

## **COPYRIGHT WARNING**

This paper is protected by copyright. You are advised to print or download **ONE COPY** of this paper for your own private reference, study and research purposes. You are prohibited having acts infringing upon copyright as stipulated in Laws and Regulations of Intellectual Property, including, but not limited to, appropriating, impersonating, publishing, distributing, modifying, altering, mutilating, distorting, reproducing, duplicating, displaying, communicating, disseminating, making derivative work, commercializing and converting to other forms the paper and/or any part of the paper. The acts could be done in actual life and/or via communication networks and by digital means without permission of copyright holders.

The users shall acknowledge and strictly respect to the copyright. The recitation must be reasonable and properly. If the users do not agree to all of these terms, do not use this paper. The users shall be responsible for legal issues if they make any copyright infringements. Failure to comply with this warning may expose you to:

- Disciplinary action by the Vietnamese-German University.
- Legal action for copyright infringement.
- Heavy legal penalties and consequences shall be applied by the competent authorities.

The Vietnamese-German University and the authors reserve all their intellectual property rights.





RUHR-UNIVERSITÄT BOCHUM

**MechEng**  
Mechanical Engineering



Vietnamese-German University

# CONTINUOUS IMPROVEMENT BY APPLYING 5S AND SMED TOOLS IN DEEP GROOVE BALL BEARING AUTOMATIC PRODUCTION LINE

BACHELOR THESIS

BINH DUONG, 2023



Vietnamese-German University

**SUBMITTED BY:** TRAN VAN NGUYEN

RUB STUDENT ID: 108 018 206 395

VGU STUDENT ID: 11541

**SUPERVISOR:** PROF. DR. NGUYEN HONG VI

CONTINUOUS IMPROVEMENT BY APPLYING 5S AND SMED TOOLS IN DEEP  
GROOVE BALL BEARING AUTOMATIC MANUFACTURING LINE

A thesis by

TRAN VAN NGUYEN

RUB ID: 108 018 206 395

VGU ID: 11541

Approved by:

Supervisor: Dr. Nguyen Hong Vi

Submitted to the Examination Board  
  
Vietnamese-German University  
RUB University Bochum

Vietnamese - German University

in fulfillment of the requirements for the degree of

BACHELOR OF SCIENCE

November 2023

Major: Mechanical Engineering

## ABSTRACT

The Deep Groove Ball Bearing (DGBB) automatic manufacturing line is the most modern production line at Schaeffler Vietnam with an investment of \$20 million. After three years of operation, the basics of Lean manufacturing have been set up over production line. However, there are many other aspects that have not been identified to improve production quality and capacity. One of those aspects is upgrading the overall image of the line, which is essential to match modern manufacturing technology and professional working environment. DGBB line operates in a fast-paced environment but still encounters inefficiencies during changeovers.

The study aims to promote the continuous improvement culture by applying 5S and SMED method integrated with a visual management system and employee-centered design thinking to enhance the functionality and aesthetics of the existing equipment and visual management systems. At the same time, it brings improvements in production efficiency and creates significant benefits in reducing waste, improving product quality and strengthen company's competitiveness in today's fierce business environment.

Firstly, the objective of the 5S project was to elevate the quality, tidiness, cleanliness, orderliness, convenience, and the overall image of the DGBB line, aligning it with contemporary industry standards. Secondly, the objective of SMED project was to cut down on changeover time

The study will give the reader an understanding of some fundamental concepts in Lean Manufacturing, 8 Wastes, Kaizen, 5S method, SMED method, Ergonomics. It shows a step by step how to implement 5S application improvements, upgrade the Visual Management system to improve worker performance and change the overall image of the DGBB line. As well as a systematic practice of implementing SMED tool integrated with PDCA cycle to reduce changeover time. The results were eliminated 70% of oil leaking spots, created a new concept for tool container, established layout for Wait In Process (WIP) areas, improved visual management system, made two water bottle container shelves and implemented visualization to make an error-proofing. Changes performed in SMED project resulted in 20% total changeover time reduction, 100% unnecessary movement has been eliminated, tools and equipments waiting time went down 80%.

In conclusion, the results show that continuous improvements using methods that have been studied has great practical value. Helps implementers develop system thinking, set effective goals, analyze comprehensive problems, and implement actions quickly. The results, however, reflect only a small fraction of the potential opportunities for continuous improvement in the future that these research methods open to the author. Further implementation of SMED in internal setup phase is recommended to apply for a better optimization in setup process.

## ACKNOWLEDGEMENTS

I would like to express my sincerest gratitude to my supervisor, Dr. Nguyen Hong Vi - Lecturer cum Academic Coordinator, Master program in Global Production Engineering & Management (GPE(M)), Faculty of Engineering for supervising and approving this study.

I also want to show my special thanks to Mr. Nam Gi Jong - the senior expert in production and project management who has more than 30 years of experience in the bearing manufacturing industry as a consultant, Mr. Vu Duy Khanh – the production supervisor who was my direct supervisor at DGBB production department. They gave me priceless guidance and knowledge to be able to complete this thesis.

I am also extremely grateful toward the DGBB production office team and direct manufacturing team for their well-support and helping me complete the concepts and tasks of the thesis and give great necessary inputs for the study.

Next, I want to show my thankfulness to Mr Nguyen Hy Duc, Mr. Dinh Quang Huy, Mr. Nguyen Thai Viet Anh - staffs at Schaeffler Vietnam also as my classmates for supporting me with their valuable sharings and companionship at the company.

Finally, special thanks to my family, friends, professors and staff at Vietnamese German University, Dr.-Ing. Jörg Franke, Dr. Tran Trung Thanh, and faculty assistents, especially Ms. Nguyen Thi Tuu for their continuous encouragement and support during the study progress at the university.

# Table of Contents

ABSTRACT.....	iv
ACKNOWLEDGEMENTS.....	v
List of Figures.....	viii
List of Tables.....	x
List of Abbreviations.....	xi
Chapter 1 Introduction .....	1
1.1 Background.....	1
1.2 Research problem.....	1
1.3 Purpose and goal .....	1
1.4 Priorities and delimitations .....	2
Chapter 2 Methodologies .....	3
2.1 Lean manufacturing:.....	3
2.2 8 wastes:.....	3
2.3 Continuous improvement.....	5
2.4 5S Method.....	5
2.5 SMED .....	6
2.6 Ergonomics .....	6
Chapter 3 Implementation of 5S methodology and Visual management system .....	8
3.1 Methodology.....	8
3.2 Identification and Planning of Improvements.....	8
3.3 Improving oil leaking on shopfloor .....	9
3.4 Redesigning the Honing Stone Container.....	15
3.5 Redesigning tool part container and implement Sort and Set in order.....	20
3.6 Layout Improvements and Labeling for WIP areas. ....	23
3.7 Visual Management system improving project.....	27
3.8 Designing Water Shelves .....	30
3.9 Error-proofing by implementing visual method .....	33
Chapter 4 Implementing Single-Minute Exchange of Die Method.....	35
4.1 Methodology.....	35
4.1.1 Description of the Manufacturing Line.....	35
4.1.2 Planning Phase .....	35



4.1.3 Execution Phase .....	36
4.2 Plan .....	36
4.2.1 Data Collection Methods .....	36
4.2.2 Defining problems.....	41
4.2.3 Problem solving tool.....	41
4.2.4 Wastes identification .....	41
4.2.5 Root cause analysis .....	44
4.3 Do.....	48
4.4 Check .....	53
4.5 Act.....	56
Chapter 5 Conclusion.....	57
REFERENCES .....	58



## List of Figures

Figure 1. Oil leaking spots layout report .....	9
Figure 2. Oil leaking spots .....	10
Figure 3. Oil leakage report and solution suggestions .....	11
Figure 4. Oil leakage report and solution suggestions .....	12
Figure 5. Warning signs of oil leaking spots .....	13
Figure 6. Old honing stone container .....	15
Figure 7. Front side of Honing machine .....	16
Figure 8. Sketch of new honing container .....	17
Figure 9. Reference for new honing stone container .....	17
Figure 10. Chosen reference for new honing stone container .....	18
Figure 11. Testing new honing stone prototype .....	19
Figure 12. Old tool parts containers .....	20
Figure 13. Prototype for new tool parts container .....	21
Figure 14. New tool parts containers .....	22
Figure 15. Optimized tool parts containers layout .....	22
Figure 16. WIP area before grinding process without proper layout .....	23
Figure 17. WIP area before assembly process without proper layout .....	24
Figure 18. Sketch of new layout for WIP area before grinding process .....	25
Figure 19. Sketch of new layout for WIP area before assembly process .....	25
Figure 20. New layout for WIP area before grinding process .....	26
Figure 21. New layout for WIP area before assembly process .....	27
Figure 22. Improvement of production document board .....	28
Figure 23. Improvement of Qx-10 document table .....	29
Figure 24. Improvement of Machine information .....	29
Figure 25. Improvement of Machine information .....	29
Figure 26. Improvement of current production type information .....	30
Figure 27. Actual situation of water bottles storing in production area .....	31
Figure 28. New water bottles containing shelf in an eligible layout .....	32
Figure 29. Before and after improvement of ball size visual board .....	33



Figure 30. Improvement of ball size visual board in other lines .....	34
Figure 31. Setup time recording form.....	37
Figure 32. Setup time statistics table .....	38
Figure 33. Simulation of changeover process.....	39
Figure 34. Setup steps and time progress analysis.....	40
Figure 35. Highlight of tool problem waiting time.....	43
Figure 36. Spaghetti Diagram of IRR machine setup.....	44
Figure 37. Cause and Effect diagram of constantly long setup time problem.....	45
Figure 38. SMED and 8 Wastes training.....	49
Figure 39. Meeting between Tool department and Production department to establish new proeedure.....	50
Figure 40. List of purchasing necessary tools.....	52
Figure 41. Setup time statistics before and after 2 months of implementing SMED actions .....	53



## List of Tables

Table 1. Root cause analysis of major problems in setup process .....	46
Table 2. PDCA timeline for implementing SMED .....	48
Table 3. Tool preparation with checklist results.....	51
Table 4. Comparison in setup time recorded before and after implementing SMED.....	54
Table 5. Purchasing status of desired equipment .....	55



Vietnamese-German University

## List of Abbreviations

SMED	Single-Minute Exchange of Die
DGBB	Deep Groove Ball Bearing
WIP	Wait In Process
ORR	Outer raceway grinding machine
Honing	Raceway Honing machine
IRR	Inner raceway grinding machine
Bore	Bore grinding machine



# Chapter 1 Introduction

## 1.1 Background

The Deep Groove Ball Bearing (DGBB) automatic manufacturing line is the most modern production line at Schaeffler Vietnam with an investment of \$20 million. After three years of operation, the basics of Lean manufacturing have been set up over production line. However, there are many other aspects that have not been identified to improve production quality and capacity. One of those aspects is upgrading the overall image of the line, which is essential to match modern manufacturing technology and professional working environment. DGBB line operates in a fast-paced environment but still encounters inefficiencies during changeovers.

## 1.2 Research problem

The study aims to first, investigate the impact of implementing 5S method and Visual Management system on overall image improvement, examine the effectiveness of Action Research method in solving persistent sanitary problem, and designing new concept to improve employees' working condition at DGBB line. Second, investigate the impact of implementing SMED methodology on changeover efficiency in manufacturing and promoting the continuous improvement culture. Besides, implementing the PDCA cycle in practice to have a systematic way of problem solving [1].



Vietnamese-German University

## 1.3 Purpose and goal

The objective of the 5S project integrated with Visual Management system was to elevate the quality, tidiness, cleanliness, orderliness, convenience, and the overall image of the DGBB line, aligning it with contemporary industry standards. Secondly, the objective of SMED project was to cut down on changeover time

The study will give the reader an understanding of some fundamental concepts in Lean Manufacturing, 8 Wastes, Kaizen, 5S method, SMED method, Ergonomics. It shows a step by step how to implement 5S application improvements, upgrade the Visual Management system to improve worker performance and change the overall image of the DGBB line. As well as a systematic practice of implementing SMED tool integrated with PDCA cycle to reduce changeover time.

#### **1.4 Priorities and delimitations**

The results show that continuous improvements using scientific methods that have been studied has great practical value. The scientific-based measures helps implementers develop system thinking, set effective goals, comprehensively analyze problems, and implement actions quickly. However, the hardest part of the project is to sustain the results of implemented measures. It requires dedication and contributions of all members to keep working on enhancement of the process standard, regularly scheduling meetings in the future to review and reassess the practices.

The conducted actions are only a small fraction of the potential opportunities for improvement in the future that these research methods open to the author. Further implementation of SMED in internal setup phase is recommended to apply for a better optimization in setup process.

## Chapter 2 Methodologies

### 2.1 Lean manufacturing:

Lean Manufacturing originated from the key principle first presented by Tahchi Ohno in the 1988 book "Toyota Production System: Beyond Large-scale Production", it is to improve company productivity by detecting and eliminating waste throughout the production flow [2]

The "Lean Manufacturing" philosophy focuses on eliminating activities that do not add value to customers through the continuous elimination of waste throughout the process of providing products and services [3]. It has been proven that applying Lean production and its tools brings many benefits to companies, such as elimination of waste, cost reduction, quality improvement, optimization, flexibility, and quick response [2] [4]

To achieve long-term results in applying the lean production philosophy, building and maintaining a Lean culture in the company is very important. The company needs to organize training sessions on Lean principles and goals for employees, from management to direct production workers. Along with that, creating an environment that encourages innovation through experimentation and information sharing is crucial. Recognizing and rewarding employees who participate in suggesting process improvements helps them feel appreciated and feel free to contribute ideas to the organization [5]

With the undeniable advantages that Lean manufacturing offers, it is being widely applied by leading manufacturing companies around the world, including major auto manufacturers and their equipment suppliers. Lean is becoming a rising concern among manufacturing companies in developed countries as they seek to compete more effectively when production orders become scarce due to the economic recession.

### 2.2 8 wastes:

The Toyota Production System was designed to identify seven primary categories of waste [6]. However, lean practitioners have extended and modified the system to address a wider range of manufacturing inefficiencies. Identifying areas where operational processes can be improved with the goal of removing non-value-adding activities [7] and increasing overall productivity is based on these eight wastes.

1. Overproduction: When too many goods are created too soon or in excess of what is needed, overproduction takes place. This leads to higher storage expenses, a larger chance of product obsolescence, and the possibility of waste or discounts. Although lean principles promote output according to demand, intentional overproduction can occasionally fulfill particular strategic objectives within lean production.

2. Defects: Defects include not just physical flaws but also mistakes in paperwork, inaccurate product information, delayed delivery, or inadequate production techniques. Waste like this raises expenses, uses too many resources, and produces more scrap.
3. Inventory: Excessive storage of finished goods, work-in-progress, or raw materials leads to waste in inventory. Keeping excess inventory increases the cost of storage, adds to financial burdens, and frequently raises the rate of defects.
4. Motion: Waste is the movement of materials between production steps that do not contribute value. Ineffective mobility wastes personnel and space, lengthens production cycles, and may even result in delays.
5. Waiting: Inefficient procedures or crowded production flows result in idle time spent by employees or equipment, which adds to waste. Waiting reduces production per unit of time and increases labor costs.
6. Operations: Waste is shown by employees moving or strolling around needlessly when they aren't involved in the production of the product. Examples include slowing down job speed, uncomfortable body motions, and tool searches.
7. Correction: Waste occurs when mistakes made during the first step have to be fixed repeatedly. Rework causes bottlenecks and extra time spent on management by interfering with efficient production flows.
8. Overprocessing: Processing data more than is required to meet client needs is a wasteful use of resources. For example, going above and beyond what the consumer requires in terms of polishing or refining raises needless production expenses without providing value.

These eight categories of waste must be recognized and removed in lean manufacturing in order to maximize operational effectiveness and motivate ongoing improvement projects. Organizations can improve overall productivity, lower expenses, and streamline procedures by addressing these inefficiencies.

## 2.3 Continuous improvement

Given the inherent challenge of achieving optimal efficiency in company operations, Lean methodology emphasizes the need for continuous improvement, preferably through a systematic approach. The objective of the system is to ensure ongoing enhancement, whereby the organization consistently identifies and eliminates non-value-added actions and techniques. The primary objective of continuous improvement should be to identify potential causes of non-value-added activities and eliminate them by optimizing the production process. The Japanese term Kaizen describes the concept of "continuous improvement," with a focus on making small, gradual gains. The main objective of Kaizen is to cultivate a culture of enhancement, mostly achieved through assigning staff with tasks and inspiring them to seek areas for improvement [8].

Employees are assigned specific duties under Lean to identify non-value-adding operations reasons and offer solutions. The majority of lean manufacturing businesses hold the belief that employees who are directly engaged in the production processes contribute the most valuable ideas for removing non-value-added tasks. At Toyota, employees are incentivized to enhance production processes. However, these enhancements must be substantiated by a compelling rationale derived from the scientific method. Moreover, they must be executed under the supervision of a seasoned mentor and meticulously recorded in terms of the new process's substance, timing, order, and results. To assess the efficiency of the proposed modifications, Toyota will initially conduct a limited-scale experiment before implementing them across the company

In addition, providing quick feedback and rapidly recording suggestions are crucial methods to assist employees in their ongoing efforts to enhance their practices. Therefore, it is important to build a framework for presenting ideas and clearly outline the advantages. This fosters a culture where staff members are motivated to proactively execute enhanced concepts without any delay. The benefits of implementing improvements in the firm frequently surpass the expense of rewards.

## 2.4 5S Method

The 5S technique incorporates a variety of principles designed to create a productive working environment [9] not just for shopfloor workers but also for office staff in businesses. These 5S principles provide numerous advantages, including cleanliness, convenience, productivity, and safety. '5S' stands for Sort, Set in Order, Shine, Standardize, and Sustain, these 5 stages are included below [10]:

**Sort:** Separate what is necessary from what is not, so that frequently used items are always close and easy to find. Items that are infrequently used should be relocated or disposed of.

**Set in order:** Including arranging and labeling tools and materials systematically in the working environment, taking into account each tool's usage frequency tool corresponding to the worker's reach. This requirement aims to minimize the number of operations the worker must perform to find the desired tool.



Shine: Keep machines and working areas clean to avoid difficulties caused by poor hygiene. Besides makes a dangerous impact on safety of operator and setter working in the shift. This provides employees chances to work in a clean and convenient environment.

Standardize: To maintain the first 3S, clearly defining procedure standards for keeping implemented actions' result are required

Sustain: Encourage, communicate, and train on 5S to make its application part of the company's culture. In addition, regular Gemba also helps raise the awareness and proactiveness of employees

The 5S concept is used in practice to create and maintain a high-quality workplace environment in a company. [11]

## **2.5 SMED**

"Single Minute Exchange of Die" (SMED) is an excellent tool in LEAN manufacturing that helps reduce setup time from a current product order to a new product order according to customer needs in an optimal and systematic way. Invented by Shigeo Shingo, SMED focuses on converting processes that were previously only performed after the end of the old batch or can be understood as machine-stopped (internal setup) into stages that can be carried out in advance to be ready to serve the setup process while the previous batch is still running (external setup) [12].

These conversion steps include preparing the necessary tools intentionally and arranging the equipment in a precise and pre-positioned sequence or layout. Along with optimizing the installation process by eliminating redundant steps by converting small steps that consume an accumulative block of time into one crucial step [13].

The goal is to reduce the changeover time to the smallest time unit of every minute, even second, to increase the flexibility and overall efficiency of the entire manufacturing line [14]. The SMED tool is essential for fully automated production lines, which can help the factory save hundreds of dollars per saved minute, equivalent to multiple thousands per year [15].

Applying SMED also helps businesses increase adaptation to market needs [16]. The ability to rapidly change product designs or molds based on market demand helps improve the company's flexibility in addressing and promptly responding to customer requests. This approach is a valuable asset in modern workplaces striving for operational excellence [17].

## **2.6 Ergonomics**

The Institute for Occupational Ergonomics (1999) defines Ergonomics as a field of research and design that aims to optimize the interaction between human work activities and the direct working environment. The Ergonomics design method focuses on designing and adjusting working conditions to suit the abilities and comfort of workers to help improve their work performance and health [18]

Applying ergonomic principles to the working environment brings many practical benefits. First, it helps reduce stress and injury for workers while working in a bad posture for a long period of time. By adjusting the height and reach of the placement of tools or operations while working, employees can work in a natural posture to reduce pressure on muscles and joints.

Second, Ergonomics helps maintain concentration and improve work performance compared to working in an improper posture. When working in an environment designed with employee-oriented principles to help them work comfortably and efficiently, employees can perform their work naturally without losing focus due to having to adjust to a difficult position or feeling pain or discomfort when performing their tasks [19]

Overall, ergonomics plays an important role in improving the health and mental state of workers. Creating an employee-oriented working environment not only shows the company's concern for employee well-being but also creates conditions for workers to express their full potential through work, thereby aiming for a stable personal career development [20]

# Chapter 3 Implementation of 5S methodology and Visual management system

## 3.1 Methodology

In this part, the author will use the Action Research method to implement and solve the small projects listed below.

Action research is a research method that according to its name is taking action and analyzing the result, reevaluating the situation and then coming up with the next solution. Including these actions: defining problems, collecting and analyzing data, making plan, taking action and observing, evaluating and adjusting actions.

The implementation of the 5S method, integrated with a visual management system and employee-centered design thinking, was conducted to enhance the functionality and aesthetics of the existing equipment and visual management system. The primary objective of this action research project was to elevate the quality, tidiness, cleanliness, orderliness, convenience, and the overall image of the operational line, aligning it with contemporary industry standards.

## 3.2 Identification and Planning of Improvements

The initial phase involved identifying outdated equipment and visual management systems associated with the 5S principles and Visual Management (VM). The subsequent planning phase focused on categorizing the required improvements into two categories: immediate implementation and those requiring in-depth analysis and input from personnel directly engaged with the objects in need of enhancement.

- Improving oil leaking on shopfloor
- Redesigning the honing stone Container
- Redesigning tool part container and implementing Sort and Set in order
- Layout Improvements and Labeling for WIP areas
- Visual Management system improving project
- Designing water shelves
- Error-proofing by implementing visualization

### 3.3 Improving oil leaking on shopfloor

#### Define problem and current situation

DGBB production line is facing a problem of oil leaking from inside of every kind of automation grinding machine including MAS machines, grinding machines and honing machines. This problem affects a major of 5S situation in DGBB grinding production line. Oil flushing on the floor also makes a dangerous impact on safety of operator and setter working in the shift. Moreover, at the end of every shift, besides of other tasks workers have to clean leaked oil on the floor that they did not cause to this problem and it takes up to 15 minutes for them to finish. This led to discomfort and disruption.

The goal of this task is for the author to find as many possible leaking point on every machine in grinding line. After that, investigate the cause to each leaking point and generate simple idea to fix the spot for short term. Besides, the intern must collect these data and make a report which later will be a material for meeting with maintenance team to search for long term solutions.

#### Leaking point finding and Recording data

- Tracking oil plough along the floor and marking which machine causing it
- Taking picture and marking on grinding line layout
- Create a report to show leaking points and promote possible ideas to fix
- Further investigate root causes and generate short term solutions



Vietnamese-German University



Figure 1. Oil leaking spots layout report

**Deployment**

The author begin the task by tracking the oil ploughs along the floor and marking which machine is causing it. This will involve close observation of the machines during operation to identify the source of the leak. The intern will also take pictures and mark the grinding line layout to create a clear visual representation of the leaking points.



Figure 2. Oil leaking spots

Next, making a report to show the identified leaking points and promote possible ideas to fix them for the short term. These solutions could include replacing faulty seals, tightening loose connections, or adjusting the oil levels in the machines. The author will also further investigate the root causes of the leaks and generate short-term solutions to address them.


Vietnam DGBB

**Line : B2**

**Machine : MAS 5**

**SCHAEFFLER**

Problem	Action
<p>Problem : No oil tray</p> 	<p>Measure : Insert the missing oil tray</p> <p>Responsible</p>

Vietnam DGBB

**Line : B2**

**Machine : ORR, IR Bore**

**SCHAEFFLER**


Problem	Action
<p>Problem : Too much oil that leaks through the bolt hole</p> 	<p>Measure : Insert an oil pan right into the circled position in order to prevent oil leaking through the bolt hole.</p> <p>Responsible</p>

Figure 3. Oil leakage report and solution suggestions

11



Vietnam DGBB

SCHAEFFLER

Line : B2  
Machine : OR Honing 1

Problem
Problem : Grinding stone tray has cracks


Action
Measure : Change tray or Cover it with something
Responsible

Vietnam DGBB

SCHAEFFLER

Line : B2  
Machine : OR Honing 2 oil pipe

Problem
Problem : Valve connection is loose


Action
Measure : Tighten and seal
Responsible

Figure 4. Oil leakage report and solution suggestions

The Maintenance and Production teams then went to Gemba and deployed oil leak alerts, making these areas more visible for technicians to come and correct later. With the pipe connections that need to be tightened up, maintenance team proceeded to repair right in that day. Other spots require more investigation to find a complete solution. In just one month the reporting points have been fixed 23 out of 30 spots.

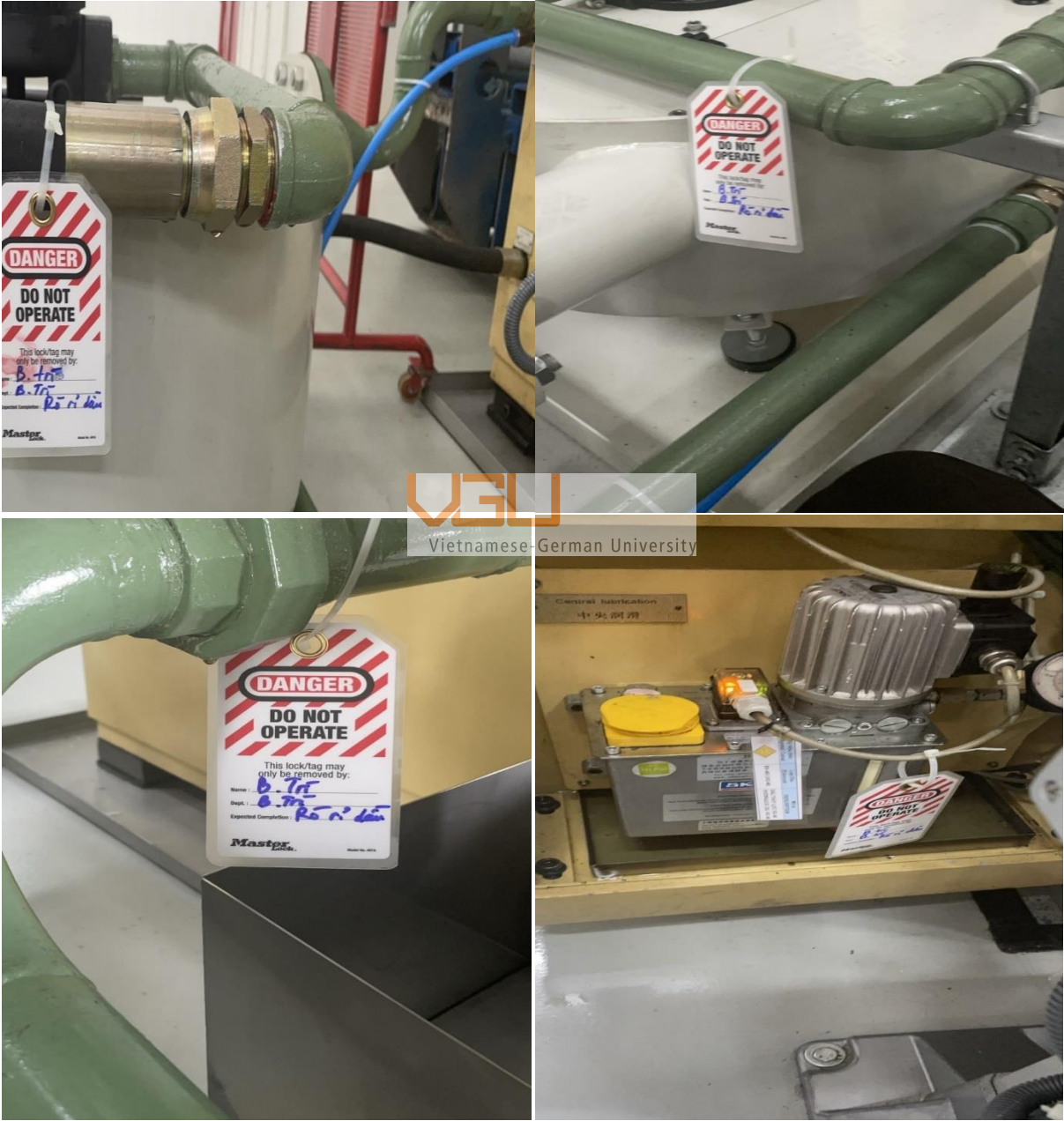


Figure 5. Warning signs of oil leaking spots



## **Result**

The author needs to regularly update the team on their progress, and they will have meetings with the maintenance team to discuss their findings and proposed solutions. The maintenance team will provide guidance on the feasibility and practicality of these solutions and collaborate with the author to implement the best ones for the long term improvement.

In conclusion, this work has significantly improve the 5S situation in the DGBB grinding production line by addressing 70% of persistent problem of oil leakage in the machines after 3 months. The author's findings and proposed solutions will serve as valuable input for the maintenance team to implement long-term solutions that will ensure safe and efficient operations of the grinding line.

### 3.4 Redesigning the Honing Stone Container

#### Define problem and current situation

Honing is an important step, because this is the decisive step to one of the key quality assessments of the product that is Noise checking, if the polishing step does not meet the standard it will give out spectrum noise beyond the permissible level, as known as defects. In the honing stone replacement process, operators have to file the polishing head of honing stone by hand before attach it to the holding clamp, it requires high concentration to file the stone into a fixed arch as well as carefully attaching the stones to the clamp, otherwise it will cause the wrong stone arch to have to be polished again or breaking it.

The replacement of the honing stone is performed quite a few times in one case. The short-sized white stone, used for rough polishing, is replaced every two hours. The long white stone used for fine polishing, it's replaced once every four hours. So in one shift, each machine has to replace two rough stones and four fine stones. Each line has four honing machines, which is equivalent to each employee in one shift having to change 24 honing stones. The pre-improvement stone container is the bottom cut from the water tank is placed on the side of the machine. As shown below, this is the view that the operator must have in order to be able to pick the right stone



Figure 6. Old honing stone container



Figure 7. Front side of Honing machine

As shown above, the stone container is placed on the side of the machine, where the operator's permissible standing position is 50 centimeters away. With the normal person's height and handbreadth, he can't stand upright to look inside and take the stone out of the container. Instead, he has to lean his body forward to look and take it out. Moreover, when standing in a stone replacement position, that is, in the middle of the front of the machine, the operator has to step aside and then leaning out to pick up the stone then return to the old position to proceed with the stones replacement. This is a huge inconvenience. This accidentally affects their concentration as well as their health. So the objective was to minimize poor posture for employees and streamline the process of changing stones, thereby enhancing efficiency.

## Design

In the current situation, the two types of stone are mixed together, along with accumulated oil, causing an unclean and disorderly situation. Therefore, a design of 2 separate compartments for 2 types of stone was included in the sketch. To move the position of the container to the front to limit bad posture for employees and improve the changing stone process, the author created an additional hanger behind the container. That way, there is no need to drill or screw to hang the box, just hook it to the side of the machine and use it immediately.

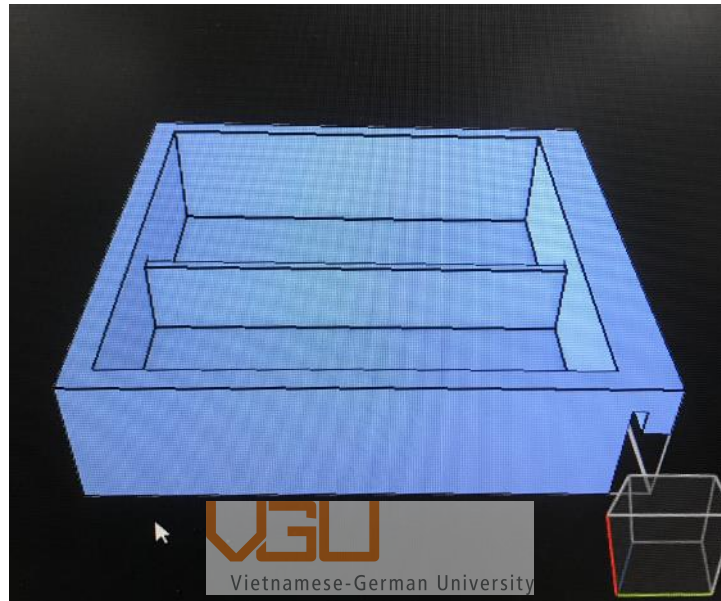


Figure 8. Sketch of new honing container



Figure 9. Reference for new honing stone container



## Deployment

After consulting with the Supervisor, this idea was designated for 3D printing to make a prototype, and after testing, it will be put into mass application. However, after talking with the tool department, we learned that the current 3D printing materials are not enough to print in large quantities, and furthermore, mass 3D printing of this product is very time-consuming. So the tool engineer suggested another direction for the author, which is to find plastic stone container in the tool shop available to test. Because of the same purpose, these plastic box designs are very sturdy. After observation, the author chose 2 plastic boxes with more suitable designs. But the size is too big and there is no hanger on the back. Figure 9 is an illustration. However, this container design is very good, it is thin and light in weight, go with high durability. To fulfill two more criteria: small size and having a hook on the back, while working with the maintenance team, saw a workstation with small containers hanging, the author asked to borrow it and conduct evaluation and testing. The result was as expected, this container met all the criteria set forth by the original design, the only thing was that it did not have separated compartments like the original idea. But in the end, the author still chose to make a prototype and decided to use 2 containers attached together to hold 2 types of stones as required. Figure 10 is the prototype.



Figure 10. Chosen reference for new honing stone container



Figure 11. Testing new honing stone prototype

### **Result and evaluation**

After conducting the test, the author received positive feedback about the working process of the operators. They no longer need to bend over to search and move away from their original working position to retrieve stones. Besides, this change also helps them observe and search easier. With this new design, the production supervisor has agreed to apply it on all 2 lines.

The cost for each container is 30,000 VND, with the required quantity being 20 pieces. So the cost for this small project is 600,000 VND and it was approved right on the testing day.

### 3.5 Redesigning tool part container and implement Sort and Set in order

#### Define problem and current situation

Similar to honing stone containers above, the containers used to store small tool parts on the workstation also need to be replaced because old containers waste time searching. With the old type, the height of the box is too high which obstructs the user's vision. When standing on the far side, the user must tiptoe and lean forward to search for tools. This is a big inconvenience. If they can't find it, they have to move to the same side as these containers to find it again, wasting more time and effort for the user.

So the objective was to minimize poor posture for employees and streamline the process of adjusting tool here, thereby enhancing efficiency.



Figure 12. Old tool parts containers

## Deployment

Inheriting the directions in the previous section, the author targets the types of boxes that have been referenced because they meet the set criteria of creating a good frontal viewing angle, low height and high durability. So the author has the desired image and size, the next step is to find out about the products available on the market through a prochure book from a stationery supplier.



Figure 13. Prototype for new tool parts container

The price of a product is 45,000 VND for medium size and 60,000 VND for large size. Within the allowable cost, 10 small boxes and 6 large boxes were ordered. Total cost is 810000 VND. After presenting the prototype idea to the production supervisor, the purchasing order has been approved.

Then the author needs to apply the Sort and Set in order methods in 5S because the number of tool parts is too much. Sorting many kinds of bolts, nuts, washers from big size to big size, small size to small size and keep them in a small proportion to make it easier to find out necessary tool. Then label each container to distinguish the function of each tray, from large to small size, and arrange each set of bolts, nuts, and washers in turn.



**Result and evaluation**

The results are very positive. After the replacement, the user's vision has been significantly improved, search time has been reduced because the number of tools of each type has been reduced and stored, but still ensures a sufficient number for each type to help increase the recognition ability when searching for tools. Then plan to refill once a month.

The image below is the result after the change and after optimization:



Figure 14. New tool parts containers



Figure 15. Optimized tool parts containers layout

### 3.6 Layout Improvements and Labeling for WIP areas.

#### Define problem and current situation

The Wait In Process (WIP) area is a place to store semi-finished products of the previous stage, where the products of the previous stage are brought in in quantities allowed according to Pull manufacturing and kept in an appropriate amount for a working shift. However, currently the WIP area of DGBB line does not have a layout, causing the arrangement to be disorganized, leading to staff spending a lot of time searching. This demonstrates a weakness in identifying and eliminating waste. Wastes operators' time and energy. So the objectives were, first to create a layout for WIP before grinding, which should have space between storing lines to facilitate searching, and assign product names to each storing line. Second, create a layout for WIP before assembly, which should also have assigned code number of production.



Figure 16. WIP area before grinding process without proper layout



Figure 17. WIP area before assembly process without proper layout

## Design and deployment

First, the author conducts measurements to get the size of the WIP area before grinding. Next, design the layout to suit the current needs of 2 production lines B2 and B4. The layout includes 8 storing lines, 4 for B2 line and 4 for B4 line. Then specify the storage purpose for each small line, ie. 2 for outer ring (OR), 2 for inner ring (IR). Storage capacity is 8 pallets per WIP line.

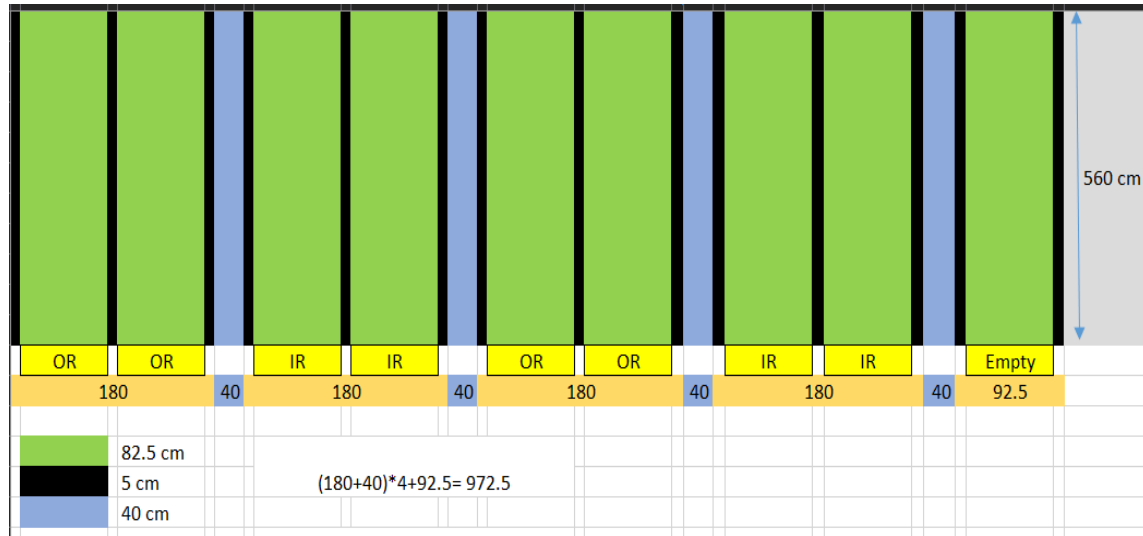


Figure 18. Sketch of new layout for WIP area before grinding process



Vietnamese-German University

The design for the WIP before assembly area needs to be divided for each type of product code being produced. Because the quantity is quite small and the size is small, the carts just need to be easy to identify and arrange.

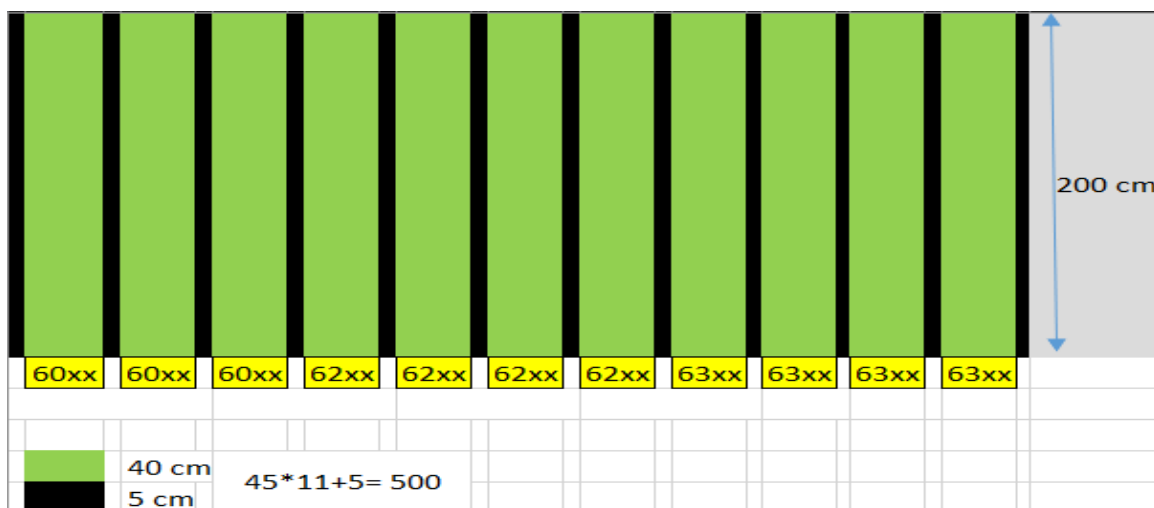


Figure 19. Sketch of new layout for WIP area before assembly process

## Result and Evaluation

After taping the layout for the WIP area, there were clearly improved results. In the WIP before grinding area, the rows have been neatly arranged in the layout and according to each type of row assigned to each storing line. In the WIP before assembly area, the storing lines have been divided and labeled with product names. These two things help employees easily determine the location as well as find the right type of goods faster and effectively. than. With the step of creating a layout and specifying labels, the author has applied the second S Set in order in 5S.



Figure 20. New layout for WIP area before grinding process





Figure 21. New layout for WIP area before assembly process

### **3.7 Visual Management system improving project**

#### **Define problem and current situation**

During last 2 months internship at DGBB, The author had the opportunity to work on a project aimed at improving the visual management system in the production line. The project involved transforming the paper documents used in the line to higher quality visual materials. In this study, he will provide a detailed account of his experiences during this project, including the challenges faced, the methods employed, and the results achieved.

DGBB is the first full automation line in Vietnam Plant, which implies that it has a modern technology and a great scale of production. However, the low-quality paper documents used in the line have resulted in a lack of visual appeal and an inefficient presentation of information. The purpose of this project was to improve the visual management system in the production line by upgrading the quality of the visual materials used.

## Project Scope

The project involved working with a vendor to investigate, transmit the idea, send them the sketch, get a quotation, check progress, and guide and supervise them to attach new material in the line. The author was responsible for calculating the number of machines, collecting and verifying the data needed, sketching the design, and pushing for a sample. Last but not least, he had to present the final product or prototype to the supervisor to get the approval.

## Deployment

To improve the visual management system in the production line, author began by researching and identifying the necessary visual materials required. He then contacted several vendors to investigate the best option and received quotations from each of them. After selecting a vendor, he worked closely with them to transmit his ideas and sketches. Next in the otherside, vendors has to quickly design and making prototypes and send back to him evaluate the sản phẩm. After testing and receiving his supervisor's approval, the installation process then began. The installation process was completed within the timeframe and budget, and the final product was approved by the supervisor. One of the key point employed in the project was the use of visual aids to convey information more efficiently. By using high-quality visual materials, the information was presented in a clear and concise manner, making it easier for workers to understand and follow.



Vietnamese-German University

## Results

The project resulted in a significant improvement in the visual management system in the production line. The use of high-quality visual materials not only improved the aesthetic appeal of the line but also made it easier for workers to understand and follow the information presented.



Figure 22. Improvement of production document board



Figure 23. Improvement of Qx-10 document table



Vietnamese-German University  
Figure 24. Improvement of Machine information



Figure 25. Improvement of Machine information





Figure 26. Improvement of current production type information

### 3.8 Designing Water Shelves

#### Define problem and current situation

When talking to the workers about some of the improvement possibilities in working environment, the inconvenience caused by employees' long-distance movement to access personal items during breaks, particularly water bottles have to be stored in distant lockers has been brought up. Despite the rule, they still try to store their such water bottles in the area of the production line, just to optimize their break time. So they tell the author to make a bottle shelf not only for them to put those item in, but also make it an eligible spot for long term using. This help them feel a lot better. Therefore, two simple water shelves were designed and installed a ground level. The goal is to make it with enough space for big personal bottles and go with a neat design to be approved to be permanently placed in the production area.



Figure 27. Actual situation of water bottles storing in production area

To begin implementation, the author estimated the possible number of bottles based on the number of employees in each shift. In the assembly area, the number of employees per shift is 10 people, equivalent to needing 10 water bottles. For the grinding area, the author does the same, the number of required cells is 8. Then, proceed to sketch the drawing, with the goal of having a neat design and not taking up too much space, along with it's cheap and the author came up with the idea of a shelf with 4 legs and the top will hold a rack to store bottles. In addition to those criteria, the average height of employees is also taken into account to choose the appropriate height for the majority.

### **Design and deployment**

After having a sketched idea, the author goes to the step of choosing materials. With the base set, the author uses Lean pipe material with low price but achieves high load-bearing requirements. This material helps save costs and ensures high durability. Next is the market research part to find a rack that has the required number of storage cells and is large enough to hold large personal water bottles. Calculating the size of the container brings a lot of aesthetic effects as well as fit when actually used, this is shown in Figure 28. After understanding the functional requirements, the author chose a rack with a beautiful design, with a number of 16 large-sized cells to meet the requirements. Partly because when choosing a smaller number of cells, the capacity of the cells will also be reduced, and the necessary performance will not be achieved. Below are the results of this process. Implementation cost is 600000 per shelf.



Figure 28. New water bottles containing shelf in an eligible layout

## Result

After completing the water shelf assembly, the product was approved by the Line manager to be placed in the production area with a clear layout. With the results obtained, the needs of employees are thoroughly addressed, working spirit increases, contributing to increasing the reputation of the management board when listening to employees' opinions. Thereby contributing to enhancing the Kaizen spirit for all employees.

### 3.9 Error-proofing by implementing visual method

#### Define problem and analysis situation

During work, the bearing ball, the author will using only ball later all, is stored in a shelf of 5 compartments with the purpose of dividing the ball according to 5 different tolerances (+4, +2, 0, -2, -4). Balls are issued by warehouse staff every 2 hours. When the warehouse staff brings the ball in, they will arrange the ball on the shelf according to each tolerance specified on the shelf.

Recently, the assembly operator during the ball input process realized that a number of ball boxes had the wrong size of the remaining line. Fortunately, no major quality errors have occurred. However, this is still a potential problem if the operator forgets to check the ball size before input. So with the goal of helping warehouse staff mistakenly supply balls between 2 lines.

#### Deployment

A visual board displaying the size ball is created. The author worked with the vendor to survey and design mica containers, collect all usable ball sizes, then send them to the vendor to design and print new ones in large font size and high prominence to increase recognition when someone look in overall at the ball shelf. After being printed, visual boards will be laminated to preserve quality for long-term use. The process of using this visual board is that when setting up, the operator is responsible for refreshing the display board to match the size of the ball about to run.

#### Results



Figure 29. Before and after improvement of ball size visual board





Figure 30. Improvement of ball size visual board in other lines

Vietnamese-German University

With this improvement, warehouse staff will easily identify the ball size being produced and supply it to the correct location as required. Thereby limiting errors that affect product quality and production efficiency of the line. The company's standards of top quality were also reinforced.

# Chapter 4 Implementing Single-Minute Exchange of Die Method

## 4.1 Methodology

The manufacturing setup section for ball bearings faced numerous challenges that hindered efficiency, including a lack of 5S principles, disorganized tool preparation, excessive movement around the shop floor to locate tools and parts, and significant delays caused by waiting for tool supply from another department. To address these issues, the implementation of the SMED methodology underwent the following phases:

### 4.1.1 Description of the Manufacturing Line

The automatic manufacturing line for ball bearings operates in a fast-paced environment but encounters inefficiencies during setups due to disorganized processes, lack of tool preparations, and inadequate part supply arrangements. DGBB line currently has 2 identical lines, the production process and number of machines are the same, so SMED application is done in parallel for both lines. The implementation of this improvement will be carried out at the grinding line with the main machines being Outer raceway grinding machine (ORR), Raceway Honing machine (Honing), Inner raceway grinding machine (IRR), and Bore grinding machine (Bore). Grinding process currently has 9 main machines including 2 ORR, 4 Honing, 1 IRR, and 2 Bore. This study aims to solve wasteful problems related to preparing tools and parts to reduce travel and waiting time related to other departments.

During implementation, the author noticed that these waste problems occurred regularly for all 9 machines on the line. The comprehensive solutions will be applied to all 9 machines under the direct supervision of the author through continuous setup sessions over 2 months.

### 4.1.2 Planning Phase

Team decided to identify problems through observation and data collection, the specific inefficiencies in setup procedures were pinpointed, including excessive downtime due to tool unavailability, disorganized tool storage leading to time-consuming searches, and delays in tool and part supply. With measurement in implemented project chart objectives were set to reduce setup time by 30%, decrease tool search time by 80%, and improve tool availability by 80% within a 3-month implementation period. A cross-functional team consisting of setup technicians, shop floor managers, and representatives from the Tool department was formed to devise strategies. The team outlined plans to implement the SMED method, using PDCA cycle to have a systematic approach to streamline setup procedures.

### 4.1.3 Execution Phase

The execution strategy centered on two primary areas: standardization and streamlining. To tackle disorganization and lack of preparation in tools, a standardized tool preparation checklist was devised. Each tool's specific placement and identification were meticulously planned, eliminating the need for unnecessary movements to search for tools. Additionally, a new way of thinking is added to encourage employees to be proactive in the external setup phase, such as checking in advanced and go ask for missing equipment like bearings and grinding stones or tools. This was allocated to the setup section to eliminate dependency on external supply, thus reducing waiting times.

## 4.2 Plan

### 4.2.1 Data Collection Methods

Time Studies: Time studies were conducted before and after the SMED implementation to measure setup times, investigate the machine bottleneck, and give an overview of the overall setup time of the entire line. Not only that, this table also helps retrieve the setup time of the same product code across setup times to show whether or not there has been an improvement in skills as well as setup time. This, along with recorded issues, will reflect the true nature of the department's continuous improvement process.



Vietnamese-German University

### Setup time recorded form

At the beginning of each setup cycle, a set of setup data collection forms are spread out for each setter to fill in the detailed time when setting up each machine. This form is used to record main steps such as Cleaning, Old tool disassembly, New tool assembly, Setup new parameter, Measure & fine adjust machine, Recleaning & setup part quality verification. Along with that, record the problems encountered during the changeover process. From there, the author uses these forms to fill in data into the spreadsheet to summarize and summarize key information during the setup process.

PHIẾU CÁI ĐẶT MÃ

SCHAEFFLER BOARD

Ngày làm Date		Mã vật tư / Mã Part No. / Code	
Số lượng / Qty		Mã máy / Mã Machine No.	
Mã công việc / Job No.		Mã vật tư / Mã Part No.	
Mã công việc / Job No.		Mã vật tư / Mã Part No.	

Thời gian đặt mã /  
Lead time

Thời gian chuẩn bị / Preparation time	Thời gian lắp đặt / Install time	Thời gian vận hành / Run time	Thời gian kiểm tra / Check time	Thời gian chờ / Wait time	Thời gian tổng / Total time

Chú ý: Người dùng chỉ được điền vào các ô trống.  
Please fill in the empty cells only.

Thiết lập một phòng máy /  
Setup a machine

Số thứ tự / No.	Mô tả công việc / Description	Mục tiêu / Target	Thời gian / Time	Thời gian / Time	Thời gian / Time	Các cột đặt mã / Columns		
						Code	Min	Max
1	Vệ sinh Cleaning		45.0	15.0				
2	Thay thế các bộ phận / Replace parts		45.0	15.0				
3	Lắp ráp mới / New assembly		15.0	15.0				
4	Cài đặt thông số / Setup parameter							
5	Đo & hiệu chỉnh / Measure & adjust machine							
6	Kiểm tra máy & các thông số / Check machine & parameters							
7	Kiểm tra chất lượng / Quality check							
8	Kiểm tra vận hành / Run test							
9	Hoàn thành / Complete							

Trưởng ca xác nhận thông tin được điền đầy đủ và chính xác /  
Shift leaders confirm that all information above is fulfilled

Ngày /  
Date

Chữ ký /  
Signature

Mã / Code	Mô tả / Description	Key	Đơn vị / Unit
01	Phân Súc Chờ		
02	Thời gian chờ		
03	Chờ máy sẵn sàng		
04	Chờ vận hành		
05	Chờ vận hành		
06	Chờ vận hành		
07	Chờ vận hành		
08	Chờ vận hành		
09	Chờ vận hành		
10	Chờ vận hành		
11	Chờ vận hành		
12	Chờ vận hành		
13	Chờ vận hành		
14	Chờ vận hành		
15	Chờ vận hành		
16	Chờ vận hành		
17	Chờ vận hành		
18	Chờ vận hành		
19	Chờ vận hành		
20	Chờ vận hành		
21	Chờ vận hành		
22	Chờ vận hành		
23	Chờ vận hành		
24	Chờ vận hành		
25	Chờ vận hành		
26	Chờ vận hành		
27	Chờ vận hành		
28	Chờ vận hành		
29	Chờ vận hành		
30	Chờ vận hành		
31	Chờ vận hành		
32	Chờ vận hành		
33	Chờ vận hành		
34	Chờ vận hành		
35	Chờ vận hành		
36	Chờ vận hành		
37	Chờ vận hành		
38	Chờ vận hành		
39	Chờ vận hành		
40	Chờ vận hành		
41	Chờ vận hành		
42	Chờ vận hành		
43	Chờ vận hành		
44	Chờ vận hành		
45	Chờ vận hành		
46	Chờ vận hành		
47	Chờ vận hành		
48	Chờ vận hành		
49	Chờ vận hành		
50	Chờ vận hành		

Version C RF SVC-PR 00094-01 Phiếu đặt mã 1/1

Figure 31. Setup time recording form

### Setup time statistics table

To monitor the effectiveness of the SMED implementation, the setup time of each machine on the grinding line is collected on the duration of the changeover by a standard setup time collecting form. This data was then entered into an Excel file and analyzed to identify any improvements or variations in the setup time of each machine.



Cập Nhật Kế Hoạch Sản Xuất/ Setup conduct plan & status		Sum of setup time will be counted from the start of the first machine to be setup to the finish of the last machine to be setup. (Click the link below to view timeline)									
Process: Grinding □ , Assembly □		B4	B2	B4	B2	B4	B4	B4	B2	B4	B2
LINE	Mục tiêu Target Time	CW 11 Mar 2022	CW 12 Mar 2022	CW 12 Mar 2022	CW 14 Apr 2022	CW 14 Apr 2022	CW 16 Apr 2022	CW 16 Apr 2022	CW 18 May 2022	CW 19 May 2022	CW 20 May 2022
		15	20	20	20	20	20	20	20	20	20
		20	20	20	30	30	30	30	30	20	20
		90	150	60	180	180	240	210	210	230	120
		20	20	20	20	20	20	20	20	20	20
		60	120	110	180	90	210	90	90	110	90
		90	240	60	210	210	240	180	150	184	120
		20	30	30	30	30	30	30	30	30	30
		60	120	60	120	90	180	90	90	180	110
		120	280	360	300	360	360	300	330	360	330
		20	20	20	20	20	20	20	20	20	20
		90	150	180	200	180	230	180	230	180	150
		20	20	20	20	20	20	20	20	20	20
		60	120	90	125	120	120	150	90	90	90
		90	150	120	180	180	180	150	150	120	120
		20	20	20	20	20	20	20	20	20	20
		60	120	105	120	90	120	120	90	90	210
		480	1200	1020	1170	1080	900	675	735	1170	630
	Chờ sửa tool	0	150	420	0	60	20	50	45	70	75
	Chờ bảo trì	0	0	0	30	0	0	40	30	45	30
	Setup form	0	<a href="#">20.03.2022</a>	<a href="#">22.03.2022</a>	<a href="#">27.03.2022</a>	<a href="#">04.04.2022</a>	<a href="#">05.04.2022</a>	<a href="#">22.04.2022</a>	<a href="#">23.04.2022</a>	<a href="#">03.05.2022</a>	<a href="#">12.05.2022</a>

Figure 32. Setup time statistics table

After collecting data on the duration of each significant section of the setup process for each machine in the Single Minute Exchange of Die (SMED) project, we were able to create a simulation progress graph to visualize the most effective order for machine setup. However, to help readers and co-workers or management individuals who do not get involved directly in the production processes to have a clear view of a changeover procedure. The author created a Gantt chart system to indicate the setup time of each machine with respect to their position in the process flow.

### Simulation of changeover process by Gantt chart

The Gantt chart consisted of a horizontal bar chart with the machines as the y-axis and the setup time as the x-axis. the chart was divided into two sections: The bars were color-coded to indicate which machine was conducted by whom. For example, there are 2 cells in blue presented as setter Hieu's works, and 3 in cells in green presented as setter Binh's works. Also, the Gantt chart shows clearly the starting and ending time for each machine on the changeover process and the decision of arrangement in which machine was prioritize to be set. Through the chart, one can easily draw an overview and conclusion about the total time that need to carried out a whole changeover session.

In addition, when looking at the chart, viewers can point out time gaps during the entire setup cycle. Therefore, the management team can rely on that to come up with plans to arrange or add personnel to quickly overcome these problems that a summary table of setup time above can hardly convey.

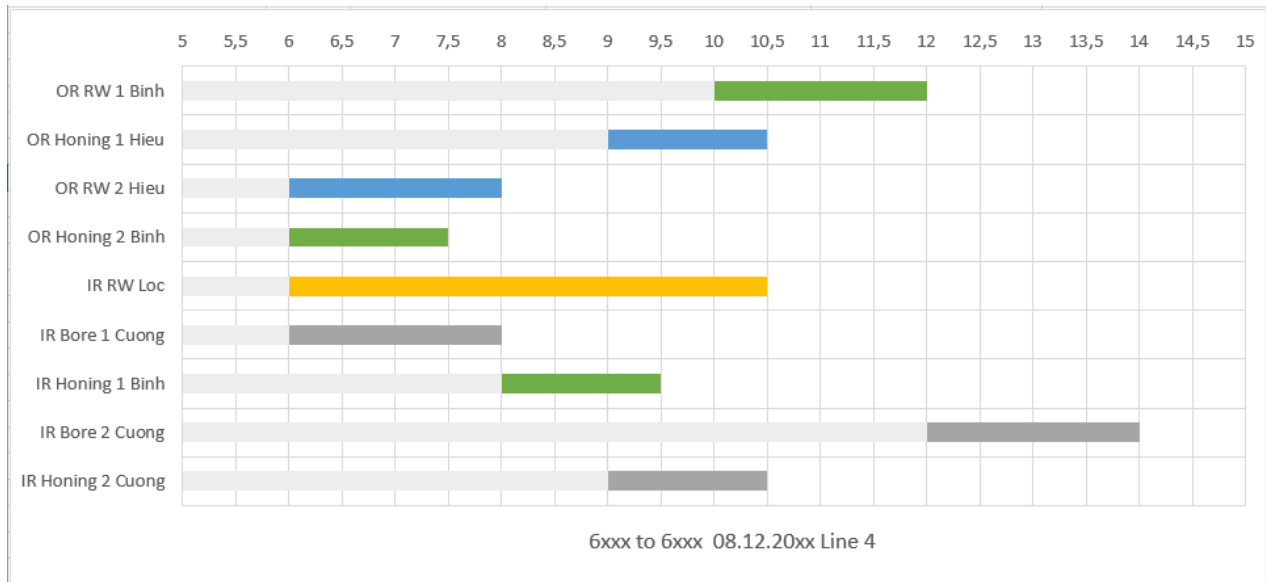


Figure 33. Simulation of changeover process

### Setup steps and time progress analysis

Furthermore a more specific quantitative time study table are generated in the analyzing meeting to identify the wastes that happened during the video taping. This table details the time taken for each smallest activity during the setup process, from moving to search for necessary materials and tools to removing and assembling tools, editing tools, and fine-tuning the machine. This is clearly demonstrated by analyzing the video footage and the Spaghetti diagram. This tool helps teams synthesize and classify redundant steps and wasting times in an easier and more systematic way. Thereby, the team will directly make decisions to convert or eliminate wasteful steps to achieve short-term efficiency and move towards long-term solutions.

No.	PROCESS STEP	Begin Time hh:mm:ss	STEP TIME hh:mm:ss	TARGET SETUP TIME	WEKUV	Operation Classification
				hh:mm:ss		
				3:55		
				235		
1	Đẩy xe tool ra ngoài máy	18:00:00	18:02:00	0:02:00	E	Transport
2	Đi lấy xe dụng cụ setup	18:02:00	18:05:00	0:03:00	E	Transport
3	vệ sinh lại máy	18:05:00	18:25:00	0:20:00		Cleaning
4	Di chuyển đi lấy búa	18:25:00	18:27:00	0:02:00	E	Transport
6	Tháo tool cũ( shoe, Driver, inchute, outchute)	18:27:00	18:32:00	0:05:00		Remove workpiece
7	Tháo đá mài	18:32:00	18:37:00	0:05:00		Remove workpiece
8	tháo roller Dresser( tháo ra khỏi máy)	18:37:00	18:42:00	0:05:00		Remove workpiece
9	gắn driver mã mới	18:42:00	18:47:00	0:05:00		Install workpiece
10	Mài Driver	18:47:00	18:52:00	0:05:00		Install workpiece
11	Gắn shoe plate	18:52:00	19:00:00	0:08:00		Install workpiece
12	Di chuyển lại xe tool lớn để set shoe + set shoe	19:00:00	19:15:00	0:15:00	E	Transport
13	gắn lại đường dẫn inchute mã mới	19:15:00	19:27:00	0:12:00		Install workpiece
14	gắn đường dẫn out mã mới	19:27:00	19:35:00	0:08:00		Install workpiece
15	Chờ toolshop cấp loading pin mới do cấp sai mã	19:35:00	20:05:00	0:30:00	E	Waiting
16	Gắn loading pin	20:05:00	20:10:00	0:05:00		Install workpiece
17	Di chuyển đi lấy 2 khóa còn thiếu	20:10:00	20:12:00	0:02:00	E	Transport
18	Gắn lại Roller Dresser vào vị trí cũ	20:12:00	20:17:00	0:05:00		Install workpiece
19	gắn lại đá mã mới	20:17:00	20:19:00	0:02:00		Install workpiece
20	set điểm dresser	20:19:00	20:42:00	0:23:00		Operation
21	Dressing đá , nhập lại parameter mã mới	20:42:00	20:47:00	0:05:00		Operation
22	chỉnh góc bàn máy	20:47:00	20:54:00	0:07:00	W	Operation
23	Di chuyển lấy ring WIP test	20:54:00	20:57:00	0:03:00	E	Transport
24	Di chuyển tới Monitor kiểm tra bản vẽ, lấy kích thước	20:57:00	20:59:00	0:02:00	E	Transport
25	set điểm mài cho mài thử	20:59:00	21:07:00	0:08:00		Operation
26	mang ring mẫu đi đo	21:07:00	21:10:00	0:03:00		Operation
27	chỉnh lại góc bàn máy	21:10:00	21:17:00	0:07:00	W	Operation
28	cho mài lại => mang mẫu đi đo	21:17:00	21:27:00	0:10:00	W	Operation
29	cho mài lại => mang mẫu đi đo =>ok	21:27:00	21:37:00	0:10:00	W	Operation
30	cho chạy mass	21:37:00	21:52:00	0:15:00		Operation
31	căn lại đường dẫn inchute (kết phối)	21:52:00	21:55:00	0:03:00		Operation

Figure 34. Setup steps and time progress analysis

### Employees' Feedback:

Regular feedback sessions were organized to note employee satisfaction and identify any challenges faced during the implementation process.

During the data collection process, communicating with employees to get information is very important. Through that, the team member willing to share and bring up the pain points that were mentioned repeatedly to the management department but up to now there have been no changes. Therefore, it becomes very valuable to discuss immediately after completing the setup session. It is at this point that the author's recorded developments and discussed them directly with setup technicians will provide the most realistic and objective perspective on what is happening on the line. Thanks to that, permanent problems will reach the management board faster through SMED improvement meetings.

Through short conversations, it is recorded that the lack of setup support tools is a painful problem. Besides, the author also derived information such as not having much training on 8 wastes, SMED and lack of proactive improvement spirit also contributing to waste. However, it is also necessary to emphasize the important role of engineers in creating streamlined setup standard work, containing the Lean philosophy to emphasize the role of eliminating waste in the work process. This indirectly helps workers improve performance and directly helps lines improve productivity.

#### **4.2.2 Defining problems**

To perform the planning step, this process includes collecting data, analyzing data, defining problem, based on cause and effect diagram to find the root cause of problems. When conducting root cause analysis, the author asked many questions to define the problem and why it happened like that. Because of the lack of practical experience as well as theory, the author conducted a number of small discussions and discuss with the supervisor, grinding engineer, as well as workers working directly on the production line. Thanks to that, he can get a multi-dimensional perspective on the management aspect as well as the machine setup process. Through the questions asked, the author has shaped the problems and included them in the Ishikawa diagram to proceed with deeper analysis steps with the 5 Whys technique.

#### **4.2.3 Problem solving tool**

5 Whys techniques are the easiest problem-solving methods to approach and implement. This technique asks why questions and continuously delves deeper into a problem until finding the final answer, thereby helping the implementer come up with a potential solution. Then large and small problems will be applied to the fishbone diagram to create a visual and overall image to proceed to the analysis summary step. In this diagram, the implementer should fill in important keywords that can clarify the nature of the problem through large and small branches representing aspects of the problem from the abstract to the detailed and finally. is the root cause of the problem. Not only that, Cause and effect diagram also helps the analysis team understand and remember the entire process because of its simplicity and effectiveness.

#### **4.2.4 Wastes identification**

##### **Tool and equipment waiting**

Through the process of observing and synthesizing data, it shows that there are many types of waste present in the setup process. These types are classified into two categories: Operation and Waiting. Video footage and Spaghetti diagram show that employees moving or strolling around needlessly too much when they aren't involved in the production of the product. They move around to get the necessary tools and materials such as wrenches, bolts, hammer, testing ring and adjusting tool at a workstation at the other side of the line. This breaks the workflow and unintentionally makes the setter less productive during setup. The result increases the setup time of each machine from 10 to 15 minutes for the whole process. In addition, waiting for the tool because the whole line only has 1 tool also has a significant impact. These tools include: gauges, which currently has

2 pieces, sometimes only 1 left due to the other being damaged, this device is used to flatness measurement for all machines. Another tool is the driver grinder, there is only one, the duration of using this device when installed ranges from 10 to 20 minutes. This equipment is needed for 3 types of machines: ORR, Bore and Honing. And some other tools. Time lost due to waiting for tools to continue the installation process ranges from 5 min to 30 min per machine. In particular, there are times when the cumulative time can be up to 1 hour for each overall setup process.. This seriously affects production capacity as well as causes discomfort for employees when having to wait like that.

Another cause of waiting is that the tool provided by the tool shop does not match the required model or is missing. When this situation occurs, technicians will have to proactively take other steps in the setup process to limit downtime. However, the process of adding or fixing tools is slow, the setup technician must take the tool to the toolshop to complete the procedure to retrieve the tool. Because the tool team's personnel are not always present at the workplace, or the necessary tool does not meet the requirements, it takes more time to correct or change the tools, so waiting when encountering this problem is often costly. a lot of time. The average waiting time for this item is 30 minutes. In special cases, it usually occurs in the evening or at night, when toolshop employees go on break or are not present at work. causing this process to last up to 3-4 hours.

Below are examples of waste that was recorded and analyzed actual evidence to investigate problems in changeover process



Vietnamese-German University

no	Machine list	CW 14 Apr 2022 04,04 6205 to 6006	CW 14 Apr 2022 05,04 6007 to 6005	CW 16 Apr 2022 22.04 6005 to 6305	CW 16 Apr 2022 23.04 6006 to 6302	CW 18 May 2022 02.05 6302 to 6206	CW 19 May 2022 12.05 6305 to 6205	CW 20 May 2022 18.05 6206 to 6304	CW 21 May 2022 23.05 6205 to 6005
1	MAS_IR	20	20	20	20	20	20	20	20
2	MAS_AU	30	30	30	30	20	20	20	20
3	IFS_LM 1 (ORR 1)	180	240	210	210	230	120	335	240
4	MAS_1	20	20	20	20	20	20	20	20
5	HM2NC_1 (OR Honing 1)	90	210	90	90	110	90	90	90
6	IFS_LM 2 (ORR 2)	210	240	180	150	184	120	180	210
7	MAS_2	30	30	30	30	30	30	30	30
8	HM2NC_2 (OR Honing 2)	90	180	90	90	180	110	90	455
9	AFS (IRR)	360	360	300	330	360	330	330	360
10	MAS_3	20	20	20	20	20	20	20	20
11	IFS_BM 1 (IR Bore 1)	180	230	180	230	180	150	270	210
12	MAS_4	20	20	20	20	20	20	20	20
13	HM2NC_1 (IR Honing 1)	120	120	150	90	90	90	120	90
14	IFS_BM 1 (IR Bore 2)	180	180	150	150	120	120	200	150
15	MAS_5	20	20	20	20	20	20	20	20
16	HM2NC_1 (IR Honing 2)	90	120	120	90	90	210	120	140
17	Sum	1080	900	675	735	1170	630	965	620
19	Tool problem	60	120	50	45	70	75	280	80
20	Maintenance problem	0	0	40	30	45	30	20	395
21	Setup form	04.04.2022	05.04.2022	22.04.2022	23.04.2022	03.05.2022	12.05.2022	18.05.2022	23.05.2022

Figure 35. Highlight of tool problem waiting time

### Waiting time analysis

In the spreadsheet above, a cell name Tool problem with indicators highlighted in yellow represents the waiting time for tools in each setup to a new product code, along with scattered cells highlighted in blue. all over the spreadsheet are setup time of each machine. These 2 highlighted items highlight the situation of waiting for tools that occurred continuously within 2 months of April and May with an average frequency of 3 machines each session. Total waiting time was 780 minutes over 8 changeovers, an average of 87 minutes per setup. That indicates that there are many errors in the tool preparation and maintenance process of the Tool shop, in addition to the lack of communication and put-in effort to address this frequently occurring problem between two departments.

In addition, the cells highlighted in also show the waiting time for equipment between machines. Although it is not clearly recorded, this problem still occurs frequently because the number of tools has not changed for a long time from the past until the 2 months highlighted in the image above.

### Unnecessary movements

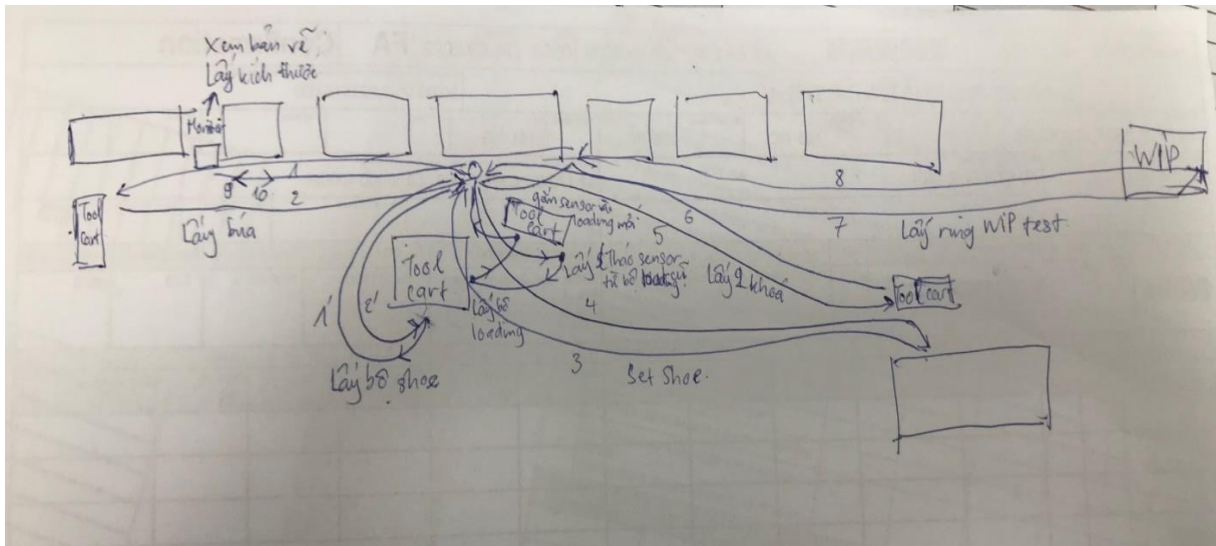


Figure 36. Spaghetti Diagram of IRR machine setup

Just using the Spaghetti diagram technique, which is drawing the technician's movement route and noting the actions for those moves, has helped the author and the team define many issues that need to be improved in the preparation actions before machine stop. The image above shows 5 moves that do not create the added value of the setter with an estimated travel distance of about 200 meters with a total time of 10 minutes walking and searching, plus 15 minutes setting the shoe. The purposes of the above moves include:

- Getting assembling tool
- Getting a hammer
- Getting a box of testing ring
- Getting 2 necessary wrenches
- Checking technical drawing on monitor
- Setting shoe at work station.

#### 4.2.5 Root cause analysis

The first step is to define the major problems, i.e., unnecessary movement, waiting for tools, and mindset. More why questions have been asked to find the deeper causes of those 3 major problems listed. In the first major problem, even though the line has been in operation for more than two years, the employees' mindset about Kaizen is just at the level of simply knowing and not having a desire to improve the work process they used to doing it for a long time. The psychology of not set out of comfort zone and working at a moderate level is still a visible problem but difficult to discuss in the group. This has become an tacit rule in the minds of most employees on the production line. The second major problem is waiting for tools. Issues of wrong tools and missing tools are continuously reported. Besides, the insufficient amount of equipment causes the setup



process to be interrupted many times. The third major problem is unnecessary movement, the setters just proceed with the setup with the motto of adding whatever is missing. The problems were no testing ring, no honing stone or bearing, no necessary equipment, and having to move to another workstation to perform the shoe setting step. Figure... is a Cause and Effect diagram that has been developed for the issue: Constantly long setup time.

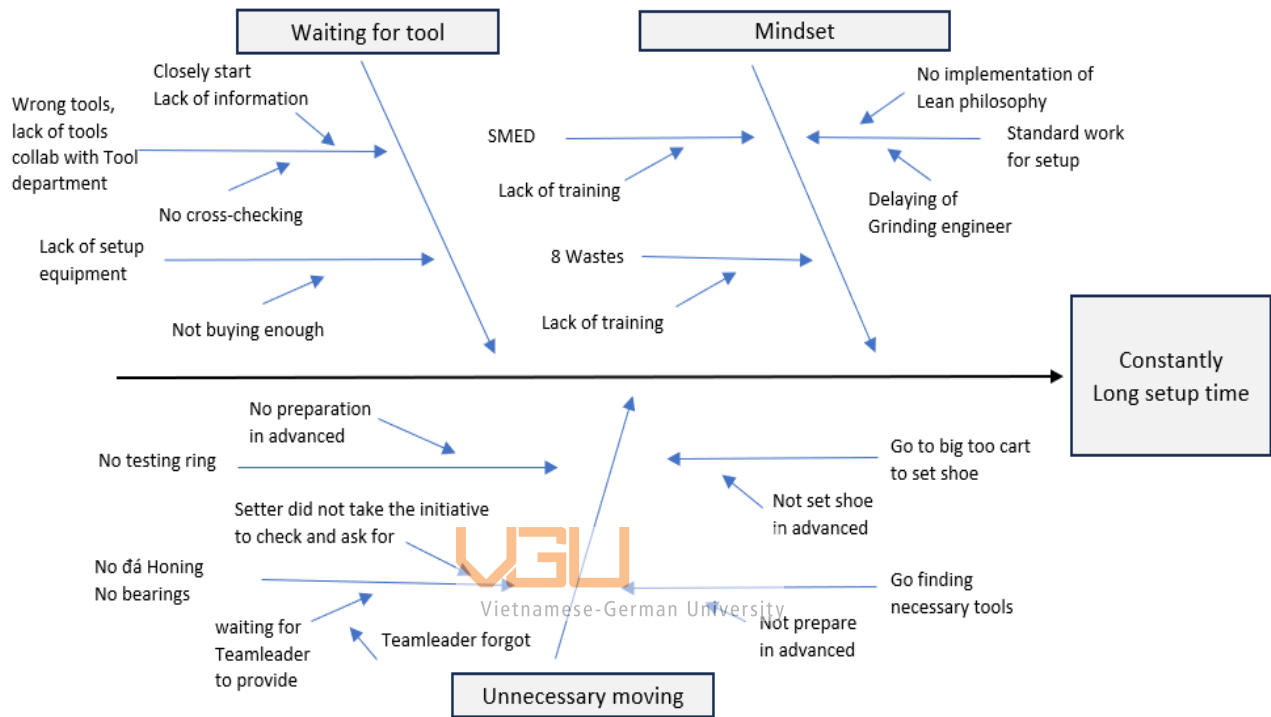


Figure 37. Cause and Effect diagram of constantly long setup time problem

The table below shows the root cause analysis process using the 5 Whys technique for 3 major problems

Table 1. Root cause analysis of major problems in setup process

Problem	1st Why	2nd Why	3rd Why	4th Why	Solutions
Mindset	Lack of motivation	Lack of knowledge	Lack of training Lack of sharing experience in identifying and eliminating waste	Not schedule	Make a schedule to carry out training and sharing experiences session a
Waiting for tool	Wrong tool, lack of tool	Lack of cross-checking and confirmation	Not report problem officially and find a solution	Delaying in taking action	Hold a meeting to report problem and create a cross-checking process
Waiting for equipment	Lack of equipment	Not buying enough	Delaying in buying equipment process	Not assign task to a specific staff	Assign this task to the author and make a deadline for it
Unnecessary movement	No testing ring	Not prepare in advanced	Not check before start setup session	Not included in the standard work	Engineer fix standard work (But first spreading checklist to test this practice)
Unnecessary movement	No honing stone, no bearings	- Wait for teamleaders to provide - Setter not checking	- Teamleader forgot - Setter lack of taking initiative to ask for it	- No daily task reminder - Not included in the standard work	Provide task reminder for Teamleader Engineer fix standard work (But first spreading checklist to test this practice)
Unnecessary movement	Go finding necessary equipment	Not prepare in advanced	Not check before start setup session	Not included in the standard work	Engineer fix standard work (But first spreading checklist to test this practice)
Unnecessary movement	Go to other workstation to set shoe	Need to set shoe	It is possible to set shoe before starting setup	Not included in standard work	Engineer fix standard work (But first spreading checklist to test this practice)

After analyzing to find the causes, some information was turned over by the author to clarify the issue. With the recorded minutes, there have been training sessions on Lean production philosophy and continuous improvement for direct production workers, however the gap between these sessions is quite large, about Every 6 months for 1 content. In addition, the summaries of experience sharing as well as typical practices only stop online, this is an information channel that operations staff as well as setup technicians do not have the opportunity to receive regularly due to the nature of the job. The job is direct production. Therefore, reality has reflected the impact of the infrequent implementation of a culture of continuous improvement and the lack of practical sharing of identify and eliminate waste thinking in the work process. Another part is that the education level of the workers is not high, according to the survey, 67% (8) of grinding line employees have a high school degree, 20% (3) of the employees have an intermediate degree, and 13% (3) have an intermediate degree. 2) The remaining employees have a degree of associate. Therefore, it is necessary to have a specific plan to open coaching sessions and share experiences

directly on the shopfloor with more practicality along with clear evaluation tools in the future. This requires stronger collaboration between the management team and Lean department. Through the above analysis, the author believes that this study will bring added value to the process of building a training program for the DGBB line. Furthermore, the Grinding engineer also has an important role as the person who sets up standard working processes for the line. When the actual situation is not as expected, the engineer is the person with good academic knowledge and can practice improvement. Do your work first and share it with the team to demonstrate the Kaizen spirit.

Through the meetings at the beginning of the day, some reasons were pointed out: too little time to prepare tools, lack of communication or timely presence of tool shop staff when errors occur, and no confirmation of tool check between the two parties. Through problems recorded in April and May, downtime for tool errors averaged 60 minutes per setup for each line. Therefore, the team needs to take stronger actions to solve this problem. Organizing a meeting with the heads of departments is essential to report these problems and work together to come up with a solution to the problem as soon as possible. In addition, the job of purchasing additional equipment has been assigned to the author with the goal of making a list of items that need to be added and getting a quotation within one week. After receiving the quotation, PR PO submission and approval will be handled by the production supervisor. In addition, the author is also responsible for creating a checklist to ensure equipment and materials are fully prepared before starting setup.

**The target** is to reduce setup time by 30%, decrease unnecessary movement by 100%, and improve tool availability by 80% within a 2-month implementation period



Vietnamese-German University

## PDCA timeline

The table below shows the timeline and specific actions for the process of applying the SMED method to reduce changeover time for the DGBB line.

Table 2. PDCA timeline for implementing SMED

PDCA	Detail actions
Plan: 15 May-30 May	<ul style="list-style-type: none"> <li>-Collecting data through video recording, setup forms, Spaghetti diagram</li> <li>-Identify problems, grasp the actual situation</li> <li>-Root causes analysis</li> <li>-Set goals</li> <li>-Propose solutions</li> </ul>
Do 1 June-30 July	<p>Conduct improvement actions below:</p> <ul style="list-style-type: none"> <li>-Video recording, drawing Spaghetti diagram, record setup form data, asking for insights and needs of setup technicians team have been carried out at the starting of planning phase (Author)</li> <li>-Buy necessary equipment (Author)</li> <li>-Create a checklist for setup equipment (Author)</li> <li>-Hold a meeting with Tool department (Production Supervisor)</li> <li>-Create daily task document for Teamleader (Production Supervisor)</li> <li>-Schedule a training before implementing SMED (Teamleader)</li> <li>-Create new standard for setup procedure (Grinding Engineer)</li> </ul>
Check 1 Aug	<ul style="list-style-type: none"> <li>-Setup time recorded</li> <li>-Tool problem report</li> <li>-Purchased equipment status</li> </ul>
Act Aug	<ul style="list-style-type: none"> <li>-Document benefits</li> <li>-New standard update</li> <li>-Plan for continuous improvement</li> </ul>

### 4.3 Do

#### Training

Comprehensive training sessions were conducted to educate the setup team on the principles of SMED, emphasizing the importance of separation of internal and external setup activities. In addition, the setup team is also trained on 8 types of waste along with specific practices sharing to improve the ability to recognize waste, thereby forming a mindset of recognizing waste and finding ways to continuously eliminate that waste. Or more simply, contribute valuable ideas to the

management department. In addition, during this training session, the data collection steps as well as details of solutions to be implemented in the near future are also informed to the setup team to help them fully understand the meaning of these actions and be ready to cooperate to produce the desired results.



Figure 38. SMED and 8 Wastes training

### **Establishing new process**

After the meeting with the Tool department, a tool delivery record is created, requiring employees of both departments to check and sign to confirm that they have received enough tools and the right quality as required when handing over the tool setup of the new product code. In addition, the two parties also agreed that the tool shop will deliver the tools one day before the setup takes place so that the two parties have time to make additions or changes when they realize errors.







Figure 39. Meeting between Tool department and Production department to establish new procedure

### **Implementing checklist**

Next, based on the analysis results as well as previous discussions with technicians, a checklist of necessary steps for the external setup process for each machine is issued and announced immediately after the training session. These steps include preparing the necessary equipment, ensuring honing stones, bearings, and ringtests are fully prepared. The setup process is only performed after employees have completed the steps outlined in the checklist and marked it as completed. In addition, a daily task template has been prepared and handout to Teamleaders. This template helps Teamleaders follow and complete their own tasks to coordinate the setup process effectively.



Table 3. Tool preparation with checklist results

Machine	Actual preparation	Follow up checklist																				
Outer Raceway Grinding Machine (ORR)		<table border="1"> <thead> <tr> <th>Máy ORR</th> <th>Check</th> </tr> </thead> <tbody> <tr> <td>Lục giác 2.5, 3, 4, 5, 6, 10</td> <td>✓</td> </tr> <tr> <td>Khóa trợ lực 19</td> <td>✓</td> </tr> <tr> <td>Khóa 13, 24 set đường dẫn</td> <td>✓</td> </tr> <tr> <td>Khóa mở trắng đen 32, 38 (Mở đầu wheel)</td> <td>✓</td> </tr> <tr> <td>Bộ mài Driver + Đồng hồ đo độ phẳng</td> <td>✓</td> </tr> <tr> <td>1 bộ ốc vít dự phòng</td> <td></td> </tr> </tbody> </table>	Máy ORR	Check	Lục giác 2.5, 3, 4, 5, 6, 10	✓	Khóa trợ lực 19	✓	Khóa 13, 24 set đường dẫn	✓	Khóa mở trắng đen 32, 38 (Mở đầu wheel)	✓	Bộ mài Driver + Đồng hồ đo độ phẳng	✓	1 bộ ốc vít dự phòng							
Máy ORR	Check																					
Lục giác 2.5, 3, 4, 5, 6, 10	✓																					
Khóa trợ lực 19	✓																					
Khóa 13, 24 set đường dẫn	✓																					
Khóa mở trắng đen 32, 38 (Mở đầu wheel)	✓																					
Bộ mài Driver + Đồng hồ đo độ phẳng	✓																					
1 bộ ốc vít dự phòng																						
Raceway Honing Machine (Honing)		<table border="1"> <thead> <tr> <th>Máy Honing</th> <th>Check</th> </tr> </thead> <tbody> <tr> <td>Lục giác 3, 4, 5, 6</td> <td>✓</td> </tr> <tr> <td>Cây (2.5, 3, 4, 5, 6, 8)</td> <td>✓</td> </tr> <tr> <td>Khóa 10, 17, 19, 7</td> <td>✓</td> </tr> <tr> <td>Bộ mài Driver + Đồng hồ đo độ phẳng</td> <td>✓</td> </tr> <tr> <td>4 con bạc đạn Honing</td> <td>✓</td> </tr> <tr> <td>1 bộ ốc vít dự phòng</td> <td></td> </tr> </tbody> </table>	Máy Honing	Check	Lục giác 3, 4, 5, 6	✓	Cây (2.5, 3, 4, 5, 6, 8)	✓	Khóa 10, 17, 19, 7	✓	Bộ mài Driver + Đồng hồ đo độ phẳng	✓	4 con bạc đạn Honing	✓	1 bộ ốc vít dự phòng							
Máy Honing	Check																					
Lục giác 3, 4, 5, 6	✓																					
Cây (2.5, 3, 4, 5, 6, 8)	✓																					
Khóa 10, 17, 19, 7	✓																					
Bộ mài Driver + Đồng hồ đo độ phẳng	✓																					
4 con bạc đạn Honing	✓																					
1 bộ ốc vít dự phòng																						
Inner Raceway Grinding Machine (IRR)		<table border="1"> <thead> <tr> <th>Máy IRR</th> <th>Check</th> </tr> </thead> <tbody> <tr> <td>Lục giác 3, 4, 5, 6, 8, 5</td> <td>✓</td> </tr> <tr> <td>Khóa 12, 16, 17, 18, 19</td> <td>✓</td> </tr> <tr> <td>Khóa đen đẹp 24</td> <td>✓</td> </tr> <tr> <td>Air gun - Súng hơi mở đá + Đầu lục giác 19 mở đá</td> <td>✓</td> </tr> <tr> <td>Ratchet extension - Cần trợ lực</td> <td>✓</td> </tr> <tr> <td>ALL - Necessary screws, nuts, washers, distance plates</td> <td>✓</td> </tr> <tr> <td>Calculation of the radius - Tính thông số set điểm mài</td> <td>✓</td> </tr> <tr> <td>Dial gauge - Đồng hồ đo độ phẳng</td> <td>✓</td> </tr> <tr> <td>Ladder - Thang</td> <td>✓</td> </tr> </tbody> </table>	Máy IRR	Check	Lục giác 3, 4, 5, 6, 8, 5	✓	Khóa 12, 16, 17, 18, 19	✓	Khóa đen đẹp 24	✓	Air gun - Súng hơi mở đá + Đầu lục giác 19 mở đá	✓	Ratchet extension - Cần trợ lực	✓	ALL - Necessary screws, nuts, washers, distance plates	✓	Calculation of the radius - Tính thông số set điểm mài	✓	Dial gauge - Đồng hồ đo độ phẳng	✓	Ladder - Thang	✓
Máy IRR	Check																					
Lục giác 3, 4, 5, 6, 8, 5	✓																					
Khóa 12, 16, 17, 18, 19	✓																					
Khóa đen đẹp 24	✓																					
Air gun - Súng hơi mở đá + Đầu lục giác 19 mở đá	✓																					
Ratchet extension - Cần trợ lực	✓																					
ALL - Necessary screws, nuts, washers, distance plates	✓																					
Calculation of the radius - Tính thông số set điểm mài	✓																					
Dial gauge - Đồng hồ đo độ phẳng	✓																					
Ladder - Thang	✓																					
Inner Bore Grinding Machine (Bore)		<table border="1"> <thead> <tr> <th>Máy BORE</th> <th>Check</th> </tr> </thead> <tbody> <tr> <td>Lục giác 2.5, 3, 4, 5, 6, 10</td> <td>✓</td> </tr> <tr> <td>Khóa trợ lực 19</td> <td>✓</td> </tr> <tr> <td>Khóa 13, 16, 20, 24</td> <td>✓</td> </tr> <tr> <td>Khóa mở trắng đen 32, 38 (Mở đầu wheel)</td> <td></td> </tr> <tr> <td>Bộ mài Driver + Đồng hồ đo độ phẳng</td> <td>✓</td> </tr> <tr> <td>1 bộ ốc vít dự phòng</td> <td></td> </tr> </tbody> </table>	Máy BORE	Check	Lục giác 2.5, 3, 4, 5, 6, 10	✓	Khóa trợ lực 19	✓	Khóa 13, 16, 20, 24	✓	Khóa mở trắng đen 32, 38 (Mở đầu wheel)		Bộ mài Driver + Đồng hồ đo độ phẳng	✓	1 bộ ốc vít dự phòng							
Máy BORE	Check																					
Lục giác 2.5, 3, 4, 5, 6, 10	✓																					
Khóa trợ lực 19	✓																					
Khóa 13, 16, 20, 24	✓																					
Khóa mở trắng đen 32, 38 (Mở đầu wheel)																						
Bộ mài Driver + Đồng hồ đo độ phẳng	✓																					
1 bộ ốc vít dự phòng																						



In the future, the author continues video recording, draws Spaghetti diagram, and records setup time data for the recording process as well as evaluating the results.

### Purchasing necessary tools

Along with the setup process, the author also made a list of missing tools, contact the supplier and get a quotation within the first week of project implementation. The image below shows a list of tools that need to be added to the line.






TÊN DỤNG CỤ/THƯƠNG HIỆU	SỐ LƯỢNG	HÌNH ẢNH	CÔNG DỤNG
Wrenches Package Garant	1 set		Dùng tháo đầu wheel spindle, đá, chỉnh góc bàn máy,....
Tool disassembly Roller Dresser	2 pcs		Dùng để tháo trục Roller Dresser, thay Roller Dresser
1 Airgun kawasaki Allen key head	1pc 1 set		Dùng tháo nhanh đá lớn IRR
1 Allen key size 12mm	2 pcs		Cần chỉnh góc máy Lip BDF, thay pully máy ORR, Bore BDF
Allen key set	2 sets		

Figure 40. List of purchasing necessary tools

## 4.4 Check

### Metrics and result

After 2 months of testing the proposed actions, the SMED team filtered and compared the results according to the proposed metrics such as tool problem record, setup time for each machine and total changeover time, purchase equipment status.

no	LINE Machine list	B2	B4	B4	B4	B2	B4	B2	B4	B2	B4	B2	B2	B4	B2	B4	B2	B4	B2
		CW 14 Apr 2022 04.04 6205 to 6006	CW 14 Apr 2022 05.04 6007 to 6005	CW 16 Apr 2022 22.04 6005 to 6305	CW 16 Apr 2022 23.04 6006 to 6302	CW 18 May 2022 02.05 6302 to 6206	CW 19 May 2022 12.05 6305 to 6205	CW 20 May 2022 18.05 6206 to 6304	CW 21 May 2022 23.05 6205 to 6005	CW 22 Jun 2022 02.06 6304 to 6205	CW 23 Jun 2022 10.06 6005 to 6303	CW 24 Jun 2022 13.06 6206 to 6006	CW 24 Jun 2022 16.06 6006 to 6302	CW 24 Jun 2022 18.06 6303 to 6305	CW 25 June 2022 25.06 6302 to 6304	CW 27 July 2022 06.07 6305 to 6303	CW 27 July 2022 07.07 6304 to 6205	CW 28 July 2022 14.07 6303 to 6005	CW 29 July 2022 24.07 6205 to 6006
1	MAS_IR	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
2	MAS_AU	30	30	30	30	20	20	20	20	20	20	20	20	20	20	20	20	20	N/A
3	IFS_LM 1 (ORR 1)	180	240	210	210	230	120	335	240	120	120	120	120	180	180	60	120	N/A	
4	MAS_1	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	N/A
5	HM2NC_1 (OR Honing 1)	90	210	90	90	110	90	90	90	120	90	105	90	90	90	120	150	90	N/A
6	IFS_LM 2 (ORR 2)	210	240	180	150	184	120	180	210	240	120	140	120	120	120	270	60	120	N/A
7	MAS_2	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	N/A
8	HM2NC_2 (OR Honing 2)	90	180	90	90	180	110	90	455	180	90	90	90	120	90	90	30	90	N/A
9	AFS (IRR)	360	360	300	330	360	330	330	360	300	360	360	240	240	240	360	360	240	N/A
10	MAS_3	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	N/A
11	IFS_BM 1 (IR Bore 1)	180	230	180	230	180	150	270	210	240	110	130	120	120	120	420	120	180	N/A
12	MAS_4	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	N/A
13	HM2NC_1 (IR Honing 1)	120	120	150	90	90	90	120	90	120	90	90	120	120	90	90	90	120	N/A
14	IFS_BM 1 (IR Bore 2)	180	180	150	150	120	120	200	150	130	120	120	120	120	240	230	120	N/A	
15	MAS_5	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	N/A
16	HM2NC_1 (IR Honing 2)	90	120	120	90	90	210	120	140	90	180	90	120	120	90	165	90	90	N/A
17	Sum	1080	900	675	735	1170	630	965	620	510	840	960	750	720	720	750	510	510	N/A
19	Tool problem	60	120	50	45	70	75	260	80	15	0	50	0	0	0	60	0	0	N/A
20	Maintenance problem	0	0	40	30	45	30	20	395	20	0	0	20	0	60	385	30	60	N/A
21	Setup form	04.04.2022	05.04.2022	22.04.2022	23.04.2022	03.05.2022	12.05.2022	18.05.2022	23.05.2022	02.06.2022	10.06.2022	13.06.2022	16.06.2022	18.06.2022	25.06.2022	06.07.2022	07.07.2022	14.07.2022	N/A

Figure 41. Setup time statistics before and after 2 months of implementing SMED actions

### Evaluating 1<sup>st</sup> metric: Tool problem and waiting time

The statistical table is used to indicate two indicators, first is the tool problems illustrated in time unit. The yellow highlight is the time the line had to wait for the tool due to tool shop errors in April and May. The green highlight is the time wasted because of tool problems after 2 months of implementing the SMED method. The spreadsheet shows that tool wait times have been reduced very impressively. From a total of 780 minutes for 8 changeovers in April and May down to 125 minutes for 9 setups in June and July. The average also decreased from 87 minutes per setup session, now reduced to almost 14 minutes or unnoticeable after 2 months of deployment. Even more optimistically, the Median value after applying the changes decreased from 70 minutes to 0. Compared to the proposed results, the total waiting time for the tool decreased after implementing the improvement steps an amount of 655 minutes equivalent to 84% waiting time reduction compared to before, which exceeded the set target

## Evaluating 2nd metric: Setup time of each machine and total changeover time

Table 4. Comparison in setup time recorded before and after implementing SMED

Machine	Average (minutes)			Median (minutes)			Standard Deviation (minutes)		
	Before	After	Difference	Before	After	Difference	Before	After	Difference
ORR 1	216	127	-41%	210	120	-43%	55	34	-38%
Honing 1	116	105	-9%	90	90	0%	43	20	-53%
ORR 2	187	146	-22%	184	120	-35%	34	62	82%
Honing 2	156	97	-38%	110	90	-18%	111	37	-67%
IRR	337	300	-11%	330	300	-9%	24	57	138%
Bore 1	203	173	-15%	200	120	-40%	34	96	182%
Honing 3	111	103	-7%	120	90	-25%	20	15	-25%
Bore 2	159	147	-8%	150	120	-20%	26	47	81%
Honing 4	122	115	-6%	120	90	-25%	35	33	-6%
Sum (Total time)	883	697	-21%	900	720	-20%	213	150	-30%
Tool problems	87	14	-84%	70	0	-100%	75	23	-69%

Second, the next index used to evaluate the results of improvement is setup time of each machine and total setup time. This step was directly supervised by the author during the preparation and marking of the checklist. After applying this measure, the travel time without creating value added is reduced to 0 minutes. This means achieving the set requirement of reducing unnecessary movements by 100% compared to before. The setup time for each machine gradually becomes stable, this is shown by the frequency of installation time being close to the median of each machine which is 6/9 most recent setups. Waiting time for the tool is 0 minutes, meaning no tool errors occur in 6/9 times of taking the improved actions.

Besides, the average setup time for each machine also decreased significantly, ranging from 7 to 40% depending on each machine. The average overall setup time decreased by 186 minutes from 883 minutes to 697 minutes, equivalent to a 21% reduction compared to the initial situation, which is a significant result.

DGGB line's average monthly profit is 650,000 Euros. With simple math, we can calculate:

650000 Euro per month / 26 days working per month / 24 hours per day = 1042 Euro per hour

Knowing that currently, direct production costs account for 60% of profit on average

186 minutes equals to 3 hours total time reduction in a changeover can save up to:

$1042 \times 0.6 \times 3$  equals 1875 Euros per changeover

Within 9 setups in 2 months of testing, the project saved for the company at least 10,000 Euros after deducting additional costs.

This contributes to increasing the company's flexibility and competitiveness significantly in today's difficult market. It should be noted that these are just external improvements, there are still many opportunities for improvement in the internal setup process that the Engineer team has spent a long time researching and planning to improve in the near future.

**Evaluating 3<sup>rd</sup> metric: Purchasing status**

Third, the result of the equipment purchasing process is completing 5/7 items to buy, shown in the following table.

Table 5. Purchasing status of desired equipment

Equipment	Status
1 Wrenches Package	Purchased and handed out
1 Tool disassembly Roller Dresser	Purchased and handed out
1 Airgun kawasaki 1 Allen key head set	Purchased and handed out
1 Allen key size 12mm	Purchased and handed out
1 Allen key set	Purchased and handed out
1 Surface planishing tool.	Waiting for good price quotation
2 Flatness measuring tools	Waiting for good price quotation

Overall evolution for SMED implementation: Through the process of summarizing the results, the proposed actions have been 100% implemented. After creating a tool delivery record and pushing the tool delivery time 1 day earlier before the changeover, the tool waiting time was reduced by 84%, surpassing the previously set goal (80%). After the training session with the setup technicians team, setters enthusiastically cooperated with the author in the process of checking and preparing full tools before starting the setup process for each machine. The results were as expected, 100% of unnecessary movements have been eliminated, thereby reducing wasted time by an average of 10 minutes per machine. In addition, 80% of the total required quantity of missing equipment has been purchased.

Through the above actions, the setup time of each machine gradually becomes stable, this is shown by the frequency of installation time being close to the median of each machine which is 6/9 most recent setup times. Tool waiting time is at 0 minutes, meaning no tool errors occur in 6/9 improved application setups, overall setup time reduced from 14.7 hours to 11.6 hours, equivalent to a 3 hour reduction. After calculation, the result of applying the SMED method in reducing overall setup time brought the company more than 10,000 Euros saving in production cost in 2 months.

#### **4.5 Act**

In the Act phase, a summary meeting was held to notify the results to relevant departments. With the expected results, the changes have been approved and continued to be deployed to the entire DGBB line. New actions have been proposed to sustain the results of implemented measures, including issuing improved standard work, scheduling meetings in the future to review and reassess the results of implemented improvements. Besides, a new plan has been proposed to continue implementing the SMED method in areas of setup procedure such as internal setup, maintenance problems, and find further improvements in adding equipment and ensuring quality. quality of tools, and promote the spirit of continuous improvement throughout the entire DGBB line.

## Chapter 5 Conclusion

In conclusion, this study highlights the benefits of the implementation of the 5S and SMED methods integrated with problem-solving methods such as the PDCA cycle and Action Research method. This results in significant overall image and production efficiency improvement. Through the practices, several changes were conducted, such as: tackling the persistent oil leakage problems and improving the working environment by creating employee-focused design products, ie. new honing stone and tool part container concept, new water bottle container shelves, design and applying new layout for WIP areas, error-proofing practice at the assembly line and a set new of visual management objects have been introduced. In the aspect of the changeover process, the problems related to tool waiting and unnecessary movement that existed in the setup process have been pointed out. By applying scientific methods, the team was able to frame the problems, analyze the root causes, and plan comprehensive implementation. Actions assigned with clear goals and deadlines for the right people and roles in the innovation team are also very important in the project. The achievements are the waste of movement and waiting has been eliminated following the set target. The setup time of each machine decreased and gradually became stable. The average overall setup time decreased by 186 minutes from 883 minutes to 697 minutes, equivalent to a 21% reduction compared to the initial situation, 100% of unnecessary movements have been eliminated, and the total waiting time for the tool decreased by an amount of 655 minutes equivalent to 84% waiting time reduction after 2 months of deployment. Also, 70% of the necessary equipment has been purchased and handed out to the production team.

In addition, actively discussing and receiving feedback from employees has great benefits in the process of analyzing the root cause and providing solutions. Through that, the team has launched actions to help them understand and feel the importance of their involvement in the SMED implementing project.

For future work, a new plan has been proposed to continue implementing the SMED method in areas of setup procedure such as internal setup, and maintenance problems. As important is to sustain the results of implemented measures. It requires dedication and contributions of all members to keep working on enhancement of the process standard, regularly schedule meetings to review and reassess the practices. With these efforts, the culture of continuous improvement in DGBB line will be strengthened and promoted better in the future.



## REFERENCES

- [1] Vi Nguyen and et al, "Practical application of plan–do–check–act cycle for quality improvement of sustainable packaging: a case study.," *Applied Sciences* , vol. 10.18, p. 6332, 2020.
- [2] J. Oliveira, J. Sá and A. Fernandes, "Continuous improvement through" Lean Tools": An application in a mechanical company," *Procedia Manufacturing*, vol. 13, pp. 1082-1089, 2017.
- [3] R. Sundar, A. N. Balaji and R. M. Satheesh Kumar, "A review on lean manufacturing implementation techniques.," *Procedia Engineering*, vol. 97, pp. 1875-1885, 2014.
- [4] A. Palange and D. Pankaj, "Lean manufacturing a vital tool to enhance productivity in manufacturing.," *Materials Today: Proceedings*, vol. 46, pp. 729-736, 2021.
- [5] A. Azian, N. Rahman and et al, "Lean manufacturing case study with Kanban system implementation.," *Procedia Economics and Finance*, vol. 7, pp. 174-180, 2013.
- [6] Ohno Taiichi, *Toyota production system: beyond large-scale production.*, Productivity press, 2019..
- [7] A. K. Möldner, Jose Arturo Garza-Reyes and and Vikas Kumar, "Exploring lean manufacturing practices' influence on process innovation performance," *Journal of Business Research* , vol. 106, pp. 233-249., 2020.
- [8] Mehta Vivaan B. and and Pranav Y. Dave, "Impact of 5S and lean manufacturing techniques in various organisations to enhance the productivity," *International Journal of Advances in Engineering and Management*, vol. 2.1, pp. 421-436., 2020.
- [9] Ghodrati, Arash and and Norzima Zulkifli, "A review on 5S implementation in industrial and business organizations," *IOSR journal of business and management*, vol. 5.3, pp. 11-13., 2012.
- [10] K. Kobayashi, "What is 5S? A Content Analysis of Japanese Management Approach," Unpublished Master's Thesis, Griffith University, Southport., 2005.
- [11] N. Khamis, M. Abrahman, K. Jamaludin and et al, "Development of 5S practice checklist for manufacturing industry," *Proceedings of the World Congress on Engineering.*, vol. 1, p. 978–988., 2009.

- [12] Antosz Katarzyna and and Andrzej Pacana, "Comparative analysis of the implementation of the SMED method on selected production stands," *Tehnički vjesnik*, vol. 25 Supplement 2, pp. 276-282., 2018.
- [13] Bidarra Tiago and e. al., "SMED methodology implementation in an automotive industry using a case study method.," *International Journal of Industrial Engineering and Management* , vol. 9.1, p. 1., 2018.
- [14] Nowakowska-Grunt Joanna and and Robert Salek, "SMED method analysis as a factor supporting enterprise management.," *Advanced Logistic Systems*, vol. Theory and Practice, p. 4, 2010.
- [15] Joshi, Rahul R. and and G. R. Naik, "Application of SMED Methodology-a case study in small scale industry.," *International journal of scientific and research publications*, vol. 2.8, pp. 1-4., 2012.
- [16] Joshi, R. Rahul and G. R. Naik, "Application of SMED Methodology-a case study in small scale industry," *International journal of scientific and research publications*, vol. 2.8, pp. 1-4., 2012.
- [17] A. Silva and et al, "Implementation of SMED in a cutting line," *Procedia Manufacturing* , vol. 51, pp. 1355-1362, 2020.
- [18] W. Karwowski, and William S. Marras and et al, The occupational ergonomics handbook, Crc Press, 1998.
- [19] T. Bossomaier and et al, "Scientific Approaches For The Industrial Workstations Ergonomic Design: A Review." ECMS 2010 Proceedings Edited by A Bargiela S A Ali D Crowley E J H Kerckhoffs, . Crossref, <https://doi.org/10.7148/2010-0189-0199>," June 2010.
- [20] Das Biman and Arijit K. Sengupta, "Industrial workstation design: a systematic ergonomics approach," *Applied ergonomics* , vol. 27.3, pp. 157-163, 1996.