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Use Case Diagram for Enhancing Warehouse Performance at PT. MDA Through the Implementation of 5S, Economic Order Quantity, Safety Stock, and Warehouse Management System

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Abstract *– An industrial water pump importing company relies on a network of distribution warehouses to efficiently manage the storage and delivery of its products to clients. This paper delves into the operational intricacies of the company, with a primary focus on sustaining a superior level of service to meet customer demands, all while attempting to minimize costs and achieve optimal inventory control. The central aspects explored in this research encompass the meticulous determination of the number of pipes needed and the optimal ordering times. To address this, the Probabilistic Economic Order Quantity (EOQ) method is used and supported by 5S concept, recognized for its ability to provide reasonably accurate estimates crucial for pivotal decision-making in inventory management. The utilization of the Probabilistic EOQ method in this context reflects the company's commitment to adopting sophisticated and proven methodologies to enhance decision-making accuracy and the warehouse area is more suitable by the 5S implementation principles. The research outcomes not only assist in refining the determination of Safety Stock levels but also contribute valuable insights into the precise quantities of goods that should be ordered. With an estimated demand for 196 units of carbon 6" in the following year, a safety stock of 13 units is required, while for carbon 4" with an estimated demand of 119 units, a safety stock of 8 units is required. These upcoming insights could encompass innovative strategies, technological implementations, or advances in supply chain optimization.*

Keywords: *Probabilistic Economic Order Quantity; Safety Stock; 5S; Use Case Diagram; Warehouse Management System*

I. INTRODUCTION

The important role of warehouses in facilitating efficient and timely delivery of goods to clients cannot be overstated. In a world that prioritizes proximity, the existence of a warehouse is a strategic necessity, so that clients don't have to bother waiting in long queues to get the goods they request. This research investigates the complex operational dynamics of a distribution warehouse, a distinct entity from its manufacturing counterpart. In contrast to a production warehouse which focuses on the manufacturing process, a distribution warehouse functions as a connecting center that directs the smooth flow of commodities through the supply chain.

At its core, distribution warehouses are designed to maximize operational efficiency, ensuring that products move smoothly from manufacturers to end users. It acts as a critical point in the distribution network, strategically placed to optimize logistics and transportation of goods. By strategically managing inventory and managing product movement, distribution warehouses play a critical role in reducing lead times and meeting dynamic market demands.

One of the main functions of distribution warehouses is to increase commodity accessibility. Through careful organization and storage practices, warehouses make it easy for businesses to find and retrieve products when needed. This accessibility is important not only to meet customer demands quickly but also to simplify the overall supply chain process.

In addition, distribution warehouses contribute to the added value of commodities. Efficient handling, storage and packaging in a warehouse can improve the quality of goods, ensuring they reach the end user in optimal condition. This added value is more than just storage; this includes careful inventory management and implementing technology-based solutions to track and monitor the movement of goods (Simic et al., 2023;Winkelhaus and Grosse, 2022;Mahroof, 2019). Therefore, distribution warehouses play an important role in the modern supply chain, functioning as dynamic points that optimize the flow of commodities from production to consumption. Their impact goes beyond storage, including strategic management practices that increase accessibility, reduce wait times, and add significant value to the goods they handle. In a global and fast-moving market, the role of distribution warehouses is indispensable in meeting client expectations and maintaining a competitive advantage for businesses (Sarkar et al., 2022).

Inventory control is an important aspect of supply chain management that requires a comprehensive and strategic approach. Considerations in inventory control are not just the acquisition of goods; this involves a comprehensive analysis of when and how much pump pipe should be purchased to effectively meet demand (Najlae, Sedqui and Lyhyaoui, 2021). Determining the timing of this purchase is very important, to ensure that the right quantity is obtained exactly when it is needed, thereby preventing excess and shortage of stock. Striking the right balance in purchasing at the right time is critical to minimizing costs and maximizing operational efficiency.

In the field of inventory management, cost minimization is a constant goal. This not only involves negotiating profitable deals with suppliers but also optimizing order quantities to take advantage of economies of scale. Purchasing in bulk can reduce unit costs, but this requires a deep understanding of demand patterns and consumption levels to avoid excess stock. By leveraging forecasting models and market insights, businesses can align their procurement strategies with actual demand, preventing unnecessary spending on excess inventory while maintaining the ability to efficiently meet customer needs.

Maximizing efficiency in inventory control encompasses various aspects, including efficient order processing, efficient storage practices, and agile response mechanisms to changing market conditions (Opalic et al., 2020). Leveraging technology, such as inventory management software and real-time tracking systems, improves the ability to monitor stock levels, identify trends and make informed decisions. Implementing lean inventory practices, where inventory is kept at optimal levels, allows businesses to reduce carrying costs and respond quickly to market fluctuations.

Discussions around inventory control are complex, involving strategic decisions regarding when and how much pump pipe to purchase, all with the primary goal of minimizing costs and maximizing efficiency. This requires a different understanding of market dynamics, demand patterns, and operational capabilities. By adopting a proactive, data-driven approach, businesses can navigate the intricacies of inventory control, ensuring a supply chain that is balanced, cost-effective and responsive to changing market demands.

Warehouse management is a crucial aspect in the supply chain that is closely related to reorder points and safety stock (Hamdy, Al-Awamry and Mostafa, 2022). Order point refers to the right moment to reorder supplies, which ensures a smooth flow of supplies (Tiwari, 2023). This requires a deep understanding of demand patterns, delivery times and lead times from suppliers. By determining the optimal order point, companies can prevent stock shortages that can result in production stops or delays in delivery to customers (Aravindaraj and Rajan Chinna, 2022).

Safety stock is an important element in warehouse management because it functions as a reserve to overcome uncertainty in supply and demand. Determination of the amount of safety stock is based on analysis of historical demand records (Zhang, Pee and Cui, 2021). By examining past demand data, companies can identify trends and fluctuations in demand levels. Safety stock gives companies the flexibility to deal with unexpected spikes in demand or constraints in the supply process without experiencing costly stock shortages.

The importance of safety stock in warehouse management lies not only in its function as a reserve, but also as a tool for optimizing the availability of goods (Jacob et al., 2023). By understanding the risks involved in the supply chain, companies can set appropriate safety stock levels to reduce the possibility of stock shortages and maintain customer satisfaction.

Overall, warehouse management is not only concerned with the physical storage of goods, but also includes strategic management of order points and safety stock. With a thoughtful approach to these elements, companies can improve their operational efficiency, avoid the risk of stock shortages, and remain responsive to ever-changing market dynamics.

The logistics industries relied entirely on paper and manual labor for all of their operations prior to the development of any IT systems or WMS. Both were costly, labor-intensive, time-consuming, and error-prone. The logistics sector faced a number of problems when there was no WMS system, including the following:

- Lack of inventory transparency - No stakeholders, including business partners and warehouse personnel in the logistics and supply chain, had the ability to view the facility's up-to-date inventory.
- Shipment processing mistakes include miss-shipping, over-shipping, and under-shipping.
- Problem with warehouse space use - Excessive or inefficient use of warehouse space.
- Documentation and Administrative Tasks - A significant amount of documentation must be completed and organized for the purpose of auditing, in addition to carrying out all warehouse tasks manually.
- Safety Concerns - The absence of IT systems or technical devices has resulted in safety concerns during the handling of hazardous materials, hefty things, and items requiring specific handling.

Warehouse Management Systems (WMS) are crucial applications in Logistics and Supply Chain that enable businesses to efficiently monitor and trace inventory. Utilizing these applications distinguishes companies as leaders in the logistics and supply chain market, in contrast to those who do not employ IT or WMS applications. The primary operations inside the Warehouse Management System (WMS) include Receiving, which involves accepting and inspecting incoming goods; Putting Away, which involves storing the received items in their designated locations; Picking and Packing, which involves selecting and preparing items for shipment; Shipping, which involves the actual dispatch of goods to customers; Cycle Count, which involves periodic inventory checks; and Replenishment, which involves restocking inventory to maintain optimal levels. Attempting to handle these operations in a business lacking IT or WMS software becomes unattainable when the client need is to oversee the complete supply chain process in real-time and without delay.(Piardi *et al.*, 2023).

5s is an integrated Japanese concept of "Work Place Management". Through which it maintains work placeq uality that makes best products. Seiri, Seiton, Seiso, Seiketsu, Shitsuke are the five steps in Japanese language of work place management. The pioneer of Five-S concept is Mr. Takashi Osada (Winkelhaus and Grosse, 2022). Five phases include in 5s are as follow:

- SEIRI – Sorting
- SEISO – Sweeping
- SEITON – Systemizing
- SEIKETSU – Standardization
- SHITSUKE – Self Discipline

The 5S concept is an integrated approach from Japan that focuses on "Workplace Management," designed to maintain the quality of the workplace with the aim of producing the best products or services. This concept consists of five main steps known as Seiri, Seiton, Seiso, Seiketsu, and Shitsuke. The pioneer of the 5S concept is Mr. Takashi Osada. By following the steps of the 5S concept, it is hoped that the workplace can become more efficient, productive, and provide an environment that supports quality in the work process.

Five-S is a set of techniques providing a standard approach to housekeeping within Lean Manufacturing. It originates, as did most of the element of JIT, within Toyota. A cornerstone of Five-S is that untidy, cluttered work areas are not productive. The presence of junk and dirt has a negative impact on the quality of our surroundings. Therefore, we tend to be happier and more motivated to work diligently and attentively in a clean atmosphere.

II. METHODS

Initial data analysis has identified areas for improvement in the warehouse, specifically in inventory accuracy, inventory control, and order picking. The client emphasized the significance of inventory accuracy as a key area of attention. The current levels of accuracy were inadequate, ranging around 90 percent. Incorrect inventory levels have a detrimental impact on the fill rate, resulting in duplicated efforts, operator dissatisfaction, reduced customer satisfaction, and increased expenses caused by backorders. Once a satisfactory degree of inventory accuracy is attained, attention can be redirected towards inventory control to identify areas for improvement. The customer also identified high backorder levels as a problem. Enhancing accuracy leads to a reduction in backorders, while optimizing inventory levels using past data helps to enhance the fill rate.

Efficient execution of order picking is contingent upon having inventory well-managed. The process of order picking is of utmost significance in the majority of warehouses, as it requires the highest amount of labor and directly impacts the level of service received by consumers farther down the supply chain. Order picking generally represents approximately 55% of the total operating costs in a warehouse, with traveling being the most significant component of the expenses associated with order picking. Due to the absence of expensive warehouse management systems, small warehouses typically do not generate picking routes using the system. The batching algorithm is proposed for the instance at the client's warehouse. The subsequent sections outline recommendations for improvement in each of the specified areas. (van Geest, Tekinerdogan and Catal, 2021;(adj Sassi et al., 2021;Zaman et al., 2023):

Choosing to use Probabilistic economic order quantity in this research because the method is one of the best guidance that is generally accepted by both academics and the business world because of its ability to balance the costs of ordering goods with the costs of storing goods in the warehouse to determine the quantity of goods ordered to supplier.

Warehouse Management System (WMS) is a sophisticated computer application anchored in database technology, strategically crafted to elevate operational efficiency by meticulously recording and managing every transaction within a warehouse environment (Lyu et al., 2020). The primary objective of WMS is to enhance the accuracy, visibility, and overall control of inventory data, marking a substantial departure from traditional manual systems.

This state-of-the-art system is a response to the evolving needs of users who demand heightened efficiency and precision in inventory management. Unlike manual approaches, WMS operates in real-time, ensuring that each movement and transaction involving inventory items is systematically logged and tracked. This not only reduces the likelihood of errors but also provides stakeholders with instant access to accurate and up-to-date information regarding stock levels, location, and movement.

The development of WMS signifies a paradigm shift in warehouse management, offering a comprehensive solution to the challenges posed by manual record-keeping systems. By automating and streamlining data recording and processing, WMS minimizes the potential for human error, thus contributing to higher data accuracy. The system is meticulously designed to cater to the diverse needs of warehouse operations, ranging from inventory tracking and order processing to optimizing storage space and facilitating timely decision-making.

One of the critical advantages of WMS lies in its ability to provide a holistic view of the warehouse ecosystem. It not only ensures the accuracy of inventory data but also addresses the broader spectrum of warehouse activities. This includes optimizing storage space based on demand patterns, improving order fulfillment processes, and facilitating seamless communication between various stakeholders in the supply chain. In essence, the adoption of a Warehouse Management System is a strategic imperative for organizations seeking to stay competitive and responsive in today's dynamic business landscape. It represents a commitment to operational excellence, where efficiency, accuracy, and real-time visibility converge to create a more agile and responsive warehouse environment (Chen et al., 2024).

The implementation of a Warehouse Management System (WMS) brings forth a myriad of advantages, significantly enhancing the overall efficiency and effectiveness of the warehousing system. At its core, WMS acts as a catalyst for operational improvements, particularly in the realms of data recording, processing, and security, leading to heightened data accuracy.

Data accuracy is another hallmark of WMS implementation. The system's ability to automate data-related processes reduces the chances of human error, leading to more accurate and reliable information. Accurate data, in turn, enhances decision-making processes and fosters a more responsive and agile supply chain. Whether it's tracking inventory levels, managing order fulfillment, or optimizing storage configurations, WMS empowers organizations with precise insights into their warehouse operations. In conclusion, the adoption of a Warehouse Management System translates into a transformative leap for the warehousing system. It not only increases operational efficiency by automating data processes but also fortifies data security and accuracy. As organizations navigate the complexities of modern supply chains, WMS emerges as a pivotal tool for those seeking to elevate their warehouse management practices and stay ahead in today's competitive business landscape (Zhan et al., 2022;Oloruntobi et al., 2023;Lydia et al., 2022).

The Five-S framework consists of a collection of Japanese terms, all of which start with the letter 'S'. Following the implementation of JIT or Lean Manufacturing, several writers and instructors have adopted various anglicized versions. Each ingredient is listed individually, and it is evident that none of them are completely sufficient. The discrete components comprising Five-S are referred to as the "pillars".

To begin with, sorting, or Seiri, is the first step in the 5S idea. This step involves separating and choosing items or products that are required for the workplace from those that are not. By getting rid of extraneous or unnecessary objects, this should facilitate access and boost productivity. Seiso, or sweeping, is the second phase. At this point, keeping the workspace clean and organized is the main priority. Sustaining cleanliness promotes employees' health and safety in addition to creating a comfortable work environment. Seiton, or systemization, is the third phase that follows. At this point, everything is placed in its proper position and is readily available throughout the workspace. This makes things less cluttered and makes it easier to find what you need. Standardization, or Seiketsu, is the fourth phase. At this point, standards and guidelines for organizing, cleaning, and sorting are developed. In addition to fostering an orderly and controlled work environment, standardization aids in maintaining the outcomes of earlier processes. Shitsuke, or self-discipline, is the final phase. At this point, employees receive familiarization or training on how to consistently uphold the 5S concept's standards for workplace excellence. The secret to preserving the viability and success of putting this idea into practice is self-control.

III. RESULTS AND DISCUSSION

3.1 Implementation of 5S

The case study conducted at PT. MDA focused on the implementation of the Five ‘S’ methodology, a systematic approach aimed at enhancing workplace organization and efficiency. This study delved into the practical application of the five ‘S’ strategies within the company’s spare part warehouse, with a specific focus on the data collected in the year 2022. The primary objective was to investigate how the principles of Sort, Set in order, Shine, Standardize, and Sustain were incorporated into the warehouse management practices.

Table I. Problems of 5S Principles Implementation in the Warehouse Department

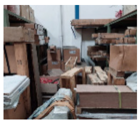
No	Before	After	Descriptions
1			Organized of the spare part warehouse. used
2			Goods are placed in the right place.

Table I provides insights into the conditions before and after the implementation of 5S, highlighting specific issues related to the principles of 5S in the warehouse department. The first issue addressed pertains to the organization of the spare part warehouse. The ‘Before’ column indicates the state of the warehouse organization prior to the implementation of 5S, while the ‘After’ column represents the improvements achieved after the implementation. The description column provides details about the specific challenges or improvements observed in each case.

The first point in the table suggests that the organization of the spare part warehouse was an area of concern before the 5S implementation. The term ‘used’ in the ‘Before’ column implies a lack of organization or a suboptimal arrangement of spare parts. The implementation of 5S aimed to address this issue, creating a more organized and efficient spare part storage system. The second point emphasizes the importance of placing goods in the right location, indicating that this aspect needed improvement in the 'Before' state. The 'After' state reflects positive changes, showcasing the successful implementation of 5S strategies to ensure goods are now appropriately placed within the warehouse (Chen *et al.*, 2024;Vicuna *et al.*, 2019)including transportation. The result of digitization is vast amount of location and time data on humans and goods, which in turn provide a valuable resource for transportation system performance for the managing and operating agencies. A wide variety of transportation performance metrics (TPMs.

In summary, the case study at PT. MDA focused on the practical application of 5S in the spare part warehouse, demonstrating improvements in organization and the placement of goods through the systematic implementation of the five 'S' strategies. The data collected in 2022 provides a snapshot of the conditions before and after the implementation, shedding light on the positive impact of 5S in enhancing warehouse efficiency.

3.2 Determining EOQ and Safety Stock

Under a periodic inventory review system, the quantity of inventory currently available is assessed at regular intervals, such as weekly or at the conclusion of each business period. Once the available inventory is calculated, an order is issued to replenish the stock to reach a pre-established goal level. The predictable stock replenishment time and planned demand, which exhibit constant intensity, can accommodate the highest degree of demand fluctuation in both directions (as depicted in Figure 3) (Jiang et al., 2021; Kara et al., 2024). Due to the unpredictable nature of the deviation from the plan, both in terms of direction and magnitude, the determination of the actual usage demand and stock levels can only be done using random variables. If we only maintain inventories to meet the projected demands, as per our stock management method, any rise in the real utilization demand beyond the plan would deplete the stocks completely before the scheduled receipt date.

When employing a periodic review system, the intricacies of inventory management extend beyond merely anticipating the demand for the upcoming period. The methodology involves a comprehensive evaluation of not only the immediate demand and its potential fluctuations but also a nuanced consideration of the anticipated changes in demand throughout the remaining duration, denoted as τ, of the ordering period.

This temporal aspect introduces a layer of complexity to the inventory replenishment process. Unlike continuous review systems where orders can be adjusted more dynamically, periodic review systems necessitate a forward-looking approach. During the placement of an order, it becomes imperative to forecast how the demand landscape is expected to evolve over the entire remaining span of the ordering period.

The variable τ serves as a crucial parameter in this analysis, representing the time interval between consecutive periodic reviews. Within this timeframe, the demand for products may exhibit fluctuations influenced by various factors such as market trends, seasonal variations, or unforeseen events. Consequently, calculating the optimal order quantity requires a predictive model that not only considers the current demand scenario but also anticipates the changes that might unfold over the τ duration.

This forward-thinking perspective becomes particularly relevant in environments characterized by stochastic demand patterns. Since the exact nature and magnitude of demand fluctuations cannot be precisely predetermined, probabilistic models are often employed. These models leverage statistical methods to estimate the probability distribution of demand changes, enabling more informed decision-making during the order placement process. In essence, the periodic review system extends its analytical scope beyond the immediate term, acknowledging that a comprehensive understanding of the evolving demand landscape is vital for effective inventory management. By factoring in the expected demand changes throughout the remaining duration of the ordering period, organizations can enhance their capacity to adapt to dynamic market conditions, minimize stockouts, and optimize inventory levels, shown in Figure 1 (Carli et al., 2020).

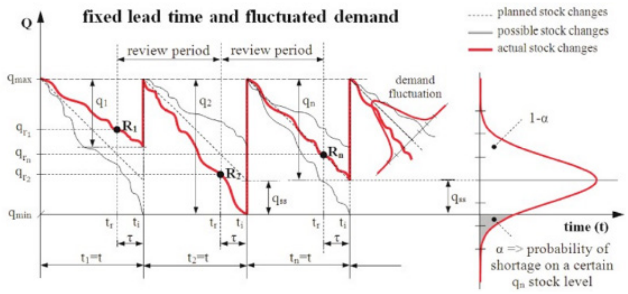


Figure 1. Periodic review in case of stochastic change of demands

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{n}} \quad (1)$$

$$z = \frac{(x - \mu)}{\sigma} \quad (2)$$

X_i = Value of the i point in the data set

μ = The mean value of the data set

n = The number of data point

z = z score normalization

$$E(Dp) = \sum X_i P(X_i) \quad (3)$$

x is a random variable

P(x)is the probability of the variable

Below (Table II) is the example of safety stock calculation as per above formula:

Table II. Determination of Safety Stock based

Months	X_i	$(X_i – X)$	$(X_i – X)^2$
January	10	-90	8,100
February	52	-48	2,304
March	12	-88	7,744
April	154	54	2,916
May	129	29	841

June	130	30	900
July	62	-38	1,444
August	88	-12	144
September	125	25	625
October	159	59	3,481
November	236	136	18,496
December	43	-57	3,249
TOTAL	1,200		51,094

The probability of out of stock is about 5%, so we use z = 1.64, which means Safety stock = 1.64 x 65.25 = 107 units.

Table III. Sales Pipe Information in 2019

Items	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
AS Screen Low Carbon 4" Slot 1mm	10	15	7	10	15	11	12	19	21	5	10	13
AS Screen Low Carbon 6" Slot 1mm	12	14	10	15	20	30	0	35	0	31	11	15

Table IV. Sales Pipe Information in 2021

Items	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
AS Screen Low Carbon 4" Slot 1mm	3	10	15	10	11	12	0	10	7	5	12	14
AS Screen Low Carbon 6" Slot 1mm	15	16	15	36	20	21	17	18	11	10	8	9

We choose observing the two above instead of all the above mentioned to show the way calculating.

Table V. US screen demand estimation 4" 1mm in 2019

Many Demand	Frequency	Probability	Hope Demand
5	1	0.0833	0.4167
7	1	0.0833	0.5833
10	3	0.2500	2.5000
11	1	0.0833	0.9167
12	1	0.0833	1.0000
13	1	0.0833	1.0833
15	2	0.1667	2.5000
19	1	0.0833	1.5833
21	1	0.0833	1.7500
Total	12	1.0	12.3333

The expected value of demand per month for the US Screen Low Carbon 4" 1mm slot in 2019 is

$$E(Dp) = \sum_{k=1}^{7} x_i P(x_i) = 12.333$$

The average demand per month for the US Screen Low Carbon 4" 1mm slot is 12.333.

Table VI. US screen demand estimation 6" 1mm in 2019

Many Demand	Frequency	Probability	Hope Demand
10	1	0.1000	1.0000
11	1	0.1000	1.1000
12	1	0.1000	1.2000
14	1	0.1000	1.4000
15	2	0.2000	3.0000
20	1	0.1000	2.0000
30	1	0.1000	3.0000
31	1	0.1000	3.1000
35	1	0.1000	3.5000
	10	1,0000	19.3000

The expected value of demand per month for the US Screen Low Carbon 6" 1mm slot in 2019 is

$$E(Dp) = \sum_{k=1}^{7} x_i P(x_i) = 19.300$$

The average demand per month for the US Screen Low Carbon 6" 1mm slot is 19.300.

Table VII. US screen demand estimation 4" 1mm in 2021

Many Demand	Frequency	Probability	Hope Demand
3	1	0.0909	0.2727
5	1	0.0909	0.4545
7	1	0.0909	0.6364
10	3	0.2727	2.7273
11	1	0.0909	1.0000
12	2	0.1818	2.1818
14	1	0.0909	1.2727
15	1	0.0909	1.3636
Total	11	1.0	9.9091

The expected value of demand per month for the US Screen Low Carbon 4" 1mm slot in 2021 is

$$E(Dp) = \sum_{k=1}^{7} x_i P(x_i) = 9.9091$$

The average demand per month for the US Screen Low Carbon 4" 1mm slot is 9.9091.

Table VIII. US screen demand estimation 6" 1mm in 2021

Many Demand	Frequency	Probability	Hope Demand
8	1	0.0833	0.6667
9	1	0.0833	0.7500
10	1	0.0833	0.8333
11	1	0.0833	0.9167
15	2	0.1667	2.5000
16	1	0.0833	1.3333
17	1	0.0833	1.4167
18	1	0.0833	1.5000
20	1	0.0833	1.6667
21	1	0.0833	1.7500
36	1	0.0833	3.0000
Total	12	1.0000	16.3333

The expected value of demand per month for the US Screen Low Carbon 6” 1mm slot in 2021 is

$$E(Dp) = \sum_{k=1}^{7} x_i P(x_i) = 16.333$$

The average demand per month for the US Screen Low Carbon 6” 1mm slot is 16.333.

From the results of the above analysis, the monthly demand expectation for the US Screen Low Carbon 4” and 6” respectively is 12,333; 19,300; 9.9091 and 16.333 so the demand expectation in one year is 147.996; 231.6; 118,9092; 195.9996.

We can find the maximum q value for each type of product with a cost of ordering S = Rp. 59.000.000, - inventory cost Rp. 275.400.000, -/ year with units stored in 300 units then h = Rp. 918,000, - per unit per year. E (Dp) refer to demand expectation in a year. Assuming the expected value of running out of inventory (BKP) is close to 0, then the successive q values are as follows.

$$Q_{Max} = \sqrt{\frac{2E(Dp)(S + hsE(BKP)}{h}} \quad (4)$$

Table IX. Qmax Calculation

Items	Qmax
AS Screen Low Carbon 4” before the pandemic	137.93
AS Screen Low Carbon 6” in 2019 before the pandemic	172.54
AS Screen Low Carbon 4” in 2021 during the pandemic	123.61
AS Screen Low Carbon 6” in 2021 during the pandemic	158.72

The max q values for the 2 types of screens measuring 4” and 6” are 124 units and 159 units. Then it is also determined that the safety stock that must be available or the inventory of goods will be calculated by the following mechanism.

Table X. AS screen Low Carbon 4”

Months	Freq	μ	$(x_i - \mu)$	$(x_i - \mu)^2$
January	3	10	-7	49
Feb	10	10	0	0
March	15	10	5	25
April	10	10	0	0
May	11	10	1	1
June	12	10	2	4
July	0	10	-10	100
August	10	10	0	0
Sept	7	10	-3	9
Oct	5	10	-5	25
Nov	12	10	2	4
December	14	10	4	16
Total	109			233

From the data analysis above, the value of σ calculated.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \mu)^2}{n}} = \sqrt{\frac{233}{12}} = 4.4$$

Standard deviation or deviation of demand is 4.4.

Assuming the chance of running out of inventory is 5% and based on the normal table reference, a value of 0.45 is obtained which is located at z = 1.65 , so the size of the safety stock is z x σ = 1.65 x 4.4 = 7.26 rounded up to 8 units.

The number of goods ordered is Qmax plus safety stock rounding. If we continue by looking for the reorder cycle, the formula used is the expected value of demand in a year divided by the number of items ordered.

For the calculation of the reorder cycle of AS Screen Low Carbon 4" is (expected value of demand in a year)/(number of items ordered) = 119/132 = 0.9 and for calculation of the reorder cycle of AS Screen Low Carbon 6” is 196/172 = 1.14. This means that the time period for orders is made over a fairly long period of time, between 10 months and 14 months for these two products, where the decision can be reviewed at any time depending on updates to changes in demand for goods.

Then the calculation of the length of a cycle is the number of working days a year divided by the reorder cycle. Length of a cycle of AS Screen Low Carbon 4” is (working days a year)/(Reorder Cycle) = 360/0.9 = 400 days and Length of cycle of AS Screen Low Carbon 6” is 360/1.14 = 315 days.

Next, the daily demand level of AS Screen Low Carbon 4” is calculated based on the following formula (number of items ordered)/(length of a cycle) = 132/400 = 0.33 units per day, while the daily demand level of AS Screen Low Carbon 6” is 172/315=0.55 units perday.

If the lead time is 30 days because goods are imported from India and Latin America, then the level of demand during the lead time is equal to the lead time multiplied by the level of demand per day. So the reorder point or minimum quantity to place a reorder for AS Screen Low Carbon 4" is 30 days multiplied by 0.33 units per day equals to 9.9 = 10 units and for AS Screen Low Carbon 6” is 30 days multiplied by 0.55 units per day equals to 16.6 = 17 units left.

After getting the total items that must be ordered, the next step for further analysis is to find the total inventory costs which are future works in this research due to limited permission given by the company to explore it further.

Table XI. AS screen Low Carbon 6”

Months		μ	$(x_i - \mu)$	$(x_i - \mu)2$
January	15	16	-1	1
Feb	16	16	0	0
March	15	16	-1	1
April	36	16	20	400
May	20	16	4	16
June	21	16	5	25
July	17	16	1	1
August	18	16	2	4
Sept	11	16	-5	25
Oct	10	16	-6	36
Nov	8	16	-8	64
December	9	16	-7	49
Total	196			622

From the data analysis above, the value of σ calculated.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\mu)^2}{n}} = \sqrt{\frac{662}{12}} = 7.4$$

The standard deviation or deviation of demand is 7.4.

Assuming the chance of running out of inventory is 5% and based on the normal table reference, a value of 0.45 is obtained which is located at z = 1.65, so the size of the safety stock is z x σ = 1.65 x 9.58 = 15.8 rounded up to 16 units.

From the analysis above, the number of units per order for AS Screen Low Carbon 4 " is 124 units plus safety stock 8 units to 132 units, for AS Screen Low Carbon 6 " is 159 units plus safety stock 16 units to 175 units.

4.3 Developing Warehouse Management System

Warehouse management systems optimize warehouse flow by analyzing the best use of floor space based on the task and material characteristics. We provide and develop Warehouse Management System to replace the existing conventional excel inventory system for better visibility of accurate and real-time inventory levels.

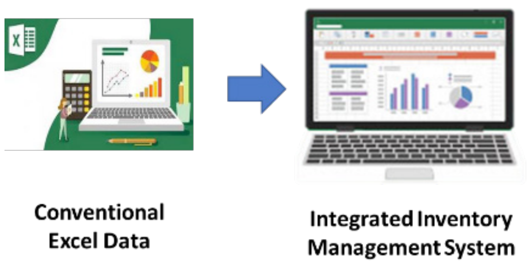


Figure 9. Warehouse Management System Evolution

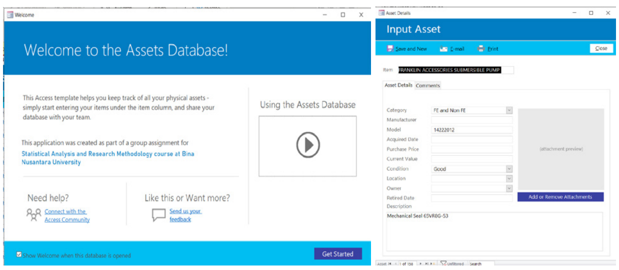


Figure 10. WMS interface development

Warehouse management systems (WMS) play a crucial role in enhancing the efficiency of warehouse operations by systematically analyzing and optimizing the utilization of floor space. These systems go beyond traditional methods by taking into account various factors such as specific tasks and material characteristics, ensuring a more strategic and streamlined warehouse flow. The primary objective is to create an environment where resources are utilized to their fullest potential, minimizing wastage and maximizing productivity.

One of the key aspects of warehouse management is maintaining accurate and real-time control over inventory levels. In many traditional setups, businesses often rely on conventional Excel-based inventory systems, which may have limitations in providing instantaneous insights and precise tracking of stock movements. To address these challenges and to meet the demands of modern business environments, we specialize in providing and developing Warehouse Management Systems (Carli *et al.*, 2020)by adopting energy-efficient *Material Handling Equipment* (MHE).

Our Warehouse Management Systems are designed to replace outdated inventory management practices, offering a comprehensive solution for businesses aiming to achieve better visibility into their warehouse operations. By leveraging advanced technologies, our systems enable organizations to monitor their inventory levels with a high degree of accuracy. This real-time visibility is essential for making informed decisions related to stock replenishment, order fulfillment, and overall warehouse optimization.

The transition from conventional Excel-based systems to a Warehouse Management System brings about numerous advantages. The automated nature of our WMS reduces the likelihood of human errors in data entry and ensures that the information is consistently accurate. Additionally, these systems provide detailed insights into stock movements, helping businesses make data-driven decisions that contribute to enhanced operational efficiency and cost-effectiveness.

In conclusion, our Warehouse Management Systems are tailored to meet the evolving needs of businesses in managing their warehouse operations effectively. By optimizing floor space, offering real-time visibility, and replacing traditional inventory systems, we empower organizations to stay competitive in today's dynamic business landscape. The implementation of a robust WMS is not just a technological upgrade; it is a strategic investment in operational excellence and long-term success.

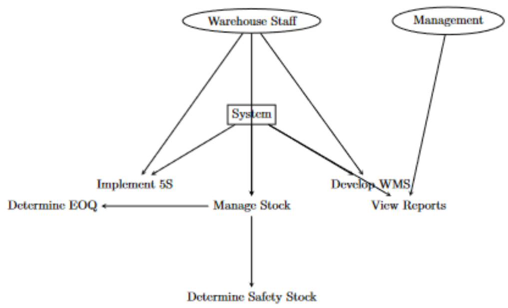


Figure 11. Use Case Diagram

Results from a case study of implementing the 5S methodology at PT. MDA showed significant improvements in spare parts warehouse conditions before and after 5S implementation. Table I describes the problems that were overcome, such as the previous disorganized spare parts warehouse arrangement and inappropriate placement of goods. This reflects improvements in operational efficiency and warehouse layout following the implementation of the 5S methodology.

Furthermore, analysis in determining Economic Order Quantity (EOQ) and Safety Stock provides an overview of stock optimization and order fulfillment. By using the Probabilistic EOQ method, this research considers demand variations that may occur, thereby ensuring optimal stock availability. The analysis results show the maximum EOQ value for certain products during normal conditions and during the pandemic.

This research also involves estimating demand for US Screen Low Carbon 4” and 6” products in 2019 and 2021. Based on the results of the analysis, the average value of monthly demand and expected demand for these products is calculated. This data helps in determining the Safety Stock needed to anticipate demand fluctuations.

Next, Table IX provides an overview of Qmax (maximum order quantity) for each product, taking into account ordering costs and inventory costs. Safety stock is also calculated based on the probability of running out of inventory.

The development of a Warehouse Management System (WMS) is also proposed as a solution to replace the conventional Excel inventory system. Figure 9 and Figure 10 show the evolution and interface of a WMS aimed at improving real-time visibility and accuracy of inventory levels.

Thus, this entire research provides an in-depth understanding of operational improvements through 5S implementation, efficient stock management, and development of a warehouse management system to support better inventory management at PT. MDA. The use case diagram can include the main actors such as “Warehouse Staff”, “Management”, and “System” involved in the 5S process, stock management, and WMS implementation. Use case diagrams can also show interactions between actors and systems in each stage of the process.

IV. CONCLUSION

Implementing the 5S concept at PT. MDA results in enhanced working efficiency. The implementation of the 5S methodology enhances environmental efficiency and minimizes time inefficiencies in the warehouse. The storage products demonstrate a high level of tidiness. Implementing the 5S methodology results in a decrease in the time spent searching for items and promotes self-discipline inside the firm.

Using a warehouse management system (WMS) will provide visibility of accurate, real-time inventory levels. This enables a company to estimate supply and avoid backorders, which leads to more satisfied customers more securely.

Implementing EOQ and Safety Stock as a guideline above mentioned is a new habit for the company, as they used to apply their intuition and experience rather than explained above. It is also found that Sales Data Information before Corona virus pandemic (2019) comparing to its 2021, Sales Data in 2021 seems decline about 15 % in the industry.

This reserach contributes to company in determining economic order quantity to be ordered in more scientifucally rather than just rely on the intuition or experience calculations from top management.

One of the future reserach is to conduct the studies to calculate actual inventory costs and stockout cost impact.

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