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Synergy of supermarket system and human resources in manufacturing industry

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Abstract

This case study explores the supermarket concept to control raw material supplies and improve process flow between departments in the manufacturing industry, PT PI in the Sidoarjo industrial area, East Java province, Indonesia. This research is combination qualitative-quantitative research. Using observations and interviews with employee and management representatives. Use brainstorming to create a Failure Mode and Effects Analysis to find recommended actions and prioritize them. Annual panel data collection to determine safe stock and minimum – maximum stock levels. The research results show that the supermarket concept provides significant improvements to distribution flows, reduces inventory levels by up to 90%, improves production inventory and increases employee maturity, all of these improvements make production more reliable. Many papers only discuss the concept, model and quantity of inventory control but rarely discuss how to apply it in limited conditions (warehouse space, production space, operator behaviour, etc.). This paper suggests several approaches and actions that can provide great benefits regarding the implementation of supermarket systems in the manufacturing industry.

Keywords: Human Resources; Warehouse; Manufacturing; Supermarket; Supply Chain

1. Introduction

High inventory levels, overproduction, ineffective transportation, unnecessary movement are wastes that must be minimized to improve company performance. High inventory levels must be reduced, controlled, or managed. Inventory control and inventory management seem similar. Both cover the same thing around the question of order quantity. Although these two phrases are often used synonymously, both are related to inventory optimization. Warehouse management is a component of inventory control. The inventory control process aims to optimize revenue with the least amount of inventory while maintaining a high level of customer satisfaction [1].

Inventory management has a broad meaning. Inventory management balances aspects of inventory costs, product availability, and customer service [2]. Inventory management is a method for managing, storing, and replacing inventory, to control adequate inventory while minimizing costs [3]. If inventory is too much (overstock), the cost of storing and maintaining inventory in the warehouse will be high, which will cause waste. On the other hand, if inventory is too little or can be said to be out of stock, it can disrupt further processes for both internal and external customers. Higher inventory management practices can lead to increased competitive advantage and improved organizational performance [4]. Managing effective inventory management practices can provide a competitive advantage for manufacturing industries to survive in the long run [5].

ABC analysis, Economic Production Quantity (EPQ), and Economic Order Quantity (EOQ) are the three most widely used inventory control models. The best way to determine how much inventory to hold varies depending on the model. The order quantity that minimizes the number of products ordered, ordering costs, total annual costs, holding costs, order size, and average inventory is known as the economic order amount (EOQ), in inventory management [6]. Economic

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Production Quantity (EPQ) is a measurement used in the supply chain, operations, and logistics departments of businesses and organizations for inventory planning and management. It optimizes the number of items to be produced and minimizes the combined production and holding costs. It helps determine the frequency of production runs to meet a given annual demand [7].

Lean manufacturing systems that use Kanban as a method to maintain low inventory levels are another strategy. Pulling materials through the production or distribution process is known as lean manufacturing. Kanban systems send orders for new inventory or reorders. By using the Kanban inventory scheduling method, businesses can supply only the components needed for production or delivery [8]. Supermarket systems, or better known as the Kanban concept, have become the focus of attention in efforts to improve the efficiency and effectiveness of inventory management across industries. This system allows companies to optimize inventory levels, reduce holding costs, and respond quickly to changes in market demand. Although many studies have discussed the application of supermarket systems in inventory management, there is still a need to look deeper into certain aspects that have not been touched on or explained in previous literature. Several studies have discussed the factors for the success of supermarket system implementation. However, it is necessary to go deeper to explain how these factors may vary across industry sectors and types of manufacturing. For example, research by [9] suggests that the specific industry context can influence the impact of factors such as employee engagement and management commitment on the success of supermarket system implementation. Although it is known that supermarket systems can improve efficiency in inventory management, there is a lack of research that specifically explores their impact on the overall performance of the supply chain. In the era of globalization, further understanding of how supermarket systems can impact relationships with suppliers and customers across the supply chain is a must. According to [10], supermarket systems have the potential to bring positive changes in inventory management, but further research is needed to understand how environmental and industry factors can affect the success of their implementation. Meanwhile, research by [11] suggests that in optimizing the supply chain, further emphasis needs to be placed on the integration of supermarket systems with the overall supply chain.

1.1. Supermarket

When creating a Value Stream Map for the future, supermarkets are one of three pull strategies that can be used to create links between process steps. When First in First out (FIFO) and One-Piece flow are no longer options, supermarkets are considered. The concept of wholesale can be implemented in two well-known ways: in the warehouse using Kanban cards, and in the so-called two-bin system, where the two-bin serves as a signal in itself [12]. High-usage components that rotate faster than those used in a typical material handling cycle and are positioned near the line to allow operators or utilities to retrieve them define the original supermarket. Electronic signals, min/max designations, Kanban cards, and other factors all lead to supermarket stock replenishment. The theoretical basis for implementing a supermarket system in manufacturing inventory management includes several key concepts related to Lean Manufacturing, inventory management strategies, and implementation success factors. The main basis for implementing a supermarket system is the Kanban concept. This concept encourages the use of Kanban cards or other visual signals to coordinate the flow of materials in the production chain. This theory is rooted in the just-in-time principle which aims to produce goods or services when needed and, in the quantities, needed. [13], one of the main thinkers behind Lean Manufacturing, suggests that Kanban is a tool to achieve just-in-time production, which allows for efficient material flow and avoids unnecessary inventory build-up.

Effective inventory management involves understanding inventory management strategies and the Economic Order Quantity (EOQ) model. EOQ is a theoretical model that helps companies determine the optimal order quantity to achieve minimum inventory costs. According to [14], the founder of the EOQ concept, making optimal decisions about how much and when to order goods is key to optimizing inventory costs. In the context of implementing a supermarket system, EOQ can be the basis for determining efficient order lot sizes.

The theoretical basis for success factors in implementing a supermarket system leads to the understanding that this concept is not only technical, but also involves human and organizational factors. A study by [15] highlighted the importance of factors such as employee involvement, management support, and a deep understanding of business processes. [16] emphasized that employee involvement in the use of the supermarket system is essential to increase transparency and accountability in the production chain.

A supermarket is a series of parallel FIFO lines arranged according to the products produced. The origin of this name is a typical retail supermarket. The fundamental aspect of a supermarket is that when a product or item is removed, a signal is sent to replenish it (a process known as Kanban). In addition, the store wants to prevent overproduction while maintaining adequate supply for each section. Supermarkets require more work to organize and manage than FIFO lines [17].

2. Material and methods

Case study research uses an approach by placing one method as the main priority while other designs are carried out to complement/develop previous priorities. In this approach, there are different priority weights. Researchers use qualitative methods predominantly by taking and analysing data according to the tradition of qualitative research using Failure Mode and Effect Analysis (FMEA). However, at almost the same time, researchers also take quantitative data and analyse it, although only as a small part of the overall research, to develop or enrich the results obtained using qualitative methods. The results of the study are then interpreted together [18]. The following are the stages in this study

2.1.1. Identification of Case Study

Selecting a manufacturing company as the object of the case study: this research was conducted at a multinational company, PT. PI in the Sidoarjo Industrial area, in the province of East Java, Indonesia.

2.1.2. Mixed Methods Design:

- Identification of research questions and research objectives to be answered using qualitative and quantitative methods
- Involving sources from the production floor to the managerial level of the company PT. PI to conduct a potential problem analysis.
- Collect customer demand data (next process).
- Determine the appropriate mixed methods research design.

2.1.3. Integration of Findings

Combine findings to gain a complete understanding:

- Conduct potential problem analysis using Failure Mode and Effect Analysis with sources from the company.
- Historical data and customer demand projections (next process) are processed to obtain stock levels and adjusted to the supermarket area.

In other words, a supermarket in the manufacturing industry can be defined as follows:

- A material storage area that is intentionally designed with a controlled amount of material.
- The downstream process takes what is needed and the supermarket owner (upstream process) refills.
- Unlike traditional storage areas, there is no need for order forms, document transactions, or stock requests other than Kanban.

A material storage area that:

- Places material close to the point of use.
- Eliminates shortages.
- Sets minimum and maximum levels for inventory.
- Uses floor space efficiently.
- Simplifies ordering and handling of materials.
- Eliminates non-value-added activities: (receiving, storing, inventory, counting, cycles, requests).
- Improve material flow in product cells.
- And make material status visible.
- Simple visual system shows material flow.
- Control location, address, and quantity.

There are three Supermarket Design Steps that can be applied to the manufacturing industry, namely:

- Determine the location of the supermarket
- Determine the size of the supermarket
- Design the delivery route

Step 1: Supermarket Location Placement

Standard Approach

- Place the supermarket at the end of the supplier process or production line
- Make problems directly visible to the manufacturer's process
- Do not sacrifice visibility to optimize the work of the material handler

Step 2: Determine the size of the supermarket

To determine the size of the supermarket, consider the following:

- Volume of use (quantity)
- Scheduling method
- Frequency of upstream deliveries
- Delivery quantity
- Container size
- Signal location

According to [19] to apply for approval to operate a factory or other facility, several types of materials needed in minimum quantities available in the warehouse, needed when damaged, can be moved immediately. However, the materials needed are too much so that the costs incurred are not too expensive. Stages with the min method - Maximum inventory when collected:

Determining safety stock

Safety stock is extra inventory that needs to be added to ensure that at any time there is an additional need or delay in the arrival of goods.

$$\text{Safety Stock} = (\text{Maximum usage} - T) \times C$$

Where:

T = Average usage of goods per period

C = Lead Time

Determining minimum inventory (Minimum Stock).

The amount of stock needed for a purchase order is known as minimum stock, and is determined by multiplying the ordering time per period by the average usage in a particular month, week, or day, plus safety stock.

$$\text{Minimum Stock} = (T \times C) + R$$

Where:
T = Average usage of goods per period
C = Lead Time
R = Safety Stock

Determine Maximum Stock.

Maximum stock is the maximum amount allowed to be kept in inventory. Maximum Stock = 2 (T x C)

Where:
T = Average usage of goods per period
C = Lead Time

The amount that needs to be ordered to replenish inventory.

$$Q = \text{Max} - \text{Min}$$

Where
Q = Inventory reorder level
Max = Maximum Stock
Min = Minimum Stock

Step 3: Designing delivery routes

Approach:

- Establish one-way and two-way aisles along the natural flow path in the facility
- Design all routes to flow through the plant and back to the supermarket
- Design stops and delivery points along the route to minimize non-value-added work for material handlers
- Design stops and delivery points along the route to minimize non-value-added work for supplied operators

2.1.4. Conclusion and Holistic Interpretation.

Present the conclusions of the study, explaining the findings

3. Results

3.1. Preparation for Supermarket Implementation

3.1.1. Failure mode and effect analysis (FMEA)

To analyze the new manufacturing process due to later changes in route design with the implementation of this supermarket and provide understanding that potential failures in this process must be considered because it will give effect to customers in this case DEPT. C and DEPT. D, even if there is a problem considering the target is to reduce the stock level from 7 days of production to 4 hours of production and to provide complete documents about the process changes to guide the development of future processes, then a Failure Mode and Effect Analysis is made on the project on table 1.

Table 1 Failure mode and effect analysis FL production

Problem	Potential Failure Mode	Potential Failure Effects	Severity	Potential Cause	Occurrence	Current Controls	Detection	RPN
Shortage product in next process (DEPT. C & D)	Imbalance of product output from internal suppliers (DEPT. B) and next process (DEPT. C & D)	The production machine in the next process (DEPT. C & D) will experience problems due to unavailability of product materials	7	Low performance of production machines at internal suppliers (DEPT. B)	5	Visual	7	245
			5	Lower production machine speeds at internal suppliers (DEPT. B) compared to next process (DEPT. C&D)	8	Visual	7	280
			7	Less skilled machine operators at internal suppliers (DEPT. B)	5	Visual	7	245
			5	Low product output High product rejects at internal suppliers (DEPT. B)	6	Visual	7	210
			5	Improper production planning schedule at internal supplier (DEPT. B)	4	Visual	7	140
			7	Less than optimal management control and reporting systems at internal supplier (DEPT. B)	5	Visual	7	245
			5	Delivery delays due to difficulty in accessing handles in the supplier's internal warehouse area (DEPT. B)	5	Visual	7	175

The FMEA is also used to set priorities actions in the process. the following table 2 below shows the ranking of risk priority numbers obtained after combining severity, occurrence and detection factors of each potential problem that arises, including recommendations for actions taken.

Table 2 Prioritization of recommended actions

Potential Failure Mode	Potential Cause	RPN	Action Recommended
Imbalance of product output from internal suppliers (DEPT. B) and next process (DEPT. C & D)	Lower production machine speeds at internal suppliers (DEPT. B) compared to next process (DEPT. C&D)	280	Building a team to carry out projects to increase machine capacity
	Less than optimal management control and reporting systems at internal supplier (DEPT. B)	245	Set up Short Interval Control for operators' guidance
			Set up escalation procedure to improve communication and maturity among employees and management
	Low performance of production machines at internal suppliers (DEPT. B)	245	Total productive maintenance implementation
	Less skilled machine operators at internal suppliers (DEPT. B)	245	Develop skilled machine operators
	Low product output High product rejects at internal suppliers (DEPT. B)	210	Develop skilled machine operators
	Delivery delays due to difficulty in accessing handles in the supplier's internal warehouse area (DEPT. B)	175	Mapping & execute of supermarket implementation areas
	Improper production planning schedule at internal supplier (DEPT. B)	140	Prepare the number of products as a basis for implementing the supermarket system

3.1.2. Calculation safety stock and min-max stock

In table 3 below, from the estimated FL demand data obtained, further calculations are carried out based on production stock for 4 hours in the form of pcs and boxes/containers.

Table 3 FL component demand calculation (in 4 hours)

	Product type FL P45		Product type FLA55		Product type FL TL		Product type FL TLD	
	In 4 hours (pcs)	In 4 hours (box)	In 4 hours (pcs)	In 4 hours (box)	In 4 hours (pcs)	In 4 hours (box)	In 4 hours (pcs)	In 4 hours (box)
WK-01	15.583	2	88.838	20	-	-	20. 788	4
WK-02	27. 683	4	149. 952	33	-	-	35.819	6
WK-03	27.133	4	153.000	34	-	-	37.897	6

WK-04	36. 667	5	132.455	29	8.175	2	26.864	5
WK-05	17.233	2	81.445	18	449	3	16.470	3
WK-06	47.117	7	136.891	30	13.59	4	27.983	5
WK-07	38.133	5	111. 755	25	6.264	2	29.103	5
WK-08	23.100	3	111. 755	25	-	-	34.539	6
WK-09	24. 933	4	106. 827	24	-	-	34.380	6
WK-10	34.833	5	123.954	28	319	0	37.418	6
WK-11	29.000	4	134.057	30	4990	1	31.981	5
WK-12	29.222	4	106.056	24	10286	3	25.300	4
WK-13	29.222	4	95.642	21	-	-	37.950	6
WK-14	17.078	2	55.304	12	10.286	3	25.300	4
WK-15	19.924	3	81.929	18	10.286	3	25.300	4
WK-16	18.000	3	64.869	14	-	-	37.950	6
WK-17	23.909	3	74.936	17	-	-	37.950	6
WK-18	20.493	3	75. 836	17	-	-	37. 950	6
WK-19	27.277	4	102. 932	23	10.286	3	25.300	4
WK-20	23.380	3	79.173	18	10.286	3	25.300	4
WK-21	24. 905	4	99.634	22	-	-	37.950	6
WK-22	17.000	3	61.496	14	-	-	37.950	6
WK-23	31. 214	4	95.642	21	-	-	37.950	6
WK-24	22.912	3	75. 680	17	10286	3	25.300	4
WK-25	22.000	3	99.634	22	10.286	3	25. 300	4
WK-26	22. 912	3	86. 095	19	-	-	37.950	6

WK-27	22. 912	3	99. 634	22	-	-	37.950	6
WK-28	22.000	3	67.943	15	-	-	37.950	6
WK-29	31. 214	4	77.614	17	10286	3	25. 300	4
WK-30	31. 214	4	78. 804	18	10.286	3	25.300	4
WK-31	7.685	1	19.540	4	-	-	37.950	6
WK-32	22. 912	3	68.390	15	-	-	37.950	6
WK-33	17.000	3	74.051	16	-	-	37.950	6
WK-34	22. 912	3	90.409	20	10286	3	25. 300	4
WK-35	22. 912	3	82. 226	18	10.286	3	25. 300	4
WK-36	31. 214	4	95.000	21	-	-	37.950	6
WK-37	22. 912	3	83.417	19	-	-	37.950	6
WK-38	22. 912	3	89.219	20	-	-	37.950	6
WK-39	28. 225	4	86.095	19	10.286	3	25.300	4
WK-40	20.066	3	58.726	13	10.286	3	25. 300	4
WK-41	23.410	3	59.289	13	-	-	37.950	6
WK-42	31. 712	5	41.138	9	-	-	37.950	6
WK-43	17.078	2	46.866	10	-	-	37.950	6
WK-44	19. 924	3	50.809	11	10.286	3	25. 300	4
WK-45	31. 712	5	54. 231	12	10286	3	25. 300	4
WK-46	23.410	3	61. 521	14	-	-	37.950	6
WK-47	10. 024	3	61.223	14	-	-	37.950	6
WK-48	19.924	3	51.553	11	-	-	37.950	6
WK-49	31. 712	5	71.068	16	10286	3	25.300	4

WK-50	31. 712	5	82.673	18	10.286	3	25.300	4
WK-51	19. 924	3	65.563	15	-	-	25. 300	4
WK-52	14.231	2	29.384	7	-	-	25. 300	4
Avg	24. 736	4	83. 346	19	9.463	3	31.708	5
Max	42. 833	6	133. 821	30	11.325	3	33000	6

The next calculation in table 4 below is done to get the safety stock and min-max stock values as the results in the table below. The basic calculation is based on production stock for 4 hours

Table 4 Calculation safety stock and min-max (in 4 hours)

	FL P45	FL A55	FL TL	FL TLD
Safety stock (# boxes)	10	46	2	2
Minimum stock (# boxes)	24	120	12	24
Maximum stock (# boxes)	28	148	20	43
Safety stock (pcs)	72,388	201,901	7,449	5,166
Minimum stock (pcs)	171,333	535,286	45,300	132,000
Maximum stock (pcs)	197,891	666,770	75,702	253,668

3.1.3. Create new location for supermarket and delivery routes

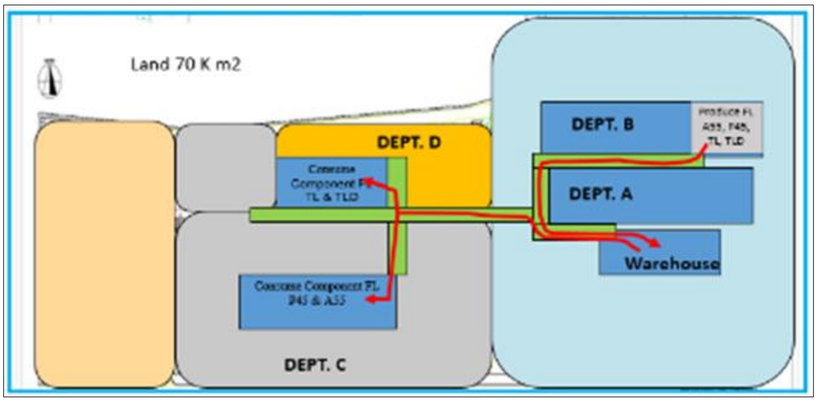

Figure 1 Previous store location and delivery routes

Previous condition Figure 1

- Components was produced by one of division of DEPT,B,
- Finish components take and send to warehouse by warehouse crew (inventory level for 1-week production stock),
- Material ordering department that take care delivery to DEPT, C and DEPT, D will take the components in warehouse then send to DEPT, C and DEPT, D for their production

On Figure 2 below, with the new route design, improvement is found, among others, there is no need for transportation routes from FL production to warehouse so that transporters can be diverted to activities that provide added value, Material ordering department that take care delivery to DEPT, C and DEPT, D can directly take the components on supermarket, just filling the card,

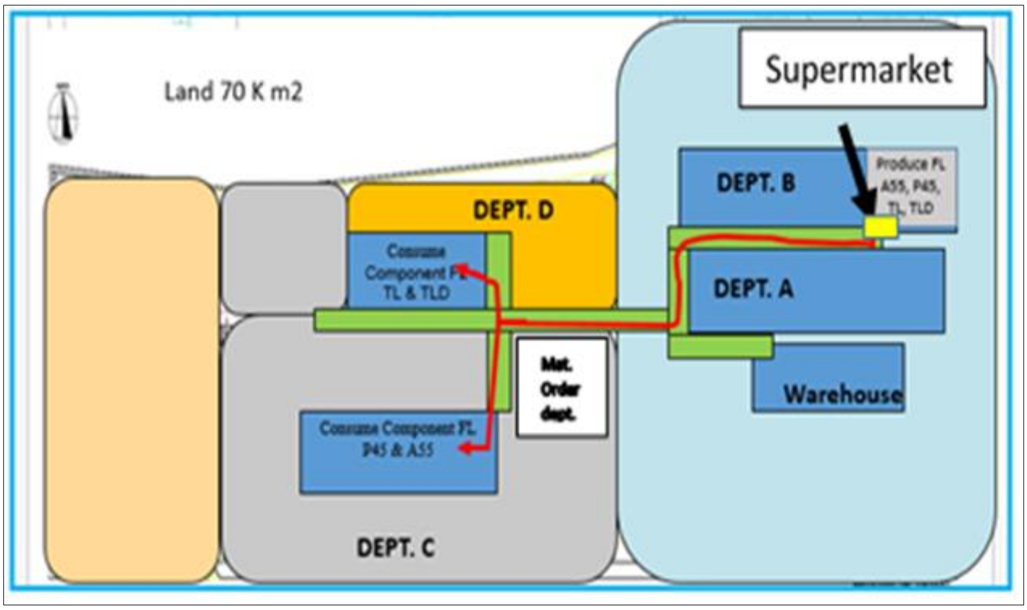

Figure 2 New store location and delivery routes

3.1.4. New adaptation in production unit FL components

With this new process change, it moves the FL production unit to adjust it, Make to stock has no problem with delivery reliability, Many problems are hidden by the make to stock, The target of reducing inventory levels from 7 days of production to 4 hours of production is very challenging and poses a huge risk to the continuation of next process production at DEPT, C and DEPT, D, Many changes made after FMEA include:

- Implementation of TPM (Total Productive Maintenance) so that optimal production machine conditions,
- Development of Knowledge operators to address changes in the process which must do the right thing from the beginning, namely to control CTQ (Critical to Quality) parameters properly so that the product produced is excellent as customer expectations, well maintained machines, increased productivity,
- Mapping operator's vs machines to adjust to these new changes,

New steps

- Components from machine which pass from quality check directly send to supermarket,
- Supermarket location is placed closed to production machine area, that production crew in unit can see the level of inventory,
- Implement min – max concept
- There are 3 colors (green, yellow, red) which indicate the level of components inventory,
- Red: Machine running for production to fill the supermarket,
- Yellow: Prepare machine start up
- Green: The inventory level is saved; machine can be stopped for maintenance activities,
- Unit Leader and machine operator's attention to those visual managements sign to decide when start and stop the machines,
- No need production planner as previous condition caused start and stop by production crew automatically,

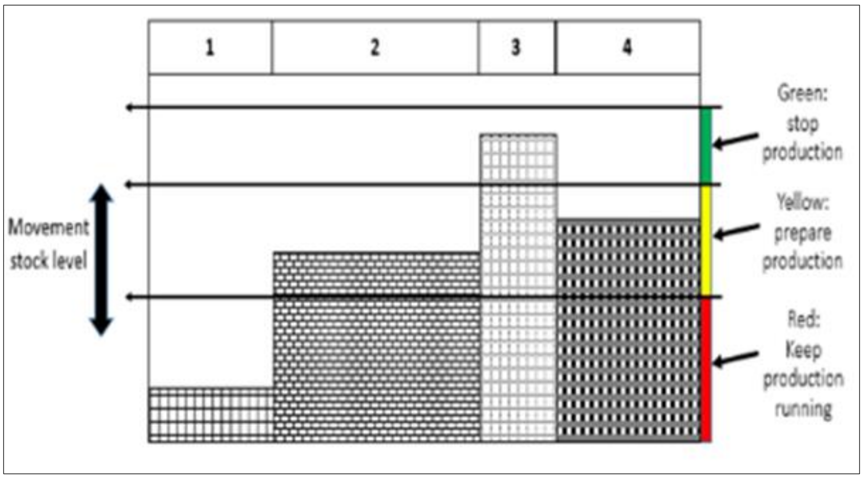

Figure 3 Visual sign min-max on supermarket

4. Discussion

The key factors of successful supermarket implementation:

- Three Steps of Supermarket Design (set supermarket location, determine supermarket sizing, design delivery routes) which have implemented correctly, these three steps of supermarket design are a package that must be carried out together so that supermarket implementation provides optimal results,
- Preparation of supermarket implementation, this preparation step is very important especially for the two departments that differ in terms of technical performance because in this supermarket concept the performance of the producer is at least balanced with the customers, for this reason, it is necessary to analyse using failure mode and effect analysis,
- Maturity of the production crew, developing a crew to be able to independently manage its production area, sense of responsibility, a high sense of ownership is a factor needed in the implementation of this supermarket,

In this paper shows the supermarket implementation to replace make to stock concept in warehouse by following the three steps of supermarket design (set supermarket location, determine supermarket sizing, design delivery routes), The other important step is preparation using failure mode and effect analysis to analyse changing in process, And development of employees' maturity, By those activities the target of reducing inventory level from 7 days' production to 4 hours' productions in customer have achieved,

To find a more optimum process flow in the future, it can be developed an inventory of research models involving suppliers and external customers where the supermarket concept certainly requires a different treatment than the relationship between the internal scope of the company so that it can realize totally lean enterprise,

5. Conclusion

In this research, we highlight the importance of supermarket system implementation in manufacturing inventory management, Focusing on key success factors such as three-step supermarket design, implementation preparation, and production crew maturity is an important step, Our findings show that by following these steps, inventory level reduction targets can be achieved significantly, even to the point of reducing from 7 days to just 4 hours of production, However, to achieve sustainable competitive advantage, the integration of supermarket systems into the overall supply chain strategy is crucial, By involving external parties, such as suppliers and customers, we can realize the total lean enterprise vision, Therefore, this research provides an important foundation for practice and theory in understanding the role of supermarket systems in achieving efficiency and competitive advantage in inventory management

Compliance with ethical standards

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Disclosure of conflict of interest

Authors do not have any conflict of interest to declare.

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