Spare parts warehouse re-layout design with kaizen 5S implementation to reduce wasted time searching for machine parts

Arif Nuryono[1], Hibarkah Kurnia[2*], Iskandar Zulkarnaen[1]

[1]Industrial Engineering Department, Universitas Bhayangkara Raya, Bekasi, West Java 17121, Indonesia

[2]Industrial Engineering Department, Universitas Pelita Bangsa, Bekasi, West Java 17530, Indonesia

*Corresponding author: hibarkah@pelitabangsa.ac.id

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Abstract. Increasing the productivity and efficiency of production machines cannot be separated from the availability of machine spare parts in the warehouse department. Delays in the delivery of spare parts if machine problems occur often become a problem that disrupts efficiency. This delay was caused by the search for engine spare parts in the warehouse taking too long to find. The long search time was caused by the irregular placement of the materials and the messy condition of the warehouse. This research aims to make improvements to the goods search process to make it faster and more effective in the warehouse area and increase warehouse capacity using warehouse re-layout. This research method uses the implementation of warehouse re-layouts combined with the application of Kaizen 5S in controlling the condition of machine spare parts. This research found that the reason for the long search time for machine spare parts was due to the lack of knowledge of warehouse operators and the absence of training regarding the application of the 5S method, as well as the careless placement of spare parts in warehouses that were not neatly arranged. This research has resulted in a reduction in search time for engine spare parts from 6.4 minutes to 4 minutes per spare part unit or a decrease of 36.5%. Meanwhile, the results of the warehouse re-layout resulted in an increase in warehouse capacity from 80 pallets to 316 pallets, an increase of 395%.

Keywords: Kaizen, 5S, Warehouse Re-Layout, Reduce Loss Time, Spare Parts

1. Introduction

In the current era of globalization, companies are required to provide innovation and improvement in every aspect of the company, both in the form of improving product quality and increasing work effectiveness (Jaqin et al., 2023; Shobur et al., 2021). Factors that support the running of the production process require special facilities related to the storage of finished products or spare parts (Purba et al., 2018). Material storage activities require a system and a container or location that is used as a means for storing both products and spare parts. So that Companies are required to always develop so that the products and goods produced are stored and placed in a special place or storage room by utilizing the warehouse as a place for storing goods in the form of finished products or machine parts (Rizkiyah et al., 2023). A warehouse is a place that is needed to store goods in a warehouse safely and in controlled use (Saputra et al., 2021).

In general, the warehouse is a place to exchange information and as a place to store inventory needed to maintain supplies of goods and maintain an inventory that supports customer service policies, anticipate market changes (such as seasonality, and fluctuations in demand), and prepare any needs required by the relevant departments and as production support. Therefore, a warehouse is needed that has a design that takes into account speed and accuracy in the process of moving goods (Wahida & Munir, 2021). So that it will be able to maintain the inventory of stored goods, by optimizing the Warehouse area it can be calculated so that land optimization can be carried out properly and effectively (Hidayatulloh & Cahyana, 2022).

To overcome the conditions that occur in the warehouse, a method is needed to optimize warehouse conditions by applying the 5S method (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) (Mukhtar & Muhajir, 2020). This method is very suitable when efforts are made when implementing and placing goods to increase the implementation of placing and storing goods in the spare parts warehouse (Purba et al., 2018). Researchers are motivated to review the re-layout and organize the storage of materials in the form of machine spare parts so that they are neat and under control (Firmansyah & Lukmandono, 2020). The application of the 5S method is expected to improve warehouse problems including stock differences and the length of time to continuously search for material in the warehouse area (Shojaei et al., 2018). It is hoped that this improvement will increase productivity, and improve Occupational Safety and Health (OSH) (Kurnia et al., 2022).

The problems that have occurred so far in the company observed by the researcher were carried out in the spare part warehouse where there was inappropriate placement and placement, the search for material took too long, and the customer department complained too often regarding the delivery of material that was not on time. The search for spare parts takes a long time, as evidenced by the results of the research before improvement, which can be seen in Table 1. In addition, there are goods with identities that do not follow the system caused by the absence of a procedure for handing over minutes of goods that do not follow the type of goods in question. in the same location and place so that spare parts are not arranged neatly and in an orderly manner according to the type and specifications of the spare parts. Then there is a mismatch between the location identity description template in the numbering of spare part items and there is no definite placement location so the goods are only placed on pallets in areas that have free space, resulting in goods piling up mixed in one area of the warehouse, resulting in the goods looking cluttered and cramped. This can have an impact on the search for spare parts which results in difficulties in the search process and retrieval of spare parts, obstructed goods, and will require a lot of time in the search (Wahyudin et al., 2019).

Preliminary observation of the actual conditions found in the warehouse area in the special storage of serialized type spare parts consisting of airlocks, blowers, gearboxes, and electro motors with spare part placement conditions. The placement of these spare parts is only placed parallel to the warehouse area with the condition that there is no grouping unit between Airlocks, Blowers, Gearbox motors, and electro motors which are in one pallet and the same location, causing problems when picking up goods. The initial capacity before the improvement was only around 80 pallets or 240 machine spare parts, this required action steps to make improvements in the placement and arrangement of the spare parts warehouse area (Figure 1).

Figure 1 Spare Part Placement Warehouse Re-layout Conditions Before Improvement

The definition of 5S in Japanese is referred to as (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) is a form of movement originating from the determination to organize sorting in the workplace, organize, clean, maintain steady conditions and maintain the habits needed to carry out job well (Mukhtar & Muhajir, 2020). The 5S concept is a simple and systematic method in terms of handling goods or products in warehouse management (Agung & Hasbullah, 2019). Implementation of 5S in the warehouse will make it more productive, efficient, safe, and comfortable, and make work safety easier for employees to carry out while working. The basic concept of implementing 5S can start from organizing the workplace until it results in disciplining employees (Abu et al., 2019). The 5S methodology with Japanese and English versions can be seen in Figure 2.

Based on Figure 2, 5S is a method that has an appropriate structure or stages in creating a safe, healthy, and comfortable workplace and reducing defective products, as a result, consumer satisfaction will increase and can encourage increased productivity (Ngadono, 2018). The application of Kaizen 5S is an improvement tool in the Lean Manufacturing (LM) approach to reducing waste (Setyaningsih & Putri, 2015). The 5S method is a stage for regulating workplace conditions that have an impact on work effectiveness, efficiency, productivity, and work safety. One way to create a comfortable work atmosphere is for the company to implement the 5S work attitude (Nallusamy, 2016). The application of 5S can also be used in manufacturing and service industries combined with other approaches such as LM or others (Havi et al., 2018). This research focuses more on the implementation of 5S in the warehouse section to organize the goods or system so that goods can be easily found.

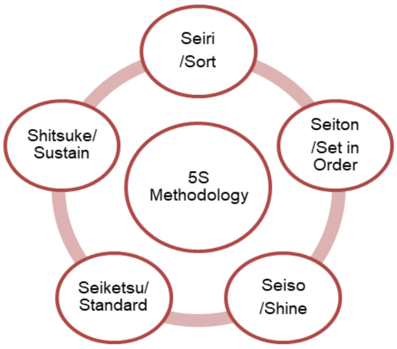

Figure 2 5S Methodology

A warehouse is a building used for storing goods, while warehousing is the activity of storing in a warehouse (Ramdhani & Supena, 2022). Warehouse functions apart from material storage can also be used as receiving, supplying, inventorying, and sending materials to other departments, depending on the type of material and material re-layout. A warehouse re-layout is a design that aims to minimize total costs by finding the best guide between space and material handling (Hidayatulloh & Cahyana, 2022). Placing materials in the warehouse initially depends on the type of material to be stored. Over time and conditions, many warehouses are converted to other storage functions, some even want to increase the capacity of the warehouse contents (Sugeng, 2016). Warehouse re-layout is very necessary and important if there is a lot of material stock and it is placed anywhere, of course, 5S and security are not maintained (Wahyudin et al., 2019).

In every activity in the warehouse, Warehouse re-layout and the application of the 5S concept are important activities that must be carried out to maximize and utilize warehouse space and minimize the time required for activities carried out in the Warehouse (Abidin et al., 2021). There are many methods used to maximize warehouses, for example, the systematic re-layout planning and Class Based Storage (CBS) approaches (Rahman et al., 2018), and the Heuristic methods and Activity Relationship Chart (ARC) approach (Wahida & Munir, 2021). In this research, the machine spare parts in the warehouse were messy, they were placed on pallets, placed in one room, and placed on the side of the road. Therefore, it is necessary to improve the warehouse with warehouse re-layouts by providing level rack facilities to maximize warehouse capacity.

The limitation of this research is only in the spare part warehouse area and only discusses serialized spare parts consisting of airlocks, blowers, gearbox motors, and electro motors. The research focuses on the arrangement of goods according to the re-layout with the classification and specifications of spare part goods in the form of Airlocks, Blowers, Gearbox motors, and Electromotors. The new approach of this research was carried out by relaying spare part warehouses, the Kaizen approach to find problems, and applying the 5S method to answer the improvements to be made. The purpose of the research that the author wants to achieve is to make improvements to the process of searching for goods so that it is faster and more effective in the warehouse area and to increase Warehouse capacity using the warehouse re-layout.

2. Method

This research method uses a Kaizen approach which consists of improvement tools such as Fishbone diagrams, why-why analysis, and 5W+1H. This Kaizen approach is combined with 5S and warehouse capacity calculations. This type of research is a type of mixed methods research where data collection is quantitative and qualitative (W Creswell, 2014). Quantitative research methods emphasize the objective and scientific measurement aspects of the phenomena or problems found (Kurnia, 2021). The data obtained came from primary data in the form of direct field observation experimental data (Nasution & Sodikin, 2018). Meanwhile, secondary data was obtained from monthly reports on inspection of spare part searches in the warehouse section.

The appropriate research design in this research is exploratory descriptive research which aims to describe the state of a phenomenon (Haslindah et al., 2020). The explorative descriptive research method is obtained by describing the circumstances of the occurrence of loss time looking for spare parts to overall corrective actions using the Kaizen approach in reducing loss time and using the 5S method to improve warehouse re-layout and warehouse capacity calculations to increase the number of spare parts that can be stored in the warehouse.

The method/technique required for data collection used in this research is observation because the type of data is primary data from measuring time using a stopwatch when searching for spare parts, the data obtained is in the form of quantitative data. Meanwhile, qualitative data was obtained from brainstorming or interviews when conducting cause-and-effect analysis using Fishbone diagrams (Aprianto et al., 2022). The research steps can be seen in Figure 3.

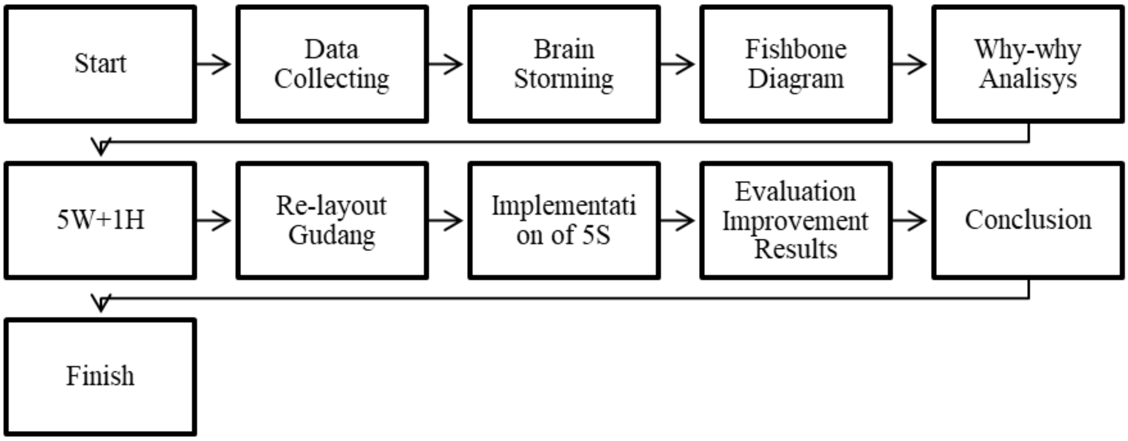

Figure 3 Research Stages

Based on Figure 3, the first step is to collect loss time data for finding spare parts in the warehouse. Then do brainstorming with the company regarding the flow of the process of receiving materials to sending materials to the customer. The next step is to make a Fishbone diagram to find the root of the problem that occurs. After that, the main causal factors were analyzed for cause and effect using the why-why analysis method (Sjarifudin & Kurnia, 2022). The next step is to plan improvements using the 5W+1H method, where each problem will be followed up in terms of improvements. Then, during the improvements, a warehouse re-layout will also be created to optimize material storage. The formula for knowing warehouse capacity is:

$$Warehouse\ Capacity = P \ x \ L \ x \ T \quad (1)$$

Where; P is the length of the warehouse, L is the width of the warehouse and T is the height of the warehouse.

$$PC = JR \ x \ PR \ x \ SL \quad (2)$$

Where; PC is Pallet Capacity, PR is Shelf Length and SL is Shelf Level.
The next step is to apply the 5S method with new re-layout conditions in material storage. The last step is to evaluate the results of improvements by measuring the search time for spare part materials and making conclusions from this research.

3. Result and Discussion

In this section, the results of several steps that have been determined will be discussed, starting from data collection to evaluating the results of improvements.

Data Collection

The spare part search time data above is data before there were improvements in the implementation and arrangement of the warehouse when searching for spare parts in the spare part storage warehouse located in the spare part warehouse area. It appears that the search time is quite long so the time needed to find one spare unit is quite a long part (Table 1)

Table 1 Result of seaceh time for spare parts before improvement

No	Airlock (minute)	Blower (minute)	Gearbox (minute)	Electro Motor (minute)
1	5	5	8	6
2	7	4	6	7
3	7	3	5	8
4	6	5	8	9
5	9	5	9	6
6	7	6	6	5
7	7	4	6	6
8	8	5	12	5
9	6	3	7	4
10	6	4	5	8
11	7	3	8	6
12	6	6	6	7
13	9	7	6	8
14	8	6	5	6
15	9	6	8	6
16	6	5	7	7
17	5	4	6	7
Amount	118	81	118	111
Average	6.9	4.8	6.9	6.5
			6.3	

Brain Storming

Interviews have been conducted with representatives from companies related to the scheme for receiving, storing, and sending spare part materials to customers. The interview results are outlined in the SIPOC diagram representing the five elements of the quality system including Suppliers, Inputs, Processes, Outputs, and Customers (Mridha et al., 2020). The SIPOC diagram of the goods delivery process can be seen in Figure 4.

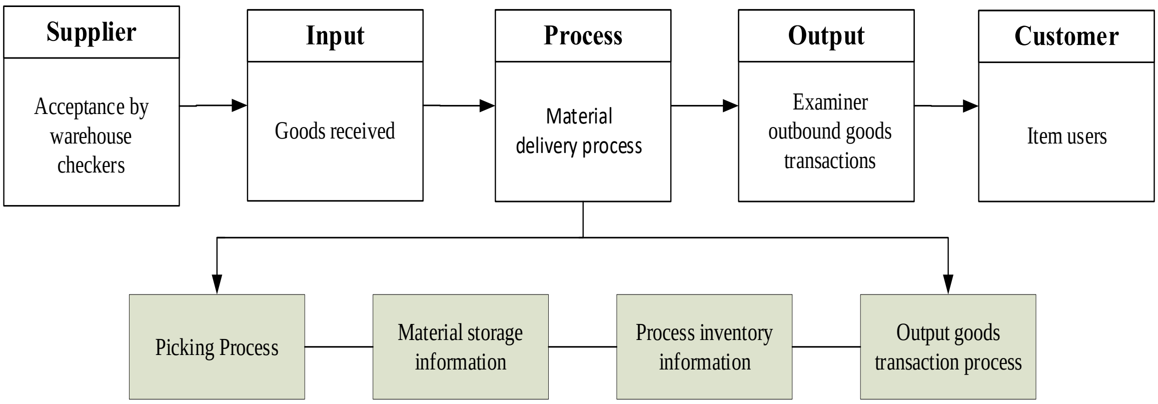

Figure 4 Warehouse Operational SIPOC Diagram

Based on Figure 4, it can be seen that in the process of receiving goods within this scope, the supplier is a warehouse. At this stage in the goods input process, it can be seen that there is a further process, namely the process of checking transaction output for use by customer needs (Kumar et al., 2020). Then picking is carried out based on the area according to the area in which the goods units are placed, then continues with information on the inventory of goods in the warehouse to ensure the suitability of the master data so that the availability of units with the appropriate data. Then the result of this process is a process carried out with goods output transactions according to needs. In the initial situation, the order of placing goods in the goods warehouse was not neatly arranged. This makes it difficult to search for and find items, the location where the items are placed does not match the location, so it will be difficult when looking for the item. Things that need to be paid attention to are items that are scattered around, which must also be paid attention to (Purba et al., 2018). This will have the effect of covering other items and thus the warehouse will appear full of items blocking the others. After searching for information and analyzing to find out the problems that occur in receiving goods and releasing goods related to operations in the warehouse resulting in delays in the process of picking up goods for customers. Therefore, interviews were conducted to find out information directly to employees.

Diagram Fishbone

A fishbone diagram (cause and effect diagram) is made by analyzing problems in the warehouse area that are not neat and messy in the process of placing goods (Sjarifudin et al., 2022). The results of the analysis of the factors that make the biggest contribution to the cause of a lack of understanding of methods and a lack of concern for employees. So the authors conducted a meeting with the improvement team to find the root of the problem. The results of the meeting are outlined in the Fishbone diagram in Figure 5.

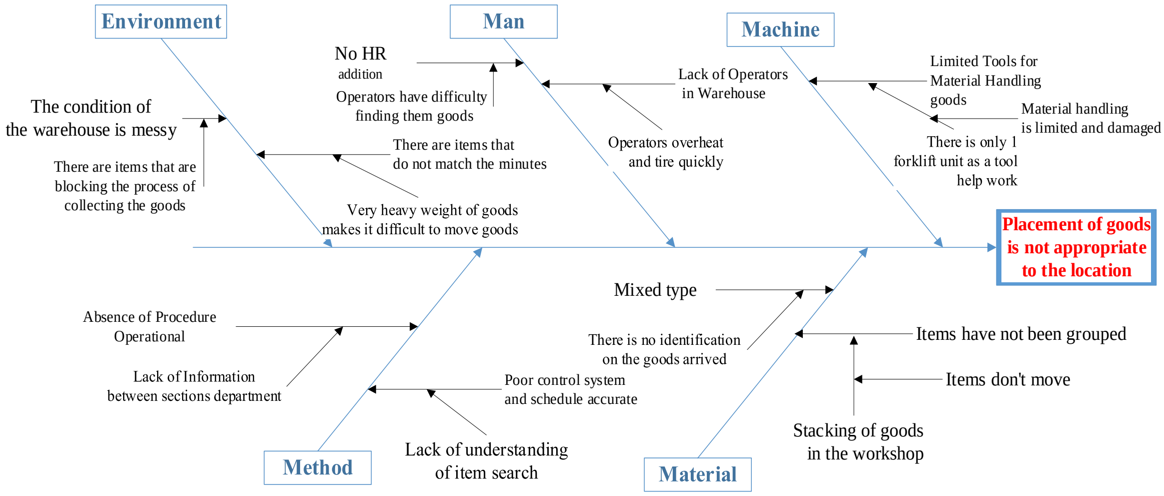

Figure 5 Fishbone Diagram for Placing Random Items

Why-Why Analysis

After carrying out a fishbone diagram, each main causal factor is further analyzed for the root of the problem using the why-why analysis method (Uddin, 2021). The results of the root cause analysis can be seen in Table 2.

Table 2 Root Cause Analysis

Factor Reason	Primary Cause	Root Cause Why 1	Why 2	Why 3
Man	Lack of Operators in the Warehouse	There are no additional human resources	Operators get hot and get tired quickly	Operators have difficulty finding goods
Material	There is no clear identity of the goods	Placement of goods is not appropriate and messy	There was a buildup of goods from the workshop	There is no identification on the goods arrived
Machine	Limited tools for material handling goods	There is only 1 unit of forklift as a tool help with work	Obstructing work because they have to take turns in usage	Material handling is limited and damaged
Method	Absence of Procedure operational	Lack of information between departments	Waiting for work aids because they take turns in use	Inaccurate control system and schedule

Factor Reason	Primary Cause	Root Cause Why 1	Why 2	Why 3
Environment	The messy warehouse conditions make operators uncomfortable work	Some items are blocking the process of collecting the goods	Some items do not match the minutes	The very heavy weight of goods makes it difficult to move goods

5W+1H Improvement Plan

After doing the analysis and knowing the dominant factors that cause the spare parts warehouse area the warehouse is not neatly organized. So the next step to be taken is to analyze using the 5W+1H method to provide improvement solutions following the root causes that have been determined at the Fishbone diagram analysis stage (Kurnia et al., 2023). The targets that will be achieved in evaluating improvement activities through the 5W+1H stages can be seen in Table 3.

Table 3 5W+1H Improvement Plan for Placement of Goods Not Appropriate to Location

Factor	Description	Remarks
Man	What	Lack of knowledge in the warehouse regarding 5S
	When	During warehouse operational services
	Where	Spare parts warehouse
	Why	To anticipate conditions in the warehouse so that it is not messy and full
	Who	Spare parts warehouse employee
	How	Requires training to implement 5S for warehouse operators to help facilitate warehouse operations
Material	What	Service and inventory section area
	When	So that operators do not make mistakes in serving and picking up goods so that there are no wrong goods transactions
	Where	Service and inventory section operator
	Why	This is done by matching data as identity and incoming goods according to the type and specifications of the goods according to the location of placement
	Who	Service and inventory section area
	How	So that operators do not make mistakes in serving and picking up goods so that there are no wrong goods transactions
Method	What	Lack of 5S material handling training
	When	During the operational process of warehouse arrangement and services
	Where	Parts warehouse area
	Why	So that the service process and collection of goods is not disrupted
	Who	Spare parts warehouse operator
	How	Provide 5S training and warehouse re-layout to increase warehouse capacity
Machine	What	Limited work aids and shelf placement in the warehouse
	When	Incoming goods transit area
	Where	The process of placing goods on shelves
	Why	So that suitable items can be arranged in a predetermined location
	Who	Electrical & Serialize Operator
	How	Additional work aids are needed to facilitate warehouse arrangement from the loading area to the goods rack arrangement
Environment	What	The condition of the warehouse area is not organized and the cleanliness of the work area is not maintained
	When	During warehouse operational processes
	Where	In the spare parts warehouse
	Why	Because the placement of goods is not organized and arranged, it results in disruption of warehouse activities
	Who	All warehouse operator employees
	How	A culture is needed with the application of the 5S method in the warehouse and all employees must carry it out properly

Warehouse Re-layout Design

Warehouse Rere-layout is very necessary because the previous conditions for machine spare parts did not have a special Warehouse between new machine spare parts or machine spare parts returned from the production department (Abidin et al., 2021). Before the improvement, the condition of the warehouse was very messy, as is evident in Figure 1 where the new spare part material was stored in a temporary room, even on the street of the warehouse. The results of the Warehouse re-layout can be seen in Figure 6.

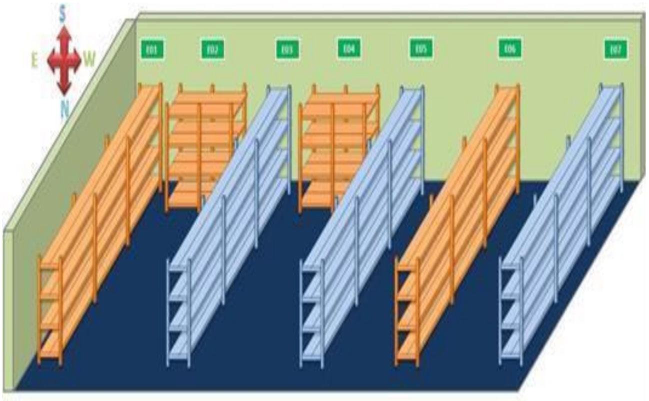

Figure 6 Spare Parts Warehouse Rere-layout After Improvement

Based on Figure 6, it can be seen that to find out the capacity of the Warehouse, it can be calculated using formula (1). The results of measuring the area of the warehouse are warehouse length 20m, warehouse width 18m, and warehouse height 10 m (safety shelf 2m) so the height of the safety warehouse is 8m. Safety rack because for safety forklifts in lowering material, the height of the safety warehouse is 8m. If everything is known then the volume of the Warehouse can be calculated using the formula (1):

$$Warehouse\ Capacity = 20\ x\ 18\ x\ 8 = 2{,}880\ m$$

The height of the shelves installed upwards is 8m per shelf. Meanwhile, the number available in the warehouse can be installed with 5 long shelves and 2 short shelves. So the long shelf capacity can be calculated using equation (2).

PC = 5 x 15 x4 = 300

PC = 2 x 2 x 4 = 16

So the total capacity of the new warehouse after re-layout is 300 + 16 = 316 pallets. Other research uses several alternatives to produce optimal warehouse capacity using the Class-Based Storage method (Rahman et al., 2018).

Implementation of Kaizen 5S

After the Warehouse re-layout is carried out, the next step is implementing 5S in the new Warehouse which has already been filled with shelves for the placement of machine spare parts. The implementation of 5S can be seen in Table 4.

Table 4 Differences Before and After Implementation of 5S

No	5S	Before Improvement	After Improvement	Remarks
1	Seiri /Sort			The improvement condition of the goods has been grouped according to specifications according to the type of goods based on the goods group
2	Seiton /Set in Order			The condition of the goods has been arranged according to the shelf space provided.
3	Seiso /Shine			The condition of the goods is separated according to the type of goods and placed according to the specified location

No	5S	Before Improvement	After Improvement	Remarks
4	Seiketsu /Standard			The condition of the goods has been given a specification identity that corresponds to the type of goods following the unit specifications and documents
5	Shitsuke /Sustain	There is no daily 5S monitoring, 5S checklist, or sanitary form yet	5S daily monitoring, 5S checklist, and sanitary forms have been implemented	As a result of the evaluation, if the 5S implementation has gone well, photos will be posted on the notice board before and after the 5S implementation

Based on Table 4, implementing concise in the work area or goods warehouse area by carrying out concise implementation is by getting rid of items that are routinely used and items that are rarely used. (Setyaningsih & Putri, 2015). Grouping criteria are used in dividing goods into 2 groups, namely fast-moving goods, and goods that have fast-moving or slow-moving frequencies. Retrieval of data on goods receipt and goods storage in the goods warehouse area can be seen in Table 5.

Table 5 List of Grouping Type Serialize in Warehouse

Rack	Grouping	Rack
E01	Electro Motor	E01
E02	Electro Motor	E02
E03	Electro Motor	E03
E04	Electro Motor	E04
E05	Electro Motor	E05
E06	Gearbox	E06
E07	Blower	E07
E08	Airlock	E08
E09	Gearbox	E09
E10	Electro Motor Flange	E10
E11	Electro Motor	E11

Based on Table 5, there are 11 groups for grouping machine spare parts on each shelf. To assess every day, the warehouse has an inspection method using a formula which can be seen in Table 6.

Table 6 Seiri Rating (Sort Check List)

No	Seiri Activity (Sort) Separate goods/stock according to location	Good	No Good (NG)	Remarks
1	Stock items are placed in their respective locations	✓		Placement of stock items according to location determined
2	Is there a mess in stock?	✓		The stock of goods follows the location
3	Are old stocks blocked by new items?	✓		Placement of stock items by incoming goods arrival data

Evaluation of Improvement Results

The final step is to find out the results of the improvement, namely by measuring the search time for machine spare parts again after the re-layout and implementation of Kaizen 5S. The experimental results can be seen in Table 7.

Table 7 Results of Search Time for Spare Parts After Improvement

No	Airlock (minute)	Blower (minute)	Gearbox (minute)	Electro Motor (minute)
1	4	3	4	4
2	5	4	3	5
3	4	4	4	4
4	5	3	3	5

No	Airlock (minute)	Blower (minute)	Gearbox (minute)	Electro Motor (minute)
5	4	4	4	4
6	4	3	4	5
7	5	3	3	4
8	4	4	3	5
9	5	3	3	4
10	5	4	4	5
11	4	3	4	4
12	4	4	3	4
13	4	4	4	5
14	4	3	5	4
15	4	3	4	5
16	5	3	3	4
17	5	4	3	5
Amount	75	59	61	76
Average	4.4	3.5	3.6	4.5
			4.0	

Based on Table 7, the average search time for engine spare parts is 4 minutes, so it is faster than the previous search time. The comparison of the data before and after can be seen in Table 8.

Table 8 Comparison of Research Results

No	Parameters	Unit	Before Improvement	After Improvement	Ratio (%)
1	Time to search for engine spare parts	minute	6.3	4.0	36.5%
2	Warehouse capacity	pallet	80	316	395%
		pcs	240	948	

Based on Table 8, Warehouse re-layout and implementation of Kaizen 5S can increase Warehouse capacity by 395%, and search time for machine spare parts can also decrease by 36.5%. Other research on increasing warehouse capacity after improvements reached 31.7% using the dedicated storage method (Sugeng, 2016). The contribution of this research includes the body of knowledge in the work design and measurement section, due to changes in working time for finding spare parts to be faster and changes in Warehouse design by way of Warehouse rere-layout to become optimal in capacity.

4. Conclusion and Suggestion

Based on the analysis and discussion of research results related to the implementation of the Kaizen 5S method in warehouses, it can be concluded in this section. This study found that three factors caused the length of time to search for machine spare parts, namely humans, methods, and the environment. The main causes consist of a lack of knowledge from warehouse operators and no training regarding the application of the 5S method, as well as careless placement of spare parts in warehouses that are not neatly arranged.

Corrective actions that have been taken are warehouse re-layout using stacking shelves in the machine spare parts warehouse, providing training to warehouse operators regarding the implementation of 5S, and providing supporting tools in warehouse operations. This research has resulted in a reduction in search time for engine spare parts from 6.4 minutes to 4 minutes per spare part unit or a decrease of 36.5%. The results of the Warehouse re-layout resulted in an additional Warehouse capacity from 80 pallets to 316 pallets, an increase of 395%.

The theoretical implications of this research can be used as a reference for other researchers in terms of accelerating material searches and warehouse re-layouts. Meanwhile, the practical implications in the manufacturing industry, especially in effective warehouse management using warehouse re-layouts, and the application of Kaizen 5S can shorten the search time for spare parts in the warehouse. Researchers also recommend that in the future regarding warehouse management, especially the implementation of 5S, the difference between inventory and safety in the warehouse is included in the company's Key Performance Indicator (KPI) method as a forum for consistent implementation of Kaizen 5S and providing rewards to warehouse employees.

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