

PROPOSED IMPROVEMENT OF RAW MATERIAL WAREHOUSE LAYOUT IN CV CMP

Loren Pratiwi¹⁾, Stevanny²⁾
Parahyangan Catholic University^{1,2}
E-mail: lorenp@unpar.ac.id

Abstract: CV CMP is a company operating in the plastic services industry. This company receives orders from other manufacturing companies to produce various types of products, including baby spoons, toys, broom handles, and others. To fulfill its customer orders, CV CMP has two types of warehouses: a finished goods warehouse and a raw material warehouse. Several issues have been identified in the raw material warehouse, such as incorrect use of raw materials, missing or hard-to-locate materials, and difficulties in the material retrieval process. The disorganized warehouse layout causes entry and exit pathways to be blocked by raw materials, preventing workers from using material handling equipment and hindering storage and retrieval processes. Therefore, a redesign of the raw material warehouse layout was carried out using the class-based storage method by grouping raw materials based on customers, resulting in two layout alternatives. Among these, the second alternative was selected as it has the shortest total material movement distance—929,065.63 meters—more accessible raw material placement for workers, and wider aisle spaces.

Keywords: *Layout, Warehouse, Raw Material, Class-Based Storage*

1. Introduction

Facility layout is a critical factor, especially for manufacturing industries and factories. This importance stems from the fact that facility layout can reduce equipment investment costs, maximize space utilization, improve the utilization of machinery and equipment, and provide ease, safety, and comfort for workers, among other benefits (Arif, 2017).

One of the essential factory facilities is the warehouse or storage space. Warehouses are generally categorized into three types: raw material warehouses, work-in-process warehouses, and finished goods warehouses. An effective warehouse maximizes area utilization and responds quickly to demands (Juliana and Handayani, 2016). A well-designed warehouse also considers the ease of item retrieval, the speed of picking and shipping, information accuracy, and methods for shipping items without damage or altering their basic form (Tompkins, White, Bozer, and Tanchoco, 2010).

CV CMP is a manufacturing company operating in the plastic services industry. CV CMP is experiencing issues in its raw material warehouse, which measures 34.56 m in length and 6.75 m in width. Figure 1 illustrates the current floor plan of the raw material warehouse. Various types of raw materials are stored, such as polypropylene (PP), polystyrene (PS), and others. These raw materials are further categorized into process or milled materials, colorants, and original

materials. The raw materials are sourced from customers producing at CV CMP and from suppliers. CV CMP serves 15 customers and one supplier.

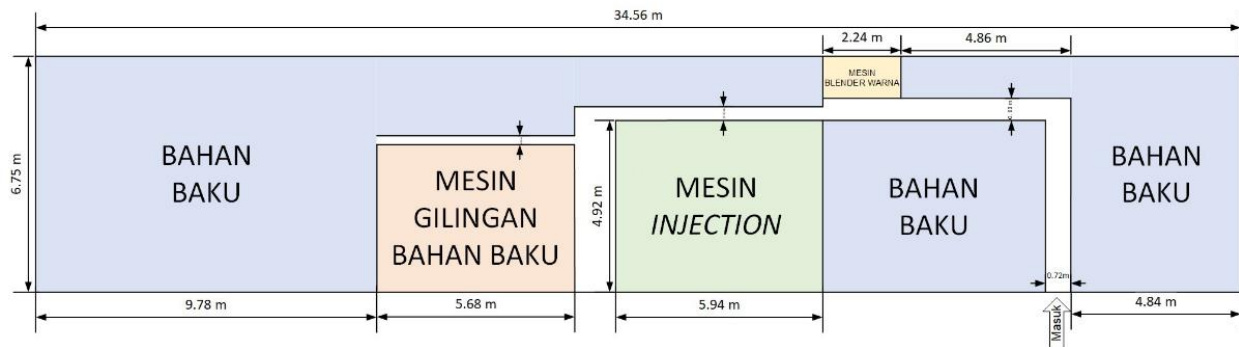


Figure 1. Layout of the Raw Material Warehouse

Initial observations and in-depth interviews identified a series of chronic issues, including a disorganized layout, frequent errors in raw material usage and loss, difficulties in the material search process, and disruptions in the flow of storing and retrieving goods. This condition is exacerbated by extremely narrow aisle widths, ranging from only 39-72 cm, which prevent the use of material handling equipment and force workers to manually move materials weighing 20-25 kg. The irregular and excessively high stacking of materials also poses a safety risk. This situation creates a gap between ideal operational conditions and the on-the-ground reality, leading to financial losses from production delays and compensation costs to customers. This research is important as it offers a structured solution to reorganize the warehousing system, which is a vital activity in the company's supply chain. Therefore, the objectives of this research is to design a new proposed layout for the raw material warehouse at CV CMP using a systematic method.

2. Literature Review

A warehouse serves as a central facility for storing inventory before further processing. The primary mission of a modern warehouse extends beyond mere storage; it includes improving the efficiency of the order picking process, utilizing cross-docking, enhancing productivity, optimizing space utilization, and increasing value-added services. (Tompkins, et.al, 2010). Essential functions in warehouse operations include receiving, inspection and quality control, repackaging, putaway, storage, order picking, sortation, postponement, packing and shipping, and replenishing. (Tompkins, et.al, 2010).

The design of an effective warehouse layout should adhere to five main principles. First, the *popularity* principle, where fast-moving products are placed closest to the entrance/exit. Second, *similarity*, which involves placing items that are often processed together in the same area for handling efficiency. Third, *size*, where larger and heavier items are placed closer to the point of use and at lower positions. Fourth, *characteristics*, which considers the special nature of goods such as being perishable, having irregular shapes, being hazardous, or requiring high security. Fifth, *space utilization*, which encompasses space conservation, accessibility, and orderliness to maximize capacity and flexibility. (Tompkins, et.al, 2010).

Several storage methods are commonly used in warehouse layout design.

1. **Class-Based Storage:** This method involves placing raw materials into classes based on similarities in item type, catalog, color, and so forth (Dwiyanto, 2008). Typically, three to four classes are defined, and each class is assigned to a specific area.
2. **Shared Storage:** This method organizes the storage area based on the floor space conditions of the warehouse (Sutisna and Irfan, 2015). It is suitable for products with many types and relatively constant demand (Frazelle, 2002).
3. **Dedicated Storage:** Also known as *fixed lot storage* or fixed storage location (Francis, White, and McGinnis Jr, 1992). This method assigns a specific storage location for each product type. Its advantage lies in its organization, while its drawback is the substantial use of space.
4. **Randomized Storage:** This method places products based on the location closest to the entry point (Amyhorsea and Pujotomo, 2016). While it is suitable for maximizing space, it prolongs the product search time.

3. Research Method

This study employs a quantitative approach with a descriptive-evaluative research design. The population of this study includes all activities and materials within the raw material warehouse of CV CMP. The data sample used is the historical data of receiving and issuing activities for all types of raw materials over a one-year period. The data analysis process was conducted systematically. First, the storage slot requirements were calculated based on the maximum volume of material per customer to ensure adequate warehouse capacity. One slot consists of 20 sacks arranged upwards and the size of the slot follows the size of one sack (58cm x 88cm).

The placement priority for each class was determined by calculating the ratio between the total movement frequency (T_j) and the number of slots required (S_j). T_j/S_j ratio represents the movement frequency per storage slot. The higher T_j/S_j ratio, it means high movement frequency relative to space. Item with higher T_j/S_j ratio should be placed closed to the input/output point. The evaluation of the layout design alternatives was performed by calculating the total displacement distance using the *rectilinear distance* method, where the alternative with the smallest total distance was considered the best proposal. Table 1 shows the total movement frequency (T_j), the number of slots required (S_j), T_j/S_j ratio, and the priority of each product.

The proposed raw material layout redesign employs the **Class-Based Storage** method. This method was chosen because it can address the current problems and fulfill the company's desire to divide storage areas based on customers. It allows for the storage of several types of raw materials in the same location, provided they belong to the same class. Moreover, this method maintains fixed storage locations for each customer's raw material, making it easier for workers to recall and locate materials, simplifying retrieval and storage, and preventing haphazard placement of materials.

Table 1. Priority determination for each product

Customer	Inventory Max (Max)	Total Movement Frequency (T_j)	Number of Slots Required (S_j)	T_j / S_j	Priority
X	1452	17085	59	290	3
ALG	25	97	1	97	15
AS	28	281	2	141	12
BY	40	154	1	154	10

CVB	320	3344	12	279	4
DWS	68	528	3	176	7
JYA	285	4230	12	353	1
KM	240	1006	9	112	14
KKY	200	1040	8	130	13
MM	114	654	4	164	8
NP	1944	24000	78	308	2
OSP	76	826	4	207	6
PAA	708	4704	29	13	9
SJ	71	760	3	254	5
UDJK	249	1486	10	149	11
YD	85	378	4	95	16

Several data are required for the fk calculation: the entry distance, the exit distance, the entry probability ($P1$), and the exit probability ($P2$). The fk value represents the expected distance from storage location k to the entrance and exit points. Following the fk calculation, each customer is allocated based on the fk results and a priority system. The highest priority is assigned to the smallest fk value, continuing sequentially until the lowest priority is assigned to the largest fk value.

$$Fk = (Total\ Entry\ Distance \times Entry\ Probability) + (Total\ Exit\ Distance \times Exit\ Probability)$$

(Eq.1)

4. Results and Discussion

4.1. Results

The data analysis indicated a total need for 239 storage slots to accommodate the maximum inventory from all customers. Based on the Tj/Sj ratio calculation, the placement priority order for customer materials was successfully established, with the customer "JYA" having the highest priority (ratio of 353) and "YD" the lowest (ratio of 95).

Based on this analysis, two proposed layout alternatives were developed. In the proposed alternative, the three injection molding machines located in the raw material warehouse are not relocated. This decision is due to the current lack of available space for these three machines on the production floor. It is considered difficult because heavy equipment would be required for the relocation, and the process could only be carried out when production is not running. Currently, production activities are still operating as usual. In these two alternatives, there is a difference in the orientation of the raw material sacks. This adjustment is intended to maximize space utilization and to widen the aisles. It is considered difficult because heavy equipment would be required for the relocation, and the process could only be carried out when production is not running. Currently, production activities are still operating as usual.

In Alternative 1, three raw material grinding machines and one color blending machine are combined in an open room built right next to the injection machine. Inside, there is also a temporary space for placing raw materials or products scheduled for the grinding process. Furthermore, the aisle width in alternative 1, ranging from 84 cm to 2.6 m, is sufficient to

accommodate both material handling equipment and personnel. The total displacement distance for Alternative 1 is **929,065.63 m**. Figure 2 illustrates the proposed layout of Alternative 1.

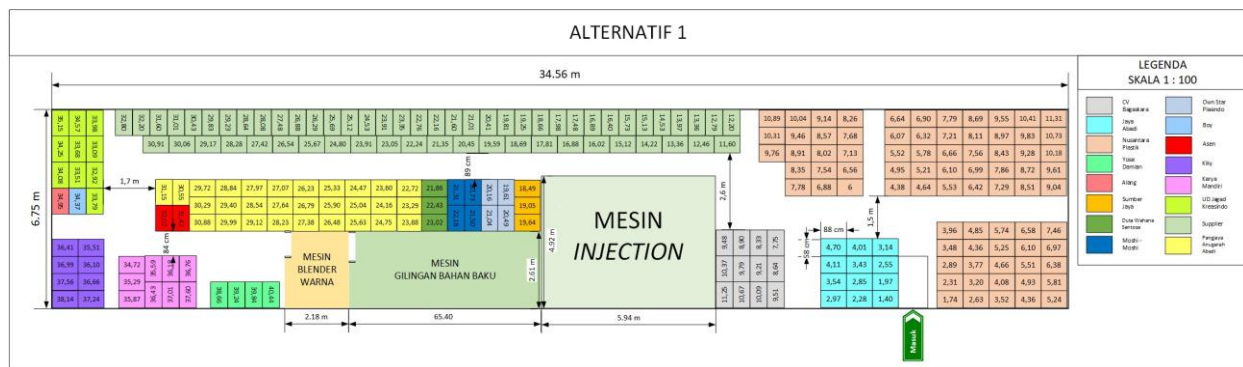


Figure 2. Proposed Layout of Alternative 1

For Alternative 2, the placement of the material grinding machine and the color blending machine is identical to Alternative 1. Both machine types are situated within a single, open-access room (without a door), ensuring personnel can readily access both machines. A temporary holding area is also provided for raw materials or products awaiting the grinding process. The primary difference between Alternative 1 and 2 lies in the placement of the storage slots for raw materials.

Furthermore, the aisle width in this alternative becomes significantly more adequate for both personnel and material handling equipment. In the original warehouse layout, the aisle width narrowed progressively from 72 cm down to 26 cm. However, in this second alternative, the aisle width ranges from 76 cm to 2.6 m. The wider aisles allow material handling equipment to be used more freely in the raw material warehouse. Workers will also not feel cramped when passing through the aisles or when retrieving and placing raw materials. There are three primary differences between Alternative 1 and 2. These differences lie in the placement of storage areas or slots for several customers, the aisle width, and the total displacement. The total displacement distance for Alternative 2 is **932,905.33 m**. Figure 3 illustrates the proposed layout of Alternative 2.

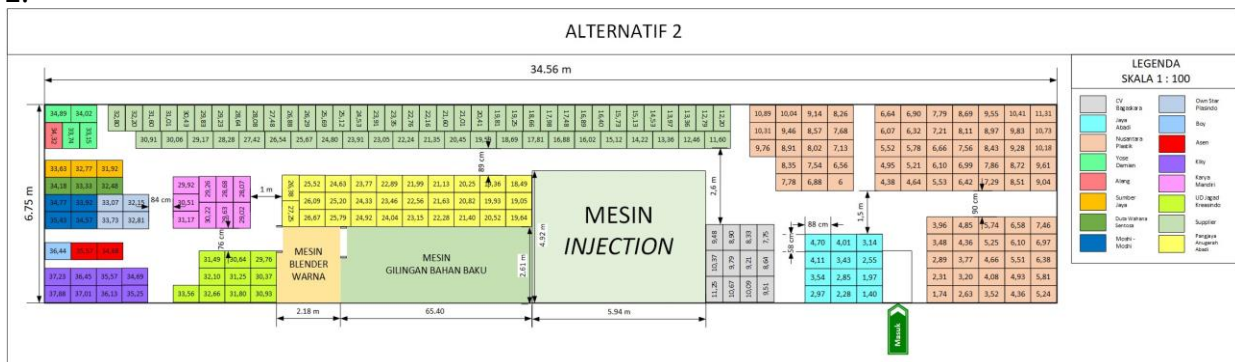


Figure 3. Proposed Layout of Alternative 2

4.2. Discussion

The warehouse layout design method chosen is class-based storage. In this class-based storage method, each raw material has a specific and fixed storage location. This method is used because it provides a fixed storage location for each raw material, ensuring neat and uncluttered

material arrangement. Furthermore, it makes it easier for workers to remember and locate each required raw material. This method also prevents haphazard placement of raw materials, which can lead to misuse or loss. Finally, the class-based storage method allows companies to store multiple types of goods in the same location as long as they are from the same class. Placing raw materials using the class-based storage method also follows the principle of popularity, which distinguishes between fast-moving and slow-moving products. Fast-moving products are those with a high rate of in-and-out movement, while slow-moving products are those with a low rate of in-and-out movement. To determine whether a raw material is a fast-moving or slow-moving product, data on in-and-out frequency, throughput, and priority calculations are used. Because the distribution of raw materials is based on customers, the determination of fast moving products or slow moving products is also based on customers.

By assigning specific and fixed storage locations for each customer's materials, this proposal directly eliminates the chaos of the previous storage system. This aligns with the principle of dedicated storage at the class level, making it easier for workers to find and retrieve materials, thus significantly reducing the potential for errors and material loss. The determination of placement priority based on the T_j/S_j ratio also applies the popularity principle in warehouse layout, where materials with the highest movement frequency (belonging to priority customers) are placed in the most strategic locations to minimize travel time and distance.

The implementation of the proposal (Alternative 1) offers significant improvements over the existing condition. The drastic increase in aisle width from a minimum of 39 cm to 84 cm not only enhances safety but also allows for the use of material handling equipment, which can potentially reduce physical workload and increase process efficiency. The travel distance for priority materials, is drastically reduced from about 23.5 m to just 1.41 m from the entrance/exit. Managerially, this proposal provides a foundation for a more organized, measurable, and efficient warehousing system, which will ultimately have a positive impact on production timeliness and customer satisfaction. Although this proposal has a limitation, namely the need for redesign if new customers are added, the benefits offered in terms of efficiency and operational safety are far greater at present.

Following the new layout design, a comparative analysis reveals significant differences between the warehouse's previous and improved conditions. Firstly, the location of machinery has been optimized; the raw material grinding machine and the color blending machine, previously separate, are now consolidated into a single open-plan area adjacent to the injection machine. Secondly, the material placement system has been transformed from an arbitrary system with no defined locations to an organized methodology where each raw material has a dedicated, fixed position allocated per customer. Thirdly, aisle width has been drastically increased from a path that narrowed from 72 cm to 39 cm, to a consistent range of 84 cm to 2.4 m, thereby facilitating the use of material handling equipment. Fourthly, for the safety and convenience of personnel, the stacking height of raw materials is now limited to a maximum of 20 sacks per slot, replacing the previous practice of stacking goods nearly to the ceiling. Finally, travel distance has been made more efficient, as high-priority raw materials are now strategically placed near the entrance, in contrast to the former layout where such materials were often located deep within the warehouse.

5. Conclusion

Based on the analysis and discussion, this study draws two main conclusions. First, a new raw material warehouse layout has been successfully designed using the *class-based storage* method with grouping based on customer. The proposed new layout features a fixed storage locations for

each customer's raw material. The aisle width in the proposed layout ranges from 84 cm to 2.4 m and one slot accommodates 25 sacks of raw material stacked vertically. This proposed layout achieving a total annual displacement distance of 929,065.63 meters. Second, a comparative evaluation shows that the proposed layout is significantly superior to the current warehouse condition in terms of orderliness because it is easier to search material and reduces issues related to material loss and misuse. In terms of safety, the proposed layout reduces the risk of workplace because of the limiting vertical stacking of sacks. In terms of accessibility, the wider aisles of the proposed layout simplify the material retrieval and storage process, reduce worker burden due to the feasibility of using material handling equipment inside the warehouse, and ensure timely production and delivery. The proposed layout also addresses the issue of financial losses due to compensation costs incurred from material loss or misuse.

References

- Amyhorsea, D. N, dan Pujotomo, D. (2016). Perbaikan Tata Letak Departemen Distribusi Pada Pt. Apparel One Indonesia (Pt. Aoi) Semarang. *Industrial Engineering Online Jurnal*, 6(1).
- Arif, M. (2017). *Perancangan Tata Letak Pabrik*. Yogyakarta: CV. Budi Utama.
- Dwiyanto, A (2008). *Perancangan Tata Letak Gudang Barang Jadi di PT. Toa Galva Industries*. Bandung: Institut Teknologi Bandung.
- Firdaus, K., Suryadhini, P. P., & Astuti, M. D. (2020). Perancangan Tata Letak Fasilitas Usulan Menggunakan Metode Blocplan untuk Meminimasi Jarak Perpindahan Material. *Seminar dan Konferensi Nasional IDEC 2020*, 15(1)-15.8.
- Francis, R. L., White, J. A., dan McGinnis Jr, L. F. (1992). *Facility Layout and Location: An Analytical Approach (2nd ed.)*. New Jersey: Prentice-Hall Inc.
- Frazelle, E. H. (2002). *World-Class Warehousing and Material Handling (International ed.)*. New York: McGraw-Hill Companies.
- Hadiguna, R. A., & Setiawan, H. (2008). *Tata Letak Pabrik*. Yogyakarta: Andi.
- Juliana, H., dan Handayani, N. U. (2016). Peningkatan Kapasitas Gudang dengan Perancangan Layout Menggunakan Metode Class-Based Storage. *Jurnal Teknik Industri*, 11(2), 113-122.
- Sutisna, E. dan Irfan, M. (2015). Analisis Perbaikan Tata Letak Gudang di PT. PLN (Persero) APJ Bandung dengan Menggunakan Metode Shared Storage. *Jurnal Logistik Bisnis*, 5(1).
- Tompkins, J. A., White, J., Bozer, Y., dan Tanchoco, J. (2010). *Facilities Planning*. Hoboken: John Wiley & Sons, Inc.
- Zheng, X. (2014). A Connectivity Graph Generation Approach for Manhattan Path Calculation in Detailed Facility Layout. *Applied Mathematics and Computation*, 237, 238-251.