SITEKIN: Jurnal Sains, Teknologi dan Industri, Vol. 20, No.2, June 2023, pp.881 - 890
ISSN 2407-0939 print/ISSN 2721-2041 online

AN ANALYSIS OF UNSCHEDULE SHUTDOWN *TOWARD ROTARY EQUIPMENT BLOWER ENGINE 18C3101-2 BY ROOT CAUSE ANALYSIS* (RCA) METHOD (Case Study in PT. Petrokimia Gresik)

Rendra Yanuarsah[1], Dzakiyah Widyaningrum[2], Moh. Jufriyanto[3]
[1,2,3] Study Program Industrial Engineering, Engineering Department, Universitas Muhammadiyah Gresik
Jl. Sumatera No.101, Gn. Malang, Randuagung, Kec. Kebomas, Kabupaten Gresik, Jawa Timur 61121
Email: rendrooo33@gmail.com, dzakiyah@umg.ac.id, jufriyanto@umg.ac.id

Abstact

PT. Petrokimia Gresik is a fertilizer manufacturer assigned by the Government to produce and distribute subsidized and non-subsidized fertilizers. The NPK 3 unit is the place where production be held. However, within March - June 2019 there was significant amount of decreasing fertilizer production caused by Rotary equipment malfunction. This occurrence caused unscheduled shutdown. PT. Petrokimia Gresik experienced loss in many breakdown units. The objection of this study is to determine the factors causing the breakdown of 18C3101-2 blower engine in NPK 3 unit and to create the most effective solution to be applied while overcoming the 18C3101-2 blower engine breakdown in the NPK 3 unit. Problem of this study is what caused a breakdown of the 18C3101-2 blower engine in the NPK unit. This research applies the Root Cause Analysis (RCA) method. The result shows that using the Fishbone Diagram approach figuring out the main problem caused troubleshooting of 18C3101-2 blower engine due to a clogged spray nozzle, the main cause of a clogged spray nozzle was the initial setting of spray nozzle pipe installation inefficient.

Keywords: Rotary equipment, unschedule shutdown, Root Cause Analysis (RCA).

Introduction

In this globalization era, company must own the responsibility to manage systems properly in order to obtain efficiency, productivity, and quality which are becoming important factors[1]. The development of a decent system is one of the implementations in PT. Petrokimia Gresik to improve quality, increase productivity, and utilize human resources to achieve work efficiency[2]. PT. Petrokimia Gresik is a fertilizer manufacturer assigned by the Government to produce and distribute subsidized and non-subsidized fertilizers, in order to maintain food security in Indonesia.

The development of a decent system is one of the implementations in PT. Petrokimia Gresik to improve quality, increase productivity, and utilize human resources to achieve work efficiency[1], [3]. PT. Petrokimia Gresik is a fertilizer manufacturer assigned by the Government to produce and distribute subsidized and non-subsidized fertilizers, in order to maintain food security in Indonesia[2].

In 2018, ± 5.5 million tons of subsidized fertilizers must be distributed to farmers. This project must be supported by a good distribution process to regions throughout Indonesia, which are the responsibility of manufacturers, including PT. Petrokimia Gresik. Regarding the production process at PT. Petrokimia Gresik, the factory is required to operate as it best so that production targets can be achieved. In order to support the NPK 3 unit in achieving the production target arranged by the company, the reliability of the equipment is the key. Thus, it will not cause downtime which make the company loss. In this study, the data analyzed was the unscheduled shutdown at the NPK 3 unit within March to June 2019.

Table 1. Data Unscheduled Shutdown NPK 3

Code	Downtime Categories	Duration (minutes)	%	Cumulative
A	Rotary	3485	35,75	35,75
B	Operational	2635	27,03	62,78
C	Electricity	1886	19,35	82,13
D	Instrumental	1742	17,87	100,00
	Total	9748	100,00	

The data from Table 1 can be concluded that the biggest malfunction occurred in Rotary equipment with downtime duration 3485 minutes (58 hours). The total downtime within March-June 2019 was 9748 minutes (162 hours). Based on problems elaborated, the authors conducted research occurred in PT. Petrokimia Gresik regarding an analysis of unscheduled shutdown rotary equipment blower motor 18C3101-2 in NPK 3 Applies Root Cause Analysis (RCA) Method. The Root Cause Analysis (RCA) method is frequently used in problem solving initiatives, to assist the team figuring out the root cause of the problem that is currently happening [4], [5].

Fishbone Diagram is a QC 7 tool works to identify and show the relationship between cause and effect in order to find the root problem [5], [6]. Next, an analysis was carried out using 5 Why-Analysis is a tool from RCA to assist identifying the root problem or a cause of mistake in a process or product [7]–[9].

Root Cause Analysis

Root Cause Analysis (RCA) is a structured approach to identify affected factors in one or more past events so that they can be analysed in order to improve performance [9]. The application of RCA in the analysis of performance improvements is able to track factors which affect performance [10]. *Root Cause* is part of several factors (events, conditions, organizational factors) that contribute to, or arise the possible causes which are proceeded by unexpected consequences.

Root Cause Analysis (RCA) is a useful work tool to find the root cause of an incident that has occurred [11], [12]. Finding the root of the problem is the key root. Because, without knowing the root of the problem, an incident cannot be handled properly, which results in the repetition of the incident in the future [13].

Research Method

The analysis in this study applies Root Cause Analysis (RCA) method in the form of 5 why analysis tool and Fishbone Diagram to find the root cause of academic fraud [14], [15]. The steps in preparing the Root Cause Analysis method as follows:

1. Identify the problem.
   While identifying problems, the researcher must pay attention to incidents which may cause a high impact or loss. Thus, it is very important to make improvement.[15]
2. Explain what happened.
   In this step, the researcher conducts a re-analysis by collecting data, information and facts about the incident to understand the problems occurred.
3. Identify the causal factors.
   In step 3, this method works to dig deeper into problems occur and find out why the problems occur.
4. Identify root causes.
   Conduct a thorough analysis of the problem factors that identify the root causes of the problem. The researcher is allowed to proceed by digging deeper into the root causes and asking the question "why" repeatedly until the root cause is known, this technique is called as the "Five (5) why analysis" method and Fishbone Diagram[16], [17]
5. Arrange and determine improvement plans.
   Arrange and determine improvement plans to fix a problem and prevent the problem happening again in the future.
6. Measure the results of the improvement evaluation.
   Improvement actions applied to reduce or eliminate root causes must be re-evaluated whether the plan is effective in reducing or preventing a problem from reoccurring.

The current object in this research is PT. Gresik Petrochemicals focusing on Unscheduled Shutdown Rotary Equipment Motor Blower 18C3101-2. First, the step started with identification of the problems cause breakdowns in the NPK 3 unit. After identifying the existing problems, it will be continued by elaborating the problems regarding the causes of breakdowns in the NPK 3 unit. From these problems, it will allow to proceed the field and literature studies to understand the causes of existing problems [18], [19].

After conducting field and literature studies, the researcher proceeds by identifying the causal factors occurred in the NPK 3 unit. This step aims to figure out why the problem raised and what are the benefits for production and maintenance department [20], [21]. The data obtained and recorded will be collected. The data taken is breakdown data at the NPK 3 unit within March-June 2019. Afterwards, the data analyzed using the Root Causes Analysis method with Fishbone Diagram and 5-Why Analysis, in order to identify the root cause [22].

Fishbone Diagrams

Fishbone analysis applied in this research in order to categorize various potential causes of a problem or subject matter in a way that is easy to understand and orderly [23]. Besides, this tool assists researcher to analyze the actual occasion by breaking down the process into several categories related to the process, including human, material, machine, procedures, policies and so on[24], [25].

Fishbone Diagram categorizes various potential causes of a problem or subject matter in an easy-to-understand and orderly [25].

The steps in Fishbone analysis are:

1. Set up a causal session
2. Identify consequences
3. Identify the various categories
4. Find potential causes by brainstorming
5. Review each main cause category
6. Resume the most probable causes

5-Why Analysis

5-Why Analysis is a method applied in Root Cause Analysis (RCA) in the scope of problem solving by finding the root cause of a problem or the cause of a defect in order to get to the root cause of the problem [6].

General steps to apply Root Cause Analysis (RCA) with 5-Why Analysis:

1. Define the problem and problem areas.
2. Assemble a team for brainstorming so that researchers may have different point of views, knowledge, experiences, and different approaches to the problems.
3. Arrange field work to see actual places, objects, and data.
4. Ask questions using 5 whys.
5. Analyze the root of the problem by examining each answer from the bottom whether the answer will trigger the consequences at the top level.
6. In general, the solution should not lead to blame other people but how to improve the system or procedure.
7. If the root cause already known, the solution must be implemented immediately.
8. Keep paying attention to the performance in order to be certain that the problem will not reoccur in the future.

The results of the analysis directed to improvement plans which applicable to fix the problems. The results obtained will be analyzed in order to avoid the same problems might occur in the future.

Result and Discussion

Based on the problems context arise, the data collection in the Unscheduled Shutdown Rotary Equipment Blower engine of 18C3101-2 Analysis applies Root Cause Analysis (RCA) Method as follows:

Identify the problem

The results of the identification exhibit malfunction to the rotary equipment can see in Table 2.

Table 2. Shutdown Rotary Equipment

Code	Item	Equipment	Duration (minutes)	%	Cumulative
A1	18C3101-2	Blower Vibration Tall	1100	31,56	31,56
A2	18M3114	Rotary Dryer Failed to Start	960	27,55	59,11
A3	18M2602-1	Conveyor Trouble	907	26,03	85,14
A4	18M3117	Replace Buckets Free	331	9,5	94,64
A5	18M3113	Replace Worn Rubber Seals	187	5,36	100
Total			3485	100	

Based on the data above, it was obtained 5 rotary equipment caused unscheduled shutdown, the data conclude that item 18C3101-2 was found as one of the most influential causes. The data above can be concluded that the biggest malfunction occurred in Rotary equipment with downtime duration 3485 minutes (58 hours). The total downtime within March-June 2019 was 9748 minutes (162 hours).

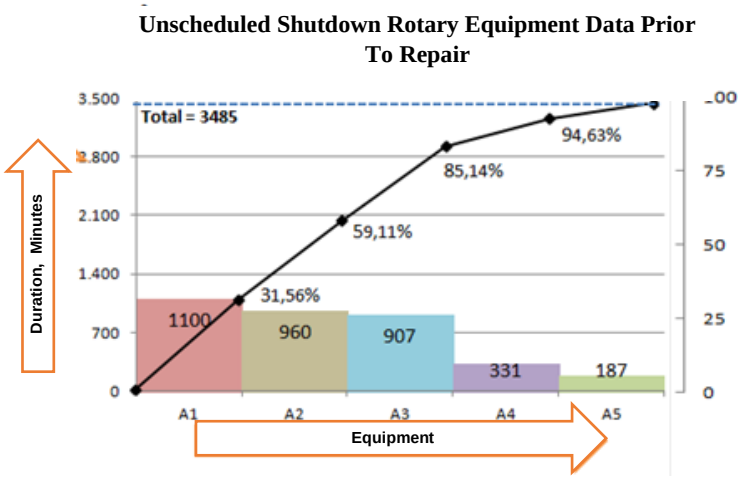

Figure 1. Pareto Diagram of Shutdown Rotary Equipment

Based on the data in Figure 1, shows that the downtime is 3485 minutes (58 hours) spread over the Blower Vibration Tall 1100 minutes, Rotary Dryer Failed to Start 960 minutes, Conveyor Trouble 907 minutes, Replace Buckets Free 331 minutes, Replace Worn Rubber Seals 187 minutes. Malfunction data was collected on Item 18C3101-2 can see in Table 3.

Table 3. Blower Engine Malfunction

Code	Item	Duration (Minutes)	%	Cumulative (%)	Information
A1.1	Impeller Scalling	900	82	82	Sandblasting impeller
A1.2	Bearing panas	150	14	96	Replace bearings
A1.3	Resetting house bearing	50	4	100	Tighten the bearing housing bolts
Total		1100	100		

The downtime duration on Item 18C3101-2 for 15 hours caused loss to the company in the form of unit breakdowns. Therefore, the total estimated loss due to the breakdown unit company for 15 hours caused by Unscheduled Shutdown Rotary Equipment (Item 18C3101-2) is IDR 1,363,636,365. The longer downtime occurred, the longer the breakdown of the unit will affect more loss to the company.

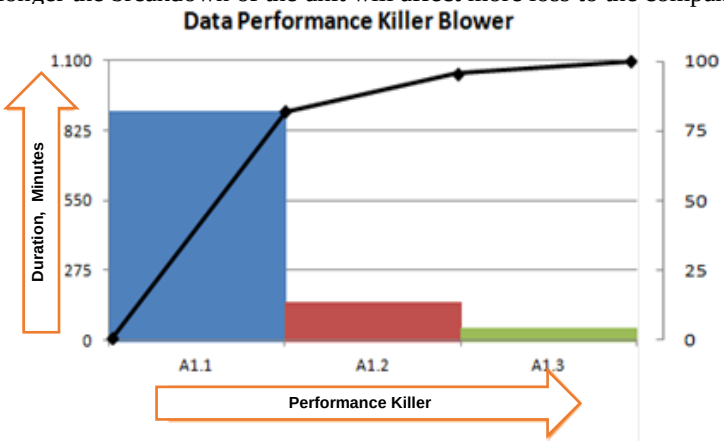

Figure 2. Diagram Pareto Blower Engine Malfunction

Figure 2 shows that the damage to the blower motor on item A1.1 impeller scaling is the highest, namely for 900 minutes or for 15 hours.

Explain What Happened

Collection and re-analysis of facts, data and information about incidents conducted to analyses and figure out the problems.

First, in the process of identifying the problem is to find what the problem is, and the second, decide a problem from alternative problems through brainstorming. The following is the result of discussion regarding the problems occurred in PT.Petrokimia Gresik NPK 3 Manufacturer.

Table 4. Discussion for problem occurred.

Analyzed Factors	Problems occurred
Man	- The operator missed control the condition of the spray scrubbing room - The operator doesn't have access to nozzle control
Material	- Natural characteristic of sticky dust - Hygroscopic material
Method	- Clogged Nozzle sprayer - Rarely cleaning - Cleaning and factory operation cannot run in the same time
Machine	- Dust passed to the impeller - Spray nozzle didn't filter the dust - Limited nozzle spray direction
Environment	- High corrosive

Based on problem identification or brainstorming in advance, it exhibits several factors affect the performance of the 18C3101-2 blower engine including Man, Material, Method, Machine, and Environment.

Identify Causative Factors

Based on problem identification or brainstorming in advance, it exhibits several factors identified probably affect the performance of the 18C3101-2 blower engine including Man, Material, Method, Machine, and Environment, which will be elaborated as the main causal factors as below:

a. Man (Human or Labor)

This variable determined as the main cause in which the operator or human resources at PT. Petrokimia Gresik on their job description:

1. Operators missed control the condition of the spray scrubbing room since the position of the spray nozzle is located in the scrubbing room.
2. Operators do not have access to nozzle control.
3. Operators relied on manholes only which working while shutdown program occurs.

b. Material

1. The natural characteristic of sticky dust. Sucked dust in the scrubbing room trapped inside.
2. Hygroscopic materials mean the ability of a substance to absorb water molecules from its circumstance.

c. Method

1. Clogged spray nozzle
   This nozzle works to break water into droplets to catch the dust in the scrubbing room.
2. Rarely cleaning schedule
   One of the important jobs in the NPK factory unit in which cleaning work is also included as preventive maintenance.
3. Cleaning and factory operation cannot run in the same time since the placement of spray line located in the scrubbing room. It caused difficulties to perform preventive maintenance on the nozzle spray.

d. Machine

1. Dust passed into the impeller.
   The impact of a clogged spray nozzle caused a lot of dust to escape and trapped into the impeller.

2. Spray nozzle didn't filter the dust
   The lack of preventive maintenance on the spray nozzle caused clogging and affected the blower engine.
3. Limited nozzle spray direction
   Since the spray nozzle still uses the umbrella model, it is easy to get stuck and the distribution of droplets is limited.

c. Environment
   High corrosive

The environment of NPK 3 factory area is high corrosive level. This place leads to trigger the equipment made of metal will corrode quickly, reduce the lifetime, and level of work accident risk is high.

Identify Root Causes

Fishbone Diagrams

Fishbone diagram is an analytical method applied to identify quality issue and check points included as four types of materials or equipment, labor and methods. The reasons related with each category sometimes tied to different branch bones throughout the brainstorming process [8], [10]

Based on the problem identification activities and the cause determination of the main problem from the breakdown in the 18C3101-2 blower engine, the following is the result of the fishbone diagram obtained from processing company data:

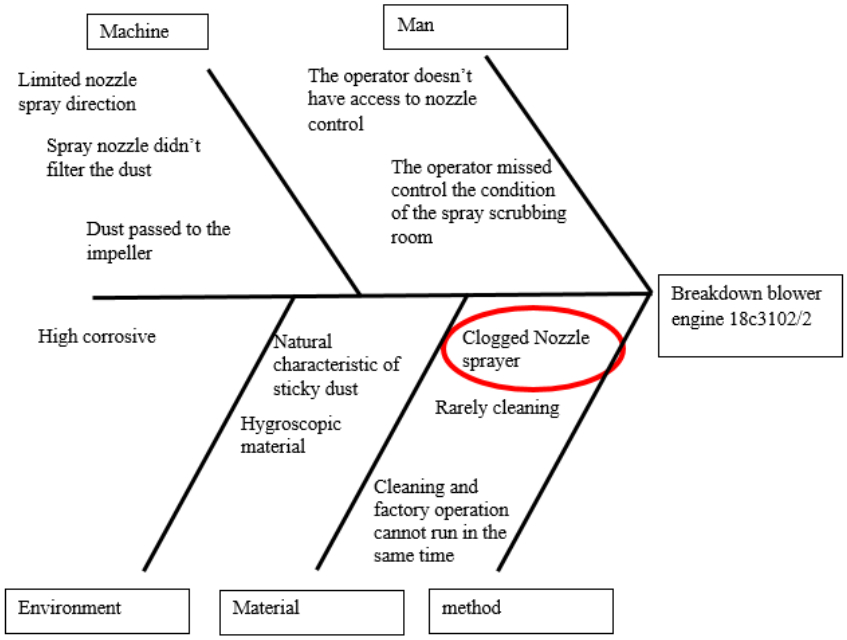

Figure 3. Fishbone Diagram

Based on the Fishbone Diagram method (Figure 3), the main problem that will be discussed is the sprayer nozzle which frequently clogged. In the previous Fishbone Diagram method, the main problems will be analysed to figure out the root of the problem. The main problem is the clogged spray nozzle. Furthermore, the main problems will be analysed to figure out the root of the problem using the 5-Why Analysis method.

5-Why Analysis

The 5-Why analysis technique is a simple and practical but considered as effective technique to discover the roots of a problem. It ensures that the solution selected works to solve the problem[16], [17]. Based on the results of data collection that can be implemented in this method, the analysis applies the 5-Why Analysis method as below.

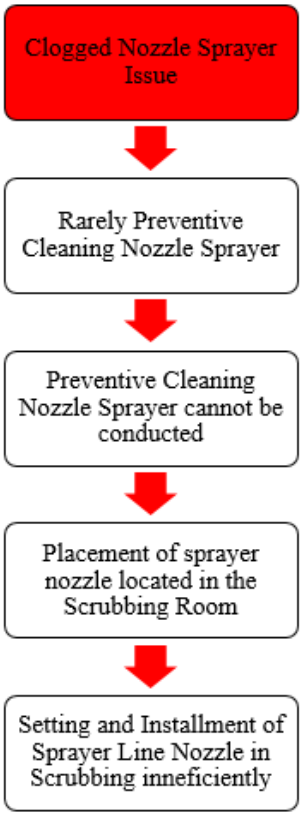

Figure 4. (5 Why Analysis Method)

The results of 5-Why Analysis shows that the main factor caused the blower engine 18C3101-2 scaling on the impeller happened since the spray nozzle is clogged. Why does the spray nozzle clogged? because preventive cleaning of the sprayer nozzle is rarely done. Why does preventive cleaning rarely done? because preventive activities cannot be conducted while the unit is operating. Why does the preventive activities can't be conducted when the unit is operating? because there is no access to perform preventive spray nozzle cleaning. Why isn't there access for preventive cleaning? because the nozzle spray pipe is placed in the scrubbing room. Why is the spray nozzle pipe placed in the scrubbing room? because the initial setting and instalment located the spray nozzle line in the scrubbing room.

Arrange and determine improvement plans

Identification of the existing problems proceeded by making a Fishbone Diagram will be forwarded to arrange an improvement plan in order to overcome the problems occurred by the amount of time. The following list elaborated many alternative applicable improvement plans.

Table 5. Improvement Plans (*Fishbone Diagram*)

Analyzed Factors	Problems occured	Improvement Plans
a. Man	- The operator missed control the condition of the spray scrubbing room - The operator doesn't have access to nozzle control	- Rearrange *nozzle sprayer* line and provided access in order to facilitate *nozzle sprayer* checking
b. Material	- Natural characteristic of sticky dust - Hygroscopic material	- Optimize production process
c. Method	- Clogged Nozzle sprayer - Rarely cleaning -Cleaning and factory operation cannot run in the same time	- Create the new SOP based on rearrangement *nozzle sprayer* line
d. Machine	- Dust passed to the impeller - Spray nozzle didn't filter the dust - Limited nozzle spray direction	- Optimize *nozzle sprayer* - Rearrange *nozzle sprayer*
e. Environment	High corrosive	- Preventive maintenance and Predictive maintenance scheduled regularly

The data taken from elaboration in Table 5, it shows improvement plans created for each problem occurred. After analysing based on 5-Why Analysis method, improvement plans conducted in order to avoid the same problem might reoccur in the future. This idea is effective to decrease malfunction and the level of loss for company.

Table 6. Improvement Plans (5 Why Analysis)

Problems	Improvement Plans
Inefficience setting and installment	Rearrange Scrubbing room in NPK 3 unit
Placement of sprayer nozzle pipe located in the Scrubbing Room	Rearrange the placement of nozzle sprayer pipe
Missing access to conduct preventive Cleaning Nozzle Sprayer	Create the new model of *nozzle spray*er with easily setting on and off
Cleaning and factory operation cannot run in the same time	Additional *Block valve* in the pipe line of *nozzle spray*er
Rarely Preventive Cleaning Nozzle Sprayer	Create the new SOP regarding preventive cleaning *nozzle spray*er
Clogged Nozzle Sprayer Issue	Arrange regular schedule to check and maintain nozzle condition. Report to maintainance team immediately once nozzle malfunction was found in order to be repaired.

Conclusion

The Fishbone Diagram approach conducted in this research, the cause of the breakdown in the 18C3101-2 blower engine occurs since the operator missed to control the spray nozzle, the material hygroscopic and the function of the spray nozzle is limited, the obstacles of preventive action, and lack of maintenance. Based on the approach through the Fishbone Diagram method, the main problem causing the 18C3101-2 blower engine troubleshooting is clogged spray nozzle. Based on the approach through the 5-Why Analysis method, the root cause of a blocked spray nozzle since the initial setting and installment of the spray nozzle pipe inefficient.

PT. Petrokimia Gresik require to consider regular review regarding maintenance applied by scheduling maintenance for the 18C101-2 blower engine and reviewing the performance of the process unit based on the reliability of the equipment supports production process properly and the company keeps improving the maintenance operational SOP in the unit NPK 3 PT. Petrokimia Gresik. Procurement of spare parts and preventive maintenance require to be improved to support the lifetime of the equipment.

References

[1] E. Nurhayati, S. Hartoyo, And S. Mulatsih, "Analysis of Indonesian Clove Export Development," *Jurnal Ekonomi Dan Kebijakan Pembangunan*, Vol. 7, No. 1, Pp. 21–42, 2018.

[2] D. Christian, A. Sutrisno, And J. Mende, "Application of The Root Cause Analysis (RCA) Method to Determine the Root Causes of Consumer Complaints," *Jurnal Online Poros Teknik Mesin*, Vol. 7, No. 2, 2019.

[3] D. G. Sihombing, Y. T. Mursityo, And N. Y. Setiawan, "Evaluasi Proses Bisnis Divisi Material Requirement Planning (MRP) Menggunakan Metode Quality Evaluation Framework (QEF) Dan Root Cause Analysis (RCA) (Studi Pada PT. Xacti Indonesia)," *Jurnal Pengembangan Teknologi Informasi Dan Ilmukomputer*, Vol. 3, No. 6, Pp. 2548–964, 2019, [Online]. Available: Http://J-Ptiik.Ub.Ac.Id

[4] I. Putu Widnyana, W. Ardiana, E. Wolok, And T. Lasalewo, "Application of The Fishbone Diagram and The Kaizen Method to Analyze Disturbances in Customers of PT. Pln (Persero) Up3 Gorontalo," *Jambura Industrial Review*, Vol. 2, No. 1, P. 2022, 2022, Doi: 10.37905/Jirev.2.1.11-19.

[5] M. Bahrudin and H. C. Wahyuni, "Measuring Employee Productivity in The Production Department Using the Objective Matrix (OMAX) And Root Cause Analyze (RCA) Methods," *Prozima (Productivity, Optimization and Manufacturing System Engineering)*, Vol. 1, No. 2, Pp. 116–122, Dec. 2017, Doi: 10.21070/Prozima.V1i2.1299.

[6] M. Rizki and A. Saputra, "Supply Chain Management Risk Analysis with The Gray Failure Mode and Effect Analysis Method and Root Cause Analysis At PT. Pertamina Fuel Terminal Meulaboh," *Serambi Engineering*, Vol. Vii, No. 1, 2022.

[7] A. O. Malahov, A. R. Zagretdinov, S. G. Ziganshin, And Y. V. Vankov, "Application of The Rescaled Range Analysis for Vibro-Acoustic Imbalance Control of Rotary Equipment," In *Journal of Physics: Conference Series*, Institute of Physics Publishing, Oct. 2019. Doi: 10.1088/1742-6596/1328/1/012049.

[8] A. Toyib Hidayat and N. Khairani Daulay, "(Media Cetak) Penerapan Metode Multi-Objective Optimization on The Basis of Ratio Analysis (Moora) Dalam Pemilihan Wiraniaga Terbaik," *Journal of Computer System and Informatics (Josyc)*, Vol. 1, No. 4, Pp. 367–372, 2020.

[9] Y. Krida Sakti, I. W. Apriliana Sari, And D. Zuhroh, "National Seminar on Research Results and Community Service 2020 Ibi Darmajaya Bandar Lampung, August 26, 2020, Analysis of The Factors Causing The Delay In The Development Of The Bulak Fish Sentra (SIB) Kenjeran Umkm Using The Fishbone Diagram Method Approach," 2020.

[10] F. Hamidy, "Fishbone Analysis Approach to Measuring E-Cooperative Information Business Process Performance," 2016. [Online]. Available: Https://Servicelink.Pinnacol.Com/Pinnacol_Docs/Lp/

[11] A. Nurlita And I. Dyah Utami, "Quality Control of Brake Lining Products in Non-Asbase Formula Using Statistical Process Control (SPC) And Root Cause Analysis (RCA) Methods At PT. Xyz Surabaya," Vol. Xx, No. 1, Pp. 1–12, 2019, Doi: 10.350587/Matrik.

[12] A. Suwarno, A. Rusdi Widya, K. A. Winelda, And F. Marhaban, "Pelita Industri Meningkatkan Nilai Oee Mesin Cutting Pada Line 6 Finishing Dengan Metode Rca Di PT. Xyz," *Pelita Industri: Jurnal Ilmiah Teknik Industri*, Vol. 1, No. 2, Pp. 2021–2022, 2021.

[13] R. J. Dan K. C. L. Latino, *Root Cause Analysis: Improving Performance for Bottom – Line Results*. Florida: Crc Press, 2006.

[14] J. & A. N.-C. Corcoran, *Risk and Resilience Ecological Framework for Assessment and Goal Formulation.*, 3rd Ed., Vol. 21. Child And Adolescent Social Work Journal., 2004.

[15] N. Eviyanti, "Analysis of Fishbone Diagram to Evaluate the Manufacture of Aluminum Equipment Case Study at Yogyakarta Aluminum Sp," *Jaakfe Untan (Jurnal Audit Dan Akuntansi Fakultas Ekonomi Universitas Tanjungpura)*, Vol. 10, No. 1, P. 10, Jun. 2021, Doi: 10.26418/Jaakfe.V10i1.45233.

[16] P. Rahmadiani, "Operator Performance Analysis in The Silent Assembly Up Using the Overall Labor Effectiveness Method with The Root Cause Analysis Approach (Case Study: PT Yamaha Indonesia)," Universitas Islam Indonesia, Yogyakarta, 2022.

[17] N. Agus Firmansyah, "Ohs Risk Management in Production Division Using FMEA And Rcadi PT. Xyz," *Jurnal Teknologi Dan Manajemen Industri*, Vol. 1, Pp. 15–21, 2020.

[18] F. Rafsyan Zani, H. Supriyanto, J. Teknik Industri, F. Teknologi Industri, And I. Teknologi Adhi Tama Surabaya, "Packaging Process Improvement Analysis Using Root Cause Analysis and Failure Mode and Effect Analysis Methods in Efforts to Improve Product Quality at Cv. Xyz," *Seminar Nasional Sains Dan Teknologi Terapan Ix2021*, P. 140, 2021.

[19] S. Latifah, "Root Analysis of Problems in Integrated Management Planning of Talung Roots Root Cause Analysis in Palung Watershed Integrated Management Planning," *Jurnal Wana Tropika*, 2021.

[20] U. Salman, "Lean Thinking Approach Using the RCA Method To Minimize Waste in Order to Improve Product Quality (Case Study: PT. Kelola Mina Laut at Gresik Ikan Unit)," *Stie Perbanas Surabaya*, 2019.

[21] H. Dewi, M. Maryam, And D. Sutiyarno, "Analisa Produk Cacat Menggunakan Metode Peta Kendali P Dan Root Cause Analysis," *Jurnal Teknologi Pertanian*, Vol. 7, No. 2, Pp. 10–18, Dec. 2018, Doi: 10.32520/Jtp.V7i2.178.

[22] N. Susendi, A. Suparman, And I. Sopyan, "Kajian Metode Root Cause Analysis Yang Digunakan Dalam Manajemen Risiko Di Industri Farmasi," *Majalah Farmasetika*, Vol. 6, No. 4, P. 310, May 2021, Doi: 10.24198/Mfarmasetika.V6i4.35053.

[23] P. D. Studi *Et Al.*, "Analysis of The Causes of Work Accidents Using the RCA (Fishbone Diagram Method And 5-Why Analysis) Method at PT. Pal Indonesia," In *Proceeding 1stconference On Safety Engineering and Its Application*, 2020.

[24] Nurlaelah, "Waste Analysis of Low-Cost Housing Development Process Using Root Cause Analysis (Rca)," *Jurnal Ikraith-Teknologi*, Vol. 6, No. 1, 2022.

[25] R. A. De Fretes, "Analysis of The Causes of Transformer Damage Using the RCA Method (Fishbone Diagram And 5-Why Analysis) At PT. Pln (Persero) Kiandarat Service Office," *Agustus*, Vol. 16, No. 2, 2022.