OPERATOR PERFORMANCE ANALYSIS AND ENHANCEMENT PROPOSALS FOR THE FINAL REGULATION ASSEMBLY UPRIGHT PIANO GROUP

UNDERGRADUATE THESIS

Submitted to the International Undergraduate Program in Industrial Engineering in Partial Fulfilment of Requirement for the Degree of Sarjana Teknik at the Faculty of Industrial Technology
Universitas Islam Indonesia

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YOGYAKARTA
2024

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Telah melakukan penelitian dan pengamatan untuk penyusunan Tugas Akhir dengan Judul *"Operators Performance Analysis and Enhancement Proposals For The Final Regulation Assembly Upper Piano Group"*.
Program ini dilaksanakan mulai Tanggal 26 Februari 2024 sampai dengan 31 Agustus 2024.
Kami mengucapkan terima kasih atas usaha dan partisipasi yang telah diberikan.

Demikian surat keterangan ini dibuat untuk dapat dipergunakan sebagaimana mestinya.

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DEDICATION PAGE

With gratitude, Alhamdulillahirabbil‘alamin, it has been a long struggle to complete this undergraduate thesis. I dedicate this page to the people who have helped and accompanied me in the process of completing this undergraduate thesis.

I am deeply grateful for the prayers and support I have received from my family and my loved ones. Throughout this study, thank you for being my support system. I hope that this small achievement from me can make you proud. That's enough to make this tiredness disappear. Also to all parties involved, thank you for the help and assistance. It would not have been possible to finish this thesis without you.

Finally, and most importantly, I want to express my sincere appreciation to myself for battling and giving it my all. It was not a short process, nor was it an easy one, but here I am, proving that even with all my weaknesses, I can do it.

MOTTO

"Do not falter or grieve, for you will have the upper hand, if you are ˹true˺ believers."
(QS Ali Imran: 139)

"Fighting has been made obligatory upon you ˹believers˺, though you dislike it. Perhaps you dislike something which is good for you and like something which is bad for you. Allah knows and you do not know."
(QS Al-Baqarah: 216)

"Doubt kills more dreams than failure ever will."

PREFACE

Bismillahirrahmanirrahim
Assalamu'alaikum Warahmatullahi Wabarakatuh
All praise and gratitude from the author for the presence of Allah SWT who has bestowed all His grace and favors so that the author could complete this undergraduate thesis as well as possible. The author conveys prayers and greetings to the Prophet Muhammad SAW, to His family, His friends, and His followers until the end of time.

The author hopes that writing this undergraduate thesis entitled "Operator Performance Analysis and Enhancement Proposals for The Final Regulation Assembly Upright Piano Group" can provide benefits for the author herself, readers, The Islamic University of Indonesia, especially the Industrial Engineering Study Program, Faculty of Industrial Technology, as well as for PT Yamaha Indonesia.

Writing this undergraduate thesis cannot be separated from help, guidance, support, and prayers from various parties. Therefore, on this occasion, the author would like to express gratitude and respect for the following:

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8. Final Regulation of UP operators as a working group where the author conducted this research. The author appreciates your cooperation and help.
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The author acknowledges that this undergraduate thesis is far from excellent because, with all the limitations of knowledge and experience, the author still has to improve to make it better. For that, the author accepts constructive criticism and suggestions from any party. Hopefully, this undergraduate thesis will be useful to both the author and the readers. Aamiin.

Wassalamu'alaikum Warrahmatullahi Wabarakatuh.

Jakarta, August 23, 2024

Ruhul Izzah Marhanuddin

ABSTRACT

PT Yamaha Indonesia is a manufacturing company that produces pianos and has a program in place to periodically increase its productivity. The production process which is mostly done manually, is a challenge, especially for operators because they play an important role in achieving productivity targets. In the Final Regulation UP group, several problems occur, making it impossible to achieve the productivity target. The problems in this group are the excessive number of operators, below-target production outcomes, and a high number of reworked products. Therefore, it is necessary to find out the effectiveness of this working group using the Overall Labor Effectiveness (OLE) method. Then it will continue with an analysis of the results using the Root Cause Analysis (RCA) tools, which will then be given kaizen or suggestions to solve existing problems. Following that, the findings will be analyzed using Root Cause Analysis (RCA) tools, and kaizen, or recommendations for solving current issues will be provided. The Overall Labor Effectiveness (OLE) value of the Final Regulation UP working group during 34 days of observation was 79% with a value availability ratio of 96%, performance ratio of 97%, and quality ratio of 85%, the OLE score is below the international standard due to the lower quality ratio. After kaizen was implemented, the OLE score increased to 89% with the value obtained from the variables 98% for the availability ratio, 98% for the performance ratio, and 92% for the quality ratio. All of the three variables are increased, making the OLE score higher than before.

Keywords: Kaizen, Operator Performance, Overall Labor Effectiveness (OLE), Root Cause Analysis (RCA)

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CHAPTER I
INTRODUCTION

1.1 Background

The manufacturing industry is concerned with transforming raw materials into finished products through the integration of people, machinery, and organized production procedures. Manufacturing is the process of converting raw materials through the assembly stage into products with added value in an economic context. Design, material selection, planning, manufacturing, quality control, product management, and marketing are some of the interconnected processes and activities that make up manufacturing. An important factor in a nation's economic development is its manufacturing sector. Manufacturing businesses need to increase productivity and efficiency in order to compete in the global market in the age of globalization and intensifying competition. In this industry, optimizing worker use is crucial for success. In addition, achieving production targets and minimizing the number of items that require rework are crucial for raising a group's or organization's productivity.

PT. Yamaha Indonesia is a manufacturing company that produces piano musical instruments. PT Yamaha Indonesia produces 2 types of pianos, namely Upright Pianos (UP) and Grand Pianos (GP), the results of which are exported to several countries in the world. There are 3 departments at Yamaha Indonesia, namely Woodworking, Painting, and Assembly. Woodworking processes the cabinets according to the specified specifications, and then Woodworking sends the cabinets to the painting department for the painting, sanding, buffing, and setting processes. After the setting process, the cabinet is sent to the assembly department for the process of installing the cabinets with strungbacks to become a piano. Department Assembly is divided into two, namely Assembly UP and Assembly GP. Then the last one is the packing process. For every work group in every production department, PT. Yamaha Indonesia applies a system to measure productivity and efficiency. It is expected that PT. Yamaha Indonesia would be able to track each group’s performance during the production process with the assistance of these calculations. In addition, the product produced (output), together with the processing time and operator count, serves as a standard for evaluating how well each work group performed during the manufacturing process. This efficiency data will be updated every week by the admin of each department and then will be processed into productivity data.

Productivity is a comparison between the output achieved and the overall input used. Final Regulation group department Assembly UP has the target of productivity to increase by 15% from the predetermined base target, which is in March 2024. The productivity in March 2024 is 0,727 units/man/hour, therefore the target is 0,836 units/man/hour. Figure 1.1 shows the graphic of the Final Regulation UP Productivity. The efficiency and productivity are always aligned, if efficiency decreases then productivity also decreases, and vice versa.

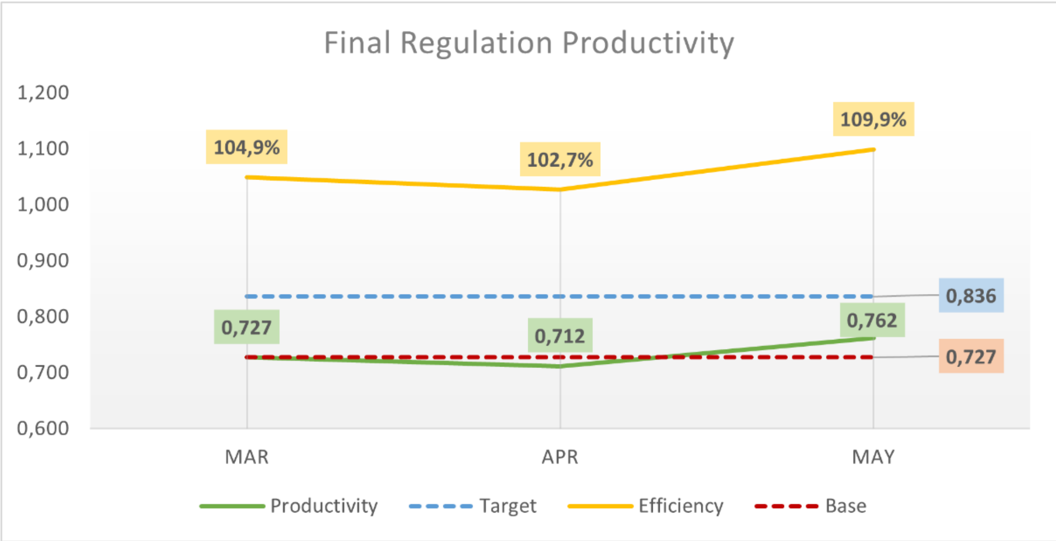

Figure 1.1 Final Regulation UP Productivity (Before)

Most of the processes in this group are done by hand, and the level of precision between hand work and machine work is definitely different. Every operator should have good performance, good use of working time, and a proper understanding of the standard of their work because it will affect the output from the group by quality and quantity. The productivity and effectiveness of an employee in completing their work is referred to as their job performance. It is necessary for organizational development since it directly affects the success and advancement of the business.

Final Regulation UP is a working group that has to do the second regulation process after the piano out of the seasoning process. The daily target of this group is 51 pianos/day. Sometimes, this working group does not achieve the daily target, which makes them have to achieve more the next day to pay the shortfall from the previous day. Besides that, this working group also has NG (Not Good) products that must be reworked and take more time to process for this group. Final Regulation has problems regarding performance and quality.

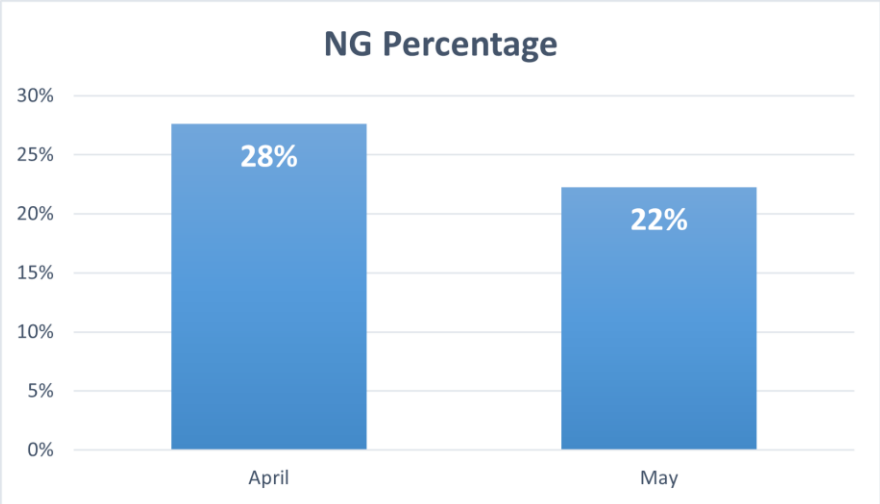

Figure 1.2 Graph of NG Product Final Regulation UP

Based on Figure 1.2 above it is shown that in April, from 561 pianos produced, 155 NGs need to be reworked, which is about 28%. In May, from 988 pianos produced, there are 220 NG that need to be reworked, which is about 22%. Overall Labour Effectiveness (OLE) could measure the level of effectiveness of the working group using three variables, which are availability, performance, and quality. The fact that the operator still performs the entire production process by hand demonstrates how much of an impact the operator has on the final product. Thus, in order to measure worker utilization, performance, and quality as well as how these factors affect productivity, researchers employ Overall Labor Effectiveness (OLE), a key performance indicator (KPI) (Devani, 2018). The researcher will use the Overall Labour Effectiveness (OLE) method combined with the Root Cause Analysis (RCA) method to analyze the cause from the OLE result and give the proposed recommendation to solve the problem.

Since operators perform the majority of the work by hand, it is crucial to conduct this research. The research project will provide information about the state of effective operator performance in the Final Regulation UP group based on current issues. It is planned that this research will offer suggestions for improvements that can address current issues using the Root Cause Analysis (RCA) and Overall Labor Effectiveness (OLE) methodologies. Businesses must strengthen their market positions to remain competitive amid global competition. Therefore, developing business strategies requires using the right performance indicators and creating goals for performance improvement (Sirikrai & Tang2, 2006).

1.2 Problem Formulation

Based on the background explained above, the problem is formulated as follows:

1. What is the Overall Labour Effectiveness (OLE) score of the Final Regulation UP working group?
2. What are the causes of the problems found in the Final Regulation UP working group based on Root Cause Analysis (RCA)?
3. What is the appropriate improvement proposal based on problem cause analysis in the Final Regulation UP working group?

1.3 Research Objectives

The following are the objectives to be achieved from this research.

1. To analyze the Overall Labour Effectiveness (OLE) of the Final Regulation UP working group.
2. To analyze the causes of the problem found in the Final Regulation UP working group based on Root Cause Analysis (RCA).
3. Provide improvement proposal based on problem cause analysis in the Final Regulation UP working group.

1.4 Benefits of research

It is expected that the results of this study will benefit multiple sectors:

1. The Benefit for Students
   a. As self-preparation and preparation when facing the work environment after they complete their studies.
   b. Understand how to apply theory, assess its relevance, and make comparisons within the professional context.
   c. Know more clearly about company activities, especially those related to the industrial world, and be able to gain work experience and be able to interact in teamwork.
2. The Benefit for University
   a. Establishing cooperation and good relations between universities and companies, so that universities can be known in companies or the industrial world.
3. The Benefit for Company

a. Provide input on problems the company has in accordance with the scientific capacity of the student concerned

1.5 Research Limitations

The researcher limits the scope of discussion of this research problem to the following points:

1. The research was only carried out in the Final Regulation group of the UP Assembly department
2. The data used in this research is from the Efficiency UP Assembly from April until May 2024
3. Not all proposals can be implemented due to limited time
4. The method used in this research only Overall Labour Effectiveness (OLE) and Root Cause Analysis (RCA)
5. The data after kaizen used in this research is from August 1^{st} until 14^{th} 2024.

1.6 Systematic research

Research is made easier and stays on course by using research systematics. The research systematics used are as follows:

CHAPTER 1 INTRODUCTION

Contains research background, problem formulation, research objectives, scope of research, research benefit, and systematic writing.

CHAPTER II LITERATURE REVIEW

Contains a review of numerous relevant research that have been conducted in the past, as well as a theoretical justification for the fundamental ideas and principles of the material brought up in order to address current issues.

CHAPTER III RESEARCH METHODOLOGY

Contains a description of the research flow chart, data collection methods used, types of data taken, tools and materials needed, as well as the research flow which describes all the stages carried out during the research.

CHAPTER IV DATA PROCESSING AND RESEARCH RESULTS

Contains the data gathered for the analysis as well as the steps taken to process the data to create information that will be referred to in subsequent research discussions.

CHAPTER V DISCUSSION

Contains a discussion of the results obtained in the research and the suitability of the results with the research objectives so that suggestions and recommendations can be produced, as well as an explanation of the research's findings and how well they align with its objectives so that recommendations and suggestions can be made.

CHAPTER VI CONCLUSIONS AND RECOMMENDATIONS

Contains answers to the objectives of this research and provides suggestions for the parties involved and for further research.

BIBLIOGRAPHY

APPENDIX

CHAPTER II
LITERATURE REVIEW

The theoretical basis of the research will be covered in the literature review. The literature review is divided into two sections: inductive reviews that explain earlier research that is relevant to the research and deductive reviews that explain the theories employed in the current research.

2.1 Literature Review

A literature review is a research procedure that entails reading through and assessing current literature sources critically. Understanding and describing the present status of research in a subject connected to the issue under study is the primary goal of a literature review.

According to the study conducted by Rahmadiani & Kusrini (2023), the goal of the study is to enhance operator performance in a manufacturing organization, with a particular focus on assembly line operators. Low operator performance has been found to be the issue, with specific problems in the performance ratio variable. In order to solve this, the study analyzes performance and pinpoints the underlying causes of subpar performance using the Overall Labor Effectiveness (OLE) technique in conjunction with Root Cause Analysis (RCA). The study identifies three key issues that have an impact on performance and suggests utilizing the House of Quality (HOQ) technique to improve things. The findings suggest that implementing the suggested adjustments to material containers and cabinet designs, in addition to offering operators motivation for their job, can greatly improve performance levels in the assembly area.

Ika Sasmita Sari and Wiwik Sulistiyowati's research focuses on redesigning a dust filter tool used in the "kerupuk gerandong" production process at a small-to-medium-sized business called "Barokah." The main issue found is that the current dust filter tool is ineffective at separating dust from raw materials, which increases air pollution and reduces the amount of clean output. Utilizing CAD software like SolidWorks to redesign the tool, the researchers used reverse engineering and Root Cause Analysis (RCA) techniques to address this problem. This innovation results in a more useful and efficient dust filter tool that generates cleaner output, drastically lowers dust pollution and eliminates the need for repeated adjustments and relocations throughout production. According to the study, the revised design may improve the dust filter tool's overall efficacy, which would increase the manufacturing process and lessen its negative effects on the environment (Sari & Sulistiyowati, 2021).

According to research conducted by Zheng et al. (2024), the objective of the project is to solve the issue of the scarcity of extensive, publicly-available datasets specifically designed for Root Cause Analysis (RCA) tasks, with the ultimate goal of improving the dependability and efficiency of complex systems. In order to address this problem, the researchers unveiled LEMMA-RCA, an extensive dataset created for a variety of RCA tasks in several domains and modalities, such as IT and OT operating systems. To assess the quality of LEMMA-RCA, eight baseline methods were tested in a variety of scenarios, including single and multiple modalities, offline and online modes, and so on. The outcomes showed how well-quality LEMMA-RCA is, which makes it a useful tool for unbiased comparisons between various RCA techniques. The study makes the improvement recommendation that RCA techniques need to be further developed and improved to effectively utilize the wide range of detailed data that LEMMA-RCA provides.

The focus of the study by Al Janahi et al. (2020) is to assess how well production lines meet customer demand by developing and implementing a system known as Fitness to Takt Time of a Manufacturing Line (FiTTML). The manufacturing line is the study's focus, and the challenge is precisely measuring and enhancing the line's performance to fulfill takt time—the rate at which goods must be produced to satisfy consumer demand. The techniques include a graph-theoretic approach, Data Envelopment Analysis (DEA), and surveying TPM-adopted plants. Furthermore, by adopting a methodology close to OEEML, the FiTTML method is proposed to quantify the fitness of an entire production line. Moreover, a built autonomous preventive maintenance program mentions the usage of root cause analysis (RCA). The findings show that FiTTML offers guidance for ongoing improvement by efficiently capturing a manufacturing line's fitness and identifying many waste sources. By identifying inefficiencies and directing focused improvements, the study indicates that the application of FiTTML can greatly improve manufacturing lines' capacity to satisfy consumer demand.

The primary objective of the study by Salguero & Rubio (2023) is to evaluate the impact of implementing systematic autonomous supervision on efficiency losses within the food industry. An analysis of existing literature indicates that the adoption of Lean tools in the food industry is relatively low, primarily due to industry-specific challenges such as the inflexible layout of production facilities, unpredictable demand, stringent food safety requirements, and the perishable nature of products. Additionally, there is a noted paucity of research focused on the practical application of Lean tools in this sector. This study details the initial two phases of implementing autonomous care at Company X within the food industry. The effectiveness of the implementation is assessed with respect to efficiency losses. The findings illustrate the performance of company X on a model production line, emphasizing loss reduction. An initial analysis identified major efficiency losses by examining common loss types. The model line incorporated autonomous maintenance tools in steps 1 and 2, including small group activities (SGA), 5S, elimination of pollution sources and inaccessible areas, equipment defect registration and elimination, autonomous cleaning and inspection of equipment, a skills matrix, one-sheet lessons, a daily activity management system, and continuous improvement tools such as Kaizen and root cause analysis. The results demonstrate significant potential for reducing line losses related to breakdowns and operational inefficiencies through small group activities and problem-solving tools like root cause analysis. The systematic implementation of autonomous maintenance steps 1 and 2 led to a 2.4% increase in overall line efficiency, equivalent to 128 hours of production time or an annual savings of €18,048 in labor costs. Additionally, the reduced product replacement time resulted in avoiding an extra €11,280 in labor costs per year due to a 20% increase in the number of product replacements. Furthermore, identifying and eliminating pollution sources and hard-to-reach areas could save an additional 1,251 man-hours, or €11,759.

In the study conducted by Nugroho (2021), the issue that needed to be addressed was how the staff members saw strategic management being used to run the company during the COVID-19 pandemic. The study aimed to examine how employees performed in IT-based firms as they adapted to remote work practices in the new normal. Employees, resource managers, and unit managers were among the research subjects that participated in performance reviews through interviews. Whatsapp Messenger interviews were done as part of a qualitative approach, and data was explored and analyzed utilizing a netnographic analysis method. The study's conclusion was that performance in remote work environments is highly impacted by technological readiness. Conducting quantitative research to classify organizations based on numerous characteristics for a broader study would be an improvement for future research.

Brabec & Jáčová's (2022) research modified the indicator from the Overall Equipment Effectiveness (OEE) method to become an Overall Labor Effectiveness (OLE) indicator in order to measure the impact of the introduction of the OLE indicator on performance in a specific automotive industry company. The benefit of this update is that in addition to analyzing employee performance indicators, the modified indicators also examine actual costs incurred and economic performance indicators. Since the Overall Labor Effectiveness (OLE) indication was created by changing the Overall Equipment Effectiveness (OEE) approach, it has been in a very acceptable value range up until this point. This indicates that the business can make excellent use of its production time. In addition, the results of the financial ratio analysis show that the introduction of the Overall Labor Effectiveness (OLE) indicator improves company performance.

Bonci, Stadnicka, and Longhi's (2022) study highlights the significance of evaluating labor efficiency in manufacturing enterprises. In this study, we examine the potential use of worker effectiveness indicators across the organization. The approach makes use of the OLE indicator (ROLE) and the new LEAN-ROLE indicator, which determines the proportion of employee work that adds value for consumers in addition to evaluating the efficacy of human resources. This will enable the detection of system vulnerabilities. Following the identification of the reasons behind the decline in efficiency, the necessary steps can be implemented to enhance employee participation in value creation.

Lestari, Kamal, and Eka (2021) used the Root Cause Analysis (RCA) method at PT Brata Indonesia (Persero) to study damage to the cylinder liner of an 18 KVA generator set engine. The cylinder block was identified in this study as one component of the generator engine. Following an overhaul, the apparatus discovered damage to the cracked cylinder block of a generator engine that had been running for four years; the damage was deemed to have occurred too quickly. Subsequently, the RCA method must be used to identify the source of the issue. The findings indicate that the machine's duration of use deviates from the established standard, and the technician responsible for its maintenance is likewise incompetent. The recommendation made by the researchers for engine use is to run the engine for eight hours a day at a load of no more than eight hundred kilowatts.

This study by Mousavinia et al. (2020) was published to find the failure's primary cause to offer guidance for assessing and averting future occurrences involving gas turbines. The researchers used microstructural analysis to determine that the main causes of the catastrophic failure were excessive load-induced deformation in bolts and corrosion-fatigue-induced failure in blades. In order to determine the main causes of the catastrophic failure, the root cause analysis (RCA) employed in this study included microstructural examinations using scanning electron microscopy (SEM) and optical microscopy (OM) to identify corrosion-fatigue-induced failure in blades and excessive load-induced deformation in bolts. The researchers identified the primary cause of the early damage to the gas turbine components by carrying out a thorough examination of the failure mechanisms. Controlling corrosion within the gas turbine components should be the top priority for preventative measures to increase their longevity and dependability and avoid similar problems in the future. The total performance and longevity of gas turbines under similar operating conditions might be greatly increased by routine maintenance and monitoring to identify early indicators of fatigue and corrosion.

The aim of the research by Wizner & Kővári, 2020) was to examine the metallurgical faults in continuous cast steel slabs at ISD DUNAFERR Zrt and determine their underlying causes. The study's focus was on evaluating the surface imperfections linked to casting powders as well as the powders' chemical and physical homogeneity. The research entailed examining the granulometric makeup of the casting powders and establishing a correlation between any compositional variations and the development of surface flaws on the steel slabs. In order to comprehend the effect of the casting powders' chemical composition and qualities on defect generation, further research was conducted on them. The findings showed that although the casting powders were uniform and consistent, differences in their makeup could cause surface flaws in the slabs. Moreover, it was proposed that surface flaws can also arise as a result of heat effects in the reheating furnace. Future studies should concentrate on carrying out experimental programs targeted at lowering flaws of metallurgical origin to further improve our understanding of defect development in the steel production process. Continuous cast steel slab quality can be maximized by exploring further the interaction between surface flaws, heat effects, and qualities of the casting powder.

The study from Zahoor et al (2019) has a goal to improve overall equipment performance, boost efficiency, and decrease waste in a flexographic printing process by applying a combined VSM and Kaizen approach to sustainable continuous process improvement. It highlights how VSM can be integrated with other lean methodologies, describes the processes in the process, and ends with suggestions for more research. A selection of research papers and case studies on lean manufacturing strategies written by industrial engineering experts and researchers is also included. It is shown that a lean method that combines VSM, 5-why root cause analysis, and kaizen can significantly reduce machine downtime and improve overall equipment effectiveness (OEE) in a flexographic printing process. In a flexographic printing process, Kaizen and Value Stream Mapping (VSM) can be used together to achieve sustainable continuous process improvement. To begin, VSM should be used to locate process bottlenecks and inefficiencies. After identifying these areas, incremental improvements and waste elimination can be achieved through Kaizen activities, which will improve overall equipment effectiveness (OEE) and lower manufacturing costs. It has been demonstrated that using both strategies together can successfully lower manufacturing costs and increase OEE by 24.31%.

The purpose of the research by Mwenda & Gasper (2022) is to look into how Kaizen, lean manufacturing techniques, and quality improvement are implemented and working in manufacturing organizations, with a special emphasis on small and medium-sized businesses. The use of several techniques, such as the Pareto analysis and PDCA cycle, to reduce waste and defects in manufacturing processes is the focus of the research. To evaluate how well Kaizen improves productivity and business performance, case studies and research were used in the study. The study's conclusions emphasize the value of Kaizen procedures for continuous improvement in manufacturing organizations, which can significantly lower defect rates. The studies' identification of the need for more research to generalize the findings across various industries and firm sizes represents one area for development.

The purpose study from Sam et al (2021) is to examine how packaging companies may apply lean manufacturing techniques and how this will affect kaizen and product defection. Three research objectives are to use lean manufacturing tools to identify the cause of product defects, assess how well they work to improve quality standards and kaizen in the packaging industry and modify lean manufacturing tools to increase kaizen in the packaging industry. For this study, 196 respondents were chosen as a sample by the researcher to complete a questionnaire. Managers at the top and intermediate levels made up the selected respondents. Using SPSS software, the researcher analyzed the data using multiple regression analysis, cross-tabulation, Cronbach's alpha, Pearson's correlation coefficient analysis, and descriptive statistics to conclude. The results show a strong positive correlation between the 4M, 5S, PDCA, and Fishbone Diagram principles when considering product defects concerning quality standard kaizen. The researcher suggests that firms and their managers gain a better grasp of how some of the most successful lean strategies relate to and impact the effectiveness of their operations. This will incentivize managers to make wiser and more sensible choices regarding the application of lean techniques.

The study by Rozak et al. (2019) stated that when considering the achievement of a high level of production activity productivity and several high-quality products that are determined using the Overall Equipment Effectiveness (OEE) value, which is valued above 85% as mentioned in the JIPM Total Productive Maintenance (TPM) global company standard, the cylinder block machining line in Indonesian automotive manufacturing has launched a world-class company. This organization continues to grow the value of OEE through Kaizen activities, even though the average OEE from September to November 2018 was 87%, meaning there was still room for improvement of 13%. Kaizen is the process of making adjustments to raise the importance of Performance Efficiency, Rate of Quality, and Availability. After measuring OEE, the six primary losses are calculated, and the largest factor influencing the rising OEE number is found. These are the methods used to enhance OEE. Next, use Fishbone Diagrams to investigate the problems and find their causes. Enhancements at the lengthy line stop machine and the frequently breaking down machine should be prioritized to raise the OEE value. We can raise OEE to 92% in December 2018 in just one month.

Table 2.1 Literature Review

No	**Author**	**Year**	**Title**	**Method**		
				OLE	**RCA**	**Kaizen**
1	Rahmadiani, P., & Kusrini, E.	2023	Operator Performance Analysis Using Overall Labor Effectiveness Method with Root Cause Analysis Approach	✓	✓	✓
2	Sari, I. S., & Sulistiyowati, W.	2021	Redesign of Dust Filter Tools in Small and Medium Industries (IKM) by Integrating Reverse Engineering and Root Cause Analysis (RCA)		✓	✓
3	Zheng, L., Chen, Z., Wang, D., Deng, C.,	2024	LEMMA-RCA: A Large Multi-modal Multi-domain		✓	

No	Author	Year	Title	Method		
				OLE	RCA	Kaizen
	Matsuoka, R., & Chen, H.		Dataset for Root Cause Analysis			
4	Al Janahi, R., Wan, H. Da, Lee, Y., & Zarreh, A.	2020	Effectiveness and fitness of production line to meet customers' demand		✓	✓
5	Salguero-Caparrós, F., & Rubio-Romero, J. C.	2023	Evaluation and comparison of selected methodologies to investigate occupational accidents		✓	✓
6	Nugroho, A. S. E.	2021	The Employee Performance Analysis in Changes Work Method to Remote Work Patterns in The New Normal Era		✓	
7	Brabec, Z., & Jáčová, H.	2022	OVERALL LABOR EFFECTIVENESS AS A TOOL FOR MEASURING PERFORMANCE IN A GIVEN COMPANY	✓		
8	Bonci, A., Stadnicka, D., & Longhi, S.	2022	The overall labour effectiveness to improve competitiveness and productivity in human-centered manufacturing	✓		✓
9	Lestari, D. V., Kamal, D. M. & Eka S., Y. M. D.	2021	Root Cause Analysis kerusakan		✓	✓

No	Author	Year	Title	Method		
				OLE	RCA	Kaizen
			cylinder liner mesin generator set 18 KVA PT. Barata Indonesia (Persero)			
10	Mousavinia, M., Bahrami, A., Rafiaei, S. M., Rajabinezhad, M., Taghian, M., & Seyedi, S. J.	2020	Root cause analysis of failure of bolts in the low pressure section of a gas turbine in an oil and gas production plant		✓	
11	Wizner, K., & Kővári, A.	2020	Root cause analysis of metallurgical defects in continuous cast steel slabs at ISD DUNAFERR Zrt		✓	✓
12	Zahoor, S., Abdul-Kader, W., Ijaz, H., Khan, A. Q., Saeed, Z., & Muzaffar, S.	2019	International Journal of Industrial Engineering and Operations Management (IJIEOM) A Combined VSM and Kaizen Approach for Sustainable Continuous Process Improvement ARTICLE INFO		✓	✓
13	Mwenda, B., & Gasper, L.	2022	KAIZEN APPROACH TO QUALITY IMPROVEMENT AND ITS FINANCIAL IMPLICATION		✓	✓
14	Sam, M. F. M., Suprapto, B., & Bakar, K. A.	2021	Application of Lean Manufacturing Tools: The Impact on Kaizen and Product Defection		✓	✓

No	Author	Year	Title	Method		
				OLE	RCA	Kaizen
			in Packaging Companies			
15	Rozak, A., Shadrina, A., & Rimawan, E.	2019	KaizeninWorld Class Automotive Company With Reduction of Six Big Lossesin Cylinder Block Machining Line in Indonesia.		✓	✓

Based on Table 2.1 above, not many studies have combined those three methods (OLE, RCA, Kaizen) to solve the productivity issue, especially for manufacturing companies. Therefore, this study will analyze the productivity problem that occurs in this manufacturing company by using the OLE method to know the problem that happens from the comparison with the world score, the RCA method to know the root causes of the problem, and the Kaizen method to give the proposed recommendation to solve the problem. If the problem is solved, it is hoped that productivity will increase and have a positive impact on the company.

2.2 Theoretical basis

The following are the several theories that support this research.

2.2.1 Performance Analysis

A performance analysis is a review of a company's or person's achievements over a specified period. This procedure entails gathering and analyzing data in order to determine areas of strength and weakness and develop improvement plans. Determining the best way to allocate resources, what kind of training is needed, and other areas that could use improvement is made possible by performance analysis (Cheng, 2023).

Measurement of performance analysis enables the process or technique to be sustained or modified in order to improve production, improve efficiency, or improve effectiveness. Any company, regardless of industry, needs to conduct performance analysis to discover how successful it is, as well as to create new systems and methods for improvement. Because without assessing and managing, it is typically hard to take corrective actions, companies should track their success and failure findings (Dametew & Ebinger, 2017).

2.2.2 Productivity

Productivity is the comparison between the output produced and the input or resources used. Productivity is the ability of a company or its workers to efficiently transform labor and capital into services or goods as outputs. It is frequently characterized as the relationship between the quantity of output produced and the quantity of inputs utilized. Essentially, it gauges the efficiency with which economic inputs such as labor and capital are employed to achieve a specified output level (Krugman, 1994). By increasing material flow velocity or decreasing variability inside the factory, inefficiencies in transformation processes can be eliminated to improve manufacturing productivity (Akarte Milind, 2018).

The Oxford English Dictionary defines productivity as the level of production (goods, products, services) per unit of input (labor, materials, equipment, etc.), reflecting the effectiveness of productive efforts, especially in industry. Productivity is described as the ratio between output and input, or results and sacrifices, in the scientific literature (Aronoff and Kaplan, 1995). There exist three methods to enhance the ratio between output and input (De Been & Haynes, 2016)

1. Generating greater output with unchanged input
2. Generating identical output with reduced input
3. Augmenting output at a greater rate than input

Productivity is inherently linked to effectiveness and efficiency. A process is effective when executed correctly, all activities contribute towards achieving predetermined goals and objectives, yielding outcomes as closely aligned as possible with expected results. Efficiency involves doing things correctly, expected outcomes can be achieved with minimal resources. In the context of productivity, effectiveness is primarily associated with output (optimal outcomes), whereas efficiency pertains to input (utilizing minimal resources).

2.2.3 Overall Labour Effectiveness (OLE)

Overall Labour Effectiveness (OLE) serves as an important key performance indicator (KPI) for evaluating how effectively Labour is used, the quality of its performance, and its impact on productivity. OLE allows companies to manage costs strategically, identifying ways to improve overall productivity and profitability by measuring labor contribution (Devani, 2018).

1. Availability

   Availability refers to the proportion of time during which the workforce is actively engaged in productive activities (Devani, 2018). Factors influencing availability include training sessions, illness, transfers out, factory downtime, absences, or organizational events. The availability percentage is computed as the total lost working hours divided by the available time.

   $$A = 100\% - \frac{LTn}{WYT} \qquad \text{(Equation 2.1)}$$

   With,

   A = Availability Ratio

   LTn = Loss Working Hour

   WYT = Available Time

2. Performance

   Performance is related to the number of products delivered (Devani, 2018). Performance-controlling variables include process availability, work instructions, equipment, resources, employees with the necessary training and skills, support staff, etc. Anjani and Pratiwi (2021) define performance as a metric that divides the actual output delivered by the workers by the company's established targets. The formula that was applied is as follows:

   $$P = \sum_{n=1}^{k} \frac{Pn}{T} \, x \, 100\% \qquad \text{(Equation 2.2)}$$

   With,

   P = Average of Performance Ratio

   K = Number of Observation

   Pn = Day n Production Result

   T = Production Target

3. Quality

   Quality is the proportion of products without defects that are produced or can be sold (Devani, 2018). In addition to the materials utilized, worker education, proper use of tools and job instructions, and equipment are other factors that affect quality (Kronos, 2007).

$$Q = \sum_{n=1}^{k} \frac{Pn - Dn}{Pn} \; x \; 100\% \qquad \text{(Equation 2.3)}$$

With,

Q = Quality Ratio

K = Number of Observation

Pn = N-day Production Result

Dn = Number of Defective Products Produced on The nth Day

After obtaining the score of availability, performance, and quality based on the formula above, furthermore is the calculation of the OLE (Overall Labour Effectiveness) score. The OLE score is obtained from the multiplication of the three ratios, after that it will compare with the OLE world standard score which is 90% for availability, 95% for performance, and 100% for quality (Yani & Lina, 2015).

$$OLE = \bar{A} \; x \; \bar{P} \; x \; \bar{Q} \qquad \text{(Equation 2.4)}$$

With,

OLE = Overall Labour Effectiveness

$\bar{A}$ = Availability Ratio

$\bar{P}$ = Performance Ratio

$\bar{Q}$ = Quality Ratio

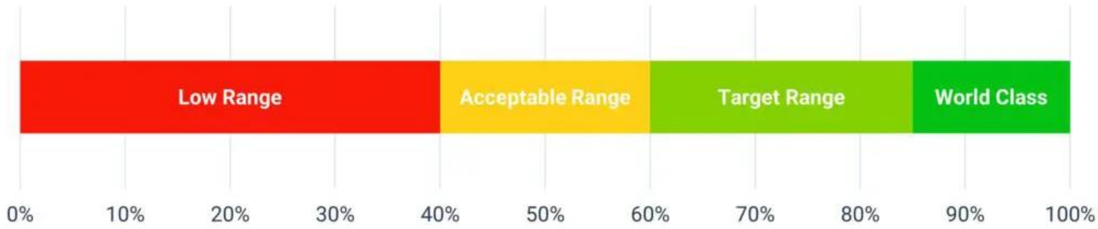

Figure 2.1 OLE Benchmarking

Source: (Crowter, 2023)

2.2.4 Root Cause Analysis (RCA)

Root cause analysis is a methodical process that endeavors to determine the actual cause of an issue and the most appropriate plan of action to resolve it (Andersen & Fagerhaug, 2006). The

Root Cause Analysis (RCA) process typically consists of five distinct steps: problem definition, data collection, analysis, root cause identification, and remedial action identification (Groot, 2021). According to Vorley & Mcqi, there are several RCA tools and techniques:

1. 5 Why’s
2. Pareto Analysis
3. Cause & Effect Diagrams
4. Brainstorming/Interviewing
5. Process Analysis, Mapping, and Flowchart
6. Fault Tree
7. Check Sheets
8. Sampling
9. Control Charts
10. Quality Planning

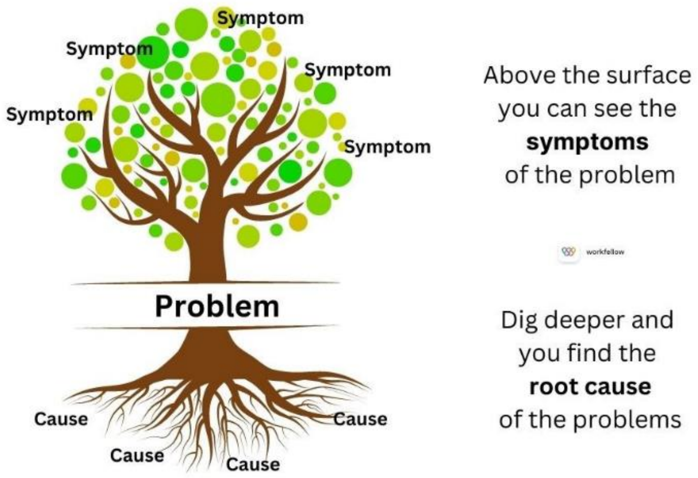

Figure 2.2 RCA Concept

Source: (Mubarok, 2023)

2.2.5 5 Why’s

A technique known as "five whys" involves asking "why" multiple times to identify the underlying cause of an issue (Fogle and Kandler, 2017). Asking "Why does this happen?" frequently is the easiest method to complete the five whys (Bowen & Brome, 2009). 5 whys is a fundamental instrument that must be utilized while conducting a Root Cause Analysis (RCA) (Anderson & Fagerhaug, 2014). Using the five whys as part of RCA helped an organization solve its primary issue, which at a manufacturing company resulted in annual savings of more than $32,000 (Benjamin et al., 2015). When trying to solve issues brought on by human mistake, the five whys method is helpful (Barsalou & Starzyńska, 2023)

Sakichi Toyoda created the "5 Whys" technique for Toyota Industries Corporation. The Five Whys approach is related to the systematic problem-solving concept since the technique can only be a skeleton of the process without the intention of the principle. As a result, there are three essential components to applying the Five Whys technique effectively according to Serrat (2017):

1. Precise and comprehensive problem declarations
2. Total honesty in question-answering
3. A willingness to investigate and address issues

2.2.6 Fault Tree Analysis (FTA)

A well-known and comprehended method for evaluating the dependability of a variety of systems is fault tree analysis (FTA). A fault tree analysis (FTA) is a methodical process that is employed to ascertain preventative measures for potential problem causes of a performance gap (failure) in a system by logically identifying, assessing, and quantifying them. Fault trees graphically illustrate the logical relationships between problems and their sources (Kabir, 2017). To make sure that vital assets are protected, risk analysis is crucial. Fault tree analysis (FTA) is one of the most well-known methods, utilized by many different industries (Ruijters & Stoelinga, 2015).

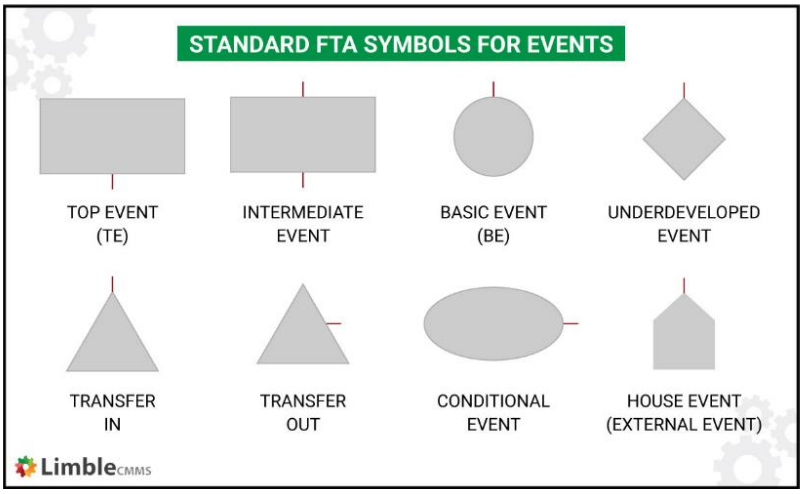

Figure 2.3 FTA Symbols

Source: (Chan, 2024)

2.2.7 Pareto Diagram

A Pareto chart is essentially a frequency block diagram in statistics that shows the relative frequency of several attributes in descending order (Grosfeld & Kozlovsky, 2007). Utilizing the Pareto diagram can assist in identifying urgent issues that require immediate attention or in resolving problems with the greatest potential impact that should be prioritized. The foundation of Pareto analysis is the realization that certain inputs contribute more than others and that economic riches and operational outcomes are not spread equally. The term "80/20 rule" refers to a sophisticated economic principle that was first proposed by Italian economist Vilfredo Pareto in the nineteenth century. The basic idea is that most issues (about 80%) are frequently brought on by a small percentage of sources (about 20%) (Powell & Sammut, 2015).

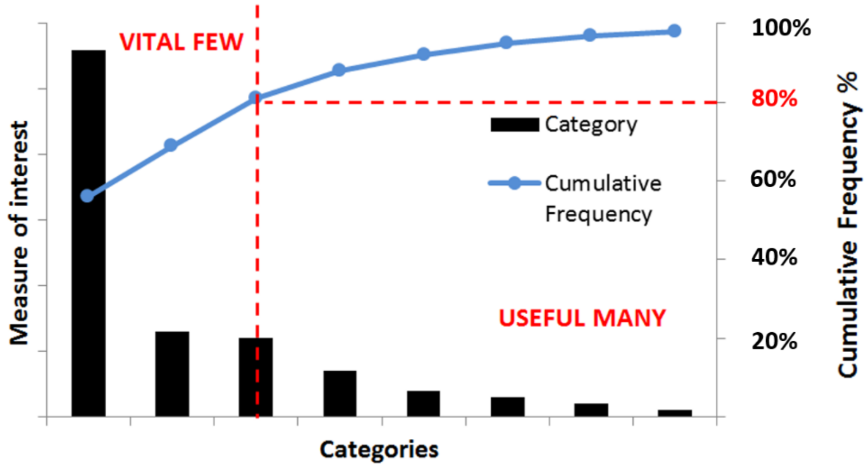

Figure 2.4 Pareto Diagram

Source: (NHS Foundation Trust, 2024)

2.2.8 Fishbone Diagram

The Ishikawa diagram, often known as the Fishbone diagram, is a tool used to determine the underlying causes of quality issues. It bears the name Kaoru Ishikawa in honor of the Japanese quality control statistician who invented this chart back in the 1960s (Juran, 1999). An analytical tool that offers a methodical approach to examining effects and the sources that generate or contribute to those effects is the fishbone diagram. The Fishbone diagram is sometimes called a cause-and-effect diagram due to its function (Watson, 2004). The diagram's layout closely resembles a fish's skeleton (Ilie & Ciocoui, 2010).

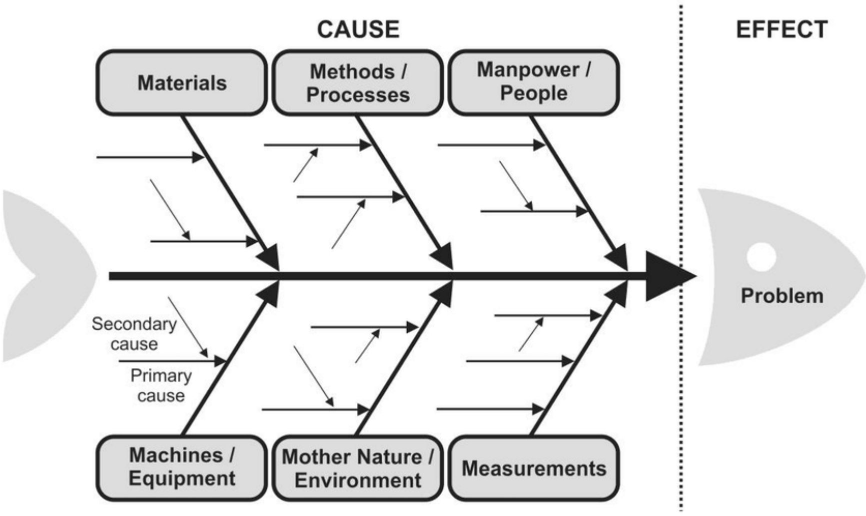

Figure 2.5 Fishbone Diagram Construction

Source: (Hristoski, 2017)

According to Yuniarto et al. (2013), fishbone diagrams have the advantage of having clear graphics that are easy to comprehend. They can also gather concepts in detail related to the 5M1E categories or factors (human, machine, method, material, measurement, and environment). A fishbone diagram is designed with the fundamental issue located on the right side, or at the head of the fishbone frame, and the root cause of the issue located on the fins and spines. Brainstorming approaches are commonly employed in the process of identifying problem reasons.

2.2.9 Kaizen

The Japanese word "kaizen" has gained popularity in many Western businesses. According to Chen et al. (2000), the term refers to a process of continuous improvement of the conventional method of work. The word is a combination that combines the ideas of Kai (change) and Zen (better) (Palmer, 2001). According to Teian (1992), Kaizen is more than merely a technique for improvement because it symbolizes the challenges that employees face on a regular basis at work and how those challenges are resolved. Any area that needs to be improved can use kaizen.

Imai (1986) defined kaizen as a continual improvement method that involves management and employees equally. In its broadest sense, Kaizen is a customer-driven approach that encompasses ideas, procedures, and instruments within the larger context of leadership encompassing people and culture. Under the general heading of "kaizen," numerous methodologies are included, such as automation, just-in-time delivery, Six Sigma, suggestion systems, Kanban, total productive maintenance, and productivity enhancement. (Imai, 1986)

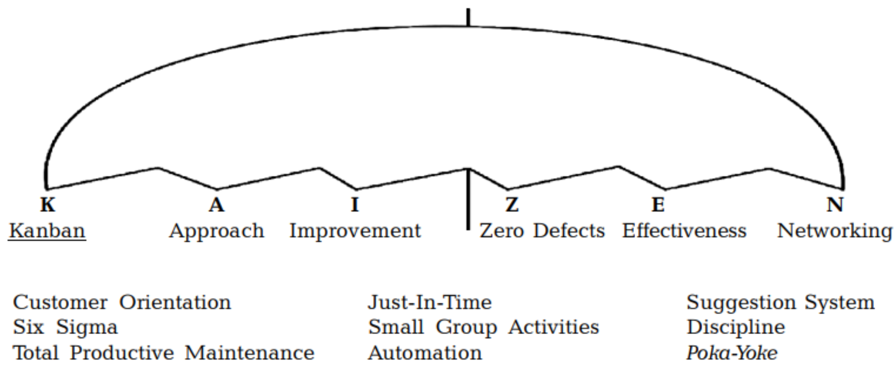

Figure 2.6 Kaizen Umbrella

Source: (Imai, 1986)

CHAPTER III
RESEARCH METHOD

3.1 Research Subject

The data obtained in this research will involve production line operators in Factory 1, floor 3, Assembly UP Department, Final Regulation group, PT Yamaha Indonesia.

3.2 Research Object

The research object used in this research is the effectiveness of workers in the Final Regulation UP group which has the output in the form of a piano UP. In this research, the Overall Labor Analysis (OLE) value will be calculated to determine the effectiveness of group performance and continued with the Root Cause Analysis (RCA) approach to analyze the causes of the problem and provide suggestions for improvements involving experts from the UP Assembly Department of PT Yamaha Indonesia.

3.3 Types of Data

The following are the types of data used in this research.

1. Primary Data

This research's primary data is obtained through Overall Labour Effectiveness (OLE) data and Root Cause Analysis (RCA) that are collected through observations and interviews with the person concerned.

2. Secondary Data

   Secondary data was collected by collecting and studying supporting documents like the company's report, as well as scientific references in the form of journals and literature studies related to this research.

3.4 Research Method

The data collection process in this research was carried out in the following way:

1. Observation

   Observation is carried out by directly monitoring the Final Regulation UP working group to determine actual conditions in the field. This is done with the aim that researchers can understand the conditions and problems that exist in the field so that they can provide appropriate recommendations for improvement.

2. Interview

   To strengthen the sources of information required for this research, interviews were carried out with parties who comprehend and have direct involvement in the Final Regulation UP, such as foreman, group chief, operators, mentors, and other parties.

3. Literature Study

   The literature review in this research comes from papers, journals, and books which are used as a basis to support the research. An examination of company reports is also conducted to complete the necessary data.

3.5 Research Flow

The flow of research carried out in this study is explained in Figure 3.1 as follows:

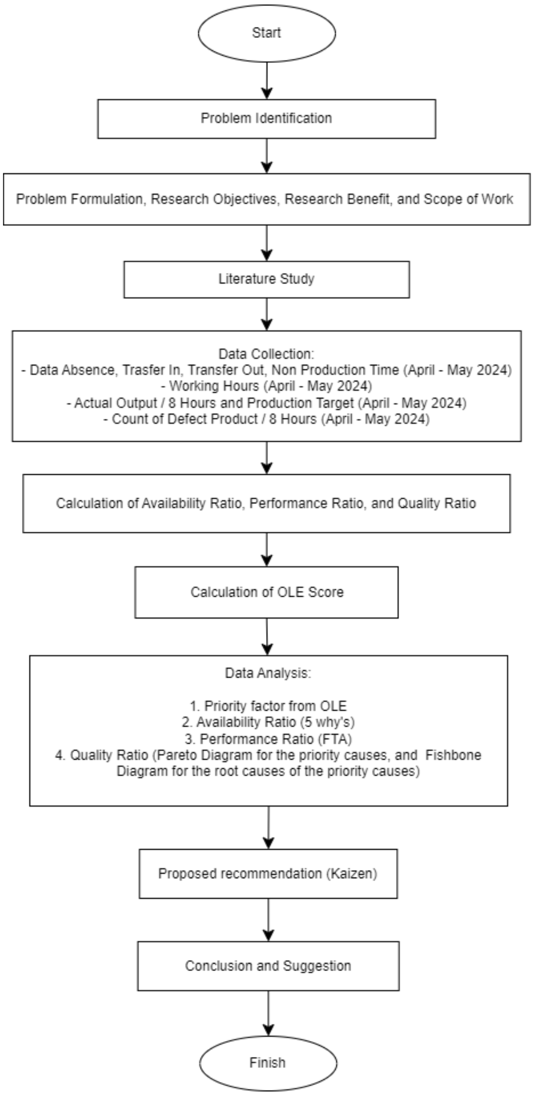

Figure 3.1 Research Flowchart

3.6 Data Processing

The following is the explanation of the Figure 3.1 above:

1. Start

   The first step in this research is determining the theme and subject whose issues will be studied.

2. Problem Identification

   Identifying problems is carried out to discover the issues that occur so that research directions can begin to be developed and directed. Identifying this problem will become the background for the research to be carried out and then be described into a problem formulation.

3. Problem Formulation, Research Objectives, Benefits, and Scope of Work

   At this stage, researchers conduct further studies to address issues emerging within the research object. A problem formulation is developed as the foundation for this research. Based on this formulation, specific research objectives and limitations are established to concentrate the focus of the research. The problem formulation primarily aims to assess the effectiveness of workers or operators within the research object.
4. Literature Study

   A literature study is a theoretical basis or relevant reference to be used as supporting research material. Literature studies are obtained from books, journals, articles, theses, and other scientific works which will later be quoted in writing research reports. From these various sources, theoretical studies are carried out and differences are made between the research that will be carried out and research that has already been carried out using the same method.
5. Data Collection

   At this point, based on the theories that have been examined, the researcher begins searching for the data required for the method that will be employed. With this OLE method, researchers need data on attendance, transfer in, transfer out, non-production day, and data on working hours per day to calculate the availability ratio, then data on actual production results per day and data on production targets per day to calculate the performance ratio, and data on actual production results per day along with the number of defective products to calculate the quality ratio. All data was taken from April to May 2024.
6. Calculation of Availability Ratio, Performance Ratio, Quality Ratio
   a. Availability Ratio

   Obtained from the results of the difference between 100% and the comparison between lost work time and available time.

   b. Performance Ratio

   Obtained from dividing production results during working hours with the output target on the nth day, carrying out calculations involving all daily data, and finding the average value of the data used.

   c. Quality Ratio

Obtained from the defect results on the nth day minus the production results during working hours on the nth day, then dividing them by the production results during working hours on the nth day. This calculation will be carried out using data from the first day to the last day and then looking for the average value of the data used.

7. Calculation of OLE Score

   The Overall Labour Effectiveness (OLE) value for the Final Regulation UP operator is then determined by multiplying the final calculation derived from the outcomes of the three existing variables.

8. Data Analysis

   After getting the calculation results from Overall Labour Effectiveness (OLE), the researcher will continue with the data analysis stage using the Root Cause Analysis (RCA) method, 5 Why's tools are used to analyze the availability ratio, Fault Tree Analysis (FTA) tools is used to analyze the performance ratio, Pareto Diagrams, and Fishbone tools is used to analyze the quality ratio.

9. Proposed Recommendation (Kaizen)

   From the root of the problem that has been obtained from the analysis using RCA, the next step is to provide a proposed recommendation by providing kaizen which can be implemented in the workgroup.

10. Conclusion and Suggestion

    The conclusion contains the answer to the problem formulation that was explained at the beginning of the research. Apart from that, suggestions will be provided for the companies and further research.

11. Finish

    The research has been completed following the above flow.

CHAPTER IV
DATA COLLECTION AND PROCESSING

4.1 Company Profile

A company profile is an overview of the company's operations made to provide the intended audience with fundamental information about the product or service. It serves as a way of communicating a company's identity, history, vision, mission, values, and significant accomplishments to the public. The following are the explanations regarding PT Yamaha Indonesia's company profile.

4.1.1 Company History

Yamaha Organ Works was a firm that was established in 1887 in Hamamatsu City, Japan. The company's goal was to produce musical instruments organ-type. Mr. Torakusu Yamaha, a Japanese businessman, was the company's founder. Yamaha then extended its company into the field of music education under the direction of Mr. Gen' Ichi. He organized concerts and festivals, started music schools and courses, and established the Yamaha Music Foundation as a platform for all of these endeavors, with its main office located in Tokyo, Japan.

Yamaha plans to build a facility in Indonesia to assemble musical instruments as part of an established corporate expansion strategy. When Mr. Gen' Ichi Kawakami made his first trip to Indonesia in 1965, he conveyed this. The Indonesian people's passion for art, particularly music, inspired him. Then, Mr. Gen' Ichi Kawakami made his second trip to Indonesia in 1972. Mr. Gen' Ichi Kawakami told his friend Mr. Drs. Hoegeng Iman Santoso about his intentions to start a musical instrument business in Indonesia during this visit. However, since Mr. Hoegeng did not have much interest in business, Mr. Gen' Ichi Kawakami was introduced to a friend, Mr. Ali Syarif, who had a wealth of business knowledge. This plan was finally realized on June 27, 1974, which was the founding date of PT. Yamaha Indonesia (PT. YI).

The beginning of the establishment of PT. Yamaha Indonesia in June 1974 was headed by a President Director, namely Mr. Hashimoto who was later replaced by Mr. Sadao Terui in 1980. During the leadership of Mr. Sadao Terui, precisely in 1980, there was an economic crisis that resulted in YI employees starting to build Factory 2. After the economic turmoil was overcome, PT Yamaha Indonesia changed its President Director and was led by Mr. Sawamoto, who was then replaced in 1993 by Mr. Shigeru Sugiyama. Two years later in 1995, the fifth President Director was appointed, namely Mr. Minoru Nagano.

PT. Yamaha Indonesia is a manufacturing company that produces pianos where there are two types of pianos produced, namely Upright Piano (UP) and Grand Piano (GP), and each type of piano has several different models. PT. Yamaha Indonesia has three production processes, namely Woodworking, Painting, and Assembly which will later be divided into four departments, namely departments namely Woodworking, Painting, Assembly UP, and Assembly GP. The components of the piano at PT Yamaha Indonesia are the Frame Group, Case Group, and Action Group. Furthermore, the results of the piano production will be distributed domestically and non-domesticly, including in Asia, Europe, and America.

PT. Yamaha Indonesia is dedicated to upholding the level of quality of the goods it produces throughout the production process. Therefore, it is critical for companies to have employees that are qualified and proficient in technology. Using top-notch raw materials is also essential to making pianos with high quality. The ISO 9001 and ISO 14001 certifications that PT Yamaha Indonesia has earned attest to their dedication to producing high-quality goods in an eco-friendly manner. Aside from that, PT. YI employs a variety of techniques to improve production processes and efficiency, including the use of Yamaha Productivity Management systems including YPM Kaizen, VSM, 5S, and K3. Productivity, quality development efficiency, distribution time, expenditure expenses, and environmental safety and security are all directly impacted by these projects.

4.1.2 Company Vision and Mission

A mission statement defines a company's current purpose, whereas a vision statement defines its future goals. The following is the vision and mission of PT. Yamaha Indonesia:

4.1.2.1 Vision

“Creating various products and services that are able to satisfy the various needs and desires of various Yamaha customers throughout the world. "The form of service and satisfaction can be seen from Yamaha products and services in the fields of acoustics, design, technology, creative works, and service that always puts customers first."

4.1.2.2 Mission

a. Promote and support the popularization of music education
b. Customer-oriented operations and management

c. Perfection in products and services
d. Continuous efforts to develop and create markets.
e. Periodic improvements in the field of research and development as well as positive globalization of business through product diversification.

4.1.3 Company Location

PT Yamaha Indonesia's main plant is located in the Pulo Gadung Industrial Area. Jl. Rawagelam I No.5, RT.5/RW.9, Jatinegara, Cakung, East Jakarta City, Jakarta 13930. Another plant is located in the Pulo Gadung Industrial Area. Jl. Pulo Kambing II. RW.11, Jatinegara, Cakung, East Jakarta City, Jakarta 13930.

Figure 4.1 YI Plant Rawagelem

Figure 4.2 YI Plant Pulo Kambing

4.1.4 Company Product

Grand pianos and upright pianos are the two varieties of pianos that PT Yamaha Indonesia manufactures. PT Yamaha Indonesia also manufactures several cabinets and piano parts that are shipped to other nations for use in the assembly of pianos. In general, PT Yamaha Indonesia produces several color variants for the Upright Piano type, namely Polished Ebony (PE), Polished Mahogany (PM), Polished Walnut (PW), and Polished White (PWH). One of the best-selling products from Yamaha's Upright Piano is the B1 PE model. The following are examples of the Upright Piano model.

Figure 4.3 Upright Piano Model U1J PE

Source: yamaha.com

The Grand Piano model also has several color variants, namely Polished Ebony (PE), Polished Mahogany (PM), Polished Walnut (PW), and Polished White (PWH). Grand Piano consists of 2 variants, namely GB and GN2. The following is an example of a Grand Piano model.

Figure 4.4 Grand Piano CX Series PE

Source: Yamaha.com

There is another type, which is the silent type. Upright Piano Silent is able to store musical rhythms and repeat the strains without having to be touched by humans. So, most of these silent-type pianos are more expensive than Upright Pianos in general because they have more added value. In addition, there is a silent Grand Piano model available. The features obtained from the silent type on this Grand Piano model are more attractive compared to the Upright Piano model. The same feature is that it is able to store music and can be played back without the touch of a human hand. The difference is that on this Grand Piano model when the music is played based on the last recording, the keyboard of the Grand Piano will move as if it were being played by a human.

Figure 4.5 Silent Piano SC3

Source: yamaha.com

4.1.5 Company Structure

The direction of tasks, coordination, and supervision concerning the accomplishment of organizational goals is specified by an organizational structure. Figure 4.6 shows the company structure of PT Yamaha Indonesia.

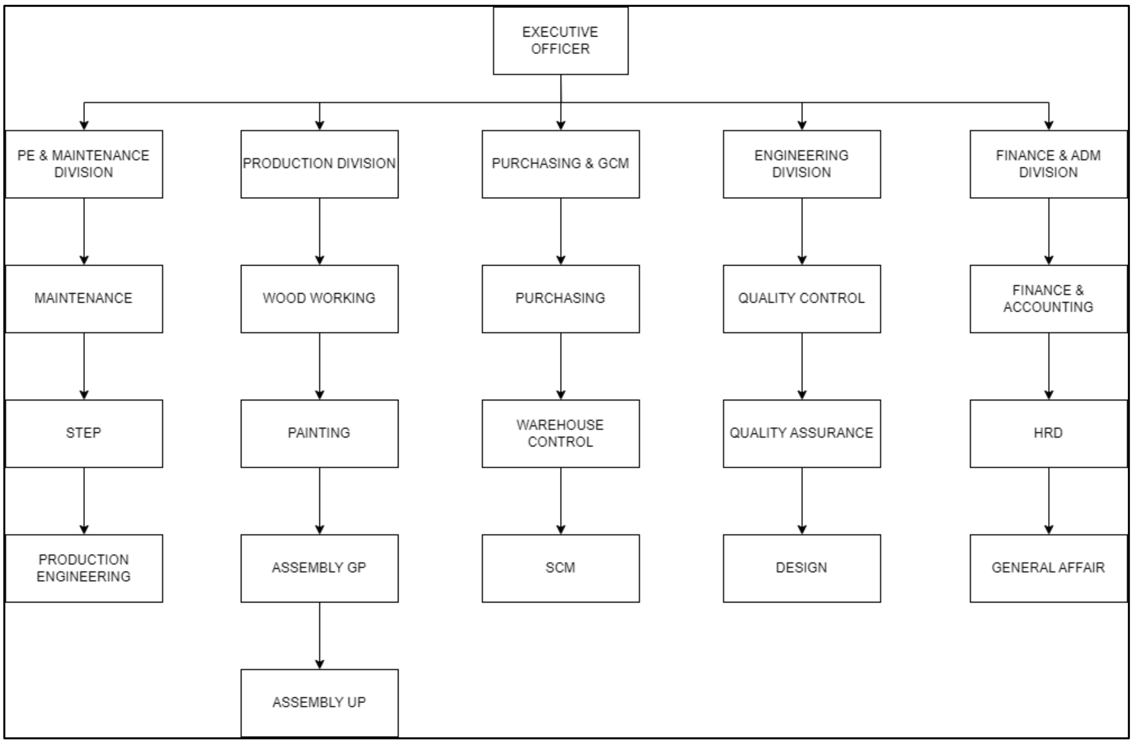

Figure 4.6 Yamaha Indonesia Structure

1. Production Engineering & Maintenance Division

   This division handles kaizen (continuous improvement) and maintenance issues. The divisions of this division are Maintenance, STEP (Supporting Team for Engineering Projects), and Production Engineering.

2. Production Division

   In this Production Division, there are 4 divisions, namely Woodworking, Painting, Assembly Upright Piano (UP), and Assembly Grand Piano (GP). The production division handles the production/manufacturing part, starting from the beginning of the piano-making process from raw materials (woodworking), assembly, and painting, to finishing. All these processes are under the Production division.

3. Purchasing & GSM Division

   This division handles matters in terms of ordering goods, both in terms of determining prices, and vendors, making reports on purchasing & releasing goods (inventory, materials, etc.), working with related departments to ensure smooth operations, and ensuring the availability of goods/materials through audits. stock control. Divisions under Purchasing include SCM, Purchasing, and Warehouse.

4. Engineering Division

This division oversees the Quality Control (QC), Quality Assurance, and Design divisions. Each of these divisions handles final checking (QC) issues and is also responsible for design.

5. Finance & Administration Division

   This division is in charge of the following smaller divisions: General Affairs, Finance & Accounting, and Human Resources Development. Handling the business's financial matters is the responsibility of the Finance & Accounting section. The distinction between accounting and finance is that accounting handles the verification, documentation, and reporting of incoming and outgoing financial transactions, whereas finance manages money and has the authority to receive and send money.

4.1.6 Final Regulation UP Group Production Flow

Final Regulation is a group from the Assembly UP Department that is responsible for doing the second regulation process after the piano is seasoned for around 1 week. Figure 4.7 below shows the mapping from this group.

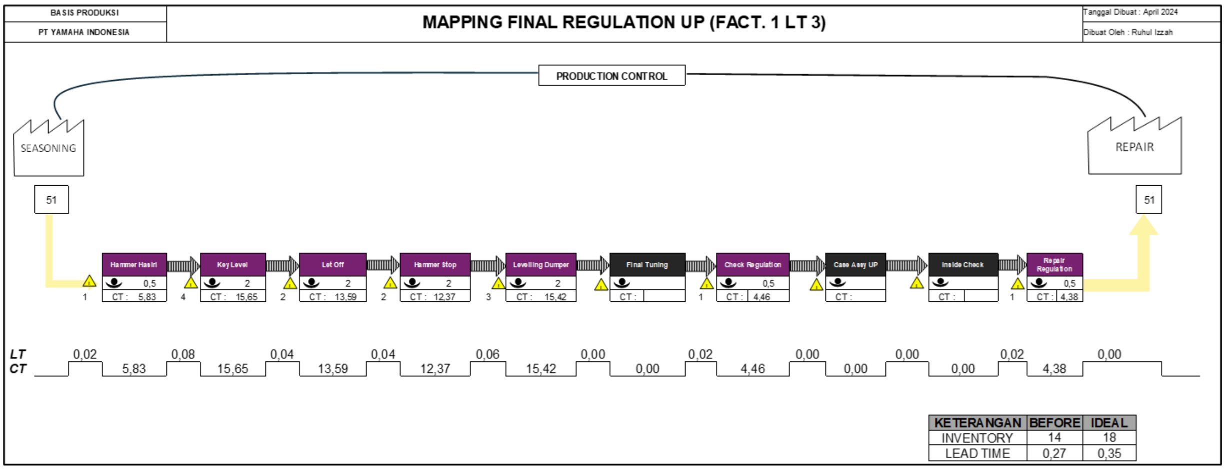

Figure 4.7 Final Regulation UP Mapping

5 main processes need to be worked on Final Regulation:

1. Key Level

   This is the first process in this group. This process consists of several steps which are key moving white key, key moving black key, key lift up, lost motion (rough), key lift up, adjusting keyboard height, and key level.

Figure 4.8 Key Level Process

2. Let Off

   The second process is Let Off. The steps of this process consist of let off, key depth, and key space.

Figure 4.9 Let Off Process

3. Hammer Stop

   This process is done by following these steps; adjust back check, lost motion, hammer stop, and centering hammer.

Figure 4.10 Hammer Stop Process

4. Levelling Damper

   This process starts with leveling damper, assemble pedal, insert pedal rod, damper spoon, buffing keyboard, and writing the result.

Figure 4.11 Levelling Damper Process

5. Check and Repair Regulation

   Check regulation is the process of checking and making sure all of the process is done in accordance with the standard. This process is carried out after the piano has completed the final tuning process and before the piano enters the inside checking process. After finishing the inside check process, if the piano has NG (Not Good) or needs to be reworked, the piano will be repaired by an operator from Final Regulation UP.

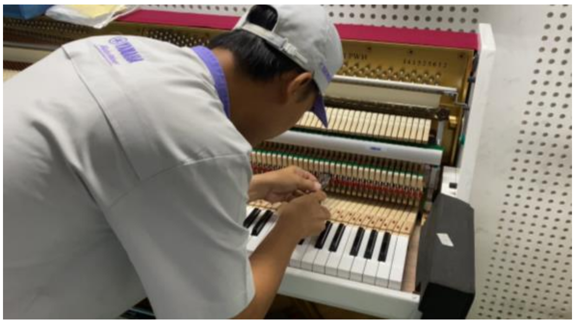

Figure 4.12 Check Regulation Process

Figure 4.13 Repair Regulation Process

4.1.7 Final Regulation UP Layout

Final Regulation UP is located at Factory 1, floor 3, Department of Assembly UP PT Yamaha Indonesia. This group has 5 main processes with 4 line production. However, because of the reduction in production, there are only required 3 lines now to be used with 2 crews of operators to process the pianos. Figure 4. 14 below shows the layout of the group.

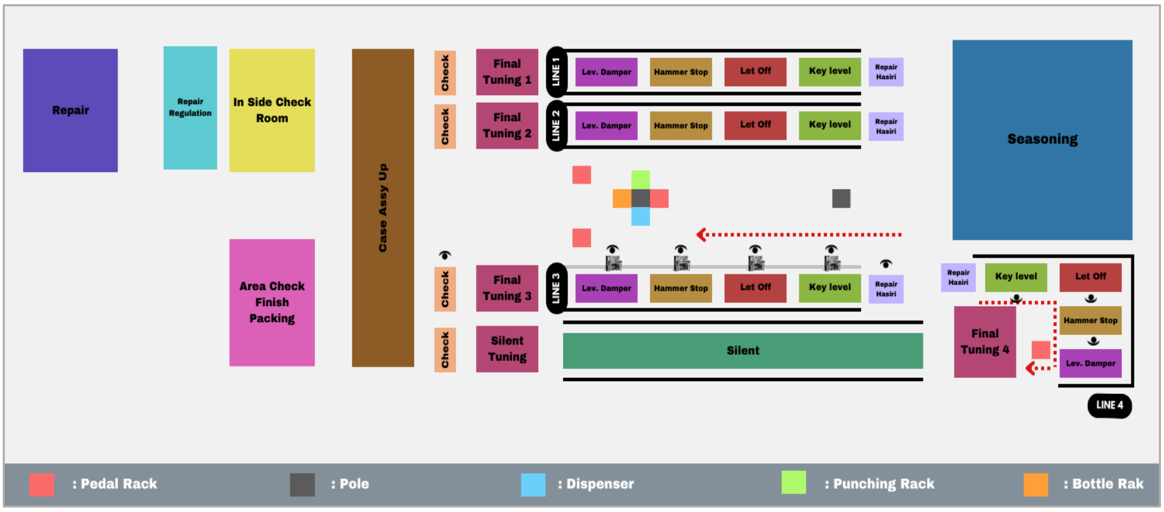

Figure 4.14 Final Regulation UP Layout

4.2 Data Collection

Data collection is the methodical process of gathering data that needs to be processed. The data collected is from April 2024 to May 2024, consisting of 34 working days. This data range was selected because the production plan during that period remained stable at 51 units per day with 5 production days per week. In June and July 2024, the production plan decreased to 46 units, and starting in August, there were only 4 production days per week. Additionally, in June, kaizen improvements began. Therefore, the April-May data range is suitable as the baseline for calculations before the kaizen implementation. The following are the data needed to generate this research.

4.2.1 Availability Ratio Data

In calculating the availability ratio value, data is needed such as data on lost working hours. The following are supporting data to calculate the number of lost working hours, where there are factors such as absenteeism, transfer out, and non-production time. Meanwhile, transfer-in data is data on additional working hours so that the total loss of working hours will be calculated based on the sum of the values for absences, transfer outs, and non-production time minus the transfer-in value. Data was taken for 34 working days with a period ranging from April to May.

Table 4.1 Availability Ratio of Final Regulation UP

Data	Date	Absent (Minutes)	Non Production Time (Minutes)	Transfer Out (Minutes)	Transfer In (Minutes)
1	01/04/2024	0	0	240	480
2	02/04/2024	0	0	240	480
3	03/04/2024	480	0	240	480
4	04/04/2024	0	0	240	240
5	05/04/2024	480	0	240	720
6	16/04/2024	0	180	810	750
7	17/04/2024	0	0	720	480
8	18/04/2024	0	0	240	240
9	19/04/2024	0	0	240	120
10	22/04/2024	0	0	240	0
11	23/04/2024	0	0	360	0
12	24/04/2024	0	0	240	240
13	25/04/2024	0	0	600	480
14	26/04/2024	480	0	240	480
15	29/04/2024	0	0	240	480
16	30/04/2024	0	90	375	210
17	02/05/2024	0	0	270	0
18	03/05/2024	0	0	270	0
19	06/05/2024	0	0	270	0
20	07/05/2024	0	0	270	0
21	08/05/2024	0	0	270	0
22	10/05/2024	0	0	270	210
23	13/05/2024	0	0	270	0
24	14/05/2024	0	0	750	420

Data	Date	Absent (Minutes)	Non Production Time (Minutes)	Transfer Out (Minutes)	Transfer In (Minutes)
25	15/05/2024	0	0	750	420
26	16/05/2024	0	0	750	420
27	17/05/2024	480	0	240	480
28	20/05/2024	0	0	750	480
29	21/05/2024	0	0	570	300
30	22/05/2024	0	0	630	300
31	24/05/2024	0	0	270	0
32	27/05/2024	0	0	270	150
33	28/05/2024	0	0	270	0
34	29/05/2024	0	0	270	0

For every operator, the total working duration is 480 minutes. Thus, each 480 in Table 4.1 above denotes the presence of one operator and multiple. Therefore, if it says the absence of 480 minutes, it means that 1 operator is absent, as well as multiples. The same as absences, if the transfer out and transfer in data shows a value of 480, it can be concluded that one person was transferred to another section or from another section to the workgroup. The non-production time value shows the value of a part of the work that is not produced. This can happen due to various factors, such as training, 5S improvement activities, morning assembly, natural disasters, and so on.

4.2.2 Performance Ratio Data

Data such as actual daily production output and daily production targets set by the company for eight working hours are required in order to calculate the performance ratio. Where the production output is in the form of piano results from the Final Regulation UP. The following is the data that has been collected for 34 effective working days from April to May 2024.

Table 4.2 Performance Ratio of Final Regulation UP

Data	Date	Production Output (Unit)	Production Target (Unit)
1	01/04/2024	51	51
2	02/04/2024	51	51
3	03/04/2024	48	51
4	04/04/2024	51	51
5	05/04/2024	51	51
6	16/04/2024	51	51

Data	Date	Production Output (Unit)	Production Target (Unit)
7	17/04/2024	51	51
8	18/04/2024	51	51
9	19/04/2024	51	51
10	22/04/2024	51	51
11	23/04/2024	51	51
12	24/04/2024	51	51
13	25/04/2024	51	51
14	26/04/2024	48	51
15	29/04/2024	51	51
16	30/04/2024	24	51
17	02/05/2024	47	51
18	03/05/2024	50	51
19	06/05/2024	51	51
20	07/05/2024	51	51
21	08/05/2024	51	51
22	10/05/2024	51	51
23	13/05/2024	51	51
24	14/05/2024	49	51
25	15/05/2024	49	51
26	16/05/2024	49	51
27	17/05/2024	50	51
28	20/05/2024	51	51
29	21/05/2024	51	51
30	22/05/2024	51	51
31	24/05/2024	51	51
32	27/05/2024	51	51
33	28/05/2024	51	51
34	29/05/2024	51	51

The daily output target for the UP assembly department is 51 piano units. As seen from Table 4.2 above, there were 9 days when this group did not reach the production target. average output for April was 48.93 units and for May was 50.33 units.

4.2.3 Quality Ratio Data

Production output, production target, and defective product data are required in order to calculate the quality ratio. This defect data is found during the inside check process. The following is data taken based on 34 working days of observation with a period of April – May 2024.

Table 4.3 Quality Ratio of Final Regulation UP

Data	Date	Production Output (Unit)	Production Target (Unit)	Defect Product (Unit)
1	01/04/2024	51	51	14
2	02/04/2024	51	51	9
3	03/04/2024	48	51	14
4	04/04/2024	51	51	7
5	05/04/2024	51	51	6
6	16/04/2024	51	51	2
7	17/04/2024	51	51	6
8	18/04/2024	51	51	7
9	19/04/2024	51	51	7
10	22/04/2024	51	51	6
11	23/04/2024	51	51	3
12	24/04/2024	51	51	3
13	25/04/2024	51	51	5
14	26/04/2024	48	51	4
15	29/04/2024	51	51	14
16	30/04/2024	24	51	5
17	02/05/2024	47	51	6
18	03/05/2024	50	51	9
19	06/05/2024	51	51	13
20	07/05/2024	51	51	7
21	08/05/2024	51	51	8
22	10/05/2024	51	51	10
23	13/05/2024	51	51	9
24	14/05/2024	49	51	5
25	15/05/2024	49	51	11
26	16/05/2024	49	51	8
27	17/05/2024	50	51	9
28	20/05/2024	51	51	16
29	21/05/2024	51	51	9
30	22/05/2024	51	51	7
31	24/05/2024	51	51	9
32	27/05/2024	51	51	5
33	28/05/2024	51	51	2
34	29/05/2024	51	51	5

According to Table 4.3 above, there is no day with zero defects. In total, 260 units of pianos have defects within 34 working days. The highest unit defect per day is 16 units, on data-20 and the lowest unit defect per day is 2 units on data-6 and 33.

4.3 Data Processing

Data processing is a cycle to transform raw material (data collected) into usable information. The following are the data processing for this research by using the OLE method.

4.3.1 Availability Ratio

The availability ratio value is obtained based on the formula previously written in Equation 2.1, which is the availability ratio value level of 100% minus the comparison between the total lost working hours per minute and the working hours per minute. Calculations for lost working hours are obtained from absenteeism, transfer out, and non-production time data which is reduced by operator transfer in data. Then the value of available time is obtained from the total working hours per day, namely 480 minutes multiplied by a total of 9 operators. For example, Table 4.4 shows the calculation of the availability ratio in the Final Regulation UP working group.

Table 4.4 Example Calculation of Availability Ratio

Data	**Date**	**Absent (Minutes)**	**Non Production Time (Minutes)**	**Transfer Out (Minutes)**	**Transfer In (Minutes)**
16	30/04/2024	0	90	375	210

Table 4.4 above is the 16th data with 0 minutes of absence, 90 minutes of non-production time, 375 minutes of transfer out, and 210 minutes of transfer in. The calculation of the availability ratio by using Equation 2.1 is as follows.

$$A = 100\% - \frac{LTn}{WYT}$$

$$A = 100\% - \frac{(Absent + Transfer\ Out + Non\ Production\ Time) - Transfer\ In}{480\ minutes\ x\ 9\ operators}$$

$$A = 100\% - \frac{(0 + 375 + 90) - 210}{480\ minutes\ x\ 9\ operators}$$

$$A = 100\% - \frac{(0 + 375 + 90) - 210}{480\ minutes\ x\ 9\ operators}$$

$$A = 100\% - \frac{255}{4320}$$

$$A = 100\% - 0{,}059$$

= 94%

According to the computation above, the availability ratio result for Final Regulation UP 16th data is 94%. That score is above the international standard. Furthermore, Table 4.5 below shows all the results of the computation and the comparison with the international standard for 34 working days.

Table 4.5 Availability Ratio Result

Data	Date	Availability Ratio	International Standard
1	01/04/2024	106%	90%
2	02/04/2024	106%	90%
3	03/04/2024	94%	90%
4	04/04/2024	100%	90%
5	05/04/2024	100%	90%
6	16/04/2024	94%	90%
7	17/04/2024	94%	90%
8	18/04/2024	100%	90%
9	19/04/2024	97%	90%
10	22/04/2024	94%	90%
11	23/04/2024	92%	90%
12	24/04/2024	100%	90%
13	25/04/2024	97%	90%
14	26/04/2024	94%	90%
15	29/04/2024	106%	90%
16	30/04/2024	94%	90%
17	02/05/2024	94%	90%
18	03/05/2024	94%	90%
19	06/05/2024	94%	90%
20	07/05/2024	94%	90%
21	08/05/2024	94%	90%
22	10/05/2024	99%	90%
23	13/05/2024	94%	90%
24	14/05/2024	92%	90%
25	15/05/2024	92%	90%
26	16/05/2024	92%	90%
27	17/05/2024	94%	90%
28	20/05/2024	94%	90%
29	21/05/2024	94%	90%
30	22/05/2024	92%	90%
31	24/05/2024	94%	90%

Data	Date	Availability Ratio	International Standard
32	27/05/2024	97%	90%
33	28/05/2024	94%	90%
34	29/05/2024	94%	90%
Average		**96%**	**90%**

As shown in Table 4.5 above, all of the data for 34 working days are above the international standard (>90%). Therefore, within 34 working days of data, the availability ratio for Final Regulation UP is 96%.

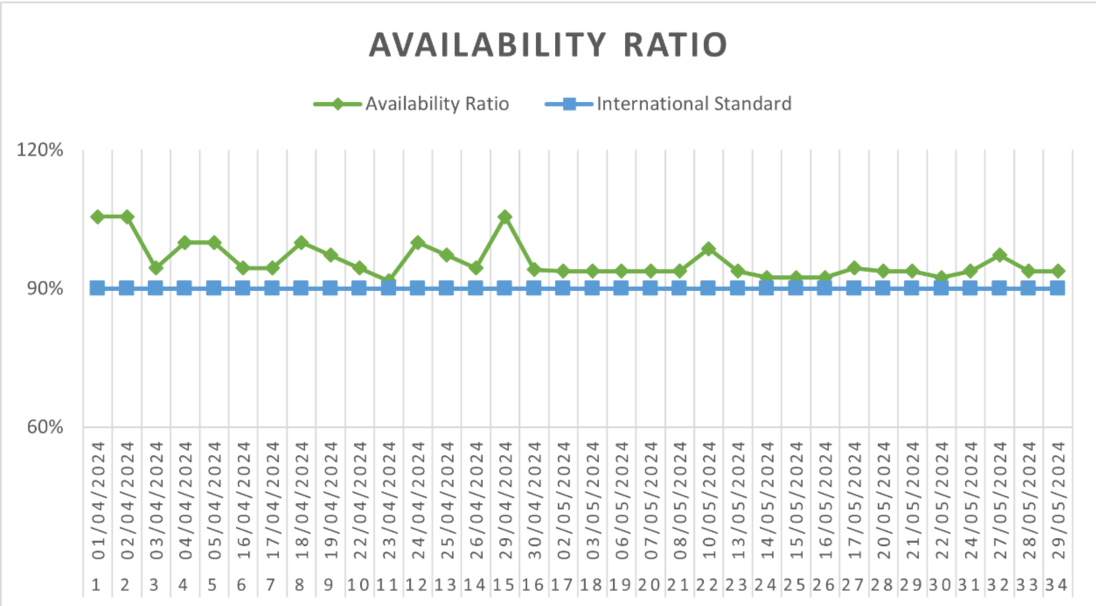

Figure 4.15 Availability Ratio Graph

Based on Figure 4.15 above, this group's availability ratio trend tends to fluctuate but remains above international standards. An OLE score above 90% is generally a positive indicator, suggesting that the labor force is performing exceptionally well. An availability ratio of 96% typically means that the labor is available and ready to perform its tasks 96% of the scheduled operating time. Only 4% is lost due to absence, transfer out, or other interruptions.

4.3.2 Performance Ratio

The performance ratio value is obtained based on the formula previously written in Equation 2.2, namely from the production results on that day which are then divided by the company target. Table 4.6 is the data that is used as an example of a performance ratio calculation that will be carried out.

Table 4.6 Example Calculation of Performance Ratio

Data	Date	Production Output (Unit)	Production Target (Unit)
16	30/04/2024	24	51

Table 4.6 is the 16th data that has an output of 24 unit pianos UP with the target of 51 unit pianos UP. Those data will be calculated by using Equation 2.2 as follows.

$$P = \sum_{n=1}^{k} \frac{Pn}{T} \; x \; 100\%$$

$$P = \frac{24}{51} \; x \; 100\%$$

$$P = 47\%$$

Based on the computation above, the performance ratio value for data 16th is 47%. This shows that the performance ratio value obtained that day was below the world standard, which is 95%. Table 4. displays the results obtained based on calculations and comparisons with established world standard values.

Table 4.7 Performance Ratio Result

Data	Date	Performance Ratio	International Standard
1	01/04/2024	100%	95%
2	02/04/2024	100%	95%
3	03/04/2024	94%	95%
4	04/04/2024	100%	95%
5	05/04/2024	100%	95%
6	16/04/2024	100%	95%
7	17/04/2024	100%	95%
8	18/04/2024	100%	95%
9	19/04/2024	100%	95%
10	22/04/2024	100%	95%
11	23/04/2024	100%	95%
12	24/04/2024	100%	95%
13	25/04/2024	100%	95%
14	26/04/2024	94%	95%

Data	Date	Performance Ratio	International Standard
15	29/04/2024	100%	95%
16	30/04/2024	47%	95%
17	02/05/2024	92%	95%
18	03/05/2024	98%	95%
19	06/05/2024	100%	95%
20	07/05/2024	100%	95%
21	08/05/2024	100%	95%
22	10/05/2024	100%	95%
23	13/05/2024	100%	95%
24	14/05/2024	96%	95%
25	15/05/2024	96%	95%
26	16/05/2024	96%	95%
27	17/05/2024	98%	95%
28	20/05/2024	100%	95%
29	21/05/2024	100%	95%
30	22/05/2024	100%	95%
31	24/05/2024	100%	95%
32	27/05/2024	100%	95%
33	28/05/2024	100%	95%
34	29/05/2024	100%	95%
Average		**97%**	**95%**

According to Table 4.7 above, the performance ratio within 34 data working days is 97%, while the international standard is 95%. Four days resulted below the international standard, and the rest is already above the international standard. Furthermore, Figure 4.16 below clearly shows the trend of performance ratio from this working group for 34 working days. Day 30 of April was quite far below international standards; this was because, on that day, a stocktaking was held which resulted in this group not being able to carry out the production process for half a day. In summary, a 97% performance ratio indicates strong performance close to expectations, with opportunities for this working group to achieve even higher levels of efficiency and effectiveness.

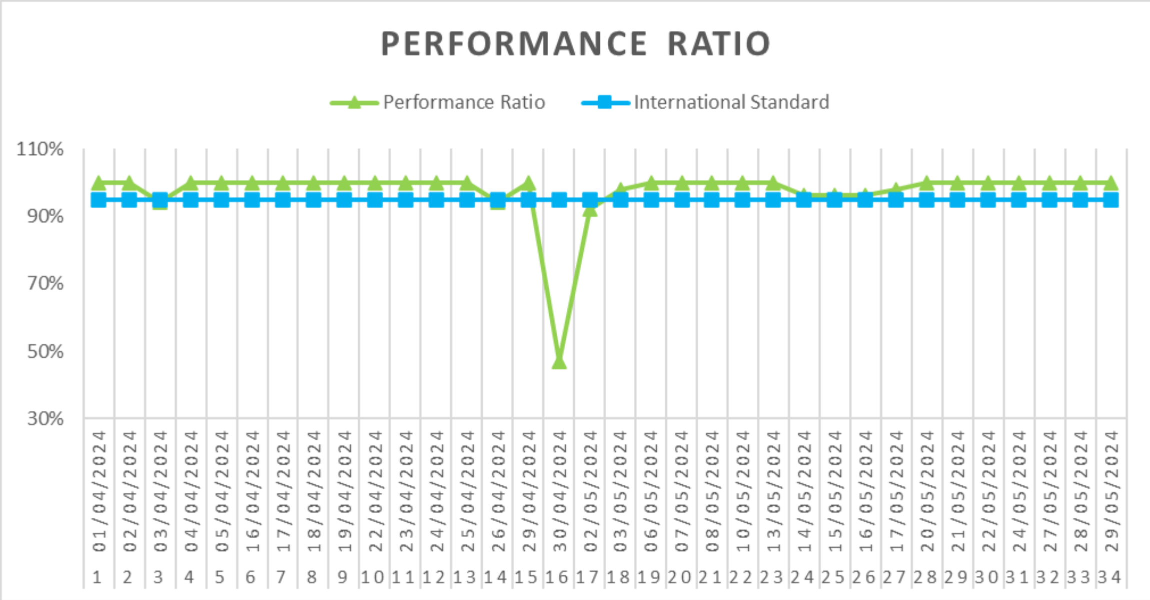

Figure 4.16 Performance Ratio Graph

4.3.3 Quality Ratio

The quality ratio value is calculated based on the formula written in Equation 2.3. For example, the calculation of the quality ratio in the Final Regulation UP working group is as follows.

Table 4.8 Example Calculation of Quality Ratio

Data	**Date**	**Production Output (Unit)**	**Production Target (Unit)**	**Defect Product (Unit)**
16	30/04/2024	24	51	5

Table 4.8 above shows the 16th data with 5 unit pianos defect from 24 produced pianos. The calculation example of quality ratio data 16th is as follows.

$$Q = \sum_{n=1}^{k} \frac{Pn - Dn}{Pn} \; x \; 100\%$$

$$Q = \frac{24 - 5}{24} \; x \; 100\%$$

$$Q = \frac{24 - 5}{24} \; x \; 100\%$$

$$Q = 0{,}79 \; x \; 100\%$$

$$Q = 79\%$$

From the calculation above, the quality ratio for data 16th is 79%, which means that the score is below the international standard which is 100%. The quality ratio value used to calculate the OLE score is obtained based on the average quality ratio value for 34 working days. The following are the results obtained based on calculations and comparisons with established world standard values.

Table 4.9 Quality Ratio Result

Data	**Date**	**Quality Ratio**	**International Standard**
1	01/04/2024	73%	100%
2	02/04/2024	82%	100%
3	03/04/2024	71%	100%
4	04/04/2024	86%	100%
5	05/04/2024	88%	100%
6	16/04/2024	96%	100%
7	17/04/2024	88%	100%
8	18/04/2024	86%	100%
9	19/04/2024	86%	100%
10	22/04/2024	88%	100%
11	23/04/2024	94%	100%
12	24/04/2024	94%	100%
13	25/04/2024	90%	100%
14	26/04/2024	92%	100%
15	29/04/2024	73%	100%
16	30/04/2024	79%	100%
17	02/05/2024	87%	100%
18	03/05/2024	82%	100%
19	06/05/2024	75%	100%
20	07/05/2024	86%	100%
21	08/05/2024	84%	100%
22	10/05/2024	80%	100%
23	13/05/2024	82%	100%
24	14/05/2024	90%	100%
25	15/05/2024	78%	100%
26	16/05/2024	84%	100%
27	17/05/2024	82%	100%
28	20/05/2024	69%	100%
29	21/05/2024	82%	100%
30	22/05/2024	86%	100%
31	24/05/2024	82%	100%

Data	Date	Quality Ratio	International Standard
32	27/05/2024	90%	100%
33	28/05/2024	96%	100%
34	29/05/2024	90%	100%
Average		**85%**	**100%**

Based on the calculation in Table 4.9, none of the 34 working days data obtained has reached the established world standards. Meanwhile, the average quality ratio value was obtained at 85%, which is still below the world standard, namely 100%. Display in Figure 4.17, the quality trend line is below the international standard. This is the only OLE variable from the Final Regulation group that has a value lower than the world standard.

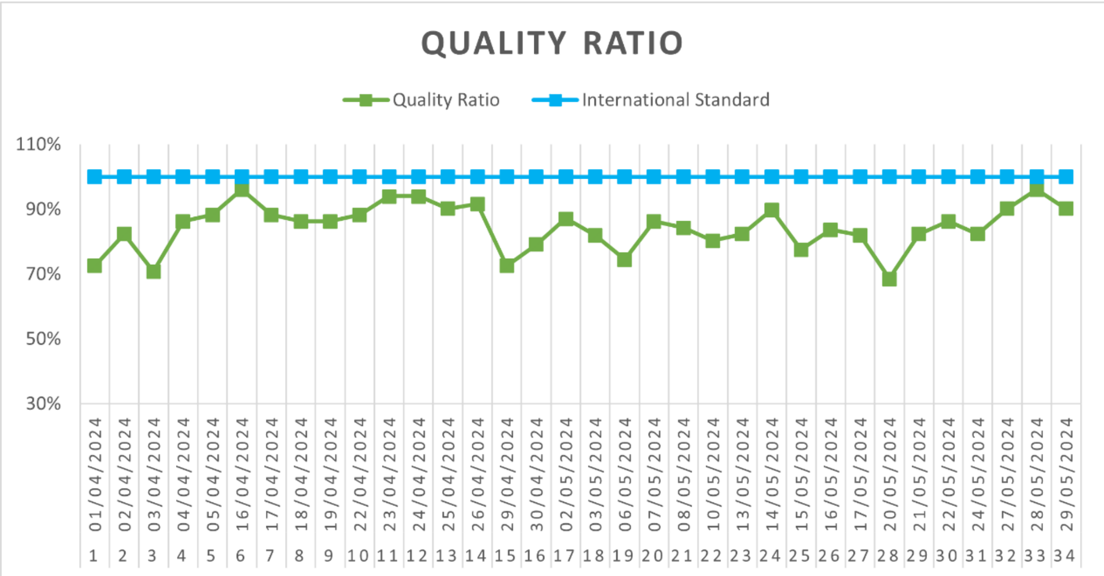

Figure 4.17 Quality Ratio Graph

4.3.4 Overall Labour Effectiveness (OLE)

The calculation of the Overall Labour Effectiveness value is carried out based on the formula written in Equation 2.4. For example, the calculation of the quality ratio in the Final Regulation UP working group is as follows.

Table 4.10 Calculation Example of OLE

Data	Date	Availability Ratio	Performance Ratio	Quality Ratio
16	30/04/2024	94%	47%	79%

Table 4.10 contains the 16th data of the Final Regulation UP OLE score. The data will be processed as follows.

$$OLE = \bar{A}\ x\ \bar{P}\ x\ \bar{Q}$$

$$OLE = 94\%\ x\ 47\%\ x\ 79\%$$

$$OLE = 35\%$$

From the calculation results above, the OLE value obtained by this working group on the 16th workday observation was 35%. It shows that the OLE value obtained that day was below the world standard, namely 85%. The OLE score used to assess the level of employee effectiveness in the Final Regulation UP working group is obtained based on the average OLE score for 34 working days. The following are the results obtained based on calculations and comparisons with established world standard values.

Table 4.11 OLE Result

Data	**Date**	**Availability Ratio**	**Performance Ratio**	**Quality Ratio**	**Overall Labour Effectiveness**	**International Standard**
1	01/04/2024	106%	100%	73%	77%	85%
2	02/04/2024	106%	100%	82%	87%	85%
3	03/04/2024	94%	94%	71%	63%	85%
4	04/04/2024	100%	100%	86%	86%	85%
5	05/04/2024	100%	100%	88%	88%	85%
6	16/04/2024	94%	100%	96%	91%	85%
7	17/04/2024	94%	100%	88%	83%	85%
8	18/04/2024	100%	100%	86%	86%	85%
9	19/04/2024	97%	100%	86%	84%	85%
10	22/04/2024	94%	100%	88%	83%	85%
11	23/04/2024	92%	100%	94%	86%	85%
12	24/04/2024	100%	100%	94%	94%	85%
13	25/04/2024	97%	100%	90%	88%	85%
14	26/04/2024	94%	94%	92%	81%	85%
15	29/04/2024	106%	100%	73%	77%	85%
16	30/04/2024	94%	47%	79%	35%	85%
17	02/05/2024	94%	92%	87%	75%	85%
18	03/05/2024	94%	98%	82%	75%	85%
19	06/05/2024	94%	100%	75%	70%	85%
20	07/05/2024	94%	100%	86%	81%	85%
21	08/05/2024	94%	100%	84%	79%	85%

Data	Date	Availability Ratio	Performance Ratio	Quality Ratio	Overall Labour Effectiveness	International Standard
22	10/05/2024	99%	100%	80%	79%	85%
23	13/05/2024	94%	100%	82%	77%	85%
24	14/05/2024	92%	96%	90%	80%	85%
25	15/05/2024	92%	96%	78%	69%	85%
26	16/05/2024	92%	96%	84%	74%	85%
27	17/05/2024	94%	98%	82%	76%	85%
28	20/05/2024	94%	100%	69%	64%	85%
29	21/05/2024	94%	100%	82%	77%	85%
30	22/05/2024	92%	100%	86%	80%	85%
31	24/05/2024	94%	100%	82%	77%	85%
32	27/05/2024	97%	100%	90%	88%	85%
33	28/05/2024	94%	100%	96%	90%	85%
34	29/05/2024	94%	100%	90%	85%	85%
Average		**96%**	**97%**	**85%**	**79%**	**85%**

Based on the calculation of the OLE value, 24 working days have not reached the set world standard, namely 85%. Meanwhile, the remaining 10 working days have reached the set world standards. This data obtained an average OLE value of 79%, which is below the world standard, namely 85%.

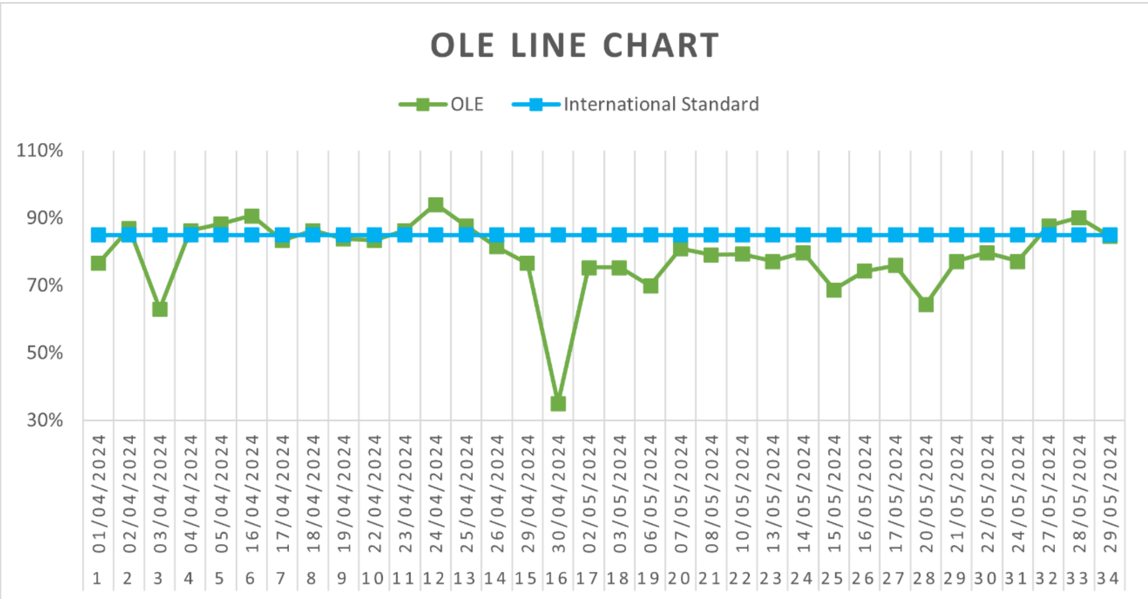

Figure 4.18 OLE Recapitulation Graph

Based on the graph above, the OLE value obtained by the Final Regulation UP section is on average 79%, which means it is below the set world standard value, namely 85%. Looking at the value per day, the Overall Labor Effectiveness (OLE) score obtained shows a fluctuating value where of the 34 data used, 24 data are below world standards, while the other 10 data are above world standards. The results of the data processing of the three Overall Labor Effectiveness (OLE) factors which include availability ratio, performance ratio, and quality ratio are presented in Table 4.12 to make it easier to compare the values obtained in the Final Regulation UP section against world standard values.

Table 4.12 Comparison Score

Ratio	Score	International Standard
Availability	96%	90%
Performance	97%	95%
Quality	85%	100%
Overall Labour Effectiveness	**79%**	**85%**

From Table 4.12, it is concluded that from 3 variables, the availability ratio and performance ratio are already greater than the international standard, meanwhile, the quality ratio is less than the international standard. Overall, the average OLE score is 79% which is lower than the international standard. The actual available time for production matches the planned production time, meaning there is no unplanned downtime or interruptions. The actual production speed and output match the planned or standard rates. But unfortunately, the output is not high quality enough, because there are defects or rework needed.

Although the only variable below the standard is quality, all three variables will still be analyzed because they are interrelated (availability, performance, and quality). A problem in one variable can affect the others. For instance, high performance might result from efforts to meet production targets, but it can lower quality due to errors or oversight. Analyzing all variables can provide a more comprehensive picture. The issue in quality may be influenced by hidden factors in availability or performance, making it essential to analyze all variables. Conducting an analysis using the RCA (Root Cause Analysis) method for all variables can help prevent potential issues in the future.

4.3.5 Root Cause Analysis From Availability Ratio

Overall, the Final Regulation UP group availability ratio value was 96%. The average value of the availability ratio, which is above world standards, indicates that the effectiveness of employee performance is quite good by utilizing the time availability determined by the company. The total number of operators working in this group is nine people per day. The standard time to produce one piano from this working group is 86,56 minutes, where the plan per day is 51 unit pianos. Therefore, the operator required to produce 51 units of pianos with eight working hours is 9 operators. The current condition of the Final Regulation UP operator is already 9, but still, there is a transfer in (± 1 operator) almost every day. Higher transfer makes the availability ratio higher but makes the productivity lower because of the excessive operator. Thus, the thing that will be discussed in this section is related to the number of operators which is still excessive. To solve the problem, 5why's method is used to know the root cause of the problem and give the corrective action. Figure 4.19 shows the 5why's created.

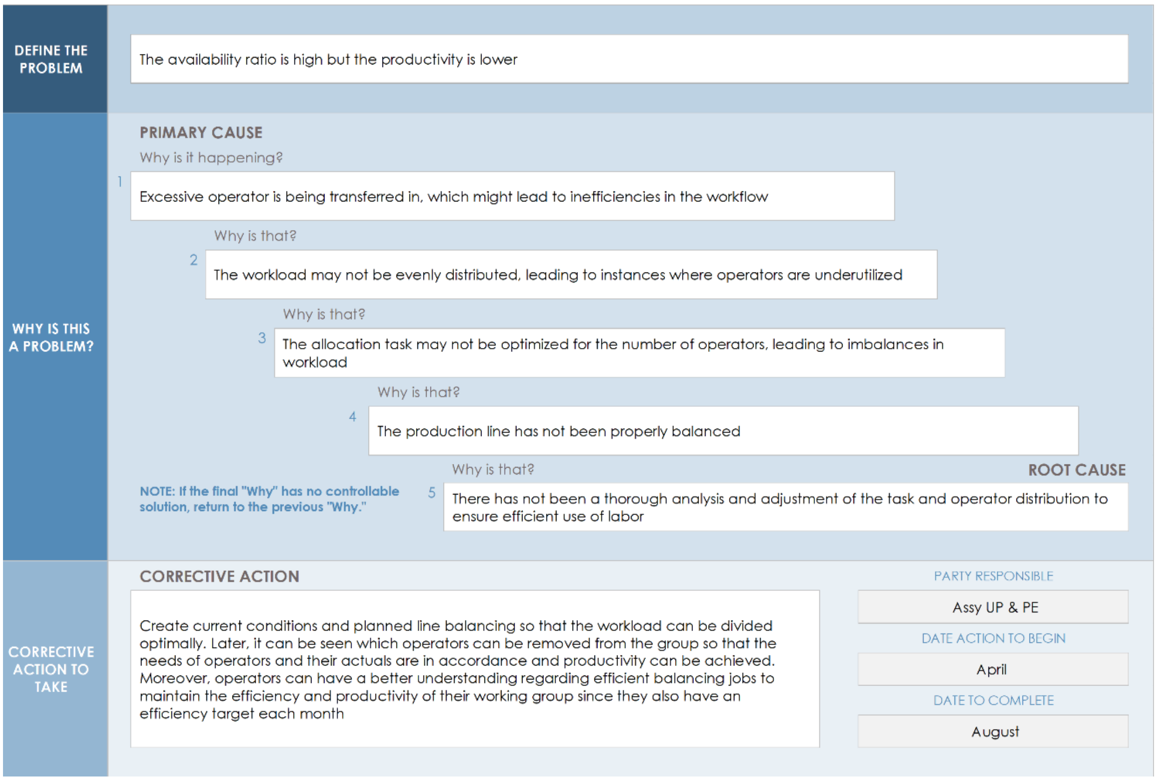

Figure 4.19 5 Why's of Availability Ratio

4.3.6 Root Cause Analysis From Performance Ratio

From 34 working days, there are 9 days that this group has not achieved the daily production target of 51 pianos. In April, the average output is 48,938 pianos, while in May, the average output is 50,333 pianos. Even though the performance ratio is already above the international standard, there should be an analysis of why the output each month does not achieve the production target to identify the root cause of the issue and offer recommendations for future improvements. The FTA approach is used to identify the problem's core cause and provide recommendations to address it. Figure 4.20 below is the FTA created.

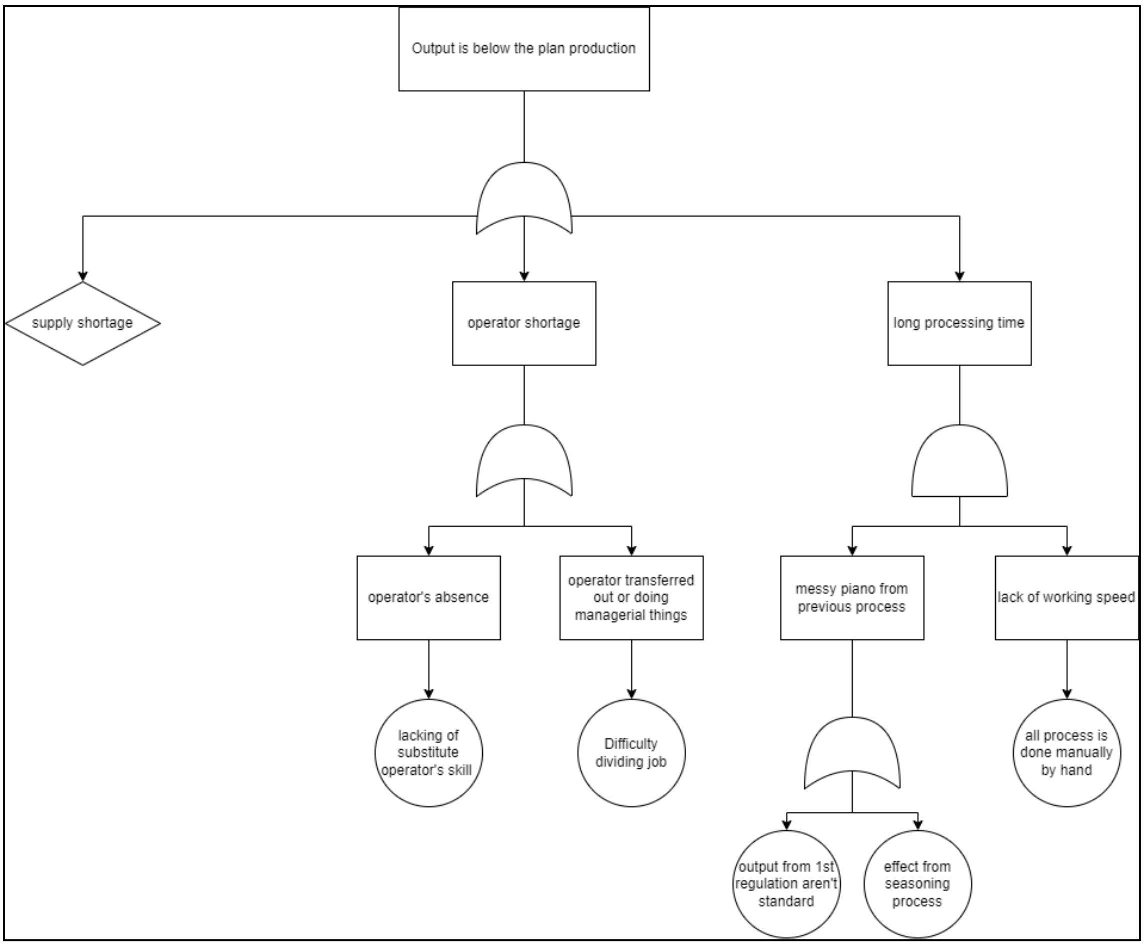

Figure 4.20 FTA of Performance Ratio

The root causes can be concluded based on Figure 4.20 above are:

1. Supply shortage
2. Operator shortage
3. Long processing time

4.3.7 Root Cause Analysis From Quality Ratio

From the computation of the quality ratio, it is clearly seen that all of the days from 34 working days data have defective products. The lowest is two defect units per day, and the highest is 16 defect units per day. This causes the quality ratio score obtained to be quite far below international standards. This variable also has the lowest value of the other three variables. In this section, two RCA methods will be used. The first is the Pareto diagram to determine the priority cause of the defect, and the second is the fishbone diagram to determine the root cause of the priority causes.

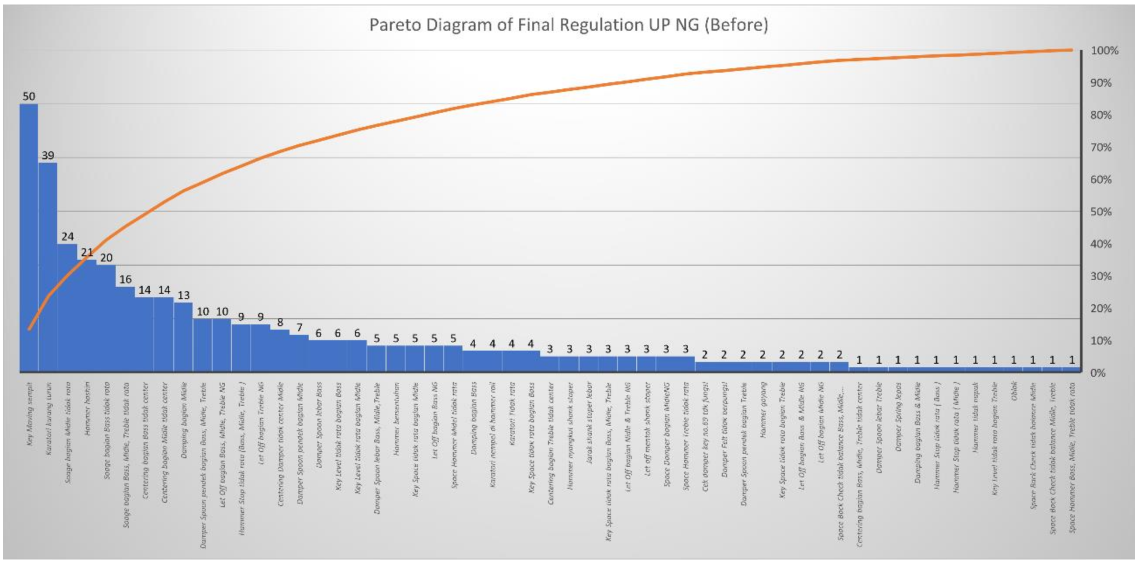

Figure 4.21 Inside Check UP NG Pareto Graph

Figure 4.21 shows the Pareto graph from Inside Check Assembly UP. This research will focus on the two greatest NGs to be solved through the kaizen from the 55 NG types found. In this case, *key moving sempit* and *karatori kurang turun* will be the highlight. A fishbone diagram will be used to reveal the root causes of the greatest problem. The following are the details.

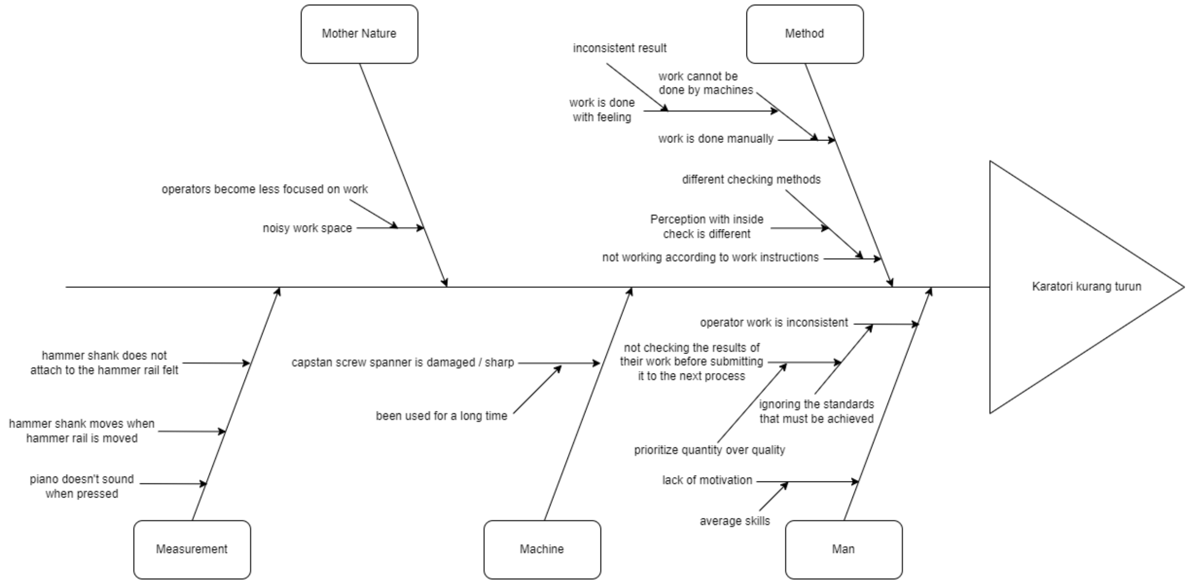

Figure 4.22 *Karatori Kurang Turun* Fishbone

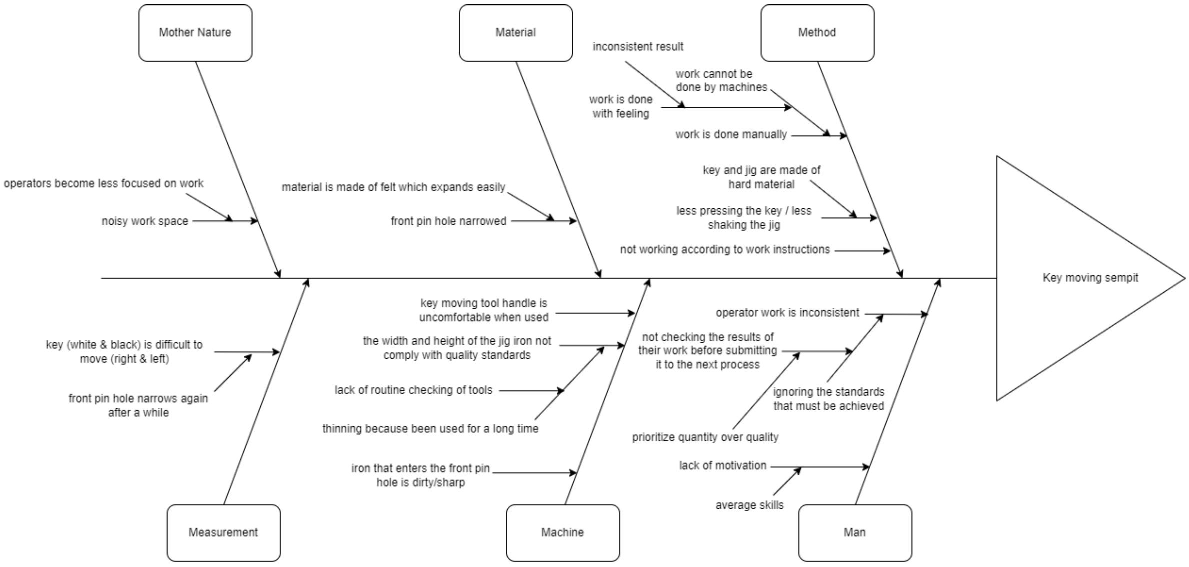

Figure 4.23 *Key Moving Sempit* Fishbone

The fishbone diagram above is the result of a brainstorming analysis to find the root of the problem broadly. The next step is to identify the kind of problem that arises. (Andersen & Fagerhaug, 2006) stated that not all problems are 'meaningful' and need to be eliminated to leave the main problem. The following table is the details for determining which problems are eliminated and which problems need to be solved.

Table 4.13 Possible Root Cause of *Karatori Kurang Turun* Elimination

Category	**Possible Root Cause**	**Discussion**	**Conclusion (Yes/No)**
Man	Prioritize quantity over quality	The Assembly UP department has a larger production plan than the Assembly GP department, which requires operators to achieve many targets each day with limited time and skills.	Yes
	Average Skills	Operators of Final Regulation mostly have average skills for each of the processes. The rating of the skills is 1-5, the higher is expert. This group's average rating is 3 which means they understand and rarely make mistake. With that score, the group thinks it is capable enough and there are no skill improvements. Moreover, they not have time to do it because of difficult to divide time between skill improvements and productions	Yes
Machine	Tools have been used for a long time	Tools (capstan screw spanner) is damaged because been used for a long time and no routine check	No

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
Measurement	Hammer shank does not attach to the hammer rail felt	The standard of *karatori* or lost motion is the hammer shank attached to the hammer rail felt but does not moves when hammer rail is moved	No
	Hammer shank moves when hammer rail is moved	The standard of *karatori* or lost motion is the hammer shank attached to the hammer rail felt but does not moves when hammer rail is moved	No
	Piano doesn't sound when pressed	The piano does not sound when pressed is happen when the piano is enter inside check process. This part is only done by inside check because there is a different way of working to check the *karatori* or lost motion with this group	Yes
Mother Nature	Operators become less focused on work	The final Regulation section is in an open area which is quite noisy because of the sound of the piano being processed	No
Method	Inconsistent result	This work is done manually by hand and uses the operator's feelings even though there is a standard.	Yes

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
		Thus, sometimes the result is not consistent, depending on the operator. Moreover, not all of the pianos are checked by the operator before sending it to the next process	
	Perception with the inside check is different	There was once a claim from Japan regarding this problem. This makes Inside Check add a process to its checks to anticipate the same thing, but this process is not added to the Final Regulation	Yes

Table 4.14 Possible Root Cause of *Key Moving Sempit* Elimination

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
Man	Prioritize quantity over quality	The Assembly UP department has a larger production plan than the Assembly GP department, which requires operators to achieve many targets each day with limited time and skills.	Yes
	Average Skills	Operators of Final Regulation mostly have average skills for each of the processes. The rating of the	Yes

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
		skills is 1-5, the higher is expert. This group's average rating is 3 which means they understand and rarely make mistake. With that score, the group thinks it is capable enough and there are no skill improvements. Moreover, they not have time to do it because of difficult to divide time between skill improvements and productions	
Machine	Iron thinning because been used for a long time	When the iron enters the front pin hole, friction occurs which can make the iron thin. This causes the felt expansion process to be less than optimal	Yes
	Iron that enters the front pin hole is dirty/sharp	Dirty/sharp iron can cause the felt expansion process to be less than optimal. Even can make the felt damaged	No
Measurement	Front pin hole narrows again after a while	Front pin hole narrow again after a while could be happen because of the process is not optimal or the material itself	Yes
Mother Nature	Operatos become less focused on work	The final Regulation section is in an open area which is	No

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
		quite noisy because of the sound of the piano being processed	
Material	Material is made of felt which expands easily	After the key moving process, the felt can expand again because the material expands easily	No
Method	Inconsistent result	This work is done manually by hand and uses the operator’s feelings even though there is a standard. Thus, sometimes the result is not consistent, depending on the operator. Moreover, not all of the pianos are checked by the operator before sending it to the next process	Yes
	Key and jig are made of hard material	The key is hard to press into the jig, and the jig is hard to shake. This sometimes makes the operator less optimum to do this process because can make their hand hurt, even when using hand gloves	No
	Not working according to work instructions	Because of many planned productions that need to be achieved, operators work in a hurry and pay less	No

Category	Possible Root Cause	Discussion	Conclusion (Yes/No)
		attention to work instructions and quality	

Then, after eliminating the problems found, the results of the root causes obtained are as follows:

1. *Karatori kurang turun*
   a. Prioritize quantity over quality
   b. Average skills
   c. A piano doesn’t sound when pressed
   d. Inconsistent result
   e. Perception of the inside check is different
2. *Key moving sempit*
   a. Prioritize quantity over quality
   b. Average skills
   c. Iron thinning because been used for a long time
   d. The front pinhole narrows again after a while
   e. Inconsistent result

CHAPTER V
DISCUSSION

After completing the data collection and processing of the research data conducted, this chapter will discuss the results of the previous chapter. This research was conducted using three variables based on the Overall Labor Effectiveness (OLE) method, namely availability, performance, and quality. The following are the detailed discussions regarding these three variables.

5.1 Availability Ratio Analysis

Availability Ratio measures the proportion of time that resources (such as labor) are available for productive work compared to the total scheduled or planned time. On average, the availability ratio for the Final Regulation UP group is 96%, whereas the international standard is 90%. With these average results, it does not indicate any significantly poor performance because the availability ratio value is still above the international standard.

There are three days that the availability ratio is higher than 100%. This is caused by high transfer in time compared to lost time and available time. There are almost transfers in for this group each day. If the number of operators available exceeds the planned needs or time, the availability ratio can exceed 100%. Besides that, there are four days that the availability ratio is equal to 100%. A 100% availability ratio is an ideal situation in terms of workforce presence. It indicates that the labor force was fully available for the entire scheduled work period without any disruptions. Then, the remaining 27 days are in the range of 91% - 100%.

An Availability Ratio value greater than 90% can have both positive and negative implications, depending on the context and the reasons behind the number. It is said to be positive if the additional labor is used to increase production output or complete additional work, and the quality of work and overall productivity increases. However, if the extra labor is not used productively or if there is a waste of resources, it can be considered inefficient. In addition, having excessive labor without enough work can result in decreased productivity.

Underutilization of labor can lead to decreased overall productivity and efficiency. This is also what makes the target of increasing productivity by 15% for this group not yet achieved. Because the number of existing operators is still excessive to achieve the target. Therefore, even though the availability ratio value for this group is higher than the international standard, this does not mean that the value can be said to be efficient.

5.2 Performance Ratio Analysis

A performance ratio of 97% means that, on average, the labor force is working at 97% of its expected performance level when they are available and working. It signifies a high level of efficiency, with only a 3% loss in performance due to factors such as slower-than-expected work speeds, minor inefficiencies, or slight deviations from the optimal pace. Based on the Fault Tree Analysis (FTA) in Chapter 4, the root causes are:

1. Supply Shortage: This is an immediate and direct root cause that affects production.
2. Operator Shortage: This is another significant root cause which further branches out into:
    a. Operator's Absence: Lack of substitute operator's skill.
    b. Operators Transferred Out or Doing Managerial Tasks: Leading to difficulty in job division.
3. Long Processing Time: This root cause has several contributing factors:
    a. Messy Output from Previous Processes: Affected by non-standard outputs from First Regulation and issues from the Seasoning process.
    b. Lack of Working Speed: All processes are being done by hand without automation.

In summary, a 97% performance ratio in the context of OLE indicates that the labor force is nearly operating at peak efficiency, with very little room for improvement in terms of speed during working hours.

5.3 Quality Ratio Analysis

Based on the computation, the quality ratio from this group is 85% by 34 days. This means that only 85% are of acceptable quality (meet the required quality standards without defects or the need for rework), while the remaining 15% are either defective or require some form of rework to meet quality standards. This indicates significant room for improvement, it highlights the need for targeted improvements in quality control, workforce training, process optimization, and technology investment to enhance overall production efficiency and effectiveness.

Because most of the Final Regulation UP process is done by hand, the operator of this group must have a full awareness regarding the quality they made. A low-quality ratio but a high-performance ratio indicates that the operator has less quality awareness but prioritizes quantity over quality. In fact, quality is just as important as achieving production targets. Moreover, since there is a specific operator to do the Check and Repair Regulation process, which is the process of checking the result from the final regulation process and reworking the NG finding from the Inside Check-UP, if all of the operators could ensure they meet the standard and also rework product is decreased, this operator can move to help the main process, and this group can decrease one operator. As a result, both OLE and productivity value will be increasing.

5.4 OLE Score Analysis

The availability score (96%) is higher than the international standard (90%), the performance score (97%) is slightly above the international standard (95%), and the quality score (85%) is significantly below the international standard (100%). Overall, the OLE score is 79%, which is lower than the international standard of 85%. From these values, it can be concluded that the Final Regulation UP does not yet have good labor effectiveness. During the research conducted from April to May 2024, only 10 out of 34 working days of this group were able to exceed the international OLE standard value.

The highest OLE value is on data-12 with the value of a 100% availability ratio, a 100% performance ratio, and a 94% quality ratio, and then the OLE value is 94%. This is influenced by working hours and the output produced is appropriate and reaches the target. Meanwhile, the lowest OLE value is on data-16 with the value of a 94% availability ratio, a 47% performance ratio, 79% quality ratio, and then the OLE value is 35%. This is influenced by the output produced not reaching the target and there are several defects.

That lower score of OLE is mainly affected by the lower quality ratio. This variable is what needs to be studied more deeply and corrective action taken. The leader of this group even said that the 2 biggest NG findings in this group have always been there for several years but there has been no action to resolve them. By focusing on improving quality, the overall efficiency and effectiveness of the labor force can be further enhanced, leading to better compliance with international standards and higher overall productivity.

5.5 Proposed Recommendation (Kaizen)

The following are the proposed recommendations for each of the three variables based on the root cause that was already analyzed in the previous chapter.

5.5.1 Availability Ratio

1. Optimize Workforce Schedule

   Implement dynamic scheduling systems that adjust the number of workers based on real-time demand and workload requirements. This helps prevent overstaffing and understaffing.
2. Create Line Balancing With The Appropriate People's Needs

   It is important to create a group line balance in order to know how optimal each operator's work is. In addition to the actual line balance, a line balance plan can also be created to find out how many people and how the work is divided so that productivity targets can be achieved.
3. Transfer Management improvements

   Develop clear policies for transferring workers in and out of different production areas. Regularly monitor and analyze the effectiveness of worker transfers. Identify if transfers are genuinely needed or if they are contributing to inefficiencies.
4. Review and Adjust Working Hours

   Ensure that working hours are closely aligned with production demand. Avoid scheduling more working hours than necessary, which can lead to overstaffing.

5.5.2 Performance Ratio

1. Optimize Workforce Allocation

   Ensure operators are allocated efficiently, balancing operational and managerial tasks to avoid bottlenecks. Previously, the Line Balance of the Final Regulation UP group was as follows.

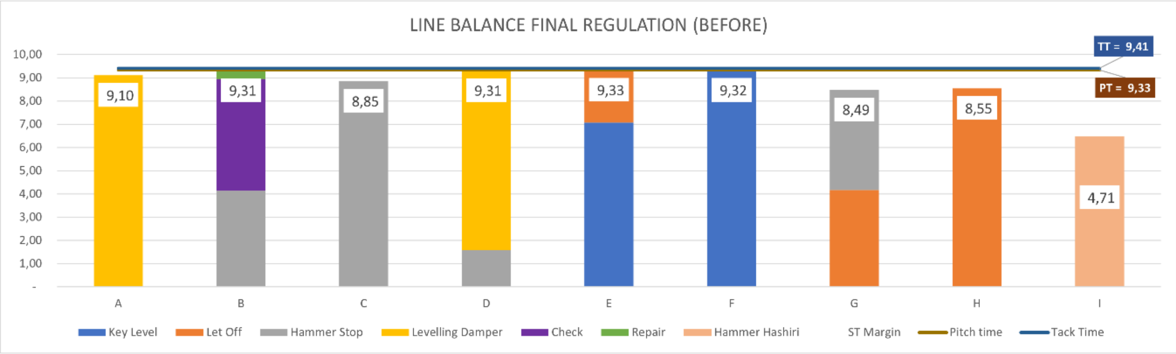

Figure 5.1 Line Balance (Before)

Starting on August 1st, 2024, the Line Balance Plan has already been implemented. This Line Balance plan is made in order to achieve the productivity target which is 0,836 units/man/hour where the required operators are 7. Through kaizen, step-by-step line balancing, and because production decreased from 51 units per day to 46 units per day, this group can reduce 2 operators from 9 total operators. The Line Balance current is as follows.

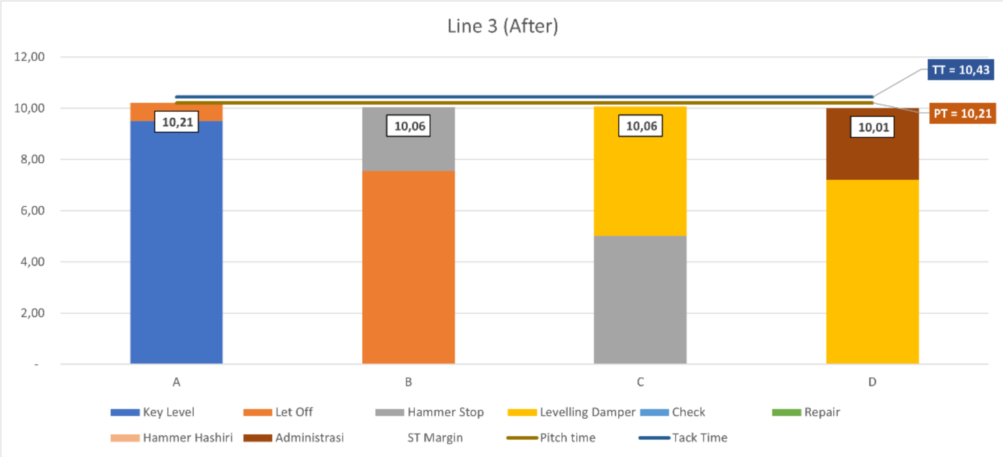

Figure 5.2 Line 3 Line Balancing (After)

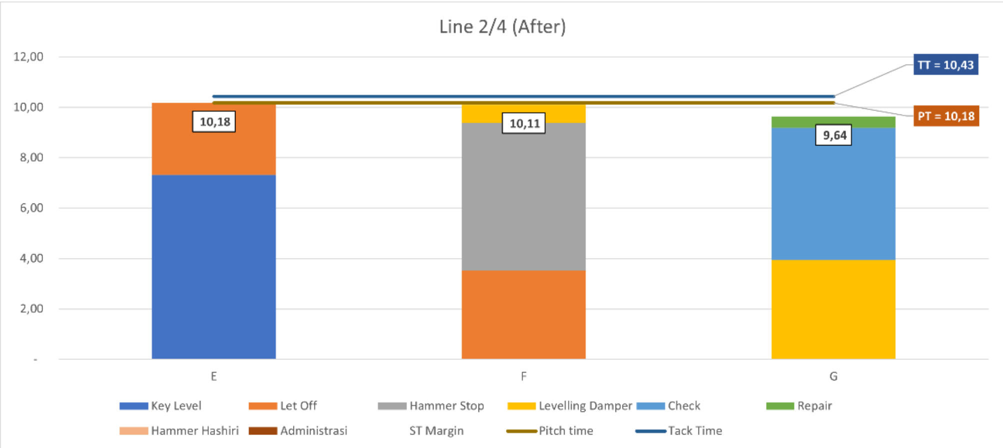

Figure 5.3 Line 2/4 Line Balancing (After)

2. Standardize Processes

   Establish clear standards and protocols for each stage of the production process to reduce variability and inefficiencies.

3. Improve Output Quality from Previous Processes

   To avoid adding to the workload for the Final Regulation, review the parts that definitely will change during seasoning and ensure that the other parts can maximize the quality from the first Regulation.

5.5.3 Quality Ratio

1. Monitoring and recording of operator work results

   Operators on Final Regulation UP often prioritize quantity over quality, because they assume that, in the end, it will also be checked and repaired. Therefore, operators sometimes do not check the results of their work before giving it to the next process, which causes many findings of NG (Not Good) on the pianos produced by this group when entering the Inside Check process.

In the findings of NG Inside Check, there is no name of the operator who did the work. So the operators whose work is lacking cannot be detected. This factor is one of the reasons why the operators are less aware of providing the best quality in their work. The absence of sanctions imposed on the operator concerned also makes NG a common thing and has happened since long ago. The role of the group leader is very important here to be able to control the results of his group's work and remind the importance of quality so that the percentage of NG can be reduced and improve the quality of the piano produced by his group.

Therefore, the kaizen needs to prioritize quantity over quality problems by monitoring and recording operator work results. This kaizen is already done on June 4th, 2024. Figure 5.1 below shows the NG resume from the recording process.

RESUME NG PROSES FINAL REGULATION (4-6 JUNI'24)

Tgl	Nama	No Piano	NG	Qty
04/06/2024	Heru	4	Soage (bass)	1
		8	Hammer Stop tidak rata (bass)	1
		12	Centering tidak center (middle)	1
	Aknes	6 & 13	Key Moving sempit	2
	Via	11	Key Moving sempit	1
	Santi	1	Let Off NG (treble)	1
		3	Key Space tidak rata	1
	Atika	5	Key Space tidak rata	1
	Khasan	2	Space Hammer tidak rata (treble)	1
		7 & 9	Hammer Stop tidak rata (bass)	2
		9	Hammer Stop tidak rata (treble)	1
		10	Centering tidak center (middle)	1
05/06/2024	Heru	26	Centering tidak center (middle)	1
	Aknes	23	Key Moving sempit	1
	Via	25	Key Lift Up seret	1
	Riyan	21 & 22	Hammer Stop tidak rata (bass)	2
		24	Karatori kurang turun	1
	Silent	20	Space Damper NG (middle)	1
		27	Soage	1
06/06/2024	Aknes	31	Key Lift Up seret	1
	Via	30	Key Moving sempit	1
	Atika	35	Hammer Stop tidak rata (bass)	1
	Khasan	34	Hammer Stop tidak rata (middle)	1
		34	Hammer Stop tidak rata (treble)	1
		34	Space Back Check tidak balance (bass)	1
	Silent	32	Space Damper NG (middle)	1
		33	Key Lift Up seret	1
07/06/2024	Aknes	44	Karatori kurang turun	1
		45	Key Lift Up seret	1
	Via	46	Key Moving sempit	1
	Santi	40	Space Hammer tidak rata (bass)	1
	Khasan	42	Space Back Check tidak balance (bass)	1
		42	Space Back Check tidak balance (middle)	1
		42	Space Back Check tidak balance (treble)	1
	Riyan	41	Hammer Stop tidak rata (bass)	1
	Silent	47	Key Lift Up seret	1
		47	Space Back Check tidak balance (bass)	1
		47	Space Back Check tidak balance (middle)	1
		47	Space Back Check tidak balance (treble)	1
				42

Nama	Total NG	%
Heru	4	10%
Aknes	6	14%
Via	4	10%
Atika	2	5%
Santi	3	7%
Khasan	11	26%
Riyan	4	10%
Silent	8	19%
	42	

Figure 5.4 NG Resume

The check operator is doing the recording of each reworked process, then the researcher will make the resume. The resume of the record will show the NG name, the responsible operator, and the count of NG per operator. These results become evaluation and monitoring material for the leader in the morning briefing. Psychologically, operators will have a feeling of not wanting their names to be recorded and become evaluation material, so they will try to improve the quality of their work. The leader also conveys every morning briefing to check the results of their work before being submitted to the next process.

2. Skill improvement

   Operators of Final Regulation mostly have average skills for each of the processes. The rating of the skills is 1-5; the higher is expert. This group's average rating is three, which means they understand and rarely make mistakes. Even though they believe they are capable enough, they still need to develop their skills to become more proficient in the work, be more nimble, and generate work of higher quality. Additionally, operators must be multiskill to support other tasks in the event of an emergency.

3. Create a limited sample

   There are still rework findings from the Final Regulation Group. And the standard limit guide for the quality of the operator's work on the line has not been installed. Although the operators in this group are experienced, in terms of data, the quality of the piano from this group is still lacking because there are still many NG findings. It is important to have a standard limit guide for the quality of work stored on the line. So that operators can continue to see it and always remember the standards that must be achieved from the results of their work. This kaizen is to solve the problem of inconsistent results, it was already done on June, 19th 2024, below is the figure of the limit sample that was installed in the line.

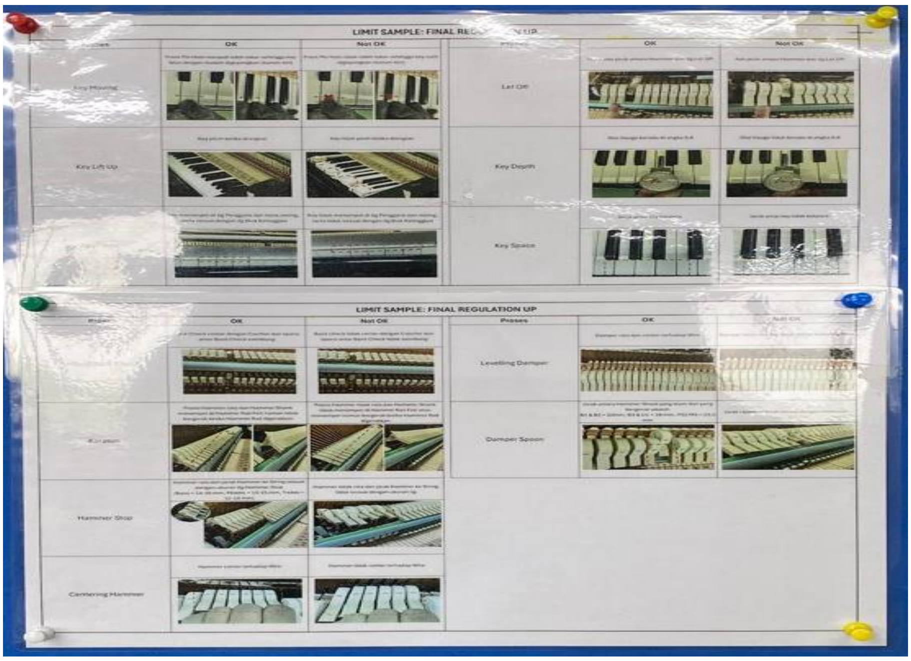

Figure 5.5 Limit Sample

In this limit sample, there is an explanation and documentation of the process that results in OK and Not OK. This limit sample has been confirmed to the leader and inside check to ensure its accuracy. This limit sample is expected to be a guide to the operator's work quality standard limits, and the result from this working group could be consistent. So the operator must ensure that all work results are OK, if they are still Not OK, then they must be worked on again until it is OK and the standard is achieved. This limit sample also functions if there is a transfer in operators, they can understand the standards that must be achieved and ensure they are achieved.

4. Build the same perception between operators and the inspection team

   Inside check is a group that is tasked with checking the inside of the piano, including checking the work results of the Final Regulation UP group. It was found that there were different standards between the inside check and this group, especially in the *karatori* (lost motion) process which caused many findings of NG *karatori kurang turun*. So far, the final regulation UP and inside check groups have their own standards and checking methods. Therefore, it is necessary to have a common perception between these two groups so that they have the same standards, and can reduce NG findings. This kaizen is to the problem of perception with the inside check being different, and the piano doesn't sound when pressed, it was done on May, 15^{th} 2024, and the result is Final Regulation UP follows the standard from Inside Check.

Figure 5.6 Build the same perception with Inside Check

5. Create a new key moving jig

   This kaizen is to solve the *key moving sempit* problem that happens because of iron thinning, and the front pinhole narrows again after a while. Pin Jig Key Moving, which has become thinner due to long-term use, is one of the root causes of narrow NG key moving. As a result, the front pinhole does not widen perfectly and narrows quickly. Then, kaizen is needed to make a new key moving jig with a larger size (0.01 mm larger than the old jig). This kaizen was done on June 26th, 2024; the following is the comparison figure between the old jig and the new jig.

Figure 5.7 Old Key Moving Jig

Figure 5.8 New Key Moving Jig

With those implemented kaizens, this group has been achieving a productivity of 13% which is 0,821 man hours with the graph as follows. This productivity value is computed based on efficiency Department UP data of August week 2. Figure 5.9 shows the productivity graph for Final Regulation UP.

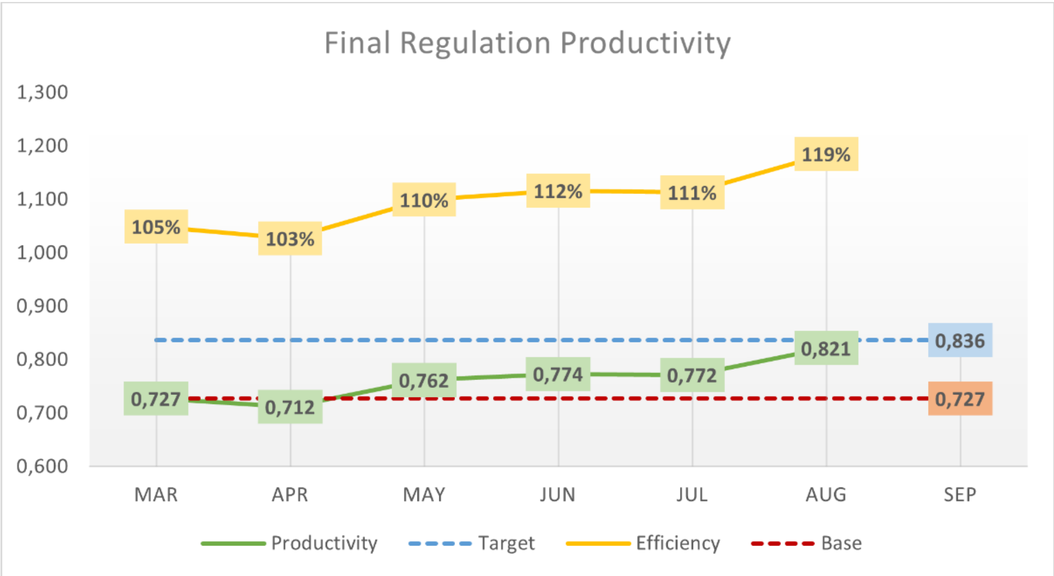

Figure 5.9 Final Regulation UP Productivity (After)

Furthermore, the biggest 2 NG (*key moving sempit* and *karatori kurang turun*) have decreased significantly. The overall NG also decreases which will make the quality ratio higher. The following is the Pareto Diagram regarding NG of Final Regulation UP.

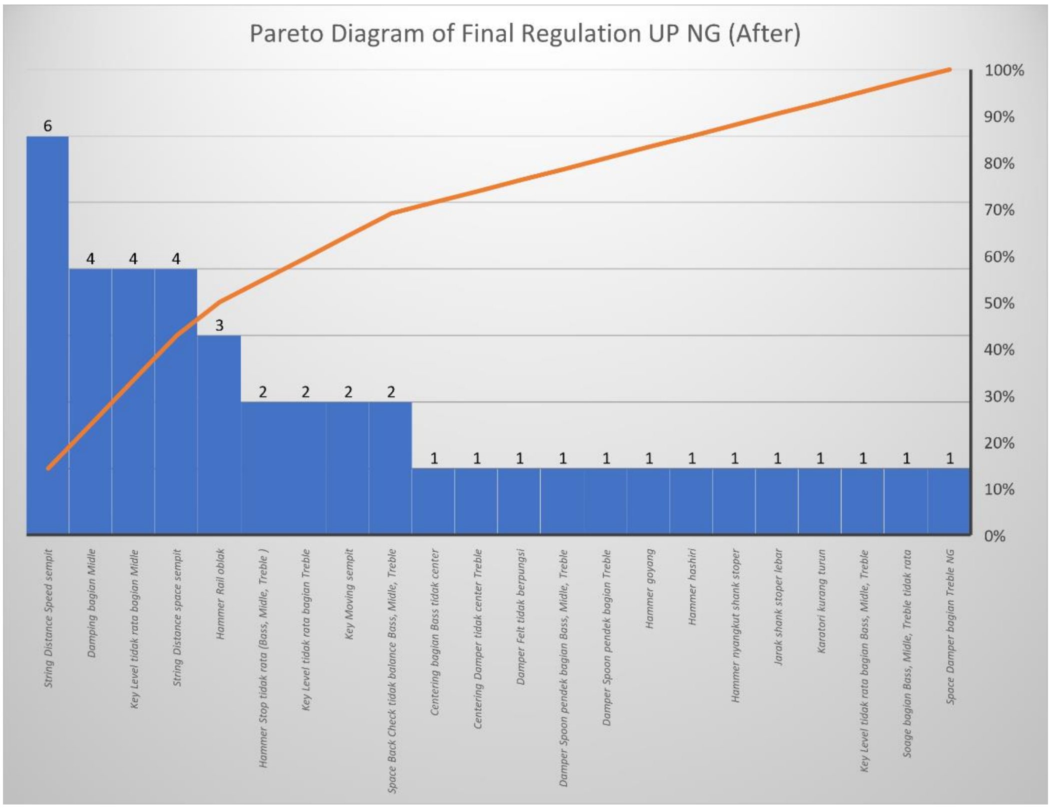

Figure 5.10 NG Pareto Diagram (After)

5.6 Overall Labor Analysis (OLE) Score After Kaizen

After the kaizen is implemented, the OLE score will be calculated again to show the effect of the kaizen. The after-kaizen data is observed within 2 weeks, from August 1st until August 14th, 2024. Further explanation will be shown below.

5.6.1 Availability Ratio (After)

The following availability data is based on 7 total operators. Now, there is no transfer in for this working group. But on data-8th there is a transfer out for 440 minutes that will lead to a lower availability ratio for that day.

Table 5.1 Availability Ratio Data (After)

Data	Date	Absent (Minutes)	Non Production Time (Minutes)	Transfer Out (Minutes)	Transfer In (Minutes)
1	01/08/2024	0	0	0	0
2	05/08/2024	0	0	0	0
3	06/08/2024	0	0	0	0
4	07/08/2024	0	0	0	0
5	08/08/2024	0	0	0	0
6	12/08/2024	0	0	0	0
7	13/08/2024	0	0	0	0
8	14/08/2024	0	0	440	0

Next, the availability ratio is computed, in the same way as the previous computation.

Table 5.2 Availability Ratio (After)

Data	Date	Availability Ratio	International Standard
1	01/08/2024	100%	90%
2	05/08/2024	100%	90%
3	06/08/2024	100%	90%
4	07/08/2024	100%	90%
5	08/08/2024	100%	90%
6	12/08/2024	100%	90%
7	13/08/2024	100%	90%
8	14/08/2024	87%	90%
Average		**98%**	**90%**

Previously, the availability ratio was 96%, after the kaizen, the availability ratio is 98% as shown in Table 5.1. The availability ratio is increased by 2%, indicating there is a positive impact from the kaizen. This 2% increase, while seemingly modest, reflects a significant enhancement in labor availability and operational readiness. Only 1 day that the availability ratio is below the international standard due to the transfer out of 440 minutes. But the other 7 days get 100% of the availability ratio which means there are no excess working hours or lost working hours.

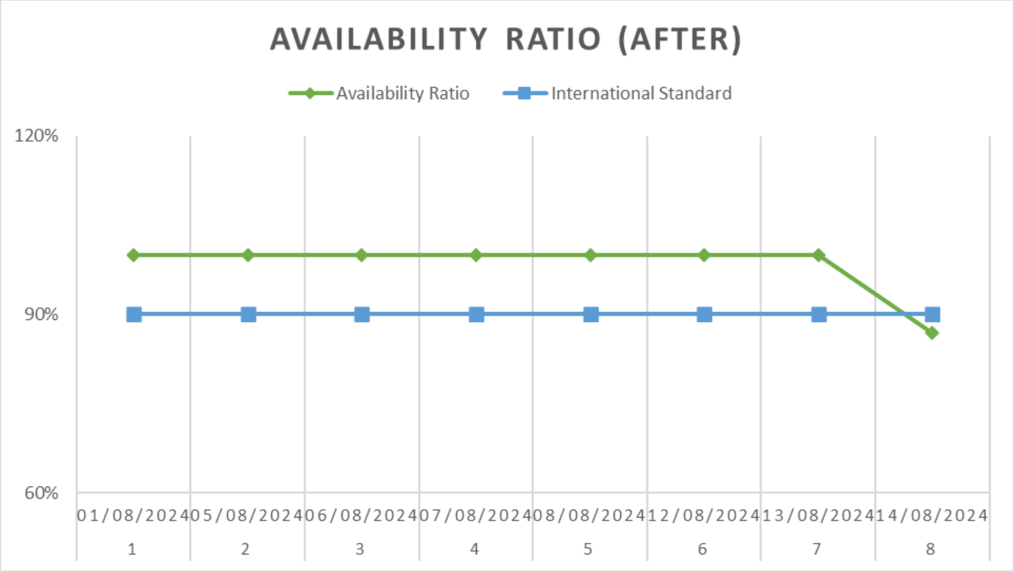

Figure 5.11 Availability Ratio Graph (After)

There is a significant difference between the availability ratio graph before and after. Before, the trend fluctuated compared to now when the trend is more stable. After kaizen indicates a positive impact on the availability ratio. The required operator and the actual operator now is equal. Proven by the availability ratio value which is mostly 100%.

5.6.2 Performance Ratio (After)

The performance ratio data is based on the new target production which is 46 units per day. The following is the data obtained for the first 2 weeks of August.

Table 5.3 Performance Ratio Data (After)

Data	**Date**	**Production Output (Unit)**	**Production Target (Unit)**
1	01/08/2024	46	46
2	05/08/2024	46	46
3	06/08/2024	46	46
4	07/08/2024	46	46
5	08/08/2024	46	46
6	12/08/2024	46	46
7	13/08/2024	46	46
8	14/08/2024	40	46

Furthermore, the computation for performance ratio will be computed.

Table 5.4 Performance Ratio (After)

Data	Date	Production Output (Unit)	Production Target (Unit)	Performance Ratio	International Standard
1	01/08/2024	46	46	100%	95%
2	05/08/2024	46	46	100%	95%
3	06/08/2024	46	46	100%	95%
4	07/08/2024	46	46	100%	95%
5	08/08/2024	46	46	100%	95%
6	12/08/2024	46	46	100%	95%
7	13/08/2024	46	46	100%	95%
8	14/08/2024	40	46	87%	95%
Average				**98%**	**95%**

Previously, the performance ratio was 97%, after kaizen, the performance ratio is 98% as shown in Table 5.3. The performance ratio is increased by 1%, indicating there is a positive impact from the kaizen. Following the implementation of kaizen, the performance ratio increased from 97% to 98%. This 1% improvement reflects a tangible enhancement in how efficiently the workforce performs their tasks. Even though the performance ratio was already high before kaizen, the continuous improvement approach has led to further optimization, indicating that the workforce is now working closer to its full potential. This improvement, while seemingly small, can have significant cumulative effects on overall productivity and operational efficiency over time. Only 1 day that the performance ratio is below the international standard. This is because two operators are being transferred out. Thus, this working group cannot perform and has a debt of 6 piano units.

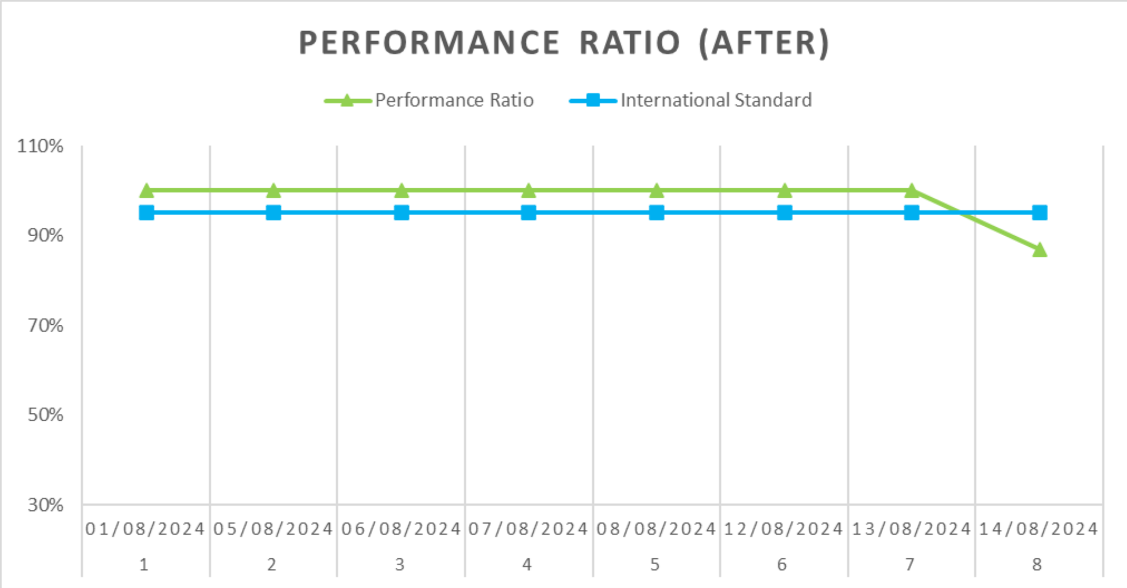

Figure 5.12 Performance Ratio Graph (After)

Based on Figure 5.10, the trend of the performance ratio is now more stable except for the last day. Even though the percentage now compared to before is not much different, but there is still good progress in the performance ratio.

5.6.3 Quality Ratio (After)

This variable is the main factor that previously the OLE score was below standard. Looking at the table below, the unit defect per day has decreased from the previous. Before kaizen, the average defect piano per day is 7-8 units. After kaizen, the average defect piano per day is 3-4 units. Overall, the defect from this group has decreased by ± 50%.

Table 5.5 Quality Ratio Data (After)

Data	Date	Production Output (Unit)	Production Target (Unit)	Defect Product (Unit)
1	01/08/2024	46	46	2
2	05/08/2024	46	46	4
3	06/08/2024	46	46	1
4	07/08/2024	46	46	4
5	08/08/2024	46	46	3
6	12/08/2024	46	46	5
7	13/08/2024	46	46	5
8	14/08/2024	40	46	6

The next step is to transform the data into the quality ratio based on the formula in Chapter 2.

Table 5.6 Quality Ratio (After)

Data	Date	Production Output (Unit)	Production Target (Unit)	Defect Product (Unit)	Quality Ratio	International Standard
1	01/08/2024	46	46	2	96%	100%
2	05/08/2024	46	46	4	91%	100%
3	06/08/2024	46	46	1	98%	100%
4	07/08/2024	46	46	4	91%	100%
5	08/08/2024	46	46	3	93%	100%
6	12/08/2024	46	46	5	89%	100%
7	13/08/2024	46	46	5	89%	100%
8	14/08/2024	40	46	6	85%	100%
Average					**92%**	**100%**

Previously, the quality ratio was 85%, after kaizen, the quality ratio is 92%. Even though all of the eight days did not achieve the standard, the score now increased by 7%. This means that the defect per day is decreased. The highest defect unit per day from this group after kaizen is six units, and the lowest is 1 unit. The kaizen impact on the quality ratio can bring about good changes. The implementation of kaizen has significantly improved the quality ratio, increasing it from 79% to 92%. This 13% improvement reflects a substantial enhancement in the quality of work performed by the labor force. The increase indicates that the continuous improvement practices of kaizen have effectively addressed issues related to defects and inefficiencies in the production process, resulting in higher quality output and better overall operational performance.

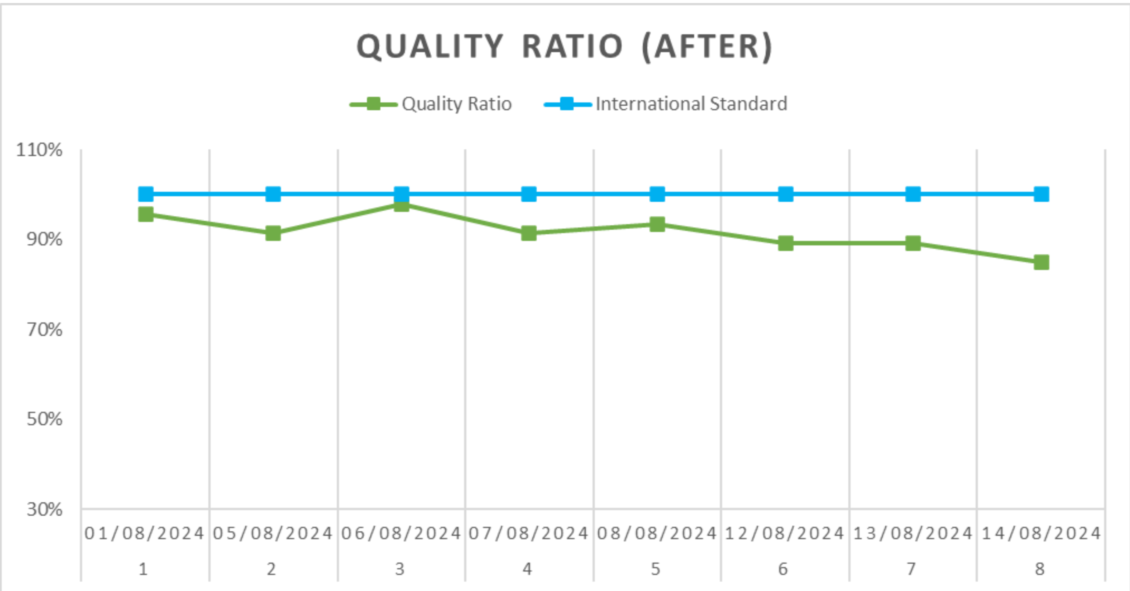

Figure 5.13 Quality Ratio Graph (After)

Even though the trend is still below the standard, now the trend is not that far from the standard. Different than the quality ratio graph before, there is a big gap between the quality ratio trend and the international standard gap.

5.6.4 OLE Score (After)

The OLE results after kaizen showed good changes. The following is the result from multiplying the result from the availability ratio, performance ratio, and quality ratio.

Table 5.7 OLE Score (After)

No	Date	A	P	Q	OLE	International Standard
1	01/04/2024	100%	100%	96%	96%	85%
2	02/04/2024	100%	100%	91%	91%	85%
3	03/04/2024	100%	100%	98%	98%	85%
4	04/04/2024	100%	100%	91%	91%	85%
5	05/04/2024	100%	100%	93%	93%	85%
6	16/04/2024	100%	100%	89%	89%	85%
7	17/04/2024	100%	100%	89%	89%	85%
8	18/04/2024	87%	87%	85%	64%	85%
Average		98%	98%	92%	89%	85%

Previously, the OLE score was 79%, which is below the international standard. Now, the OLE score is 89%, which is above the standard. The difference in OLE scores before and after kaizen action is 10%.

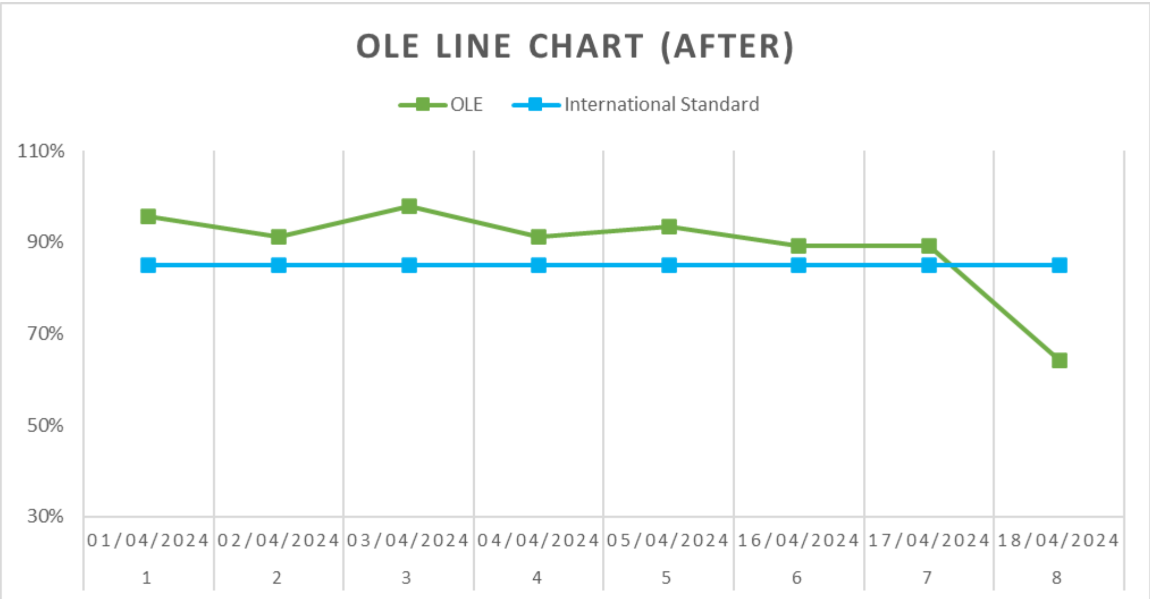

Figure 5.14 OLE Score (After)

Prior to the implementation of the Kaizen, the Overall Labor Effectiveness (OLE) score was 79%, which was below the industry standard of 85%. This indicated inefficiencies in labor utilization and highlighted the need for process improvements. After applying the Kaizen methodology, which focused on continuous improvement and waste reduction, the OLE score increased significantly to 89%, surpassing the standard. This improvement demonstrates the effectiveness of the Kaizen approach in optimizing labor efficiency, leading to enhanced productivity and operational performance.

CHAPTER VI
CLOSING

6.1 Conclusion

The following conclusions have been drawn by the researcher based on the completed research:

1. The Overall Labor Effectiveness (OLE) value of the Final Regulation UP working group during 34 days of observation was 79%, which is below the international standard of 85%. The value of each variable is 96% for the availability ratio, with an international standard value of 90% (higher than the international standard). Value of 97% for the performance ratio, with an international standard value of 95% (higher than the international standard). Value of 85% for the quality ratio, with an international standard value of 100% (lower than the international standard). The low OLE value is influenced by the quality ratio values , which are quite far from the international standard.
2. The results of the Root Cause Analysis (RCA) method show that the problems that occur are; there are excess operators because the appropriate line balancing has not been carried out, the production target is not achieved because of the difficulty in organizing work with a fairly long process time, and many NG findings with the two largest findings being the focus (*key moving sempit* and *karatori kurang turun*).
3. The proposed improvements are made by referring to the problems faced by the Final Regulation UP. For the problem of excess operators, the suggestions that can be given are to optimize the workforce schedule, create line balancing with the appropriate people's needs, transfer management improvements, and review and adjust working hours. If the problem production target is not achieved, the suggestions that can be given are to optimize workforce allocation, standardize processes, and improve output quality from previous processes. For the NG problems, the suggestions that can be given are monitoring and recording operator work results, skill improvement, creating a limit sample, building the same perception between operators and the inspection team, create a new key moving jig.

6.2 Suggestion

The following are suggestions that the researcher could provide.

1. For Further Research

a. Conduct OLE research on each operator to get more accurate results.
b. Analyze operator workload to obtain other factors that can be considered in providing improvement proposals.

2. For the company

   Companies can run kaizen that focuses on reducing defective products, especially defects that occur frequently, seeing the lowest OLE value from the quality ratio. Therefore, the defects can be analyzed thoroughly to find the cause of each defect.

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APPENDIX

Figure 8.1 Final Regulation Up Group

Table 8.1 NG's Glossary

No	NG's Name	Description
1	*Key moving sempit*	"*Key moving sempit*" refers to an issue in keyboard instruments, such as pianos, where the keys—either black or white—are stiff or difficult to move. This problem is often caused by the felt around the keys being too tight, restricting the smooth movement of the keys. The felt, which is designed to cushion the action of the keys, can sometimes become compressed or improperly aligned, leading to friction that prevents the keys from functioning as intended. This can affect the playability of the instrument and may require adjustments or repairs to restore proper key movement.
2	*Karatori kurang turun*	"*Karatori kurang turun*" refers to an issue in pianos where the capstain screw is not lowered sufficiently during the adjustment process. The capstain screw plays a crucial role in regulating the action of the piano keys. When it is not lowered enough, the hammer may not strike the strings properly, leading to the keys either failing to produce sound or producing inconsistent tones. This issue can affect the responsiveness of the keyboard and may require careful adjustment to restore proper functionality and sound.