Analisis Risiko Kegagalan Menggunakan Metode FMEA pada Mesin Cetak Digital UV di PT XYZ,” *JURRITEK*, vol. 4, no. 2, pp. 173–184, Jun. 2025, doi: 10.55606/jurritek.v4i2.5524.

[3] Qanita Zahira Muhar Arifin and Akmal Suryadi, “Analisis Prioritas dan Strategi Perawatan Mesin Bubut Menggunakan Metode Failure Mode And Effect Analysis (FMEA) dan Diagram Pareto Di PT XYZ,” *Venus*, vol. 2, no. 1, pp. 200–208, Jan. 2024, doi: 10.61132/venus.v1i5.114.

[4] D. Maulana, B. Sumartono, and H. Moektiwibowo, “Pengendalian Kualitas dengan Menggunakan Metode Six Sigma pada Proses Produksi Komponen Plate Di Line 3 PT GS Battery,” Aug. 2018.

[5] K. Lynch, F. Lorenzi, J. Sheehan, D. Kabakci-Zorlu, and B. Eck, “FMEA Builder: Expert Guided Text Generation for Equipment Maintenance,” Jul. 2024.

[6] Y. Ran, X. Zhou, P. Lin, Y. Wen, and R. Deng, “A Survey of Predictive Maintenance: Systems, Purposes and Approaches,” Dec. 2019.

[7] S. Gawde, S. Patil, S. Kumar, P. Kamat, K. Kotecha, and A. Abraham, "Multi-fault diagnosis of Industrial Rotating Machines using Data-driven approach : A review of two decades of research," *Engineering Applications of Artificial Intelligence*, vol. 123, p. 106139, Aug. 2023, doi: 10.1016/j.engappai.2023.106139.

[8] A. Maulana and M. Nuruddin, "Analisis Kinerja dan Pemeliharaan Mesin dengan Metode Availability dan FMEA Pada PT. XYZ." *Journal of Information Technology and Computer Science*, Nov. 2025.

[9] M. R. N. Alamsyah and W. Widiasih, "Analisis Komponen Kritis dan Penjadwalan Perawatan Mesin Inject Molding dengan Metode FMEA Pada PT. Angkada Raya" *JISO*, vol. 6, no. 1, p. 17, Jun. 2023, doi: 10.51804/jiso.v6i1.17-24.

[10] E. Krisnaningsih, G. Kristiyanto, S. Dwiyatno, and D. Cahyadi, "The New Framework Maintenance Optimization Using Reliability Centered Maintenance-FMEA," *IJIEEM*, vol. 7, no. 2, pp. 157–166, Dec. 2025, doi: 10.24002/ijieem.v7i2.10798.

[11] L. Xiao, G. Huang, and G. Zhang, "An intuitionistic fuzzy cloud model-based risk assessment method of failure modes considering hybrid weight information," *IFS*, vol. 42, no. 6, pp. 5237–5263, Apr. 2022, doi: 10.3233/JIFS-211793.

[12] B. C. Jung, Y.-H. Shin, S. H. Lee, Y. C. Huh, and H. Oh, "A Response-Adaptive Method for Design of Validation Experiments in Computational Mechanics," *Applied Sciences*, vol. 10, no. 2, p. 647, Jan. 2020, doi: 10.3390/app10020647.

[13] J. Fabis-Domagala, M. Domagala, and H. Momeni, "A Concept of Risk Prioritization in FMEA Analysis for Fluid Power Systems," *Energies*, vol. 14, no. 20, p. 6482, Oct. 2021, doi: 10.3390/en14206482.

[14] G. M. Mardhotilah, M. Rizal, and R. Tahir, "Penanganan Kegagalan Pengiriman Barang Antar dengan Metode Failure Mode and Effect Analysis (FMEA) dan Fault Tree Analysis (FTA) Studi pada Perusahaan Jasa Ekspedisi," *jiip*, vol. 7, no. 9, pp. 10148–10154, Sep. 2024, doi: 10.54371/jiip.v7i9.5774.

[15] J. Fabis-Domagala and M. Domagala, "A Concept of Risk Prioritization in FMEA of Fluid Power Components," *Energies*, vol. 15, no. 17, p. 6180, Aug. 2022, doi: 10.3390/en15176180.

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