WAREHOUSING PROCESS IMPROVEMENT IN JUICE MANUFACTURE

Ms. Apasorn Prairajata

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By	Ms. Apasorn Prairajata
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Thesis Advisor	Assistant Professor Paveena Chaovalitwongse, Ph.D.

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

……..…. Dean of the Faculty of Engineering
(Associate Professor Boonsom Lerdhirunwong, Dr. Ing.)

THESIS COMMITTEE

……..….. Chairman
(Professor Sirichan Thongprasert, Ph.D.)

…… Thesis Advisor
(Assistant Professor Paveena Chaovalitwongse, Ph.D.)

…….... Examiner
(Assistant Professor Rein Boondiskulchok, D.Eng.)

…… External Examiner
(Associate Professor James Wallbank, D.Eng.)

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วิทยานิพนธ์ฉบับนี้ได้ทำการศึกษา คลังสินค้าสำเร็จรูปของโรงงา นผลิตน้ำผลไม้ ซึ่ง จะขอกล่าวอ้างอิงเป็นโรงงานเอบีซี แม้ว่าลักษณะการดำเนินงานของโรงงานศึกษาจะใช้นโยบายการผลิตตามคำสั่งซื้อ การดำเนินงานภายในคลังสินค้ายังค่อนข้างซับซ้อนและต้องการความยืดหยุ่นสูงซึ่งเป็นผลสืบเนื่องจากนโยบายทางการผลิตและลักษณะความต้องการของลูกค้า คลังสินค้าทำหน้าที่หลักในการรับสินค้าจากฝ่ายการผลิตเพื่อทำการรวบรวมและจัดเรียงตามคำสั่งซื้อของลูกค้า ซึ่งแต่ละใบสั่งซื้อมักจะมีความหลากหลายทำให้จำเป็นจะต้องรวบรวมสินค้าจากหลายรอบการผลิต และมีช่วงเวลาการรับเข้าคลังที่แตกต่างกัน ซึ่งทำให้ต้องมีการเก็บรัก ษาสินค้าจากการผลิตในบางช่วงเวลาเพื่อรอให้ใบสั่งซื้อของลูกค้าสมบูรณ์ตามรายการสั่งสินค้าทั้งหมดเพื่อทำการจัดส่ง ในเบื้องต้นพบปัญหา ความล้มเหลวในการดำเนินการออกสินค้าตามใบคำสั่งซื้อ ซึ่งถือเป็นปัญหาหลักของการศึกษาในงานวิจัยการปรับปรุงกระบวนการจัดการการคลังสินค้านี้

ในขั้นแรกผู้จัดทำได้ศึกษากระบวนการคลังสินค้า พบว่า แม้ว่าปัญหา นั้นเกี่ยวเนื่องกับกระบวนการทำงานในคลังสินค้าทั้งหมดโดยมาจากสาเหตุหลัก ดังนี้ การขาดการ จัดระเบียบภายในคลังสินค้า ส่งผลให้เกิดความยากต่อการตรวจสอบและการปฏิบัติงานในขณะที่ง่ายต่อการเกิดความผิดพลาดโดยเฉพาะทางด้านข้อมูล และ การที่คลังสินค้ามีกระบรวนการทำงานที่ไม่สอดคล้องกับการไหลของตัวสินค้าและการปฏิบัติงานจริง เนื่องจากให้ความสำคัญกับกระบรวนการหยิบสินค้าในลักษณะการหยิบจากพื้นที่เก็บรักษาที่แทนด้วยขอบเขตของพื้นที่คลังสินค้าทั้งหมด โดยที่ไม่ได้คำนึงถึงกระบรวนการรับเข้าเพื่อสนับสนุนกิจกรรมการนำออก ทำให้มักพบปัญหาในเข้าถึงและนำออกสินค้าที่ต้องการ นอกจาก นี้ยังพบว่าภายในคลังสินค้ามีการไหลของสินค้าจำนวนมาก โดยที่มีพฤติกรรมการไหลผ่านระบบในเวลาอันสั้นคล้ายคลึงกับกิจกรรมcross-docking คือแทบจะไม่มีกิจกรรมการเก็บรักษาเลย

แนวคิดที่นำเสนอในการควบคุมจัดการคลังสินค้าได้แบ่งกิจกรรมหลักและนำหลักการ cross-dockingเข้ามาร่วมพิจารณา ซึ่งได้นำการวางแผนกิจกรรมเข้ามาประยุกต์ใช้ในแนวทางการปรับปรุงดังนี้ 1.ออกแบบหลักการวางแผนกระบรวนการทำงานภายในคลังสินค้าล่วงหน้า เพื่อควบคุมกลไกลการไหลภายในคลังสินค้าและชี้นำกิจกรรมcross-docking 2.ทบทวนและปรังปรุงกระบวนการไหลของงานภายในคลังสินค้า ให้สอดคล้องกับระบบการวางแผนและลักษณะการไหลจริงของสินค้าภายในคลังสินค้า 3.ทำการออกแบบผังการแบ่งโซนของพื้นที่คลัง สินค้าเพื่อให้ง่ายต่อการควบคุมดูแลและดำเนินงาน จาก ผลการปรับปรุงพบว่า ผลการปฏิบัติงานของคลังสินค้าโดยรวมดีขึ้น ดังนี้ ค่าเฉลี่ยของอัตราส่วนความล้มเหลวในการนำออกสินค้า ลดลง จาก 5.45% ก่อนการปรับปรุง เหลือเพียง 1.41% หลังการปรับปรุง หรือปรับปรุงดีขึ้นประมาณ 74% โดยในเดือนแรกของการปรับปรุงอัตราส่วนความล้มเหลวลดลงอย่างรวดเร็วเหลือเพียง 3.3% แล้วค่อยๆลดลงต่อในเดือนถัดไป โดยมีแนวโน้มของค่าอยู่ในช่วง 0-1.5% นอกจากนี้ พบว่า กิจกรรม cross-docking เกิดการส่งผ่านโดยตรงจากขั้นตอนการรับเข้าไปสู่การจัดเรียงใบสั่งซื้อ และ การออกแบบแบ่งโซนตามกิจกรรม หลัก ช่วยลดเวลาในการตามหาสินค้าเนื่องจากคนงานสามารถระบุขอบเขตในการตามหาได้ นอกเหนือจากนี้ ปฏิบัติการในคลังสินค้ามีการดำเนินงานและทำการควบคุมได้สะดวกขึ้น

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต……..

สาขาวิชา …การจัดการทางวิศวกรรม…… ลายมือชื่ออ.ที่ปรึกษาวิทยานิพนธ์หลัก……..……..

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This thesis studies the warehousing process of finished goods in juice manufacturer, hereinafter referred as ABC company. Although the business model is 'Make-to-Order' policy, there are still difficulties regarding warehousing process which comes from the requirement factors of its production and customer orders. The significant role of this warehouse is to assembly finished goods from various production batches according to each customer order. Each order instructions has to collect product from many production batches which came in the different time. It causes the inventory holding to wait for the completeness of each order. In the preliminary observation, the significant facing problem is the situation that was unable to load product out as scheduled due to the unready of order fulfilling step so that this is the focusing area in warehousing process improvement.

The warehousing process analysis and the problem solving showed two significant root causes. Firstly, the warehouse is unorganised and leads to difficulty to control and investigate warehouse. Secondly, the warehousing process flow is inappropriate, which is emphasis only on the picking process while ignoring the role of inbound receiving. The pick- process took long time by searching and collecting product from all warehouse area as the inbound and storage are unconcern in the accessibility of the outbound. Moreover, The product profiling analysis showed that many flow lines act like a cross-docking flow, which means no storage activities and fast coming-in and going-out. The suitable warehousing improvement concept is the controlling strategy of activities category policy and also need to consider the cross-docking concept.

In the warehousing improvement, warehousing plan was used as tool for controlling and monitoring the warehouse activities which is sensible pattern following the order characteristic and production plan. The proposal for warehousing improvement includes three designs. First, the design of planning flow process to define the cross-docking flow and the short-term product in advance. This algorithm purposes on controlling and monitoring warehouse by forming product profile at the inbound receiving stage especially the cross-docking line. Second, the warehousing flow is redesigned to be appropriate for the actual product and activities in warehouse and also the warehousing planning design. Finally, the warehouse layout is set by zoning warehousing activities for the ease of control and investigation.

This warehousing improvement result shows that the percentage of order fulfilment process failure was reduced from 5.45% to 1.41% or about 74% improving. The percentage of failure is dramatically reducing to be 3.3% in first month from the average value of two previous months at 5.45%. After that, the failure is gradually reducing to be about 0-1.5% in the last researching period. Furthermore, the warehousing operation is easier to control and operate. Warehousing flow becomes smooth. The cross docking is identified and directly sent to picking at the beginning of inbound receiving stage. The activities zoning layout reduces time of searching process as the boundary guideline.

The Regional Centre for Manufacturing Systems Engineering Student's Signature:……

Field of Study: …Engineering Management……. Advisor's Signature:……...

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Chapter I
INTRODUCTION

1.1 Background of the Study

As the book "World-Class Warehousing and Material Handing" by Edward H. Frazelle, it is no way that customers and suppliers will be well coordinated to each other until the warehouse is unnecessary in supply chain. The warehouses is always still in the chain. Anyways, its role was not only the main purpose of storage as in the past but also be called for more capabilities of other operation such as dispatch, assortment, and consolidation. As the beginning of industry history, the mass production industries were trying to serve customers with low cost products by the large volume production. Then the continuous production process was developed by taking of advantages in time and cost. Therefore the manufacturing warehouse in the beginning times had to be in a large size to hold all stock of raw material, work-in-process, and finished good before the continuous process strategy can reduce the size of warehouse down by increasing frequency and reducing lot sized quantity. Just-in-time and Lean, which is very popular in the manufacturing industry reduce the size of warehouse to be optimum by simple concept of waste reduction. Today's Agile manufacturing with the concept of market responsibility, the manufacturing need well management to be more flexible support the high complicate and uncertain business situation including the warehouse activities where have to serve more varieties product mix in one order line. From all influences of industry trend theories, today warehousing process flow is faster and more complicate as less time of operation and higher requirement of inbound and outbound flows.

The case study company does business in juice beverage and food market. The company sells the product in both domestic and export through international. This manufacturer's warehouse is the focusing areas in this study as it is one important chain of business logistic. This warehouse receives and holds all products from juice production line before organize and deliver to each company partners so the product volumes flow through this warehouse is a high level as the first stage of product distribution.

1.2 Statement of Problem

The case study company, which is juice manufacturer, has a high variety product in term of package and flavour. The company runs business operation under the 'Make-to-Order' policy that mean each finished goods product is built follow a placed order instruction from customer. Even though it is a 'Make-to-Order', there is still the high level of holding inventory. The reason of a high inventory is the variety mixing per one order line of the customer demand and the minimum large batch size production requirement.

The current warehouse process is started by receiving products from production then assembling follow customer's order instructions. The production runs as a batch so the finished goods come into warehouse everyday as a large sized lot of variety products. Order instruction fulfilment needs to collect products from different lots as many different time of production. In the other hand, one production lot will separated to serve many customer orders and each finished good products in each lot may be held in warehouse for different time period. It shows that the warehousing process flow is complex.

With the current situation, the required products are available in warehouse but cannot loading out from warehouse to deliver on time. This is showing that the occurred problem is obviously not related to the lack of production capacity. The company faces with the problem of inefficient warehousing process. With this consequence, the company cannot cover all commitment of order instruction at the high peak demand and also cannot define what the significant cause is. Thus this research focuses on reducing loading failures caused by warehousing processes.

1.3 Objective

This study is to improve the warehousing process which has the main focus on the effectiveness of warehouse performance.

1.4 Scope of the Study

This research is studied in the ABC warehouse system area. The study is focus on the juice products under company brand. By the way, the production plan and the other manufacturing operation will be beyond this thesis area.

The final deliverables of the project includes:

A warehouse configuration and warehouse process improvement

- A warehouse work flow design
- A physical zoning layout

1.5 Expected Benefits

- It is the guideline to improve warehouse process in the similar business characteristic.
- It is the approaching of measurement in the warehousing performance of the manufacturer case study appropriate.
- It is the reference for future determining the suitable direction for warehouse developing plan to add higher value to company
- This will improve customer and employee satisfaction such a higher service quality and a better working environment
- This reducing waste in warehouse process such as waiting time, unnecessary movement, and error.
- It will be benefit in the future warehouse management system developing

1.6 Research Procedure

1. Study related literatures and theory.
2. Observe and interview the natural current of all warehouse process and its problem
3. Study and collect data of the existing warehousing activities, demand and production characteristic.
4. Analyze data
    - The current warehouse system problem and weakness
    - The of characteristics of order instructions
    - The warehousing material profile
5. The problem solving analysis
    - The root cause of the problems and the solutions searching
6. Warehouse process improvement design
    - The warehouse process flow
    - The warehouse physical (activities zone and layout)
7. Warehousing improvement implement and evaluation
    - Evaluate the warehouse process improvement result
8. Summarize of the thesis
    - conclusion and recommendation
9. Thesis write up

Chapter II
THEORY AND LITERATURE REVIEW

This chapter will give an overview of all theories and the studies that the author has studied and used as foundation. Initially, it starts with describing theories which are related to warehouse process and problem analysis. Then, the previous literature related to this thesis will be concluded at the end of this chapter.

2.1 Warehouse Theory

Definition of the Warehouse

Warehouse is defined as "the function of storing a variety of product types [stock-keeping units (SKUs)] that have a small or large quantity of storage units between the time that the product is manufactured by your facility (vendor) and the time that the product identification required by your customer or workstation within your manufacturing facility." (Mulcahy, 1994)

Warehouse Type Classification

There are many classification types for warehouse as Rushton and teams(2006) give the reason in their book that warehouse is an integral part of the supply chains in which it operates, and therefore recent trends have an impact on the roles that warehouse is required to perform. Warehouse needs to be designed and operated in line with the specific requirements of the supply chain as a whole."

There are many different types of classification that can be adopted, for example:

- *by the stage in the supply chain :* materials, work-in-process or finished goods;
- *by geographic area:* for example, a parts warehouse may serve the whole world, a number of countries, one country, or a specific region of a country;
- *by product type:* small parts, large assemblies (e.g. car bodies), frozen food, perishable, security items and hazardous goods;

- *by function:* inventory holding or sortation;
- *by ownerships:* owned by the user or by a third-party logistics company;
- *by company usage:* a dedicated warehouse for one company, or a shared-user warehouse handling the supply chains for a number of companies;
- *by area:* ranging from 100 m^2 or less to well over 10^5 square metres;
- *by height:* ranging from warehouses about 3 metres high through to 'high-bay' warehouses that may be over 45 metres in height;
- *by equipment:* a largely manual operation or a highly automated warehouse.

(Rushton, 2006)

In fact, there are many different classifications for warehouse, but there are two main widely for technical warehouse study. These are *the stage in the supply chain* and *the function or the value-added of warehouse*. As the classification of warehouse in the supply chain by Frazelle (2001). There are seven warehouse types.

1. **Raw material and component warehouses:** Hold raw materials at or near the point of induction into a manufacturing or assembly process.
2. **Work-in-process warehouses:** Hold partially completed assemblies and products at various points along an assembly or production line.
3. **Finished goods warehouses:** Hold inventory used to balance and buffer the variation between production schedules and demand. For this purpose, the warehouse is usually located near the point of manufacture and is often characterized by the flow of full pallets in and full pallets out. A warehouse serving only this function may have demands ranging from monthly to quarterly replenishment of stock to the next level of distribution.
4. **Distribution warehouses and distribution centers:** Accumulate and consolidate products from various points of manufacture within a single firm, or from several firms, for combined shipment to common customers. Such a warehouse may be located central to either the production locations or the customer base. Product movement may be typified by full pallets or cases in and full cases or broken case quantities out. The facility is typically responding to regular weekly or monthly orders.

5. **Fulfillment warehouses and fulfillment centers:** Receive, pick, and ship small orders for individual consumers.
6. **Local warehouses:** Distributed in the field in order to shorten transportation distances to permit *rapid response* to customer demand. Frequently, single items are picked, and the same item may be shipped to the customer every day.
7. **Value-added service warehouses:** Server as the facility where key product customization activities are executed, including packaging, labeling, marking, pricing, and returns processing.

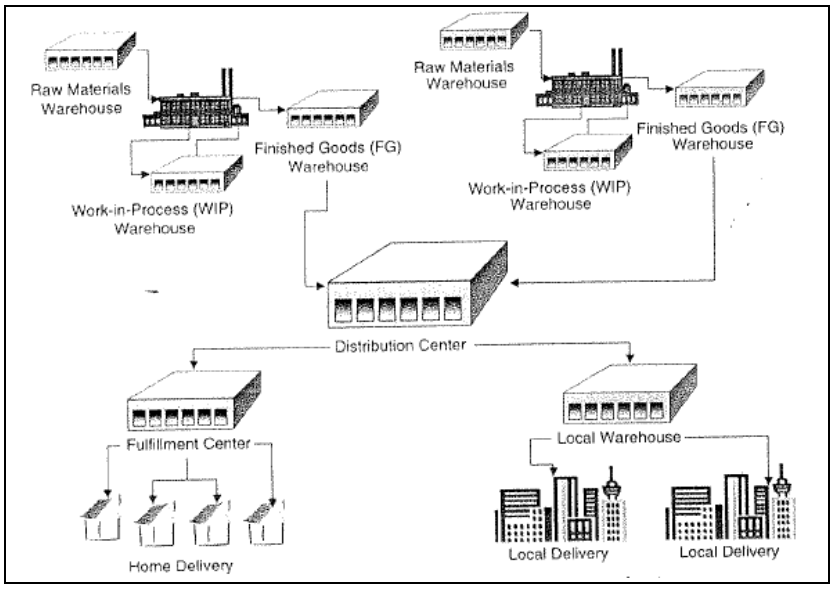


Figure 2. 1 The warehouse roles classification in logistics and supply chain. (Frazelle, 2001)

Current changes in the availability and cost of transportation options of today make combining activities in a single location and link skipping possible for many products. In particular, small high-value items with unpredictable demand are frequently shipped worldwide from a single source using overnight delivery services. (Frazelle, 2001)

The Role of Warehouse

The significant role of warehouse is not only main focusing on storage as in the past because of the change of supply chain and industry trend. The role of items movement becomes another significant in warehousing management. The aspects of warehouse changing role were described in many articles such as "*The warehouse of*

today is not a long-term storage facility" said by Coyle in 2003, *"The warehouse is still very much in use – some just to store things, and others to provide efficient throughput of goods which is more accurately described as a distribution center*." came from Wisner's book in 2005, "*By the increasing emphasis on the movement of goods through the supply chain, many of the roles may be related to this aspect as well as to inventory holding*." Said by Rushton in 2006 and also including Frazelle's word in the last previous content.

The common roles of warehouse performance

The following list is some of the common warehouse roles performed:

- *Inventory holding.* This may involve the holding of critical parts in case of breakdown or acting error but it is not the main holding inventory. There are two main conditions. First is *the demand for the product is continual.* The most goods sale on a continual condition basis therefore they need to be 'pulled' through the supply chain. Second is *the supply lead time is greater than the demand lead time.* It is often the case that materials cannot be sourced, goods manufactured and transport undertaken within customers request timescale so that the goods must be supplied from inventory. There is also in fact a wide range of reasons for holding inventory including to provide a buffer to smooth variations between supply and demand; to enable economies of long production runs in manufacturing; to provide a buffer between different manufacturing operations; to enable procurement savings through large purchases; to allow cost trade-offs with the transport system; to cover for seasonal fluctuations and peaks; to provide a wide range of different products, from different suppliers, in one location; to cover for planned or breakdown production shutdowns. (Rushton, 2006)

- *Consolidation*. Customers frequently prefer order a number of product lines to just one, and would normally prefer these to be delivered together. The warehouse may perform the function of collecting these together, either from its own inventory holdings or from elsewhere in the supply chain. The benefit of consolidation is to reduce transportation cost by using warehouse capability to group shipments.

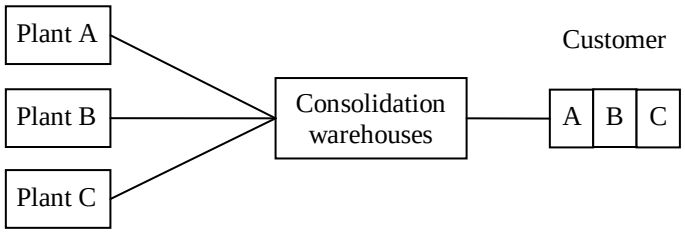


Figure 2. 2 Consolidation role of warehouse (Bowersox, 2007)

- *Break-Bulk.* The economic benefit of this is also to reduce transportation same as consolidation. A break-bulk operation receives a single large shipment and arranges for delivery to multiple destinations.

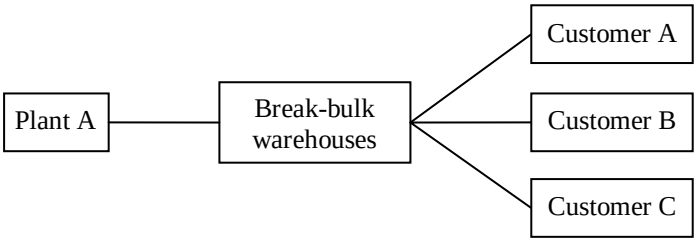


Figure 2. 3 Break-bulk role of warehouse (Bowersox, 2007)

- *Cross-dock.* This is one of assortment role in warehouse, another two are mixing and and assembly. If goods are brought from elsewhere in the supply chain (e.g. directly from manufacturers or from other warehouses) to combines for a specific customer order, then they are likely to be cross-docked. This means that the goods are transferred directly from the incoming to the outgoing, without being placed into storage.

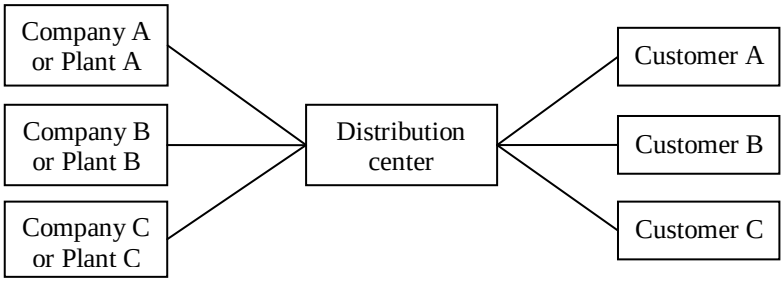


Figure 2. 4 Cross-dock role of warehouse (Bowersox, 2007)

- *Sortation centre or mixing.* This is basically a cross-dock centre, however this term tends to be used for parcel carrier depots, where goods are brought to the warehouse specifically for the purposes of sorting the goods to a specific region or customer. For example, a similar operation occurs in

the case of fashion goods being ‘pushed’ out to stores, whereby goods are brought to a warehouse only for the purpose of sorting into vehicle loads.

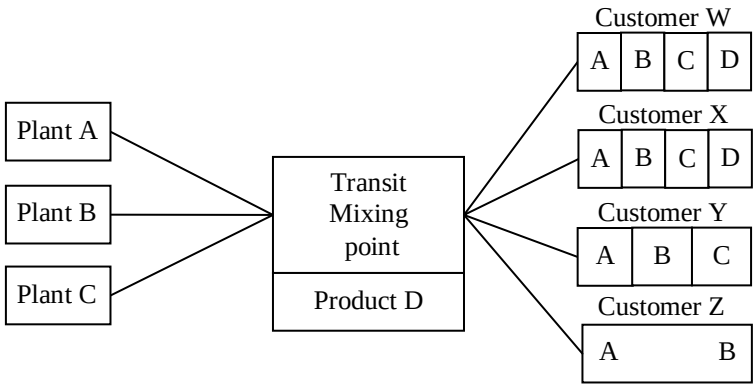


Figure 2. 5 Mixing of warehouse (Bowersox, 2007)

- *Assembly facility*. This is often useful in postponing production as far as possible down the supply chain in order to minimize inventories. The warehouse may thus be used as the final assembly point for the product, involving activities such as kitting, testing, cutting and labeling.

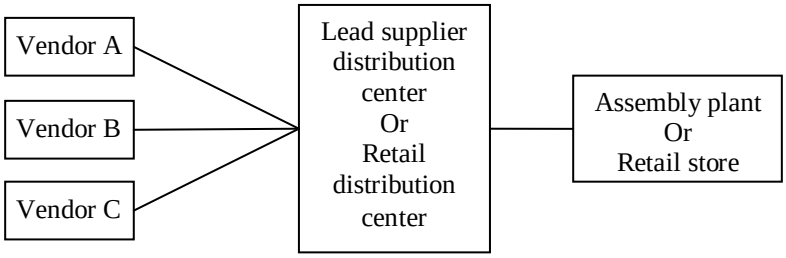


Figure 2. 6 Order assembly role of warehouse (Bowersox, 2007)

- *Trans-shipment point.* These are particularly common to serve outlying regions of a country. In a typical scenario, orders would be picked at a national distribution centre and transported to a ‘stockless’ trans-shipment depot, where the goods are sorted to smaller vehicle loads for immediate delivery to customers. These trans-shipment depots may be small warehouses that are used just for sortation purposes, or this operation may even be performed on a concreted area by using draw-bar trailers carrying swap-bodies that have already been loaded for the local delivery vehicle route. The local vehicles would just pick up each swap-body and deliver directly to the customers.

- *Returned goods centre.* The handling of returned goods is increasingly important. This designed to facilitate the reverse logistic flow of product

that did not sell or to recall for remanufacturing or remarketing or recycling or disposal. This is being driven both by environmental policy (e.g. on pack-aging and on the recovery of materials from electrical/ electronic items) and by the growing use of internet shopping (which tends to be associated with higher percentages of returned goods than in the case of store shopping).

In conclusion, warehouse often performs under the merging of these different roles as the handling steps in the chain should be minimized, and it is important to be clear as to the particular roles being performed.

Objective of the Warehouse

In generally, warehouses have to manage their activities to meet these objectives.

1. The utilized space of warehouse should be maximize
2. The equipment and labor of the warehouse must be effective used.
3. The SKUs in the warehouse must be stored for accessing and controlling easily.
4. The warehouse must be handling all items effectively.
5. Warehouse cost must be minimized.
6. All items in warehouse must be protected in a good condition.

The increasing capability requirement in today warehouse style

The above objectives of warehouse are the general goal points which relate to the role of holding inventory of warehouse as initial base. However warehouse not pay only inventory keeping and also absorb the changing effect of supply chain, the warehouse in today need to improve their capability responding more request from customer and its suppliers.

While Wisner said that "as more firms develop their supply chain management capabilities, more pressure will be placed on warehousing to support JIT operations from the companies and production facilities supplying the warehouse as well as the customers supplied by the warehouse". Some examples of these capabilities include:

- *A commitment to customers and service quality*: Warehouse employees must perform warehouse activities so as to meet the requirements of their inbound and outbound suppliers and customers.

- *Reduced lot sized and shipping quantities*: Inbound and/or outbound shipping quantities are likely to be smaller and more frequent, containing mixed quantities of goods, requiring more handing.
- ***Greater emphasis on crossdocking***: Warehouse employees must receive shipments and mix these quickly into outgoing shipments.
- *Increased automation*: To improve handling speed and reliability, more warehouse activities will become automated.
- *Increased assembly operations*: As more firms implement JIT combined with mass customization, warehouses will be called upon to perform final assembly operations to meet specific customer requirements. This will change the skill requirements of warehouse employees, along with equipment requirements.

(Wisner, 2005)

2.2 Warehouse Operation

As the variety in the classification and role of warehouse in the previous part, warehousing operation should be design to meet the particular requirement of each warehouses or distribution centers. However, there are common operations which every warehouse have to be sharing, the warehousing activities operation aspects of many warehousing academics are different in concept detail as revealing in the warehouse flow chart. Anyways, there are three academic aspects of warehousing operation overview will be reviewed in this part. After the overview of warehouse operation aspect, the detail of common warehousing activity operations will be concluded.

The warehouse operation basic by Coyle is some different to the aspect of warehouse operation by Frazelle. There are in activities flow as the cross-docking adding show in Frazelle's warehouse flow. From the flow chart of Coyle, it can be refer that every flow lines go through the same activities in warehouse while Frazelle's activities chart show the direct flow of cross-docking from receiving to shipping that mean line of cross-docking not pass through storage. For the last aspect, typical warehouse function and material flow in warehouse by Rusnton and Baker is similar to Frazelle aspect in the items flow lines concept, but Rusnton's flow chart show in the line shape and separate cross-docking from common warehouse holding flow while Frazelle's flow chart is U-shape.

I) Basic warehouse operations from Coyle and teams

As from the book "The Management of Business Logistic: A Supply Chain Perspective" by Coyle, The basic warehouse operations are movement and storage.

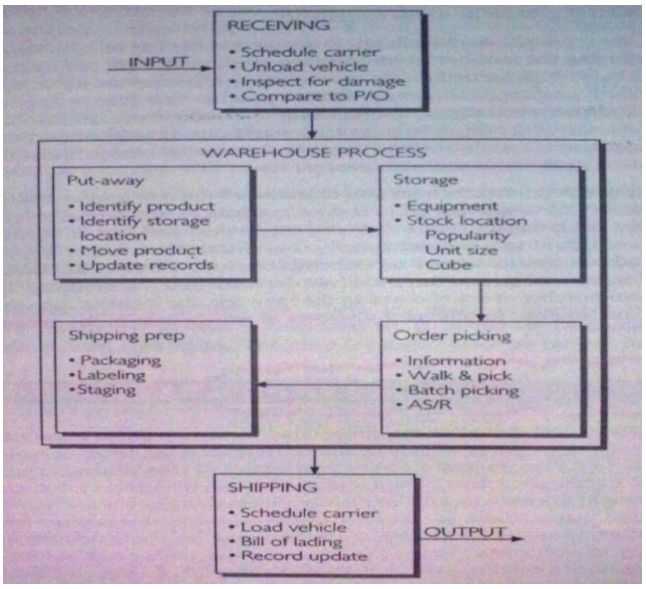


Figure 2. 7 Basic warehouse operations (Coyle, 2003)

receiving At the receiving operation, The goods are physically moved to the receiving dock and inspected for damage.

put-away the put-away operation physically moves the items from the receiving dock to the storage area of the warehouse.

order-picking This process requires warehouse personnel to select from the storage area the items ordered by the customer or manufacturing operation. The order information is given on a pick slip.

shipping After the outbound carrier arrive, the goods are moved from the staging area to the loading dock and into the carrier.

storage The other major warehouse operation is storage.

(Coyle, 2003)

II) Common warehouse operation activities flow of Frazelle

Though warehousing is increasing value in logistics and supply chain management, it is still integrated with and to a large degree dependent on other logistics activities. Frazelle's teams present warehousing as the last of the five

logistics activities because the warehouse is a service to all the other areas of logistics as in three bellowing points.

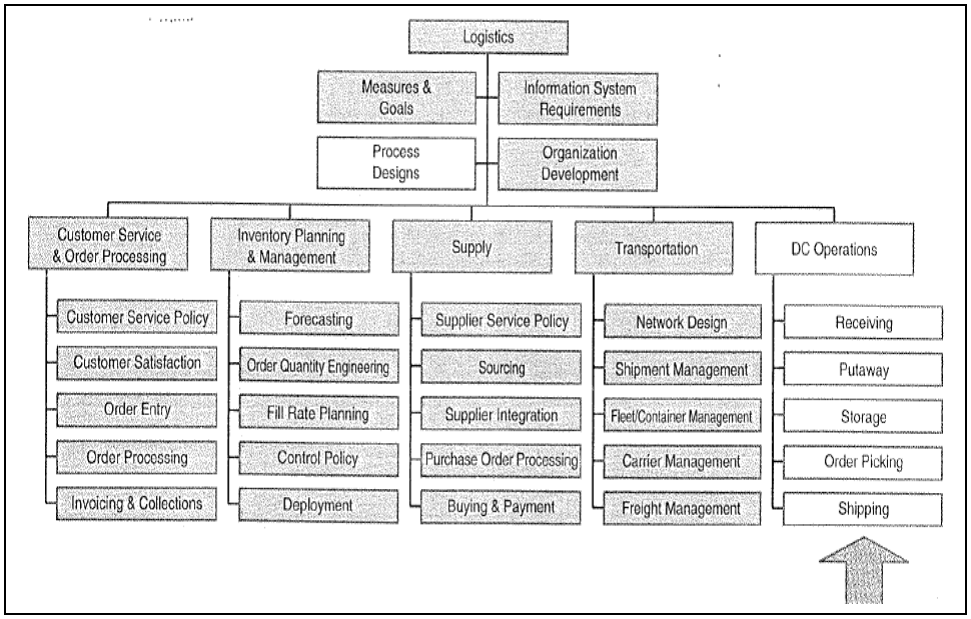


Figure 2. 8 Warehouse in the logistics framework. (Frazelle, 2001)

1. Good planning in the other four areas of logistics may eliminate the need for warehousing.
2. Requirements in the other four areas of logistics may propose that a third-party warehousing firm should be retained to operate the warehouse.
3. The warehouse must be designed to meet all the requirements of the customer service policy, the entire inventory master plan, work to receive in quantities stipulated by the supply master plan, and serve a mission stipulated by the transportation master plan.

The fundamental warehouse operation by Frazelle is indicated on a flow line in figure 2.9 to make it easier to visualize them in actual operation.

The functions may be defined briefly as follow: (Frazelle, 2001)

1. *Receiving* is the collection of activities involved in (a) the orderly receipt of all materials coming into the warehouse, (b) providing the assurance that the quantity and quality of such materials are as ordered, and (c) disbursing materials storage.
2. *Prepackaging* is the performed in a warehouse when products are receive in bulk from a supplier and subsequently packaged singly.

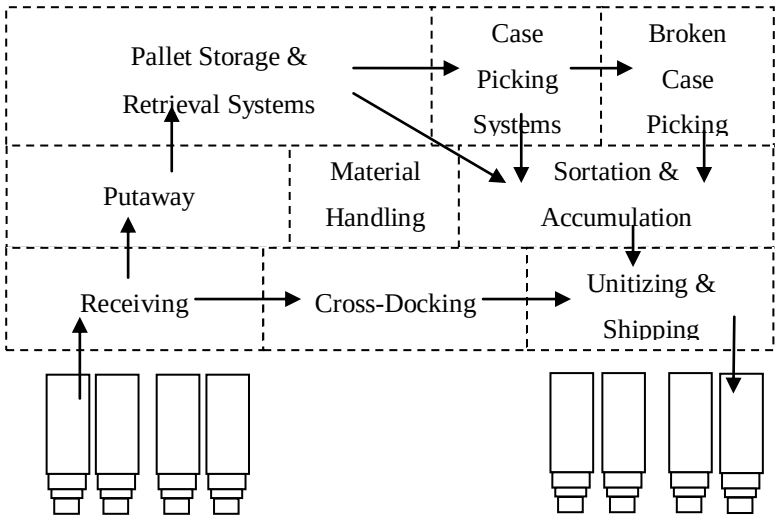


Figure 2. 9 Common warehouse operation activities flow by Frazelle

3. *Putaway* is the act of placing merchandise in storage. It includes material handling, location verification, and product placement.
4. *Storage* is the physical containment of merchandise while it is awaiting a demand. The storage method depends on the size and quantity of the item in inventory and the handling characteristics of the product or its container.
5. *Order picking* is the processes of removing items from storage to meet a specific demand. It is the basic service a warehouse provides for customers and is the function around which most warehouse designs are based.
6. *Packaging* and/or *pricing* may be done as an optional step after the picking process. Waiting until after picking to perform these functions has the advantage of providing more flexibility in the use of on-hand inventory.
7. *Sortation* of batch picks into individual orders and accumulation of distributed picks into orders must be done when an order has more than one item and the accumulation is not done as the picks are made.
8. *Unitizing* and *shipping* may include the following task:
    - Checking orders for completeness
    - Packaging merchandise in appropriate shipping containers
    - Preparing shipping documents, including packing lists, address labels and bills of lading
    - Weighing shipments to determine shipping charges
    - Accumulating orders by outbound carrier

- Loading trucks (in many instances, this is a carrier's responsibility)

(Frazelle, 2001)

III) Material flow in warehouse by Rusnton and Baker

This aspect indicates the principle activities in warehouse operations by separating warehouse function into two types. First is an inventory holding warehouse and second is a cross-dock warehouse functions and material flows.

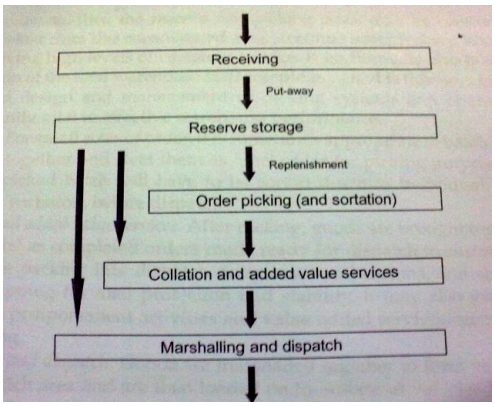


Figure 2. 10 Material flow in a stock-holding warehouse by Rusnton

These functions are as follows:

- *Receiving.* This involves the physical unloading of incoming transport, checking, and recording. From here, the goods are then put away in the warehouse.
- *Reserve storage.* Goods are normally taken to the reserve or back-up storage area, which is the largest space user in many warehouses. This area holds the bulk of warehouse inventory in identifiable locations. When required, the goods are taken from reserve storage either directly to marshalling or to replenish a picking location.
- *Order picking.* Goods are selected from order picking stock in the required quantities and at the required time to meet customer orders. Picking often involves break-bulk operations, when goods are received in, say, whole pallet quantities, but are ordered by customers in less than pallet quantities (e.g. cases or items). If only small quantities of a product are stored in a warehouse, then the reserve and picking stock may be combined, and goods picked from this consolidated area. Accurate order picking is important for achieving high levels of customer service. It traditionally also takes a high

proportion of the total warehouse staff complement and is therefore expensive. The good design and management of picking systems and operations are consequently vital to effective warehouse performance.

- *Sortation.* For small sizes of order, it is sometimes appropriate to batch a number of orders together and treat them as 'one' order for picking purposes. In this case, the picked batch will have to be sorted down to individual orders before dispatch.
- *Collation and added value services.* After picking, goods are brought together and consolidated as completed orders made ready for dispatch to customers. It may also involve final production postponement activities and value added services, such as kitting and labeling.
- *Marshalling and dispatch.* Goods are marshaled together to form vehicle loads in the dispatch area and are then loaded on to outbound vehicles.

The holding of inventory is not the only role of a warehouse since some warehouses perform as cross-dock or trans-shipment points and, in these cases, there is no reserve storage function. A simplified material flow is typical of such warehouses as shown in a bellowing figure.
(Rushton, 2006)

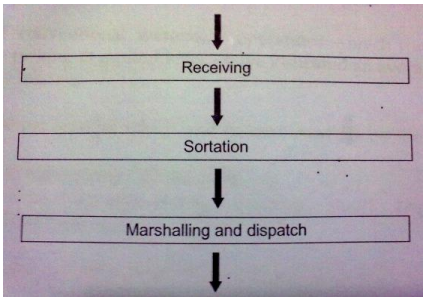


Figure 2. 11 Material flow in a cross-dock warehouse by Rusnton

The main functional areas of a cross-dock operation are as follows:

- *Receiving.* Goods may be received in a condition ready for immediate dispatch to the customer or may require labeling or some other form of activity.
- *Sortation.* The goods then need to be sorted to their destinations.
- *Marshalling and dispatch.* The goods are then marshaled into vehicle or equipments loads and loaded on to them.

(Rushton, 2006)

Receiving

Normally, receiving is the activities about the orderly receipt of all items coming into the warehouse, to ensure that the quantity and quality of them are correct, and the passing of the materials to any appropriate function or storage location.

Receiving is critical to successful warehouse operation, as it is the setup for all the subsequent activities of the warehouse. A key objective in designing the receiving process is to facilitate the goods to be put away to the required location in the warehouse with the minimum handling and minimum delay as possible. If incoming loads are booked in advance, the appropriate resources should be allocated to the activity. The properly merchandise receiving means to be easy operate in put away, storage, picking, or shipping.

The highest warehouse productivity can be infinite, if the denominator goes to zero. In other words, if we could somehow get the warehousing work done without having anyone employed in the warehouse. There are two possibilities. The first is to completely automate the warehouse, but the investment required is nearly infinity as well. Better than completely automating the warehouse is *to completely eliminate the material handling via direct shipping or minimize the material handling via* ***'cross-docking'***. Opportunities for direct shipping include large, bulky items, made-to-order items, and combinations of items for which the regular shipping volume occupies at least a full truckload. The reduction in handling steps that can be achieved by applying advanced receiving and put away practices illustrates in figure 2.2.6. (Frazelle, 2001)

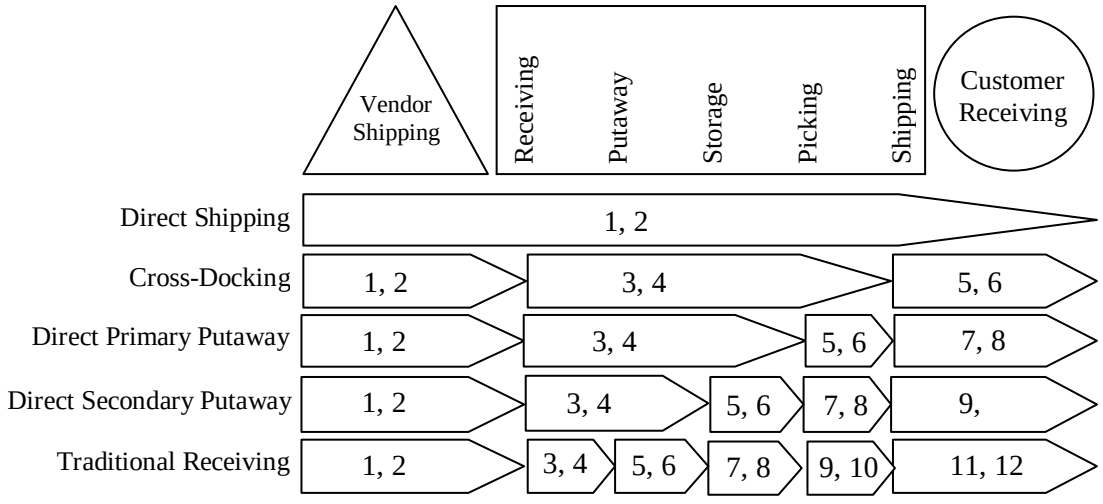


Figure 2. 12 Alternative receiving practices (Frazelle, 2001)

Cross-Docking

Cross-docking is the "direct flow of goods from the receiving process to the shipping process with the least handling and storage between. It is as much information handling as it is material handling." (Schwindt, 1995)

Cross-docking compresses the receive-to-ship time period, as well as reduces handling between receipt and shipment of goods and merchandise. (Bolten, 1997)

Cross-docking is an activity whereby goods are received at a warehouse and dispatched without putting them away into storage. Goods for cross-docking need to arrive by a strict time schedule linked to the vehicle departure times. The outgoing vehicles may be taking a mix of cross-docked goods (e.g. fresh goods) and stocked goods (e.g. long-shelf-life items), and thus a great degree of co-ordination is required to ensure that the operation can occur smoothly. (Rushton, 2006)

The principle of cross-docking

- Loads are scheduled for delivery into the warehouse from vendors
- Inbound materials are sorted immediately into their outbound orders
- Outbound orders are transported immediately to their outbound dock
- Product storage is not required.

In addition to common order flows, backorders, special orders, and transfer orders are good candidates for cross-docking as the sense of processing urgency.

The procedures of good receiving activities

1. Analyzing the documents for planning the receiving
   - Using spotting information to control and schedule the incoming traffic
   - Preplanning the storage position
2. Unloading and clearing bills and unpacking the materials as necessary
3. Identifying and sorting the receiving materials
4. Checking receipts against the packing slips and other documentation
5. Marking records of the unusual actions
6. Disbursing materials to the appropriate location
7. Recording receipts on receiving slip and the receiving activities adequately and accurately

(Tompkins and Smith, 1988)

The principles of receiving

1. Some materials can let the vendor ship to the customer directly. The warehouse will save the time and cost to receive and ship fewer materials.
2. The information of the materials will be pre-received by using IT while the materials are being transported. Time can be reduced.
3. Cross-dock the materials as many as possible.
4. Put-away directly to the reserve locations for the "uncross-dockable".
5. Stage the materials in the storage area.
6. Complete the necessary activities for efficient load and movement at the receiving area.
7. Prepackaging the materials
8. Labeling and tagging the packages
9. Cube and weigh for planning
10. Sort the materials for efficient put-away.
11. Combine put-away and retrieval activities.
12. Balance the use of resources at receiving by scheduling carriers and shifting time consuming receipts to off-peak hours.
13. Minimize walking by flowing the materials past workstations.

(Tompkins, 1996)

Put-away

Put-away is the transportation and placement of the materials in the storage. This operation has to concern a location allocation which relate to storage policy. Two principles for improving efficient in put-away are an inbound assortment and a combination of put-aways and retrievals as much as possible.

Storage

Storage is the activities of the handling, protecting, and storing the materials for a period time.

The objectives of storage planning

1. Utilizing the space effectively.
2. Providing efficient materials handling.
3. Minimizing the storage cost.
4. Providing maximum flexibility.

5. Providing good housekeeping.

(Tompkins, 1996)

The principles of storage

1. Popularity concerning in the storing method for minimizing the travel distance. The more popular materials will be stored in front. While the less popular materials will be stored in back. Travel distances may be minimized by storing popular materials in deep storage area and non-popular materials in shallow storage area.
2. Similarity is the storing method of materials that are received and put away together to be in the same area.
3. "Size" is about the method of storing to fit to the size of the materials.
4. "Characteristics" is the special materials characteristics.
    - Perishable materials, Oddly shaped and crushable materials, Hazardous materials, Security materials and Compatibility
5. "Space utilization"
    - Maximizing the space utilization and minimizing honeycombing by storing the materials at the proper height and depth.
    - Concerning the limitation of space by the truss, sprinkler and ceiling heights, floor loads, posts and columns, and safe stacking heights of material.
    - Concerning the accessibility in the warehouse.

(Nathapong Amarase, 2000)

Space planning and layout

1. Studying the information of the space and the materials.
    - Quantity of materials, Warehouse Policy, Issue Unit, Materials, Transport per time, Type of storage, Material handling method and Material handling equipment capability
2. Planning the storage of any materials groups.
3. Identifying the space for storage.
4. Analyzing the storage planning.
5. Designing the layout by concerning.

- Materials size, Pallet size, Material handling equipment, Aisles for the equipments and employees, Pallets per stock, Location of the receiving and shipping area, Location of the aisles and Space for other services areas

(Nathapong Amarase, 2000)

Order Picking

Order picking is the processes of retrieving the materials from the storage to meet the specific demand from the customers, so order picking is about the removing of the materials with low time and high efficiency. Assortment, which is merged in picking process near to shipping, is done for sorting the batch picks into an individual order and accumulation of distributed picks into orders. The general principle of picking stock items is to minimize traveling time by concentrating its into the smallest feasible area while the general the picking movement items is to maximize the its present in picking by making its brought forward from pre-activities area.

The principles of order picking

1. The followings are the several methods of order picking. By the ways, it may appropriate to combine two or more methods in one picking system.
    i. Pick-to-order or Single order picking is the method that each order picker completes one order at a time. This method is appropriate for the order that typically fill the capacity of the picking trolley or truck.
    ii. Batch picking is the method that each order picker response to retrieving a batch of orders during a picking tour. So the travel time per line item is reduced but the time to sort and the potential for picking errors increases. This case is about the uneconomic to pick only one of small order.
    iii. Zone picking is the method that each order picker is assigned to pick the materials in the assigned zone. The travel time can be saved by this method but the costs of sorting and errors will be high.
    iv. Pick-by-line or pick-to-zero. In this case, the exact numbers of cases or items are presented for picking. For example, they may

be brought forward from the storage area or specifically order from cross-docking.

2. Encourage and design the customer orders for full pallet load will help the works of picking and counting easier.
3. Concern the storage location to the picker for increasing the picking productivity and accuracy.
4. Planning work to eliminate waiting or other waste time.
5. Eliminate and combine the order picking activities as much as possible. The activities are traveling, extracting, reaching, bending, documenting, sorting, packing, and searching. Eliminate the activities by:
    - Bringing the pick location to the picker can eliminate the traveling activity.
    - Using automate information flow can eliminate the documenting activity.
    - Presenting the materials at waist level can eliminate the reaching activity.
    - Assigning one picker per order and one order per tour can eliminate the sorting activity.
    - Bringing the pick location to the picker or taking the picker to the pick location can eliminate and searching activity.
    - Using automated dispensing can eliminate extracting activity.
    - Weigh counting or prepackaging in issue increments can eliminate counting activity.

    Combine the activities by

    - Stock-to-operator (STO) systems are used for combining traveling and extracting together. The systems are designed to keep order pickers extracting while the mechanical device travels around the storage location.
    - Traveling and documenting can be combined by the order picker is free to document picking transactions, sort materials, or pack materials while the storage/retrieval machine is traveling around the storage location.

- The order picker can combine picking and sorting together if he/she completes more than one order.
- Picking, sorting, and packing can be combined when the ordered materials are small. So the order picker can pack while picking.

6. Increasing the orders per tour can reduce the travel distance and time.
7. Establish the forward and reserve picking areas.
    - Determine the items to store in the forward picking area. The items should be the entire slow-moving items and some fast moving items.
    - Determine the quantities of each item to store in the forward picking area.
    - Plan the size for the storage in the forward picking area.
    - Identify the alternative storage methods.
    - Determine the operation methods within each storage alternative.
    - Estimate the costs and savings for each alternative system.
8. Balance workloads across the various picking workers.
9. Balance picking activity across picking locations to reduce congestion.
10. Assign items that are likely to be requested together to the same or nearby locations.
11. Sequence picks location to reduce travel time.
12. Organize the picking documents to minimize search time and errors.
13. Design picking vehicles to minimize sorting time and errors and to enhance the pickers' comfort.
14. Eliminate paperwork from the order picking activity.

Packing and Shipping

Packing and shipping is the activity of checking orders for completeness, weight checking, packing in the appropriate shipping container, preparing shipping documents, weighing orders, accumulating orders, loading trucks and dock management.

The principles of shipping

1. Select cost and space effective handling units.

- For loose cases, select the wood, plastic, metal, and nestable pallets. For loose items. Select totes and cardboard containers.

2. Minimize product damage.
    - Unitize and secure loose items in cartons or totes by using foam, peanuts, popcorn, bubble wrap, newsprint, and air packs.
    - Unitize and secure loose cases on pallets by using stretch wrapping, Velcro belts, and adhesive tacking.
3. Eliminate shipping staging, and direct-load outbound trailers.
4. Use storage racks to minimize floor space requirements for shipping staging.
5. Route on-site drivers though the site with minimum paperwork and time.
6. Considering factors of shipping
    - Shipping materials characteristics, volume, and weight; Number of shipping position; Shipping type; Arriving day and Documents

(Nathapong Amarase, 2000)

2.3 Warehouse Design

This study is about warehouse improvement which relating to some topic of warehouse design. So that, the warehouse design concept will be briefly described.

The design of a warehouse and handling system involves a number of stages, starting with the definition of system requirements and constraints, then data acquirement, planning base formulation, operation principle setting, data evaluation and analysis, warehouse design drawing & calculating and lastly finishing with an evaluated preferred design

The accuracy and completeness of the data on which any design is based will affect how well the final design meets the specified requirements. The data required for warehouse design include: product, order characteristics, goods arrival and dispatch patterns, warehouse operations and site, external area requirements and building detail. A useful way to present the data is as a warehouse flow diagram. The flow are presented by the arrows, and should be given in the most useful units for the operation under consider. (Rushton, 2006)

Warehouse activity profiling

Warehouse activity profiling is the systematic investigation of item and order activity. The activity profiling process is recommended to identify major opportunities for process improvements by quickly point to root causes of material and information flow problems. "A Picture is worth 1,000 words: We are aiming for the same effect in warehouse activity profiling as we paint a picture of what is going on inside the warehouse. In profiling, we are typing to capture the activity of the warehouse in pictorial form so we can present the information to management and so we can make quick consensus decisions as a team" said by Frazelle. He also said that one warning before begin to profile warehouse is to be careful to draw the line and say, that is enough.

This profile set is presented as an example of the set of profiles should have to effectively plan and manage warehouse operations. The profile set stems directly from the seven key planning and design issues in warehousing. (Frazelle, 2001)

Table 2. 1 Warehouse design issues and related profiles (Frazelle, 2001)

Planning and Design Issue	Key Questions	Required Profile	Profile Components
1. Order picking and shipping process design	• Order batch size • Pick wave planning • Picking tour construction • Shipping mode disposition	Customer order profile	• Order mix distributions • Lines per order distribution • Lines and cube per order distribution
2. Receiving and putaway process design	• Receiving mode disposition • Putaway batch sizing • Putaway tour construction	Purchase order profile	• Order mix distributions • Lines per receipt distribution • Lines and cube per receipt distribution
3. Slotting	• Zone definition • Storage mode selection and sizing • Pick face sizing • Item location assignment	Item activity profile	• Popularity profile • Cube-movement/volume profile • Popularity-volume profile • Order completion profile • Demand correlation profile • Demand variable profile
4. Material transport systems engineering	• Material handling systems selection and sizing	Calendar-clock profile	• Seasonality profile • Daily activity profile
5. Warehouse layout ad material flow	• Overall warehouse flow design: U, S, I,	Activity relationship	• Activity relationship distribution

Planning and Design Issue	Key Questions	Required Profile	Profile Components
design	or L flow • Relative functional locations • Building configuration	profile	
6. Warehouse sizing	• Overall warehouse space requirements	Inventory profile	• Item family inventory distribution • Handling unit inventory distribution
7. Level of automation and staffing	• Staffing requirements • Capital-labor substitution • Level of mechanization	Automation profile	• Economic factors distribution

Customer Order Profiling

In general, the management of material and information flow through a warehouse should facilitate excellent customer service. As customers really want their order fulfilled the, the first thing must be clearly understand in the planning and design of warehouse operations is the profile of customer orders. The customer order profile includes order mix distributions, lines per order distribution, cube per order distribution and lines & cube per order distribution

Seasonality Distribution

The seasonality distribution indicates the peaks and valleys in inventory levels as well as receiving, shipping, and returns activity. The storage systems require to be sized to accommodate near-peak inventory levels, and also material handling systems require to be sized to accommodate near-peak activity levels so it is critical to spot peak inventory and activity levels. (Frazelle, 2001)

2.4 Warehouse Layout

The warehouse layout should be related to the warehousing flow. There are two main relating aspects of theory which are a warehouse layout topic from the book “Work System and the Methods, Measurement and Management of Work” and a material flow planning topic from the book “World-Class Warehousing and Material Handling”. These two concepts which are used for foundation in this study will be provided next.

Warehouse Layouts Planning

In the book "Work System and the Methods, Measurement and Management of Work" of Groover, the warehouse layout designs are divided to two types which are centralized and decentralized of receiving and shipping. These two warehouse layouts are similar to U-shape and straight-thru in Frazelle's material flow planning concept which is shown nextly.

As Groover said in the book, the layout of a warehouse must be planned for the principle function of a warehouse. The four main warehouse functions are (1) receiving, (2) storing, (3) order picking, and (4) shipping. In addition of the four functions, the facility may also be requires to perform additional services, such as preparing special labeling and packaging to satisfy particular customer requirements.

One of the important decisions in warehouse layout design is where to locate the receiving and shipping functions. The obvious answer is that they must be located against an exterior wall of the building, and access must be provided to the transportation infrastructure. But should the two functions be combined at one location or separated? The figure 2.13 illustrates the two alternatives. The advantages of centralizing receiving and shipping at one location include (1) sharing of personnel and material-handling equipment; (2) sharing of docks and docking space; and (3) facilitating ***cross-docking***. The incoming materials from suppliers are shipped to customers without the steps of storing and order picking.

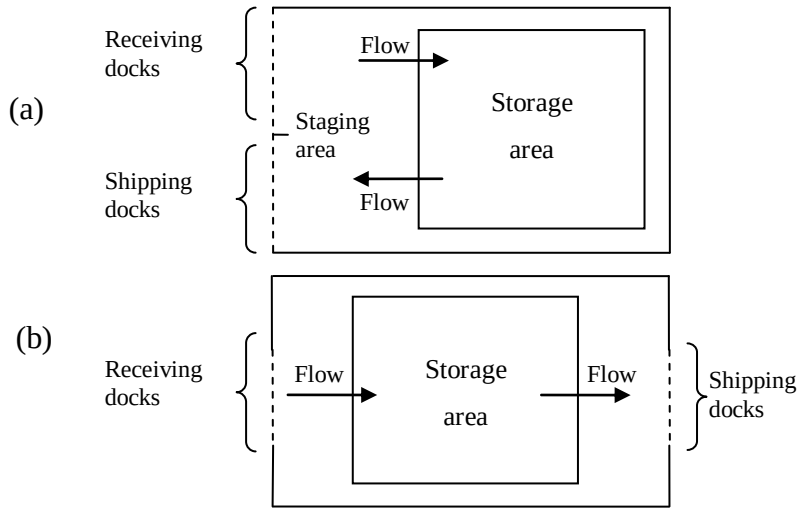


Figure 2. 13 Warehouse layout: (a) centralized receiving and shipping and (b) decentralized receiving and shipping to achieve a flow-through in the storage facility. (Groover, 2007)

The advantages of separating or decentralizing the two functions of receiving and shipping include the following: (1) reduced congestion in the dock areas, (2) reduced risk of confusion incoming loads with outgoing materials, (3) the layout can be designed to provide a flow-through of materials, from receiving to storage to shipping, as indicated in figure 2.13 (Groover, 2007)

Warehouse Material Flow Planning

In the book "World-Class Warehousing and Material Handling", the material flow planning specifies to four types which are U-shape, straight-thru, modular-spine, or multistory flow pattern. (Frazelle, 2001)

1. **U-Shaped Flow**

In the classic case, products flow in at receiving, move into storage in the back of the warehouse, and then to shipping, which is located adjacent to receiving on the same side of the building.

A U-shape flow design has a number of advantages over other flow designs including

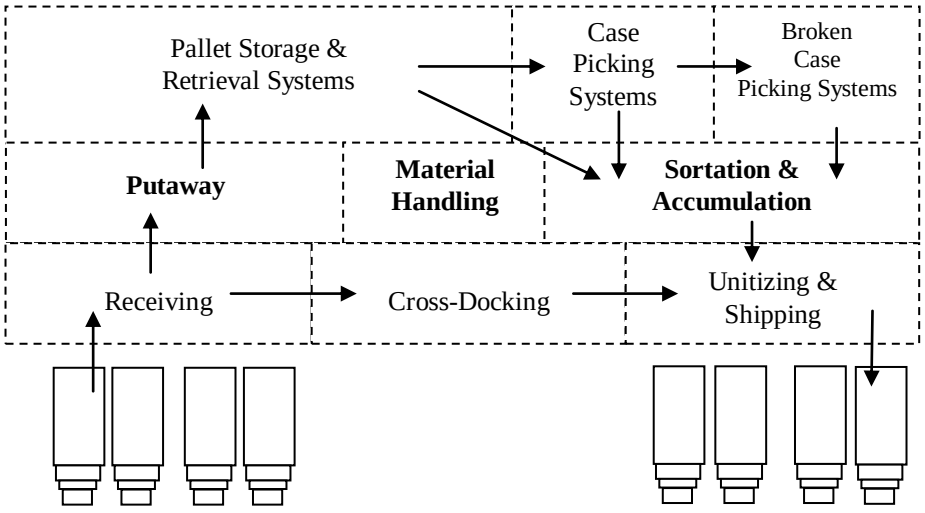


Figure 2. 14 Typical U-shaped flow pattern. (Frazelle, 2001)

- Excellent utilization of dock resources (dock doors, dock equipment, dock space, dock operators, and doc supervisors) because the receiving and shipping processes can share dock doors
- Facilitating cross-docking because the receiving and shipping docks are adjacent to one another and may be co-mingled

- Excellent lift truck utilization because putaway and retrieval trips are easily combined and because the storage locations closest to the receiving and shipping docks are natural locations to house fast moving items
- Enables expansion opportunities in three directions
- Yields excellent security because there is a single side of the building used for entry and exit

With these inherent advantages, the U-shape flow design is the benchmark upon which all other flow designs should be compared.
(Frazelle, 2001)

2. Straight-Thru Flow

Example straight-thru flow designs are illustrated in Figure bellow. The straight-thru configuration lends itself to operations that are pure cross-docking facilities (sometimes referred to as flow-through facilities) or operations in which the peak receiving and shipping times coincide. The major disadvantage is that the design makes it difficult to take advantage of ABC storage and dual command trips.

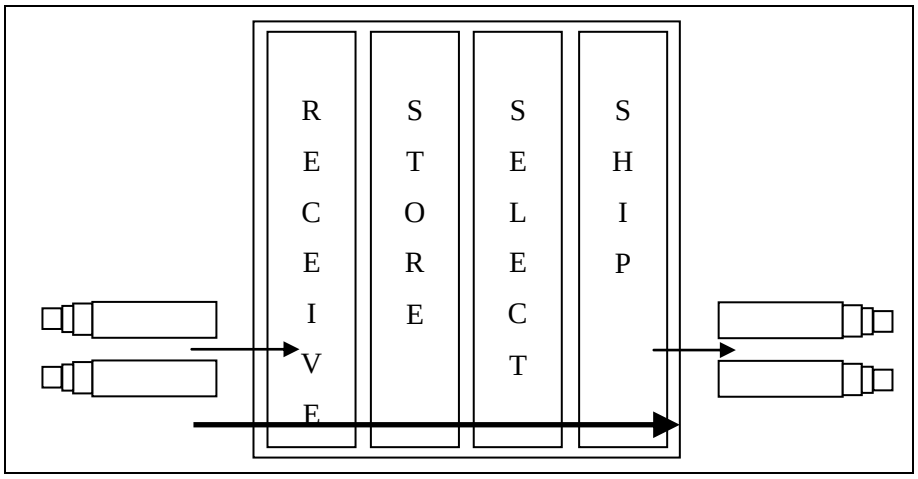


Figure 2. 15 Straight-thru flow design *Source*: Bruce A. Strahan

(Frazelle, 2001)

3. Modular-Spine Design

Modular flow design is well suited for large-scale operations in which individual processes are so large they merit stand-alone and uniquely designed buildings.

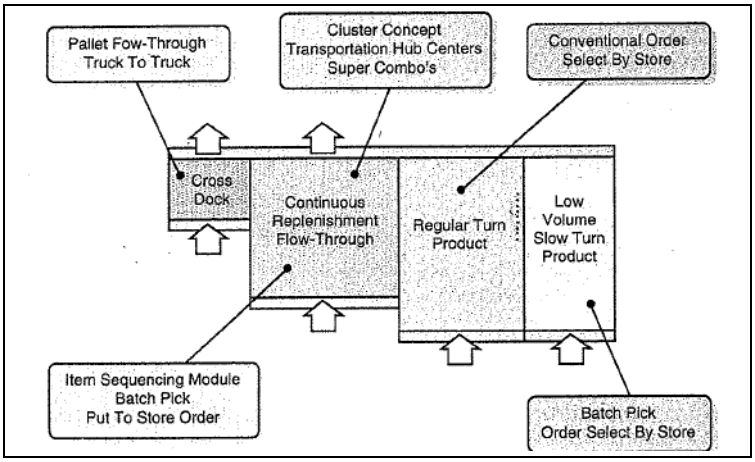


Figure 2. 16 An example of modular flow design (Frazelle, 2001)

4. Multistory Layouts

Multistory distribution buildings are necessary when land is extremely scarce. They are the least desirable of the flow path alternatives because of the material handling difficulties and bottlenecks encountered in moving merchandise between floors. (Frazelle, 2001)

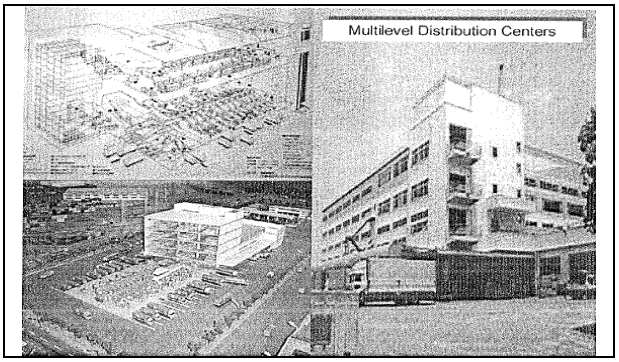


Figure 2. 17 Multistory warehouse designs (Frazelle, 2001)

2.5 Warehouse Measurement

2.5.1 The Concept of Warehouse Performance Measurement

The warehouse is accountable to the same competitive indicators the business held to. Businesses complete on the basis of financial, productivity, quality, and cycle time performance. (Frazelle, 2001)

I) Warehouse Financial Performance

This is about warehouse activity-based costs which become the basis for comparing warehousing service. This relate to the decision of warehouse strategy in third party.

II) Warehouse Productivity Performance

The most popular and traditional warehouse performance measure is productivity. The formal definition of productivity is the ratio of the output of a resource to the inputs required to achieve that output. The recommend is to monitor the productivity and utilization of the key assets in the warehouse – labor, space, material handling systems, and warehouse management systems. Edward' teams typically measure overall labor productivity. Used in isolation, labor productivity can be a very misleading indicator. For example, an operation may have a very high labor productivity achieved via inappropriately high investments in material and information handling systems.

Storage density, the ratio of the amount of inventory storage capacity to the square footage in the warehouse, is recommended productivity indicator for floor space. It is normally expressed as the value, cube, pieces, or positions of inventory that can be accommodated per square foot. Unlike productivity and accuracy, where the objective is clearly to maximize the indicator, the storage density should be within a world-class range. Storage density that is too high may indicate overcrowded conditions and storage density that is too low may indicate underutilized facilities.

III) Warehouse Quality Performance

There are four key quality indicators for warehouse performance – two for inbound handling and two for outbound handling:

- *Put away accuracy* The percent of items put away correctly
- *Inventory accuracy* The percent of warehouse locations without inventory discrepancies
- *Picking accuracy* The percent of order lines picked without errors
- *Shipping accuracy* The percent of order lines shipped without errors

IV) Warehouse Cycle Time Performance

The warehouse track performance recommend in two key areas:

- *Dock-to-Stock Time (DTS)* The elapsed time from when a receipt arrives on the warehouse premises until it is ready for picking or shipping
- *Warehouse Order Cycle Time (WOCT)* The elapsed time from when an order is released to the warehouse floor until it is picked, packed, and ready for shipping

(Frazelle, 2001)

The standard of warehouse performance means to deliver the right product; the right quantity and the right package at the right time and the right price with the right quality to customer and it also need to define what the right is. The elements of warehouse performance standard are clearly identified, achievable, measurable, productivity and consistent. (Bolten, 1997)

The admired measurement of warehouse performance

1. Space utilization: compare reserving area, rental area to using area
2. Order fulfillment: total number of order, variance, completed order and uncompleted order
3. Inventory accuracy: the number recording with the exceeding or lacking
4. Total Throughput: the storage pallet, box and weight
5. Transportation: the number of loading, cost of one line loading out, on time and late picking
6. Loss and damage: loss from storage, moving and delivery

2.5.2 The Measurement Calculation of Outbound Warehousing

From the book “Inventory best practices” of Steven M. Bragg, there are two involving measure index of picking which is the main process of outbound warehousing. (M.Bragg., 2004)

i. Average Picking Time

The measurement of average picking time is a good way to see the order picking speed so, though one must be aware of its shortcomings. To measure the average picking time at the most detailed level, one can subtract the time at which an order was complete from the time when a picker received the order. Since this approach to the measurement clearly involves a massive amount of nonvalue-added timekeeping, one can do it only if wireless, real-time terminals are being used, so the computer system automatically tracks order duration. In the absence of such a system, the best approach is to divide

the total number of orders completed during the measurement period by the total person-hours of picking time during period. The calculation is:

$$\text{Average picking time} = \frac{\text{Total number of orders completed}}{\text{(Total person-hours worked by picking staff} + \text{Total person-hours worked by contract staff)}}$$

Though this measure gives a good summary-level view of picking efficiency, it can be misinterpreted. The main issue is variations in the size of orders picked; if a larger proportion of single-line orders are processed in one month than in the next, then efficiency levels will appear to have declined, because orders are easier to fill when they contain only a single line. If the measurement appears to be skewed by this issue, it may be possible to have the computer system summarize the total number of order lines picked during the period, and use this figure in the numerator of the measurement; this approach is usually too labor-intensive to attempt manually.

ii. Picking Accuracy for Assembled Products

A significant customer relations problem, as well as added costs to locate and ship missing part to customers, is reason that the picking accuracy of assembled products is considered very important for company.

To calculate this measurement, conduct an audit of a sample of completed kits, counting as an error every kit where the quantity of parts is incorrect, as well as an error for every kit where the quantity of parts is correct, but the types of parts included are incorrect. Once a kit is considered incorrect for either reason, it cannot be counted as an error again (thereby avoiding double counting). Then divide the total number of errors by the total number of product kits sampled. Finally, subtract the resulting percentage from 100 percent. The formula is:

$$\text{Picking accuracy for assembled products} = 100\ \% - \frac{\text{Number of quantity errors} + \text{Number of part errors}}{\text{Total number of product kits sampled}}$$

(M.Bragg., 2004)

2.6 Problem Analysis Tools

Problem Solving for Continuous Improvement

Problem solving is fundamental to any serious investigation of improvement opportunities. There are several problem-solving models. A graphic portrayal of Robert K. Wysocki, which is the problem-solving model applied in this case, consist of the seven steps outlined in the bellowing figure. (Wysocki, 2004)

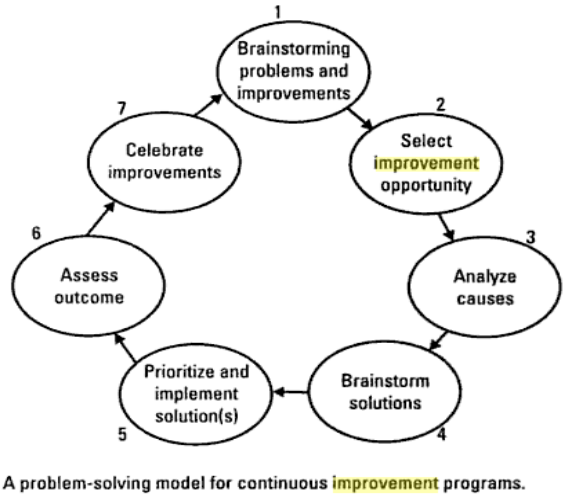


Figure 2. 18 A problem-solving model for continuous improvement programs. (Wysocki, 2004)

Brainstorming

This is a short description for this tool. A session begins with the facilitator stating the reason for the session. Often it will be a problem that needs a solution. The facilitator invites the attendees to offer any thoughts, ideas, or suggestions that may be relevant to the solution. The only discussion that is allowed is for clarification of some point that was raised. It is often that one ideal lead to another and another and before you realize it you are converging on a solution. When no new ideas are forthcoming the session is ended.

The Cause and Effect Analysis

A cause-and-effect analysis is about the device for generating the possible causes of the identified problem. There are so many devices relating to this process topic. The different patterns of this analysis can categorize follow the ideal shaping design. In this study founding, the three main widely using patterns are the fishbone

diagram or Ishikawa diagram and the hierarchy diagram or chain of causes or tree diagram and lastly the relation diagram which example is the balance scorecard chart.

Fishbone Diagrams

The fishbone diagram, also known as cause and effect diagrams and Ishikawa Chart, is a graphical representation of the possible cause of an outcome or effect. The box at the right end describes the effect or outcome that is being targeted. The ellipses identify the major categories within which the causes are to be defined. The categories for this diagram very widely depending on the relevant to the topic detail. Some examples are a "what, how, when, where" and a "man, methods, machine, material, measurement". Along the line leading from a major category to the horizontal arrow are listed all of those specific cause within the cause category that might be contributing to the effect. (Wysocki, 2004)

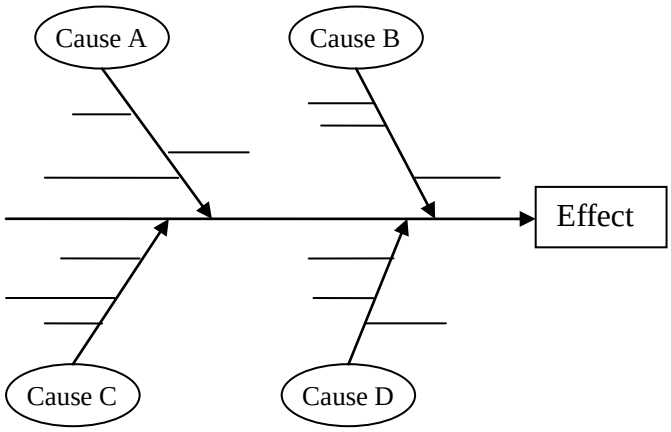


Figure 2. 19 The structure of the fishbone diagram (Wysocki, 2004)

Relation Diagram

This device is similar to cause and effect diagram in concept which is to divide the problem to be a small part and find the relationship of each causes and effects. The significant different point of this tool from the cause and effect tool, which is the special point, is an ability to link all units in all direction. This is usually used with brainstorming then the matrix diagram or tree diagram and also using with other problem analysis tools. (Wannarat chantakij, 2003)

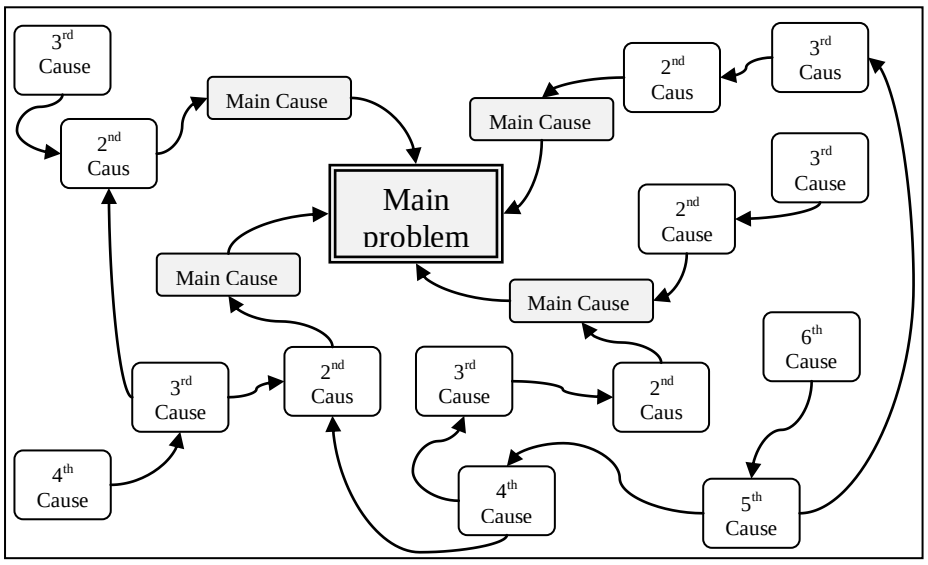


Figure 2. 20 The relation diagram (Wannarat chantakij, 2003)

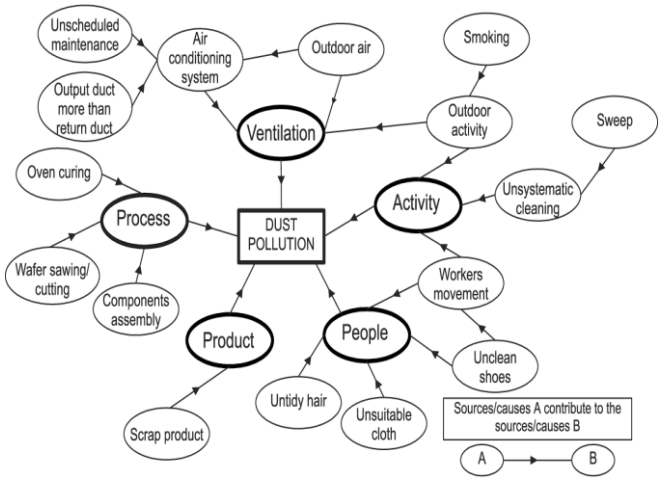


Figure 2. 21 The example of relation diagram (Ahmad, 2006)

Tree Diagram

Tree Diagram is developed from the same concept of Family Tree and Organization Chart. It is an analysis tool for breaking down the main goal point into many levels of increasing detail stated points. It displays the chain of causes by starting with the main problem statement in the top of tree then following by the branches layers of causes in the down level. The starting problem for root cause analysis is usually an undesirable situation exists. The next several levels of branches are coming from "why" or "How" questions. There may be more than one question per reason and more than one answer per questions

The tree diagrams for problem solving are two main types. First is the Why-Why analysis which is used to define the root cause of the problem. Second is the How-How analysis which is used to define the solution of the problem.

Five Whys Analysis

Five whys analysis is known as the why-why chart and root cause analysis. As these names imply, the purpose is to find the true root cause of a problem. The technique can very well be used in connection with a cause-and-effect analysis to analyze each identified cause to ensure that it really is the root cause of the problem and not only a symptom of another and more deeply rooted cause. The analysis can be conducted in different ways. (Andersen, 2007)

The procedure for conducting the five whys analysis :

1. Determine the starting point, either a problem or a high-level cause that should be further analyzed.
2. Use brainstorming to find causes at the level below the starting point.
3. For each identified cause, pose the question, why is this a cause for the original problem?
4. For each new answer to the question, ask the question again and again until no new answers results. This will probably be one of the root causes of the problem. As a rule of thumb, this often requires five rounds of the question why.

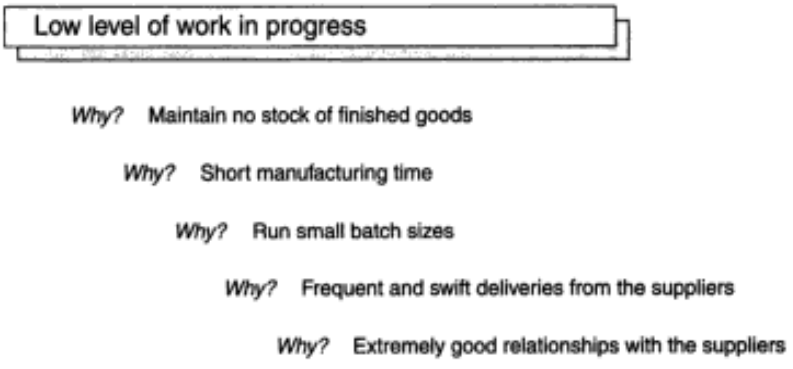


Figure 2. 22 List representative of five why (Andersen, 2007)

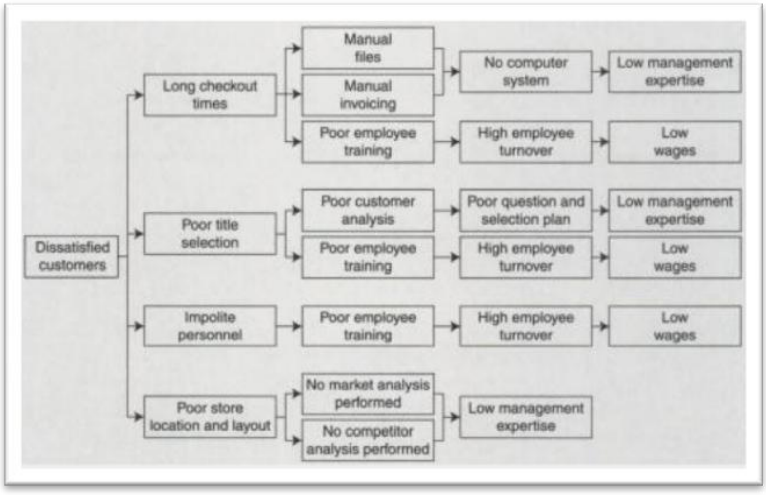


Figure 2. 23 Example of five whys analysis chart (Andersen, 2007)

How-How diagram

How-How diagram is a technique to creatively explore and consider numerous solution alternatives instead of jumping to the obvious solution. It helps hence formulate a specific solution action plan. (Spenley, 1995)

The procedure for conducting the How-How analysis :

- Begin with a solution statement and explore possible ways of accomplishing the action at each stage by asking "how?"
- At each stage of the chain a convergent process can be used to narrow the list of alternatives before the next divergent step is taken.
- Advantages and disadvantages change of success, and relative cost of each alternative can be established to get a more objective selection process.

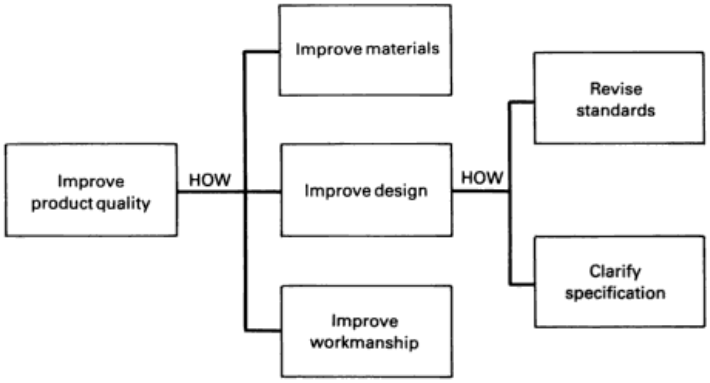


Figure 2. 24 Example of How-How diagram (Spenley, 1995)

Process Mapping

A variety of flowchart symbols represent different activities, but the most common symbols are described below. (Wysocki, 2004)

Box

The box represents an activity. Within the box are verbs and nouns. Activity boxes have an activity described within. This is the most commonly used flowchart symbol.

Figure 2. 25 Activity boxes (Wysocki, 2004)

Diamond

The diamond represents a review, inspection, or decision. Inside the diamond are questions. For review or inspections, common question are, "Does it pass?" or "Is it OK?" Likewise for these two situations, the number of routes out of the diamond is two: It either passed, or it didn't. It was OK, or it wasn't. However, in the case of a decision, the number of paths the flow can take might be greater than two. For instance, the question might have several answers.

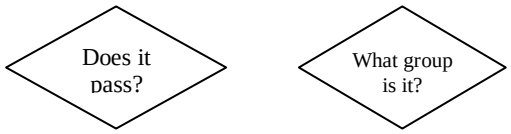


Figure 2. 26 Activity diamond (Wysocki, 2004)

Arrow

The arrow indicates the direction of the flow. It also can represent transport.

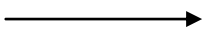


Figure 2. 27 Activity arrow (Wysocki, 2004)

The big D

The "Big D" represents a delay. batching, bottlenecks, equipment break-downs, and waiting for information are example of delays..

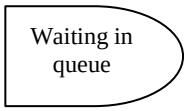


Figure 2. 28 Activity big D (Wysocki, 2004)

2.7 Literature Review

To design Warehouse layout in order for supporting operation needs many requirements. The warehouse design framework of Mohsen was presented by including several factors and design decision. It attempts to develop a layout that has several characteristic such as modularity, adaptability, compactness, accessibility, flexibility, and distribution of movement to enable it to respond to changing conditions, improve space utilization, and reduce congestion and movement.

The ordered steps of the framework are listed below:

Specific the type and purpose of the warehouse/ Forecasting and analysis/ Establishing operating policies/ Determining inventory levels/ Class formation/ Departmentalization and the general layout/ Storage partition/ Design of material handling, storage and sorting systems/ Design of aisles/ Determining space requirements/ Determining the number and location of OI points/ Determining the number and location of dock/ Arrangement of storage / Zone formation. ***(Mohsen M.D. Hassan, 2002)***

There are many research in warehousing design such as automotive manufacturing case by ***Kanokkarn Khanthong (2006)***, which separate warehouse into 3 zone by part characteristic and operation then the result shows 54.22% improvement of operation and information flow, a plastic resins trading company case conducted by ***Nathapong Amarase (2001)*** which give the example of detail in operation procedure of warehouse such as the sequence in order-picking customer and the relating of product characteristic to the warehouse design, and a finish good warehouse in a transformer factory case by ***Panika Chaitamart (2000)***. The storage layout, location assignment system and work procedure in warehouse system was redesign and the result picking time is 43% reduction.

An extensive review on warehouse operation planning problems is presented in the research of ***Jinxiang Gu and Marc Goetschalckx and Leon F. McGinnis (2007)***. The purpose of the study is to provide a bridge between academic researchers and warehouse practitioners. The problems are classified according to the basic warehouse functions, i.e., receiving, storage, order picking, and shipping. The summary of literature in each category emphasis on the characteristics of various decision support models and solution algorithms.

The important function of picking process in design a warehouse was said in so many researches such as ***Mihaela Stet (2008)*** and ***Rene de Koster and other (2006)*****.** Rene de Koster and other also said that the cost of order picking is estimate to be as much as 55% of the total warehouse operating expense and any underperformance in order picking can lead to unsatisfactory service and high operational cost and consequently for the whole supply chain.

Charles G. Petersen research focuses in the picking process. In 2002, he examine the configuration or shape of these picking zones by simulating a bin-shelving warehouse to measure picker travel where SKUs are assigned storage locations either using random or volume-based storage. The result shows that the size or storage capacity of the zone, the number of items on the pick list, and the storage policy has a significant effect on picking zone configuration. In 2004, He and his friend study by comparing the performance implications of Class-based storage (CBS) to both random and volume-based storage (VBS) for a manual order picking warehouse. In addition, the study also considers the effect of the number of storage classes, the partition of storage classes, and the storage implementation strategy applied in the warehouse. The simulation results show that CBS provides savings in picker travel over random storage and offers performance that approaches VBS.

The significant relating of picking and storage process to efficiency in warehouse operation also found in ***Pongpat Phetruangrueng (1997)*** which suggests increasing the efficient usage of warehouse by allocating storage area and confining the area of warehousing operations corresponding the product attribution and product quantity.

The research about cross-docking activity conducted by ***Udomtasanee Intarachote (2001)*** is “warehouse management system design in the cross-docking activity”. This research develop the cross-docking system design for processing the customer orders, planning inventory requirements, issuing the purchase orders, receiving and transferring the receipts of purchased over materials in stores. By the way, the just-in-time concept was applied in this thesis in the first time. The research of ***Wooyeon Yu and Pius J. Egbelu (2006)*** purpose to find the best truck docking or scheduling sequence for both inbound and out bound trucks to minimize total operation time when a temporary storage buffer to hold items temporarily is located at the shipping dock. The objective of this research comes from one objective of cross-

docking system which is how well the trucks can be scheduled at the dock and how the items in inbound trucks can be allocated to the outbound trucks to optimize on some measure of system performance.

The simulation in the warehouse research was conduct by many people. ***Franco Caron and other (2000),*** present a simulation approach to efficient layout design of the picking area in picker-to-part systems using random or cube per order index (COI)-based storage policies. ***Burin Tungpaisan (2001)*** was developing the simulation model for distribution management in warehouse by research and study warehousing procedure in the customer service support aspect. The simulation model is developed in "Extend" program by separate program into 4 parts; customers get in, full pallet arranging, un-full pallet arranging and loading. The result of the research shows that the simulation can show the real activities picture in warehouse and supporting the analysis and evaluation for developing new warehouse system.

There also many interesting warehouse researches and studies covering more process relating to warehouse system than in this literature review which focus on picking process, zone warehousing and cross-docking.

Chapter III
BACKGROUND OF THE CASE STUDY

Chapter three is the beginning content which provides the necessary background and the introduction of current situation to have more understanding in the analysis of existing warehouse and problems in the next chapter. It will describe the information about the business and warehouse of ABC Company. Firstly, it begins with the company's background and overall business process. As this study is about warehousing process, warehouse activities and relating details are also described. Lastly, it also introduces the problem by describing the limited factors and the preliminary warehousing observation which is about the difficulty in warehousing process and the problem situation.

3.1 Background of ABC Company

ABC Company does the business in Food & Beverages industry as a manufacturer. Their two main products are juices and jams. The company is also subcontracting this same product lines for other companies. The total numbers of employees are 250 people.

Product

The most significant product group is the juice and other beverage under company's brand in which this research is focusing. The fruit juice product is separated by standard packaging into three main features which are UHT package (200ml and 1000ml), can (240/230/250ml and 315ml) and bottle (200ml and 700ml). Each packaging feature also has more than 20 varieties category due to the fruits flavor and their concentration. The product life is 1 year for UHT and bottle while 2 years for can package.

Figure 3. 1 Example of products group

The total juice product volumes are about 30 million liters a year for UHT and 15 million liters a year for Can.

The Market and Its Customers

The company product was sold through both domestic and international. The juice product of ABC Company was sold widely though more than 300 shops in Thailand and also exported to other countries as shown in figure below.

Figure 3. 2 Exporting customers

In summary, the product range is very high variety as the difference in flavors, packages, and sizes to fulfill the customer preference which is also very high variety as the broadly global market. It is one of factors causing a complexity in warehousing process which needs to perform for the diversity of requisition.

3.2 Overview of Business Process of ABC Company

For the manufacturing activities unit, the characteristic of overall process is ‘Make-to-Order’ because the product is already stocked at the company’s partners (downstream before ending customer) so the production is started after acquiring the order instruction (OI) from the direct customers of company. The business strategy is similar to JIT (just-in-time) by using demand forecast, production plan and material requirement planning tools.

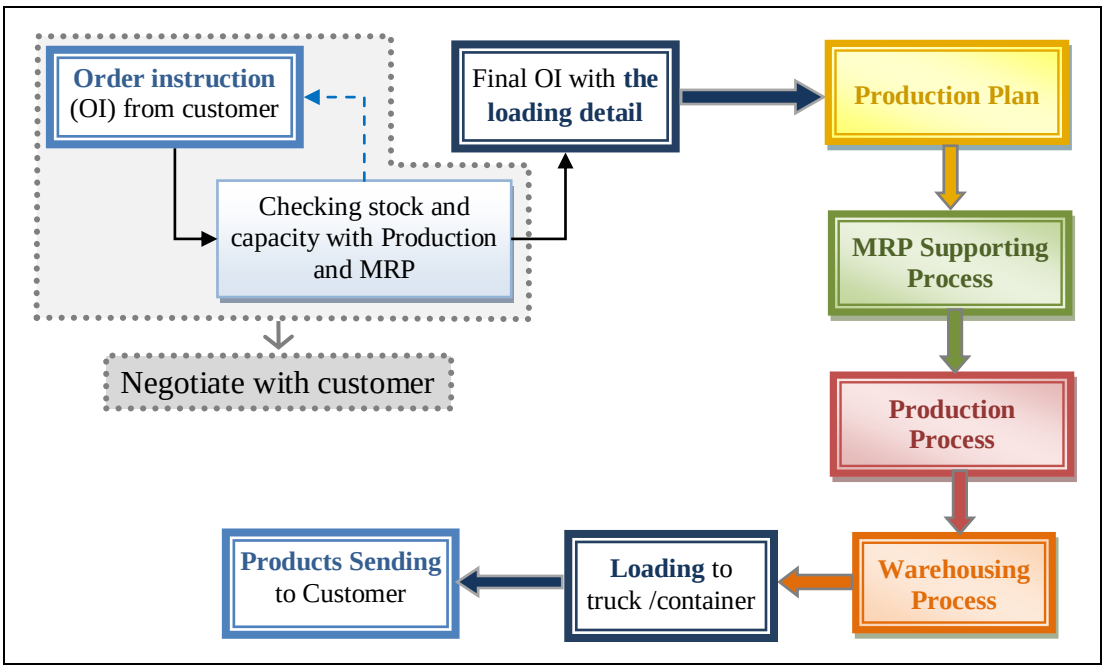


Figure 3. 3 The overall business activities flow chart

The overall business activities start at the first draft order instruction (OI) from customer to sale department then the sale will communicate to warehouse for stock, to production for capacity & schedule, and to MRP for all raw materials, supplier and lead time. This first negotiation period may rerun many times before the final order instruction together with the details of loading and shipment come out. After the confirmation from OI, the real production plan will be developing to be suitable for the production process, loading date, manufacture capacity and other prioritized factors. The real production activity starts at the MRP department following the production plan. MRP will collaborate with suppliers and prepare all necessary raw materials and packaging materials for feeding in production line. Production runs step by step following the schedule including the quality control. The product is come out from production line then is transferred to warehouse. Products pass through each activity in warehouse to prepare for loading as the company's last stage.

In addition to the 'Make-to-Order' and 'Just-in-time', the manufacturing also produces the finished goods as the large batch. The minimum size of large batch production, which is a strict policy, comes from the cost and other manufacturing support factors. Production is planned by aggregating many customer order instructions together so that the finished goods will be sent into warehouse as the large volume of each product code per times. After the production process, many finished goods will be accumulated as a huge volume inside warehouse so that

warehouse is the station for collecting and holding all finished goods to rearrange finished goods for each individual customer orders.

3.3 Warehouse Background

ABC Company's Warehouse is like a general manufacturing warehouse. The physical structure is a simple clear room building. The operation is the same as other manufacturing warehouse. There are four main activities in warehousing processes which are Receiving, Storage, Picking and Loading. The finished goods will be arranged upon the wooden pallet and piled on the floor. The finished goods product is moved as a pallet by using a counter balance forklift.

Although this warehouse looks like other general warehouses of manufacturer, the mechanism of the product flow is different by some specific warehouse characteristics. Transferring of finished goods inside warehouse area depends on its package size. As there are several package types which are different in size, the standard arrangement of pallet pattern and the total number carried on pallet can also be different. The transportation method is referring to the outbound flow of warehouse. Like the unit to be transferring and the transportation as mentioned above, the layout and area is another specific characteristic of this warehouse which can impact the inside warehousing process.

For warehousing characteristic background, the finished goods product is pushed into warehouse area one by one as a large batch size for holding purpose and waiting for the loading time. On the other hand, each product from the order instruction is gradually produced then collected inside the overall warehouse storage area. This is the warehousing outline flow characteristic by considering the production and customer order which are outside warehouse factors. Whereas the warehouse handling mechanism is described on the above paragraph, all details related to warehouse characteristic are provided next to understand the overall warehouse appearance. There is also the warehouse organization detail, which is unlikely related to this warehousing study and provided in the appendix A.

Finished goods warehouse activities

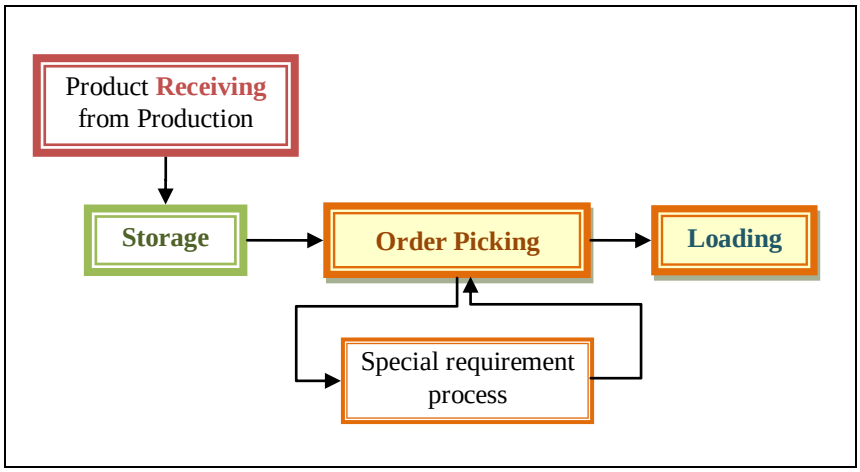


Figure 3. 4 The warehouse activities flow chart

First of all, the warehousing process starts with receiving process which is the process of receiving, and transporting products that come out from production to warehouse area. Products that come out from production line will be packed in carton and arranged on pallet then checking both quality and quantity including the separation of damaged items. Next is the storage process which has the main purpose of holding products in the short term to wait till the loading time. However, there is a small volume of the excess product from demand in customer's order, which has a low turnover rate, will be held in warehouse for long term.

Thirdly, the order picking process is the process for separating, mixing and arranging products into piles by following each order instruction to prepare for loading. The special requirement process, which depends on the special requirement from some customers, will occur during the order picking process to reduce risk of reprocessing and follow the FIFO policy. The special requirement process contains the shrink-wrap process to hold 3, 6 or a dozen of product items together, re-labeling process to adhere new special labels to product items or cartons and the special ink code process. Finally, the last activity is the loading process which is to design for size and loading patterns and then transfer finished goods products into the container. In addition, other two activities which are also important and frequently occurring in every step are the put-away and the stock-checking process.

The Unit of Finished Goods

The unit system using in ABC Company has three major levels which are pallet, carton and item unit. The one item unit may refer to one UHT box or one glass bottle or one can. It depends on the package. The countable units of product are shown in figure 3.5. The factor value of X in the above figure is dependent on the size and type of packaging items.

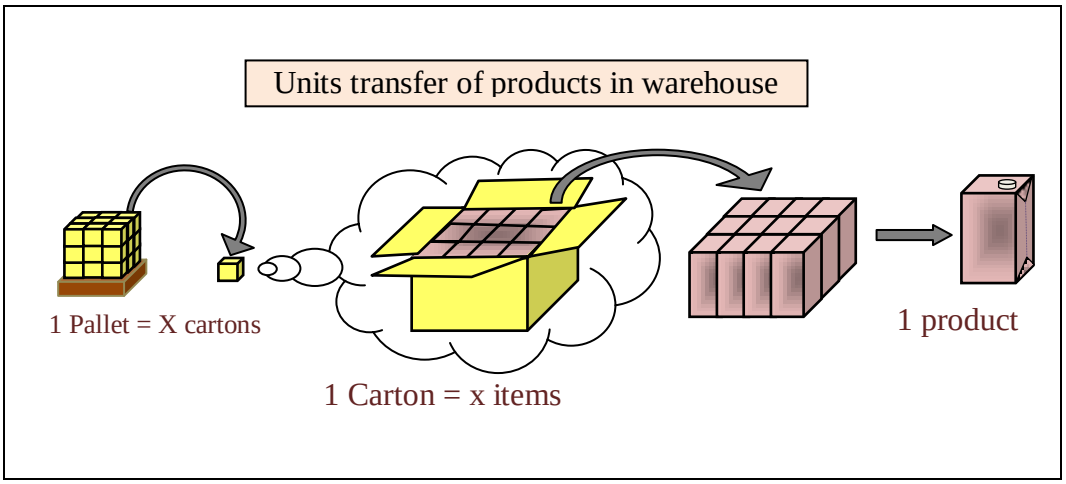


Figure 3. 5 Units of finished good product

The number of product items per cartons (ctn) is shown in table 3.1. For example, one carton of UHT size 1000ml has 12 UHT-boxes inside while UHT size 200ml has 36 UHT-boxes inside.

Table 3. 1 Product items unit per carton

Type	UHT			Can					Bottle	
	1,000 ml	200ml		230ml	240ml		250ml	315ml	200ml	720ml
Items per carton	12	24	36	24	30	24	24	24	12	12

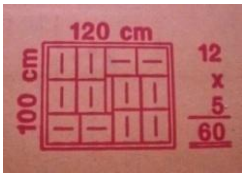
The arranging pattern of each types of product packaging is designed to be suitable for each characteristics and safety. The total number of cartons per one pallet transferring unit is shown in table 3.2 below. It also described the figure of arranging pattern in details of the number of cartons per layer and number of layers per pallet.

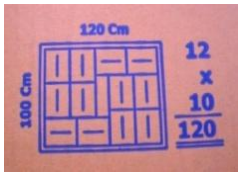
Table 3. 2 Product carton unit upon pallet

Type	Size	unit/ctn	Carton Dimension (cm) (Width x Length x Height)	Pallet arrangement		
				ctn/layer	layers/pallet	ctn/pallet
UHT	1,000 ml	12	26.01 x 30.56 x 23.07	12	5	60
	200 ml	24	26.72 x 30.78 x 13.64	19	7	133
	200 ml	36	26.72 x 30.78 x 13.64	12	7	84
Can	230 ml	24	22.33 x 32.53 x 14.60	12	10	120
	240 ml	30	27.43 x 32.60 x 14.59	12	10	120
	240 ml	24	27.43 x 32.60 x 14.59	16	10	160
	250 ml	24	27.61 x 40.44 x 13.25	16	8	128
	315 ml	24	27.61 x 40.44 x 13.25	10	10	100
Bottle	200 ml	12	17.41 x 22.97 x 20.33	27	8	216
	720 ml	12	25.54 x 33.55 x 31.21	11	6	66

From the above table 3.2, one pallet of the 1,000ml UHT products is 60 cartons while the pallet of the 200ml bottle product is 216 cartons.

For example, the product which is 240ml in can packaging will be arranged 12 cartons per layer like the pattern shown in figure 3.3.2.2b bellowing. After arranging the first layer on pallet, the second layer will be arranged by alternate the left and the right of the first layer arranging pattern on the first layer. Another layer of product carton will be arranged over another layer until 10 layers. In conclusion, one pallet of 240ml product is 120 cartons which come from 10 layers of 12 cartons piled on pallet.

a) 

b) 

c) 

d) 
e) 

Figure 3. 6 Example product carton arranging pattern upon pallet

Transportation

Export orders are usually loaded into two standard sized containers (20 and 40 cubic ft. sized) then shipped to final destination by sea freight while domestic orders are using both the containers and trucks(i.e. 4 wheeled, 6 wheeled and 18 wheeled trucks) to deliver to customers. The loading unit is usually in the carton but some customers require product to load as the pallet. The main transportation unit used in warehouse is in a pallet unit which fully contains about 60-200 cartons depending on the product package of item product inside.

Figure 3. 7 Product loading in container picture

Warehouse Resource

This warehouse resource details give draft picture of warehouse working environment. Three main resource types using in warehouse are warehouse staffs, movement equipments and container type. For the man resource, there are two main workers which are warehouse staff responding for product activities and office staff responding for document and information system. There is also the detail of organization chart providing in the appendix A.

1. Employees

Manpower of Finished Goods Warehouse

- Only the researching area, Juice finished goods product line

Manager		1	person
Supervisor		3	people
Foreman		3	people
Team members	Fulltime	2	people
	Part-time (outsourcing)	10-20	people

2. Mobile Equipment

There are two types of equipments using in juice finished goods warehouse

Fork lift truck

- used for transporting one pallet per times.

Figure 3. 8 Fork lift truck

Hand pallet jack

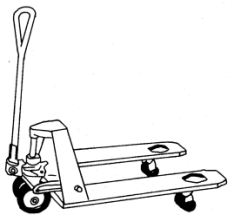


Figure 3. 9 Hand pallet jack

3. Pallet Container

The pallet container in ABC manufacture's warehouse uses the wooden of standard size as 1,200 x 1,000 x 140 mm (Length x Width x Depth). All pallets have four ways entries, compatible for forklift.

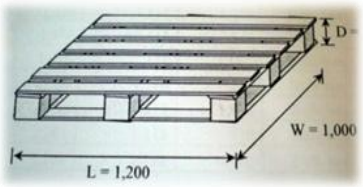


Figure 3. 10 Standard pallet size

Figure 3. 11 Picture of pallet using in warehouse

Layout and area

The layout and area of warehouse relate to the boundary of warehousing flow and its outline pattern. Figure 3.12 shows the position of warehouse in overall plant while figure 3.13 shows the detail of juice finished goods warehouse.

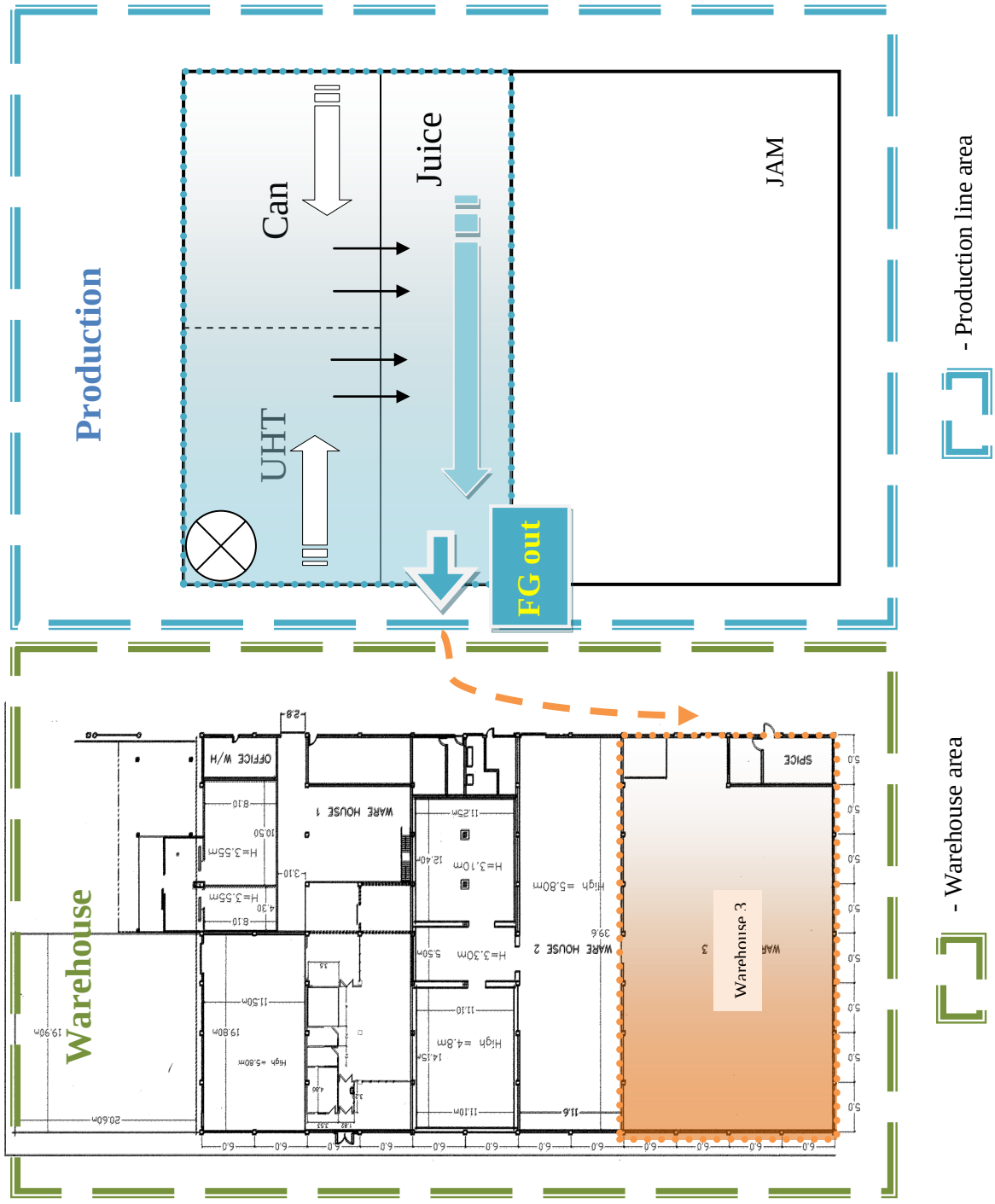


Figure 3. 12 Plant layout and finished good flow

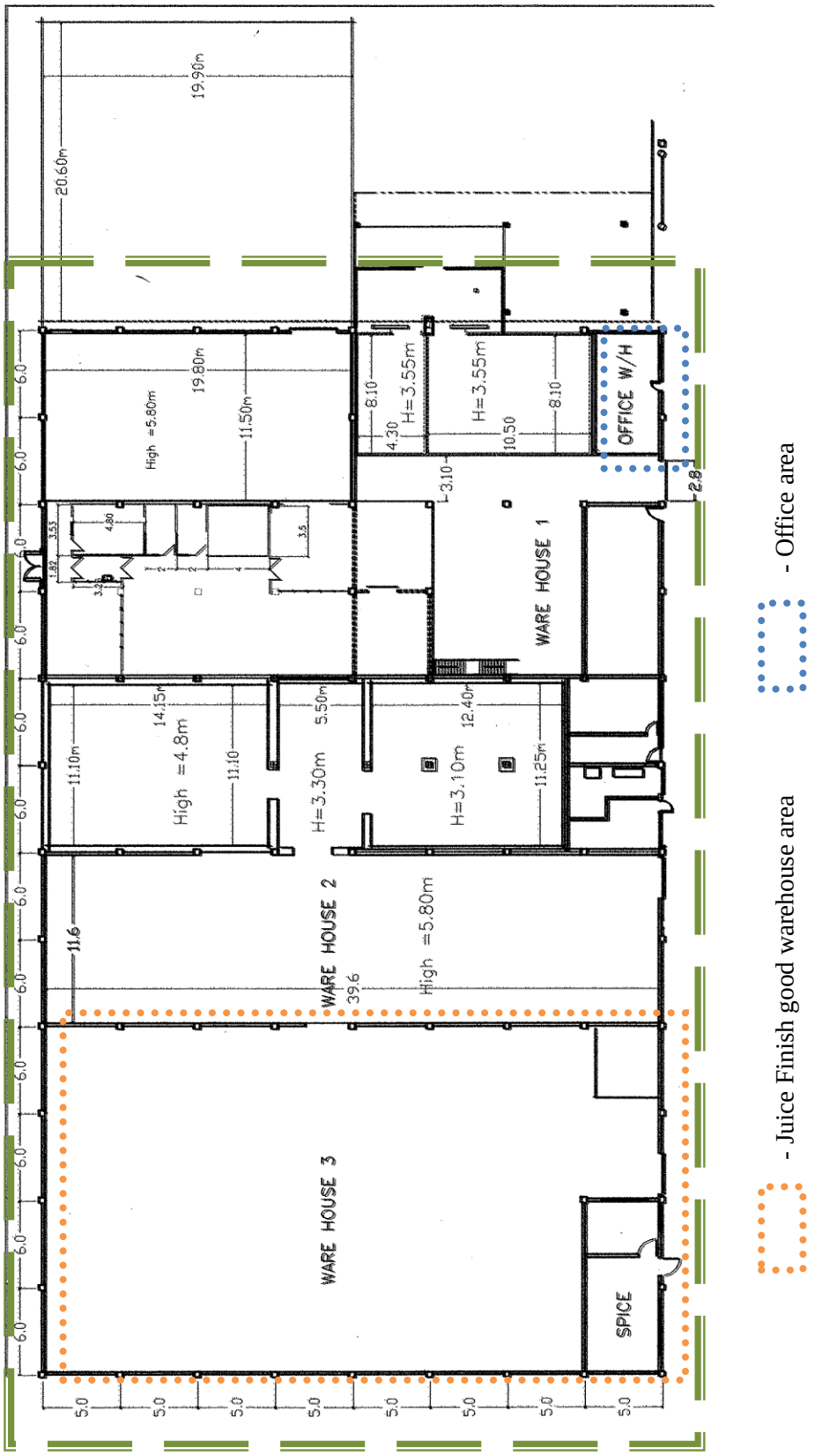


Figure 3. 13 Overall warehouse layout area

3.4 The Limited Factors in ABC's Manufacturing Warehouse

A bulky and cumbersome product when moving

Juice product in the package of UHT and can are easy to be collapsed or damaged while the glass bottle packaging is easy to be broken. As a result, the product movement in the warehouse needs a high attention. The juice product is also cumbersome which is not only due to the big size as pallet but also the heavy weight when in large quantities make such a hard work in moving and transferring.

Pile with limited layers

Generally, UHT package products are prohibited to place one upon another pallet, while the Can packaged products can stack one pallet up to another. That means the UHT packed products need more space for storage and during the put away process. It is less fulfilled the limited storage policy

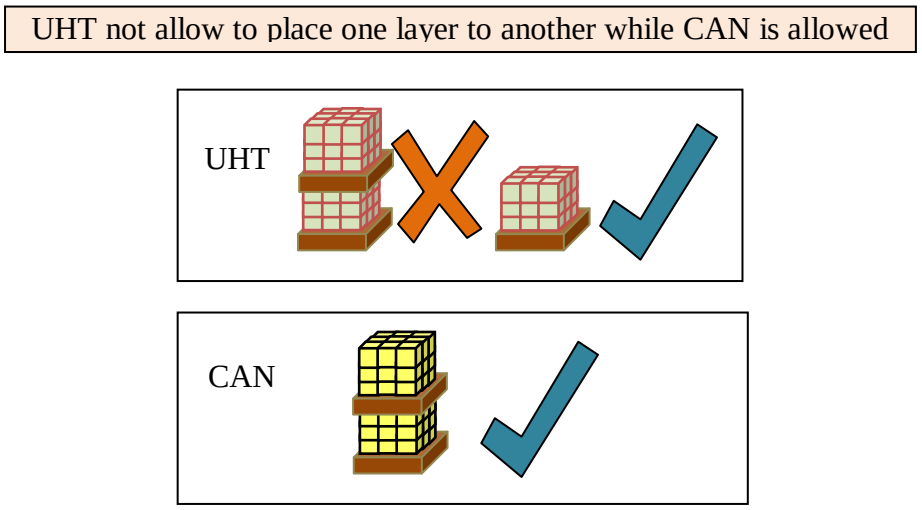


Figure 3. 14 UHT finish good storage principle

That means UHT need more space for storage and put away process.

The FIFO Policy

The serious FIFO policy is also one of limited factors in ABC warehouse which is because of the short life cycle of products. Usually, a juice product has a life cycle only 1-2 years. For the logistic chain, this will impact the period of time used for loading and shipping to sellers especially the exporting market to be less. Lacking

of the good performance in stock management during warehouse activities means to the more nearly expired products kept in warehouse and the more company lost.

Fix Loading Time Period

As the high cost of penalty for extending shipping process, the company is also required to rapidly respond all order requirement to load and delivery product to customer on time commitment. Usually the product loaded out from manufacture is a big volume. An allowing time period for truck and trailer on road following the Thai government policy is another critical factor that forces the picking and loading activities by limit working time period.

3.5 The Preliminary Observation in a Case Study Warehouse

The Difficulty of Case Studied Warehouse System

From the background of ABC Company, it is showed that the company needs more flexible and effective in overall processes to increase the customer satisfaction. ABC company has the 'Make-to-Order' policy as their business characteristic which means the uncertainty in production schedule and also the high variety of product categories in term of favors and packing patterns cause more complicated in the flow of both information and product items going through ABC organization.

Currently, the total product line is up to more than 200 SKU code.

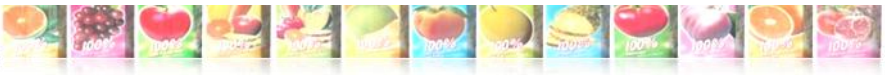


Figure 3. 15 Some product favors example

Not only the very high variety of product lines but also the variety mixing orders from many different customers creates the complicated crossing route of the product profiling in ABC manufacturer's warehouse. In addition, FIFO policy and other limitations also lead to more difficulties in warehousing activities. The customer order characteristic and the seasoning also create the dynamic of profiling in warehouse system to follow the change of conditions in each individually local area as the target markets of company are all around the world.

Although the company has the business strategy as ‘Make-to-Order’, the warehouse still has to manage a big amount of the finished goods flow inventory. The finished goods inventory, which flows pass warehouse, contains product from the holding period between production and loading and also the products from the over production to compensate the lose during production process and for replacing damaged products in accident case.

The finished goods flow model in the warehouse system

Figure 3. 16 is the flow diagram of finished goods that shows the actual process of inflow and outflow of finished goods that pass through ABC juice warehouse.

The actual inventory level is low comparing to the total production volume but it can be cluttered in the warehouse and block the flow of warehousing products by unsuitable warehousing operations of the current low turnover inventory items. Not just the real inventory, there is also the hidden inventory which comes from the cost benefit of the big volume production and the high customer satisfaction in responding the high variety mixing in order. As a flow of one big lot of finished goods flow from production line into warehouse (as shown in figure 6 the finish good profile modeling) is not continuously directly going out of warehouse at the same time, it is firstly separated into many piles according to many customer’s orders before it is collected again with other product lot to fulfill each order instruction. The production normally produces each product as one big size combining from many orders of customers, while one container loading out usually also collects from many product codes and lot details. The product will be stored in warehouse from several days to several months. The difference in time period for storing product in warehouse depends on the production schedule and loading date required by customers. Hence, the total inventory of holding products is quite big caused by the effect of merging the big lot production factors with the customer mixing order factor.

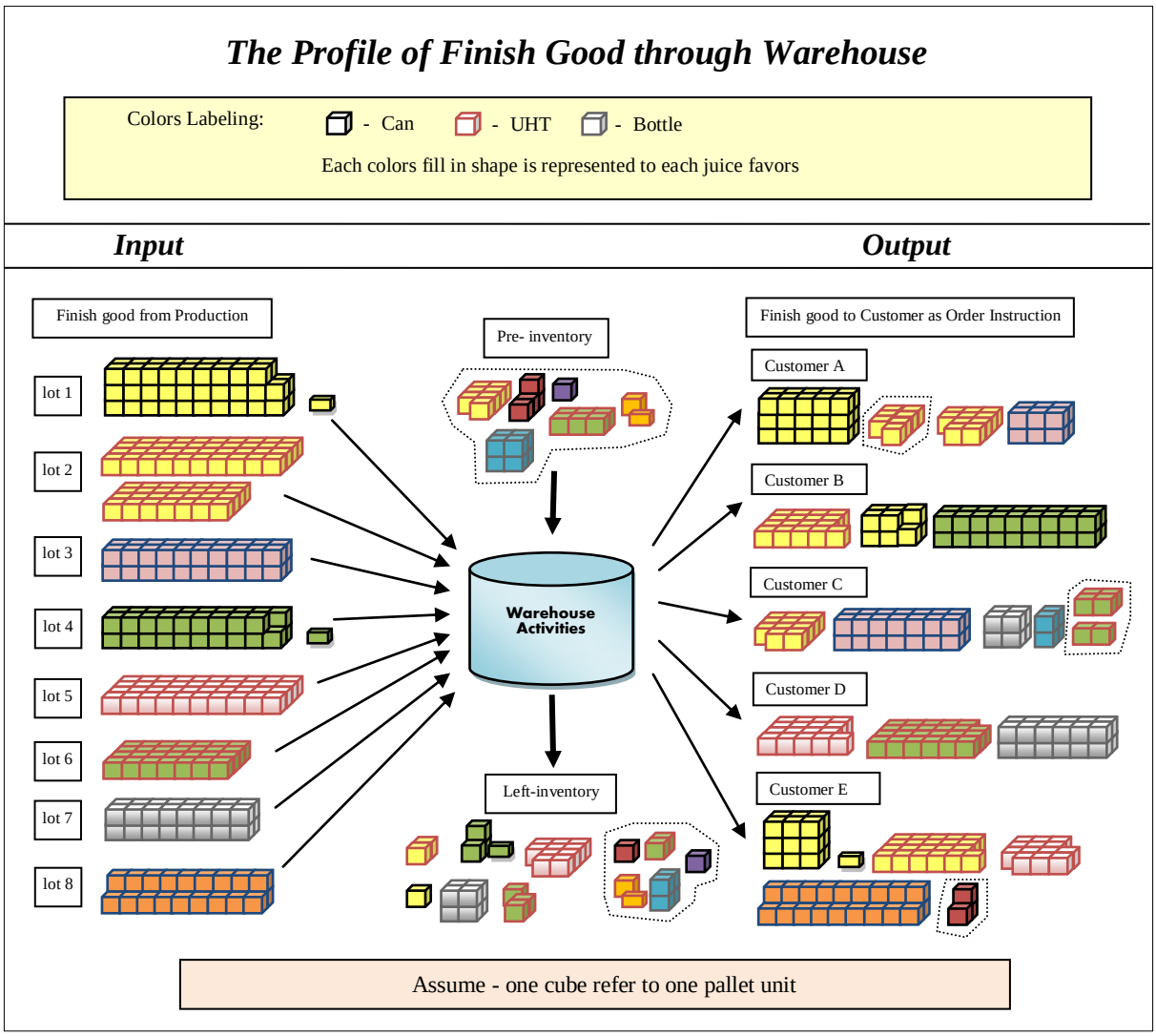


Figure 3. 16 The finish good profile

The Problem Situation

In conclusion, the previous sectors show the overall picture of the difficulty in warehouse system which is dynamic and complicated by the big size and the high varieties mixing in order of customer requirements and show the environment of the warehousing system. The warehouse has to run under the limitation of working factors, time loading period and area supporting as their forcing environment factors. The higher demand level from customer to be fulfilled is the higher bustle in warehousing system under the limited working area and time period ABC company has to handle.

Figure 3. 17 The finish good warehouse

Now the company is facing the problem of inefficient warehousing process especially the problem in picking order process. The company cannot commit all order instructions during the high peak demand. This problem shows in the situation that all required products are available in the warehouse stock but they cannot be loaded out from warehouse caused by many warehouse's problems during different activities. Moreover, when warehouse processes are failed, it takes a lot of time to investigate and cannot define the main cause of the problem.

In addition, to remain the company's competitiveness in today's company market and being ready for expanding to new markets in future, the improvement in warehouse processes will be one of the significant considering areas.

Due to many reasons mentioned above, it is quite clear that why the warehouse process should be investigated to find how to improve the warehousing process and the ability to deal with the risk of warehouse process failing at the high peak demand period. This is about what this research is.

Chapter IV

THE ANALYSIS OF CURRENT WAREHOUSING

This chapter discusses about the current warehousing process and the existing problem in ABC manufacturer's juice finished goods warehouse. It will be divided into two main parts. The beginning part is the analysis of the current warehousing which has the main focusing on the unable-to-load-product-out problem as founding in the prelim observation. The last part is the problem solving analysis, which leads to the approach of warehousing improvement.

To study and investigate the current situation and problem, the author starts by interviewing all warehouse teams and also related stakeholders in organization such IT, Sale & Marketing, Production and Management. After acquiring an initial picture of current warehousing process and the opinion from stakeholders, observation technique is used in the working place to study about product flow, information flow and real work flow. Moreover, there are also some information collected more such as the document, historical data and physical structure survey. Lastly, the current warehousing process is discussed, analyzed and concluded as in this chapter detail.

By the way, to make this first part analysis easy to follow up, it is divided into four main relating discussions which are warehousing process, warehouse operation, the information data system and physical structure. Firstly, the overview of warehousing process is described then the warehouse operating activities details is given in work flow process and its procedure. Secondly, the current warehouse information system analysis is discussed to make more understanding in the information data base flow. Next, warehouse's physical structure analysis is shown in the warehouse layout and area. Finally, the summary of the current warehousing analysis is concluded in the end of this part then problem solving tools are applied to find out the improvement solution for this case study in the next part of this chapter.

For the last part of this chapter, which is the problem solving analysis, is divided into 4 stages. Firstly, the existing problem description will give a detail of occurring problems in this case study situation. The existing problems come from the current warehousing analysis in the previous part. Next, the relation diagram of

problems will be used to give more understanding of an overview of all problems in the warehousing process and its problem in the relating area. Next step is the problem solving analysis. The 'why-why' technique is used to find the root causes and the 'how-how' technique is used to find the problem solving ways. By the way to make this part easy to follow up, it will be divided into three main views which are operation process, the information data recording system and physical structure. Finally the warehousing improvement solution, the summary of the cause & effect of problems and its solution will be provided respectively, then the improving strategy that is chosen from all problems solving analysis.

4.1 The Current Warehouse Process

The four main warehousing processes, show product and information flow, are Receiving, Storage, Picking and Loading. Stock-checking is also another significant activity operation which is not in the work flow process of warehousing.

4.1.1 The current receiving and storage process flow

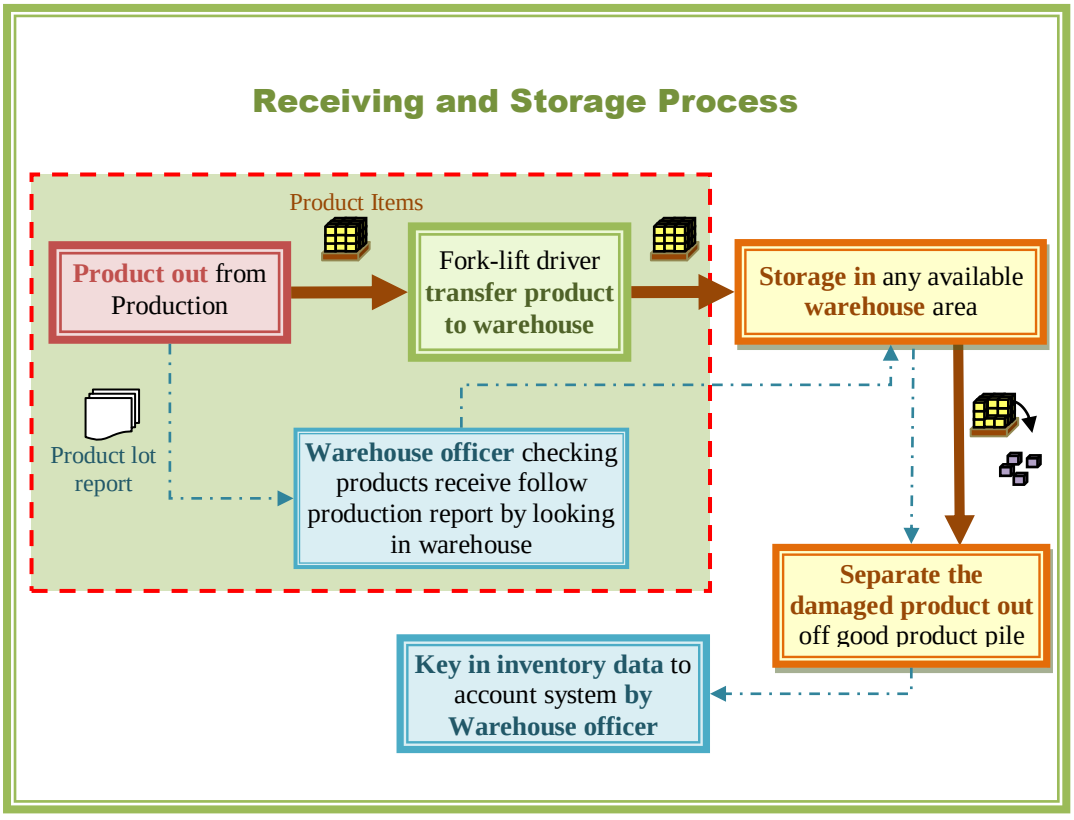


Figure 4. 1 The current receive and storage process flow chart

Generally, the receiving process has no responsible worker and no any algorithm. When the new product lots come out of the production line, whoever drive the forklift passing will be asked to drag these products to place in any areas in the warehouse even though such person not warehouse staffs of the juice product team. For the information flow, the product lot report will send from pallet recording production worker to warehouse officers, who are responsible in finding and checking the receiving product items based on the report. The storage process is randomly placed in some free area, unaware of the ordered loading instruction or the storage category policy. Moreover, during the storage time, there is some put-away processing occurred which is use the random area utilizing policy too. All above processes lead to many following problems in warehousing process.

At the current receiving step, it is usually done by production and QA then product is pushed in warehouse area waiting for investigation again by warehouse officer. This investigation step is sometime fail as cannot find the incoming product as the production report and do not take any action after its failure. Moreover, it leads to problem in checking activities of warehouse.

The put away and storage operation is the random method by placing product on floor as a row. The warehouse staff will be observing for the available area, which is two rooms, to place product pallet. It creates the confusion in warehouse physical storage. The arrangement in warehouse relies on warehouse experience and memory so that it leads to long time searching problem and the cannot-find-the-required-product problem. The warehouse officer usually forgets the keeping position at the end especially at the peak period. If the picking and the storage arranging staff was not the same person, it would need long time to find the required product. Moreover, it is also an obstacle to the stock investigation as cannot define the position area of each product detail and which area should be checked first.

4.1.2 The current order-picking and loading process flow

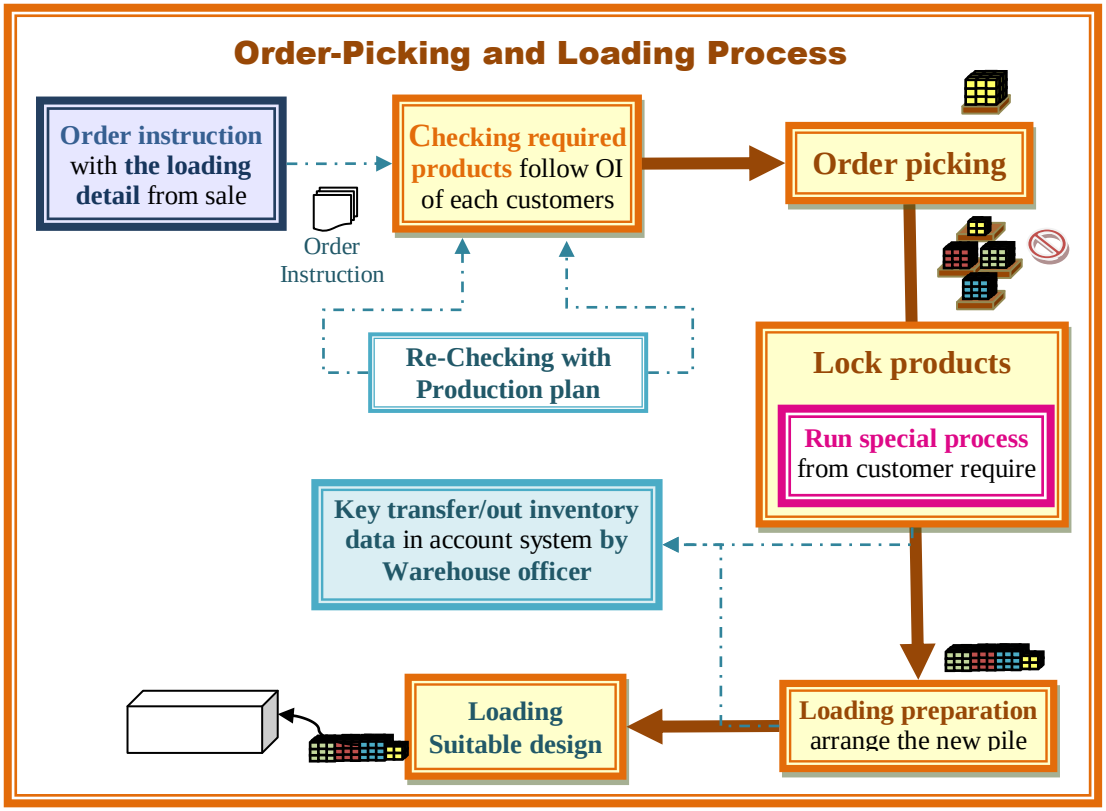


Figure 4. 2 The current order picking and loading process flow chart

The general process of current order-picking process is started near to loading date by checking and searching the required products follow the order instruction in the warehouse, then lock by labeling and sort these products together in the new pile. Order-Picking is a complicated activities because some order needs to collect the product from more than 20 production lots. Moreover, the special process, which depends on customer request and not frequency occur, will be run during picking order for specific customer. The special process is the specific requirement of customer in product packaging which is different from the basic package, such as shirk wrap pack size to be 3 items or dozen, or special ink code pattern. After order picking complete, the number adjusting will be run by the balancing database and waiting for loading time. Loading process is to arrange all products into container as order instruction including checking the completeness of container. Loading process needs the skillful worker to design and arrange the product layers and sequence into container or truck. Some customer requires the product loaded as the pallet size (with pallet) while normally product will be loaded as the cartons units. It usually uses one warehouse staff to drive fork lift for transferring product pallet to container and

another warehouse staff to control activity at the container for arranging and recording steps. The worker who drives the fork lift to transfer loading products may be responsible for many containers at the same time. After loading, the document process and the adjusting process of account system will be run at the end.

In order picking stage, the main problem found is unable to find the required product in warehouse. This problem relates to the pre-stage process, such as the receiving, storage and also the production plan which is not in the warehouse operation area.

At the pre-stage of picking, there are many times that some required products in the order list were not come in warehouse therefore it is not shown in the system. It will wait until the production finished all products in the list to start the next step of picking process. However, in the critical time, the picking process will be pushed the work to the actual shop-floor warehousing step without database checking. The actual finding product in warehouse room usually found problems of long time searching and required product missing which are frequently occurring in the peak period. The shop floor of order picking is usually hastened by previous uncompleted step and sometimes the sales approval step of product detail is skipped or not finished before starting the actual picking. The actual product picking and collecting processes need to put away the other product pallet that obstructs the required product movement, so it may need long time if the required products are spreadably placed along the warehouse area and get stuck in the back of each row. The picked products number which are in the delay picking is not cut off in system so that it may cause the error gap occur in actual available stock and information, leads to duplicate reserve.

For the loading process, the research shows the problem of unready product to be loaded. If the picking out staff is not the same person as the order picking preparation, it may need long time to find and check the picked product especially in the full-stock keeping area. Moreover, another problem found is the mistakes occurred because some staffs are unskillful in arranging pattern design. The closing container step is also easy to be mistake. The arranging pattern design of loading is complicated depending on a variety mixing product level of each order. It can be separated into inner, middle and ending sections. Each section also has many layers

and each layer also has to design arranging pattern which depends on the product package types.

The warehouse stock-checking activity

This activity's purpose is to investigate the actual stock number compare to the number of information system. This process is two pattern methods. One is the random product checking. The warehouse manager will be specific the product code for warehouse staff to check. Another is a full stage checking overall warehouse area, and then summarizes the result and compare to the information system. In this warehouse case study, this activity is usually implemented to adjust the stock because of error founding.

The relating problem found is the longtime checking process as the staffs have to walk and scan for product around the warehouse area and the difficulty of warehousing process backward tracking. For the excel file, warehouse manager can adjust by himself and it is frequency adjusting. On the other hand, for accounting system, warehouse manager have to write the report with error reason to inform accounting manager first, then the manager will take an adjusting action. The error adjusting is not frequency occurred the error as the weak ability to investigate warehouse.

4.2 The Warehouse Information System

This is about information data system using in this warehousing process case study. There is only accounting information system using in this manufacture so that the information data base is designed to main purpose for supporting accounting and business management of company. The system keeps the product detail in term of total volume and customer sale report. It shows much useful information to support in term of business decision but it didn't support the warehouse management. Even it can show the turnover index but it can't refer to the real activities and product status flow in warehouse. This weak information warehouse system causes to the problem in manage and control the warehouse activities and also the problem in researching and improving the warehouse process.

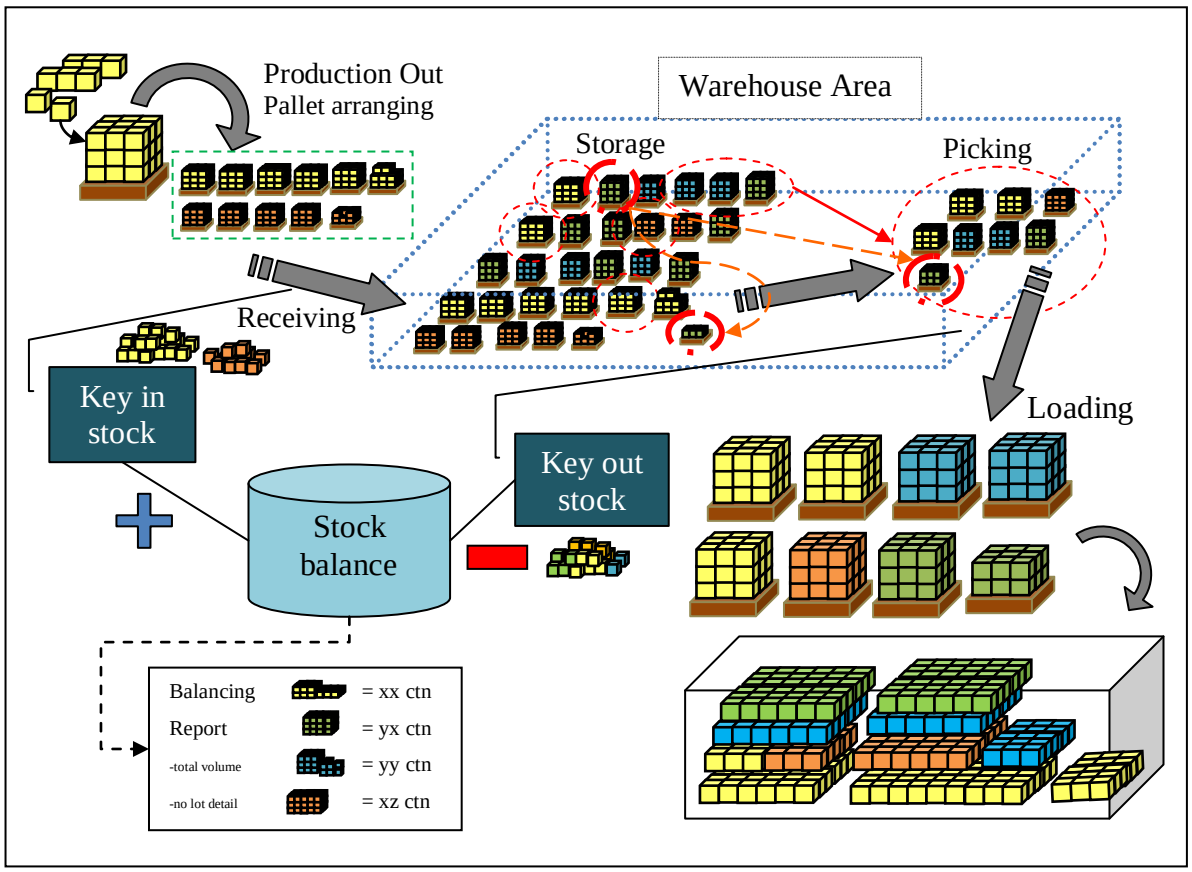


Figure 4. 3 The using of accounting balance system in warehouse

The figure 4.3 shows the process of accounting balance compare to warehousing process. The office stuff will be key data when the products come in warehouse then key out when the products were loading out. The stock balancing number in accounting system is the total product code volume in the warehouse as it may be locked by other customer. Moreover, the using unit of the accounting system is the carton or the piece units (box or can) while in warehouse the product was transfer upon the pallet and storage as the pallet. The accounting system is also not support the lot detail of warehouse products although this detail information is significant in warehousing activities because of FIFO policy.

In addition, as the warehouse has the FIFO policy so the lot detail is a necessary input data in order picking and stock cutting, warehouse develop the excel file for stock balance supporting inside warehouse department. Anyways, it is just the stock note not balancing as it isn't recording the detail of in and out flow. This excel file is shown in the figure 4.4

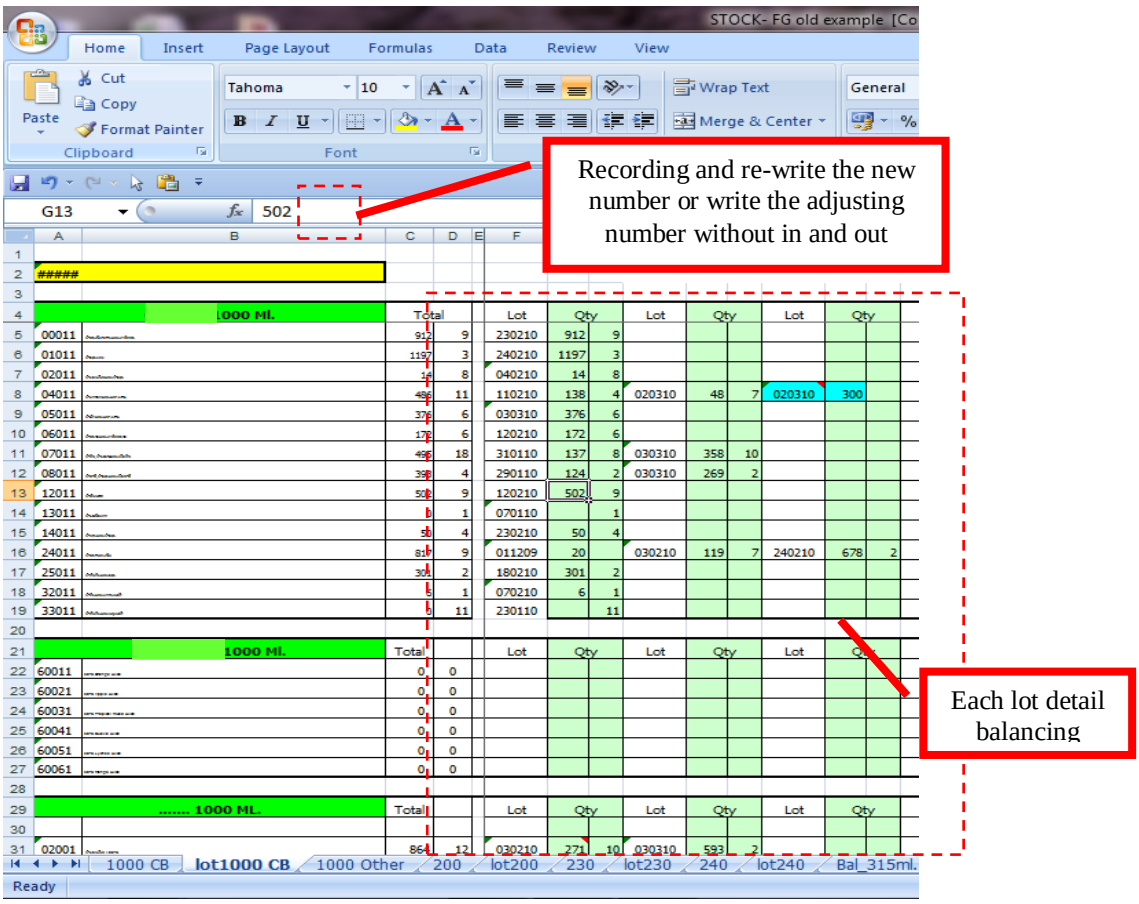


Figure 4. 4 The excel file of stock balance using in warehouse

This excel file of stock balance note is the recording data base for warehouse manager and other in guideline using for stock locking plan. The number in this balance note refer to what exactly warehouse stock available at that time as it cutting stock out when product is locked. Although it can refer to the real stock available on hand but it is inaccuracy because of an easy to error of the short note and an inability of tracking backward.

In conclusion, the main information data base using in warehousing process is only the excel file which is like the balancing shot note. The backward checking of in-flow and out-flow have to checking the document file which keeping in the time sorting so that it takes so much time checking which customers are the specific product lot send to and how much sending product volume is. The in-flow document is the production lot detail reports which will be sent to warehouse office every day. The out-flow document is the order instruction loading reports which is keeping all

document of picking and loading after finish all process. To match the small SKU[1] of single small part-volume from each total production lot with the detail product list in the OI loading document is not just an easy work. The SKU detail which refers to warehouse profiling is the necessary data for warehouse management.

4.3 The Warehouse Layout and Area

The company bought this existing manufacturing from the similar business which has drinking can and jams as their product. The old building structure manufacturing was not well suitable for the ABC company activities especially the finish good warehouse.

Even though the business of ABC company is very similar to the old owner manufacture, the drinking product of the older company is in only a canned package, which can pile up in multiple pallet layers, with a few favor while the juice product of ABC company is also in UHT and glass bottle package with very variety favor so the old area utilization design of warehouse cannot support well to the ABC company finish good requirement and obstacle to the order-picking process which is one of the significant activities effect to customer satisfaction. The more variety product and the more limited package in storage method make that the ABC company may need more warehouse area and the different operation policy. The *Lack of Warehouse Space Utilization problem* is firstly remarked as the physical structure problem by the background of warehouse.

As the initial warehouse area (only warehouse room 3), the product is usually overflow but recently the product warehouse area just expand to use warehouse room 3.1 which is the free area. This expanding is not official. It just starts by temporarily finding some place for placing the overflow product stock. Anyways, now the warehouse room 3.2 is including into total warehouse product area as it be

[1] SKU – A **stock-keeping unit** is a unique identification of each particular product that allows it to be tracked for inventory purposes or can be purchased. Typically, an SKU use is associated with rooted in data management.

A goal of a warehouse or distribution center is to track items moving in and out, which is the purpose for using SKUs or product data, and can include product dimension, weight, color, etc [source: http://en.wikipedia.org/wiki/Stock-keeping_unit on 18 March 2010]

unquestioning used as product warehouse area so that the sufficient of warehouse area capacity should be evaluated again.

The warehouse layout and capacity detail

To evaluate the sufficient of warehouse capacity, the total warehouse capacity has to provide firstly. The overall warehouse layout and area with the nearby manufacturing department such the production line is already provided in chapter III. The detail of warehouse room 3 and 3.1 is given in figure 4.5.

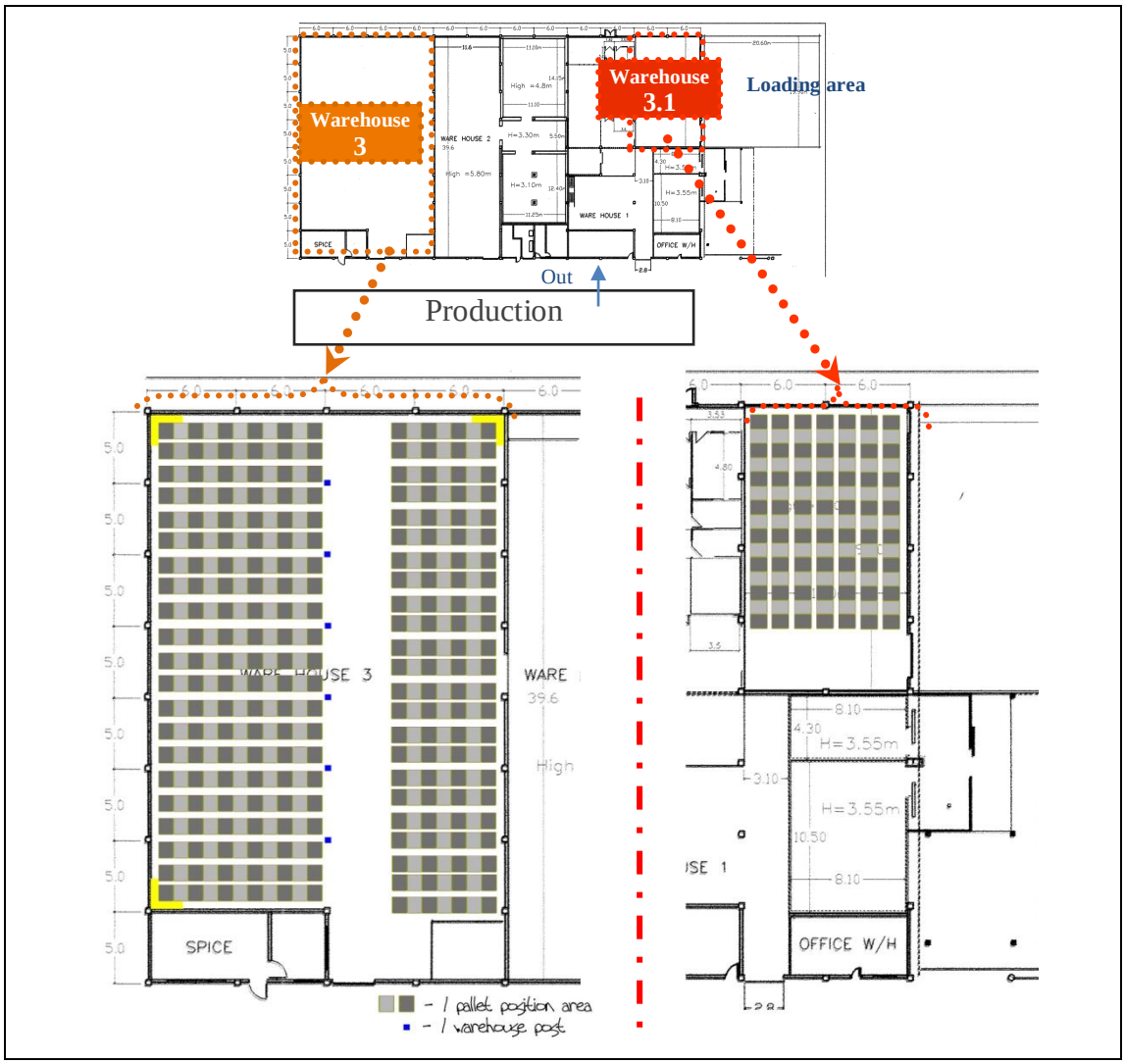


Figure 4. 5 Total warehouse pallet area and layout

Figure 4.5 is the warehouse layout and area detail with the zooming picture of warehouse room 3 and 3.1 at the bottom. The top of figure is the overall warehouse

layout with nearby department position while the bottom part is the zooming layout inside warehouse room 3 and 3.1.

Warehouse room 3 is at the back side near to spice room and its size is 40x24 m^2 estimated. In the other hand, warehouse room 3.1 is at the front side of manufacturing area nearby the loading area and the area of warehouse room 3.1 is estimated to 12x19.9 $m^{2.}$

The finished goods pallets in the warehouse room area use the laying on floor for storage method and its will be arranged in the deep row. The design factor of pallet area layout policy is to maximize the storage area capacity and to minimize aisle. In warehouse room 3, product will be placed like a set of couple rows. The gap between each row of pallet in the set is about 20-30 cm only for prevent the friction following the safety policy including 50cm space far from a wall. The gap between each set is estimated to 60 cm for only stuff can walk in and out. Stuff will walk thought aisle between two set of couple pallet row for checking both pallet in the front row of the back set and the back row of the front set as man-to-pallet checking ability policy. There are only one aisle for forklift car transport at the centre of warehouse 3 directing to the enter way. The right side in warehouse 3 is arranging follow the policy and has 23 rows (or 11 sets and 1 row) of 7-pallets-deep.The left side in warehouse 3 has 7 posts in ridge which are obstacle in picking pallet so that it has 21 row of 11-pallets-deep. Warehouse room 3.1 has 7 rows of 15-pallets-deep.

From the above figure, it shows that in room 3 the total pallet area equal to (11x3x7) + (7x23) which is 392 pallets area unit. In room 3.1, the total pallet area is (15x7) which is 105 units. In conclusion, the total pallet area of juice finished good product equal to 392+105 which is 497 units. The capacity of warehouse is calculated in pallet area unit for easy to compare to the demand volume while the equation for total pallet area calculation come from multiplying number of pallet in row with the number of row then summarizing them together.

The capacity sufficiency evaluation

The capacity sufficiency evaluation is done by compare the yearly 2009 demand forecast to the warehouse capacity area in pallet area unit. It will be presented in bellowing figure 4.6.

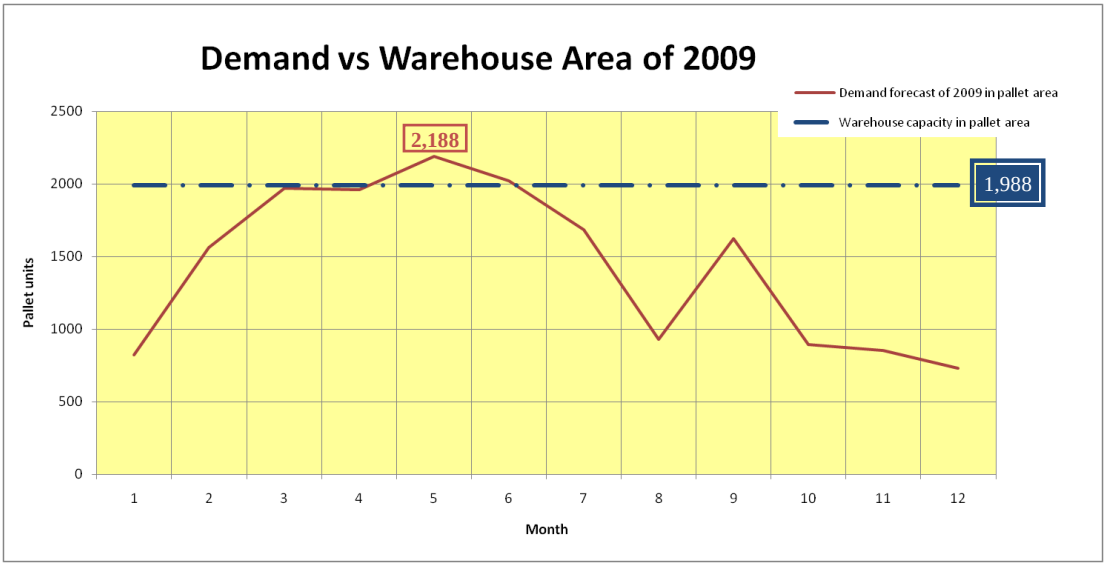


Figure 4. 6 Chart of the warehouse capacity estimation

The above line chart consists of two data series. One is 2009 demand forecast which is the red line and another is warehouse monthly capacity estimate which is the blue line. The 2009 demand forecasting data come from the sale and customer forecasting by using the sale volume of 2008 as data beginning. The demand forecast data will be converted from canton units to pallet units by the depending convert factors of each package then it will be changed from pallet to pallet area by dividing by two for can package and doing nothings for UHT and bottle. As the 2009 demand forecast line chart is the total demand of all package type in monthly so the warehouse area capacity will be convert to monthly period too. The warehouse monthly estimate is calculated by multiple total warehouse pallet area 497 units with 4 which come from weekly loading out so that it is 4 times turnover a month.

Total monthly capacity area = 497* 4 = 1,988 pallets unit storage area

Demand line in chart show that it is seasonal along the year whereas warehouse capacity in pallet area is a constant line at 1,988 pallet units. In the New Year period or December to January, the demand is the lowest period then it rise to the high sale volume period in March to June. During the high period, demand is peak

in May which is the highest peak of all year. After that the demand drop down in August and then increase to be a peak again in September before it is reducing in October and then remaining the same level until December.

From the chart, it shown that the demand is usually much under warehouse capacity except the period of March to July. The required area of demand forecast in pallet unit is going almost equal to warehouse capacity, which is at 1,988 pallets area, in March and April then it rise to be higher than warehouse capacity at 2,188 in May and then it drop to be a little higher than warehouse capacity at 2,033 in June before it is going down to be about 1,000 pallets area in August.

There are 2 months (March, April) that the demand is almost equal to warehouse capacity, 2 months (May, June) that demand is higher than capacity and another 8 months that the demand is under warehouse capacity. The under capacity period are 3 months (Feb, July, Oct) in the medium level in 1500-1700 pallet area units requirement and 5 months in the low level at 700-1,000 pallet area units requirement.

The warehouse layout evaluation

Warehouse layout of this case study is the random utilization policy which means that any products can be placed in every warehouse area. There are no specific identify zoning in all warehouse area which are two rooms. Only one ideal of put the same product code together is referable. That warehouse storage ideal is hard in the real operation as there are many product codes and each product lot coming time of the same product is uncertainty so that the position allocation of each product pallet is influenced from experience and memory of warehouse team members. This creates the untidy warehouse environment which leads to the product searching problem in the picking process and also the stock checking process.

In conclusion, the analysis of current warehouse layout and area shows the problem cause from lack of warehouse capacity at the high peak demand period and also the problem cause from the unorganised of warehouse area utilization. The warehouse physical structure problem relates to the main problem of untidy warehouse environment especially every high density stock then it will lead to the problem in the picking process.

4.4 The Summary of Current Warehouse Analysis

In this case, the inefficient warehousing process problem is defined to the situation that the products cannot be loaded and sent to customer as committed. In the initial study shows that the main frequently problem is in the picking process caused by the product's long time searching and cannot find the required product, leads to unready to load situation. Although the beginning propose of this research is focusing on the warehousing process especially picking process, but the other relating problems also appears during the study as describing in this beginning part of chapter.

The current warehousing analysis shows that there are many problems, related to the main focusing of the unable to load product out situation. The analysis parts of warehousing process and operation show that the occurring problems in picking process are relating to the beginning of warehouse processes operations which are *receiving and storage processes* not just picking's operation itself. Those beginning warehouse activities are not concerning with the accessibility and management of the outbound warehouse flow.

Moreover, *not only the problems in warehousing process and its operation were found, but also the problems from information system, other warehouse activity operation and area utilization*. All problems are related to each other and lead to the inefficient warehousing process problem so that they become the study concerning.

The conclusion of problems foundation in the current warehousing analysis:

The warehousing process and operation

There are three problems found in the picking process

- Long time searching process
- Hard to reach the required product
- The product missing

There is one problem found in the loading process

- The mistake during loading steps

There is one problem found in overall warehousing

- Weak ability to investigate warehouse: this include stock checking and warehousing tracking back in picking, receiving and storage.

The warehouse information

- Invalidation and inaccuracy information of warehouse stock

The warehouse physical structure (layout and area)

- Untidy warehouse environment

All these problems' relationships and their root cause analysis to find the improving solution are conduct in the problem analysis part

In conclusion, the analysis scope covers all the relating area as found in this study not only in picking process as the preliminary observation.

4.5 The Problem Symptoms Relation

This part chooses the relation diagram to give an overview of the inefficient warehousing process problem and to reveal the cause-effect relationship of all problem symptoms more obvious. To create the relation diagram is started with the problem defining so that all problem symptoms description will be provided, after that they will be considered in the relationship between each other and be linked in the relationship diagram at the end.

4.5.1 Problem Symptom

The warehouse is the fussy work. The warehousing process failure is usually come from many small incidents. Moreover, these incidents, which are like problem symptoms in warehousing system, can affect to another problem and becomes side effect back to the origin problem or other problem. It looks like symptom of chronic disease. There are many problem symptoms that show low efficient warehouse process. The information problem is also link to work process fail, therefore it will be including in this problem analysis so do the working environment problem. All problem symptoms which relate to order loading out failing problem will be described below.

<u>The main direct problem symptoms</u>

There are four main direct problems which affect the failure of product loading process. Three of these problems involve in the picking process which is the significant step of warehousing process. Another one is in loading process which requires skill and experience of worker.

- **Hard to reach to the required product**

  - Warehouse storage uses the pallet laying on floor method. The layout arranges in row from each side of wall and each row may have a number of series pallets depending on deep area available. If the required product is stuck in the back, to get it will have to move away all pallet in front of it and move back. The more required product position spread in warehouse area is

the more difficulty and workload in put away activities during order picking process.

This problem causes a long time picking until cannot finish picking order then failing product loading in time.

- **Long time searching process**

- The first step of current picking order is searching process in this case the worker will walk through all warehouse area to find required product follow the order instruction then check the production lot detail to make it first-in-first-out. After the worker walk around and list in short note, the checking process is done and come up with the lot detail for each list in order. This searching process step takes long time. For example, for all warehouse area checking stock with full product stock, the searching time will take more than two hours. For scanning checking based on one order instruction with 5 product lists, the searching will take about 30 minutes or more. Moreover, this searching may have to repeat again and again and it frequently comes up with failing result as cannot find the requested product in warehouse at the end.

The bigger of searching area is the higher time for searching process. Searching process in this warehouse always has to scan all of total warehouse area because of no any product storage category for the route guideline. The warehouse searching process is an important part of ABC warehousing process but it turns to be one weak point that leads to warehousing order loading fail as the long time processing and cannot finding the required product. The required product missing problem and the long time searching problem are close-related to each other. This problem symptom comes from untidy warehouse problem, the product missing problem and the weak ability to check warehouse stock and status. It is a high frequently one comparing to other of the main problem symptoms that directly lead to warehousing failure.

- **The required product missing**

- The required product missing is the incident that cannot find the required product. It takes many resources to handle after it was occurred. As the business process model showing that production plan create from input required order information in schedule so the missing product should not just disappear from all process but it is hard to find where the missing product go

in this case. The recording information of this warehouse not supports the checking backward for each single product lot units in and out as the recording keep in order instruction document and production report document with date ordering while the accounting information system providing only the total number of quantity product in/out which is obstacle to check product flow. Two involving causes of this problem are the inaccuracy information system and the weak ability to investigate warehouse.

The necessary point is to define why this problem happens and how to handle it then get rid of the organization process weakness that risk to product missing. Therefore, the first important question is the product stuff missing or the number error or the product is hidden among the huge product pile in warehouse.

The order instruction is the agreement between company and customer to sending the required product with the required quantity at the dealing loading time. The required product missing means that the company cannot make the order instruction done as commitment. This problem may not give a direct effect to company sale but it affect to the customer royalty and waste the resource to reprocess or revise order instruction.

This problem may causes to result warehouse process fail or long time searching then failing product loading in time.

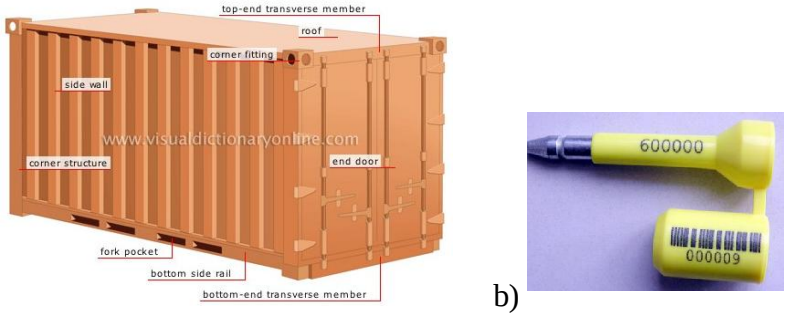
- **Mistake during loading process**

- As the loading process is not just put all product in container but it is need the calculation skill and experience skill from stuff to make all step right at first time cause rearranging one container is not an easy job. The worker who controls loading process have to design placing form and to calculate the number row and layer. The difficulty of this job is to mixing product package size with the different ratio and the surface inside container is not smooth as a cubic. The inside container have some bulging area. The product cartons that pile up in layers will be flat down. The calculation has to concern the limit factors of each packaging type in layer up.

This problem symptom not usually happens. It causes from human error and lack of worker skill. The mistake is not only the activity transferring into container but including the pre container checking and the after checking

process. The closing process is one that is easy to be mistaken. Each door latches have to checking that both top and bottom ending getting into their joints before putting the container seal lock which is specific code, one time use and expensive.

This problem can cause to failing loading in result if it is cannot loading entire product list as order instruction in time.



a) b)

Figure 4. 7 The picture of container feature (a) and seal lock (b)

The indirect problem symptoms

There are also three indirect problems to failing in product loading process as the commitment

- **Untidy warehouse environment**

  - In warehouse, there are no locations or zoning. All product stuff mixing places in warehouse room without any category. Every carton box upon pallet unit look similar to each other so the worker have to go standing in front of each pallet unit to see what product code is and what product being locked or not. For the searching process, which may run for stock checking or order picking, there are no clues to start or to narrow scope. The worker has to walk through all warehouse area and write a short note to check how much the required product is and how many the required product lot is. Many lots of one product code can be split out to many places in entire warehouse area (two rooms). The groups of picking product, which is locked for preparing process to load, may be placed alternately with receiving product or long-term storing product. Even though it is a lock document label on it to identify, it is still need long time searching especially the loading worker isn't the one who done these order picking. It is not only the long time searching for the

required product in picking and loading process but it also including the long time searching for the available area for placing product at the receiving and put-away storage process.

The untidy in this case didn't mean to messy appearance but it mean to orderly arrangement. This untidy warehouse environment make easy to confuse and error in warehousing process. The product is alternately placing in warehouse not only product code but also the product lot and the status. It will lead to error and long time in warehousing process at last. Moreover, this problem also affects to difficulty in product stuffs movement in warehouse.

- **Invalidation and inaccuracy information of warehouse**

- The information number from warehouse is always error. The number accounting balance not matches to the real stock inventory and not relate to warehouse activities. This problem symptom relate to error in production plan and the product missing as actual production will not relate to customer order and then stock information error again. Furthermore, the number adjustment and stock checking is frequency implementing during work process so that warehousing process flow will be interrupted. There is no accounting balance for product lot detail in warehouse, it is just the number show present status for communicate to outside department but useless for checking and easy to error. Warehouse stuff record balance number of each lot detail in the excel file then input the new balancing number replace the last one when the product flow in and out warehouse system. The warehouse lot detail information is invalidation so it is hard to find how the balancing number of each product lot detail comes from and cause to trouble in investigate warehouse failing problem.

As the only product lot detail data base is the stock balance short note in excel file, which is inaccurate, when the requirement of lot detail information come, warehouse stuff have to walk around warehouse area for investigate all stuff by scanning the focusing product then listing the lot detail inventory data until got all product in the requirement that is how the result product lot report come from without pre-information to cross checking unless the total number of all product lots from organization accounting system.

Moreover, the untidy warehouse environment lead to easy to error in report from stock detail checking and also hard for all products stock checking.

This problem symptom is the main effect to the ability to investigate warehouse and also close relate to the untidy warehouse environment.

- **Weak ability to investigate warehouse detail stock & to evaluate warehouse situation**

  - Warehouse spends a lot of time in investigate process but it always implement after the error found and cannot tracking to a cause. As an inaccuracy information and untidy warehouse, to investigate warehouse needs long time to re-checking and adjust an error.

  All products that come from production will be sent into warehouse for storage with no any concerning order instruction or where it should be at the loading stage while the order-picking will not start until near to the loading date by check all product lists available in warehouse firstly. If the problem incidents such cannot picking or find the required product happen, it should take action as fast as it can to increase ability to get rid of the failing warehouse process risk. The investigation cannot check product lot detail flow in warehouse as the invalidation of the detail stock information and also untidy warehouse. The validation of information has to get from the document history files which are the receiving from production report and the loading report. The receiving from production report and the loading report was keeping by date ordering so to create one product code detail balancing isn't an easy job. At the end warehouse will usually adjust the new balancing without defining cause of error.

  This problem symptom is the main effect to the product missing problem symptom and also weak accuracy of stock information as it cannot define the cause of error and get rid of it in long term.

4.5.2 The Relation Diagram of warehousing problem

As the relation diagram is a special tool that is prominent in ability to link all sub-cause in all direction. The relation diagram will be using to explain the relationship of all fussy sub-problems that always happens in warehouse and lead to the process failing in high peak period of finished goods warehouse. This research is

focusing on the effective warehousing process, which means to load finish good out following customer commitment. At the beginning of this study, it founds that the main problem of warehousing fail are order-picking fail or it not ready to loading product out follow the schedule. If order-picking fail, the warehousing result will fail at the end of process.

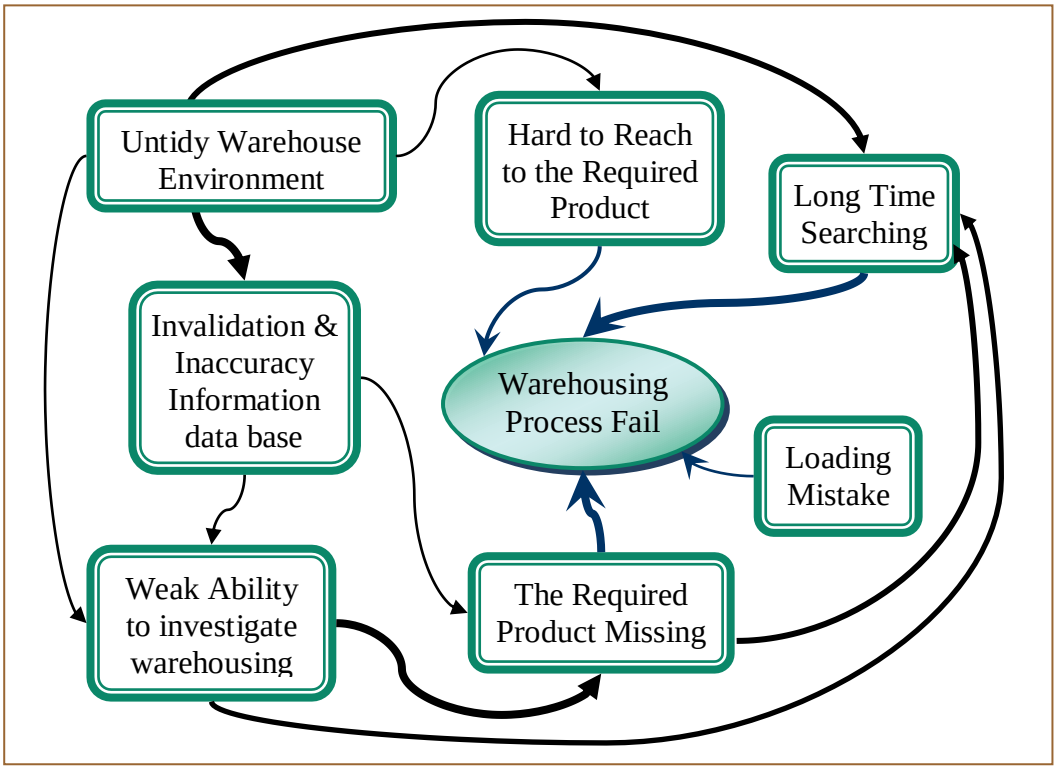


Figure 4. 8 The relation diagram of warehouse process failing problem

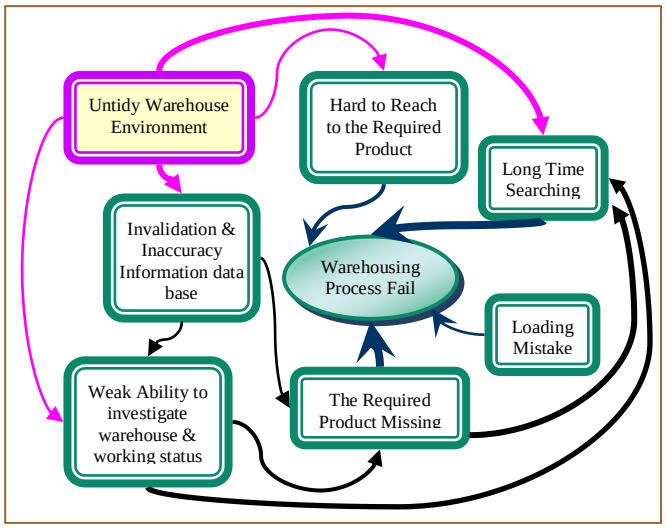
From historical data, warehousing fail also come from another reason which is loading mistake. Anyways, the warehouse process failing from loading mistake is rarely happen compare to order-picking fail. The order-picking fail come from three main roots which are long time searching, the required product missing and hard to reach to required product.

The diagram is created by drawing all problem symptoms and linking the relation of each problem boxes by arrows. The head of arrow mean to effect while tail of arrow mean to cause so that the box that has many arrow tails out from is the main root cause of the problem. To solve the root problem symptom will reduce all effect of many connection problem symptoms that come from the root then the main problem will solved at the end. The significant root is the box that holds the most of major arrow tails.

An overall picture was given by reading the diagram following arrow route which pass through many nodes (problem boxes). Warehouse process fail as cannot loading the required product follow order instruction in loading time usually comes from long time searching, hard to reach to the required product, and the required product missing. As these causes lead to failure of order fulfils in picking process that mean to not ready to load then failure in loading process at the end. There is also the mistake during loading which create reprocess or process breaking gap then lead to time fail at the end too. From the diagram, the loading mistake is only one box that no links to other problem symptoms so that this problem symptom will be consider separately.

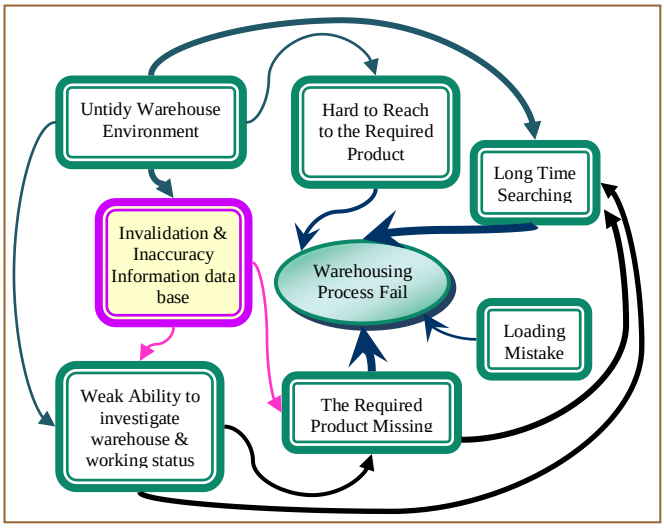
The conclusion of diagram meaning

The relation diagram of problem symptom shows that there are three boxes which have many arrow tails come out from them. Those three boxes are Untidy warehouse environment, invalid and inaccuracy information and weak investigate & monitor ability.



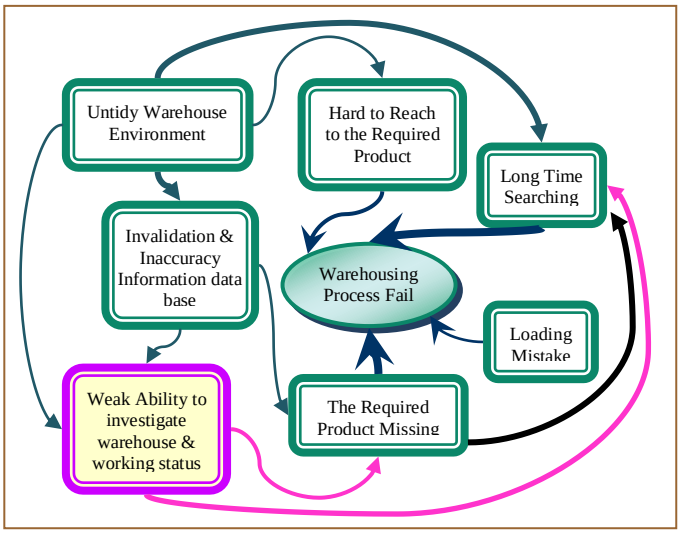
Untidy warehouse environment is the first root of significant problem symptom as the chart show that it is the main root cause of the most problem symptoms by the most arrows come out from its box and effect to other problems then process fail at the end. It cause to other four problem symptoms which are long time searching, hard to reach to the required product, weak information data base and weak ability to monitor and investigate.

Figure 4. 9 The relation diagram of first root warehouse process failing problem



Secondly, weak information data base error; as the untidy warehouse environment makes it is difficult to relate the inventory number to real stock as no categories so that it cause to this problem. This problem also got an effect from weak ability investigating warehouse. This problem causes to a frequency product missing as the gap between real stock and inventory number.

Figure 4. 10 The relation diagram of second root warehouse process failing problem



Weak monitor & investigate ability is the third root problem symptom which is cause from weak information data base (2nd) and untidy warehouse environment (1st). It causes to the longtime searching and product missing.

Figure 4. 11 The relation diagram of third root warehouse process failing problem

The first root problem is the main point that causes to major other problem and most effect of the main topic problem. To cut this first root problem out will solve the main problem by reduce the major effects that lead to the problem but to get rid of this first root problem may be too difficult to solve so that it may need to get rid of the nearly step problem such a 2nd and a 3rd root problem before solving it, as those root problems are close relating to the first root problem so that solving those problem will support in solving 1st root problem.

4.6 The Root Cause Problem

The problem symptoms, which are usually occurred and leaded to warehousing process fail, was clarified by the relation diagram in the previous 4.5 topic. Then, this topic is to find out the root causes of the problem by using the why-why analysis tool. After that the evaluate of each root cause will be implement then how-how analysis will be used to find solution in the next part. The significant root problems from the previous part are Untidy warehouse environment which is the problem in physical structure, Invalidation & inaccuracy Information data base which is the problem in Information system view and Weak ability to investigate warehouse & working status which is the problem in the operation and procedure view that why in this part will be divide into three main topics to be easy to Understand.

The Why-Why analysis diagram

Why-why tree diagram start by setting the problem at the head left side and ask with the Why? question again and again until lead to the root cause of the problem or no answer for it. After that, reading backward will be used to checking the link between nodes again. The root problems which are the ending nodes from the relation diagram are the start problem in this part to find what their root causes are.

The root cause evaluation factors

The root cause evaluation is considering by analysis the demand and production characteristic then compare the following factors.

- The probability of occurrence for a root cause and leading to be the main problem
- The potential impact from each cause to the main warehousing process fail problem in case of each problem symptoms from root cause incidents occur

The first root of significant problem symptom is the most cover all effect that leads to warehousing fail so that why it was choose for the beginning of root cause analysis.

The Physical Structure: the untidy warehouse environment problem

The Why-Why analysis diagram of untidy warehouse environment

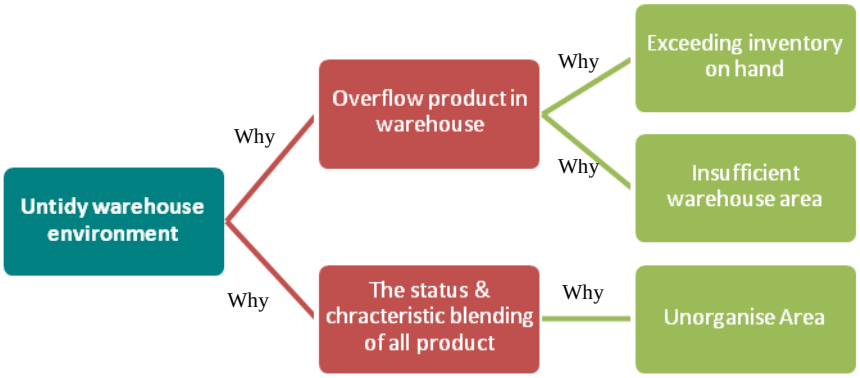


Figure 4. 12 The why-why tree of untidy warehouse problem (1st root problem) before evaluation

This above figure shows the reason why warehouse environment is untidy and lead to difficulty in warehousing activities. The untidy warehouse environment is the situation that product is crowded mixing in warehouse area (2 rooms). The two possible answers that are why product is crowded mixing in warehouse area are overflow product in warehouse area and the high blending in status and characteristic of all warehouse products. The overflow product in warehouse area can come from the exceeding inventory on hand or lack of warehouse area. In the other hand, if ask the question why products are high blending in overall warehouse area, the answer will be there is no area organised policy in warehouse. Next part is an evaluation for three ending root causes at the right side of the chart.

Exceeding inventory on hand

As this business strategy is "make to order" and the production plan created by mixing customer order and adding only 0.5% error in necessary case, the exceeding inventory should be very low. This cause is not the root cause of this case warehousing problem as it cannot lead to overflow in warehouse or it have very low effect to untidy warehouse problem.

Lack of Warehouse Space Utilization

The warehouse capacity area is under the demand requirement but this period, which product is going to overflow in warehouse, is only 2 months in the total 12 month and just a little bit higher. This lack of warehouse space is the root cause of this

case study main problem but its effect is low level comparing to other and occur in a short term.

Unorganised warehouse area

The current area utilization of ABC warehouse use the random method for keeping stock no any category for grouping product units in warehouse and no area zoning for warehousing activities especially the receiving, the picking and the loading area which relate to stock status. Moreover, there is also no position identity in all pallet area layouts. It means that both product characteristic type and product status is blended in overall warehouse area like a huge jar of many variety candies. All activities random using the warehouse area make the product items flow block the way of each other and cause many warehouse difficulty problems such a big area boundary in searching and checking and a easy to confuse during working.

This unorganised warehouse area is the root cause of this case study main problem as it relate to untidy environment in warehouse with a high impact level as it send many difficulty effect to warehousing process.

<u>The Physical Structure Root Cause</u>

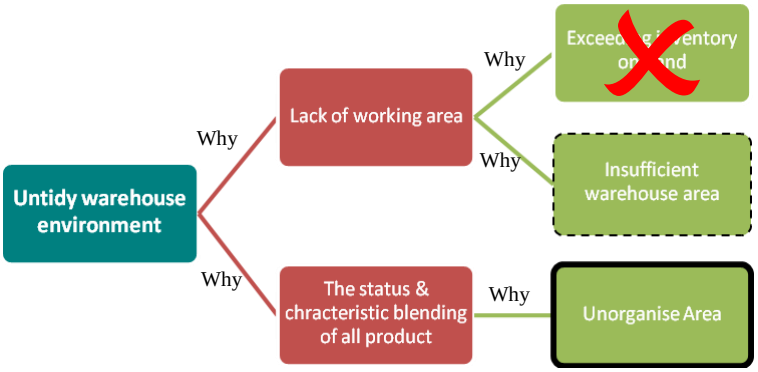


Figure 4. 13 The why-why tree of untidy warehouse problem after evaluation

In conclusion, the evaluate shows that the root causes of untidy warehouse environment problem are the unorganised area and insufficient warehouse area while exceeding inventory is not the root cause of this problem. The unorganised warehouse area is higher priority than insufficient warehouse area as it much more relates to the effect that lead to the problem and insufficient warehouse area also create an effect in the short period.

The Information System: the invalidation and inaccuracy information data base

The Why-Why analysis diagram of invalidation and inaccuracy information data base

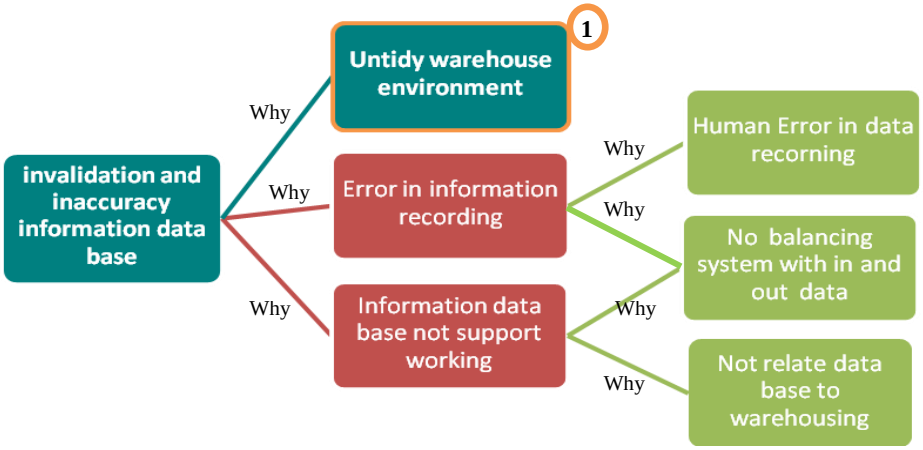


Figure 4. 14 The why-why tree of invalidation and inaccuracy information data base problem (2nd root problem) before evaluation

The above figure shows the reasons why the information database is invalidation and inaccuracy. There are three mains causes which are untidy warehouse environment, error in information data recording and information database not support working. For the untidy environment root cause analysis is already mentioned in the previous part, this cause is lead to difficulty and error in the stock checking and information transfer so it is the cause of this problem. Next, Information recording is usually error then leads to in accuracy of information database. The reasons that why information data recording is always error are the human error and also relate to the bad recording system which is no in and out background as it make an easy to error. Another cause of the information database not supporting work problem is the database is not related to warehousing work. The validation of information which means to specify which number comes from is important as it is many variables of stock changing in warehouse. As the information data base is not support warehousing activities so it is also hard to check the error compare to actual product flow in warehouse. If it cannot define the cause of each error, it will hard to reduce an error or to prevent the next same error situation.

Human error in data recording

The human is the basic root cause of the error problems. The error in warehouse data which is always happen is usually cannot define where the beginning of error is so that it is more relate to the bad information system than human error.

No balancing system with in and out data

The recording system that is no in and out background history leads to be easy to error at the beginning. This cause is the significant reason obstruction in the checking and correcting the number error. The number error is the cause that leads to the long time searching and the missing product which are the difficulty order picking process.

Not relate data base to warehousing

The information data base system is not relate to the actual warehousing process and stock because it show only the overall data but it cannot providing any the detail data such the positioning or status to support the significant warehousing activities which is order-picking. It also causes the difficulty to see the warehousing work progress. The product statuses are available as just coming or short holding or the long term holding or and unavailable as locked status of reservation's product for waiting to loading. The not-relating warehousing database also show in the unit using which is in carton for excel file and piece single product unit in accounting data system while the warehouse use the pallet in main transferring unit.

<u>The Information System Root Cause</u>

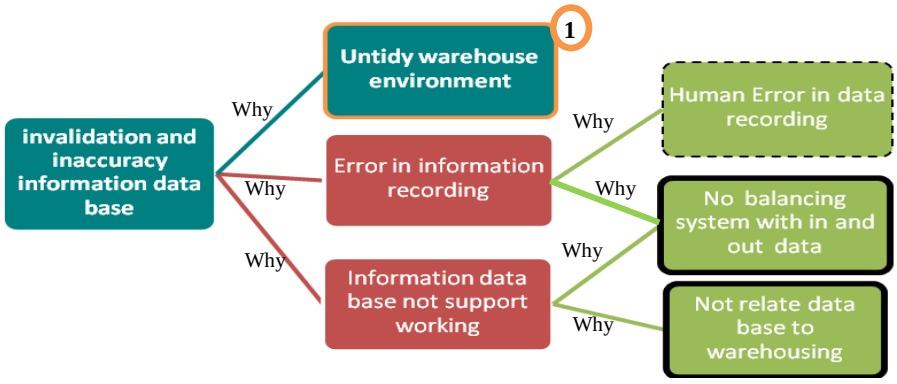


Figure 4. 15 The why-why tree of invalidation and inaccuracy information data base problem (2^{nd} root problem) after evaluation

In conclusion, the evaluate shows that the root causes of invalidation and inaccuracy information data base problem are the no in-and-out recording of balancing data and the unrelated data base to warehousing process while the human error in data recording is also the root cause of this problem but its effect is low compare to the two before causes.

The Operation: **weak ability to investigate warehouse mistake in loading process**

The Why-Why analysis diagram of weak ability to investigate

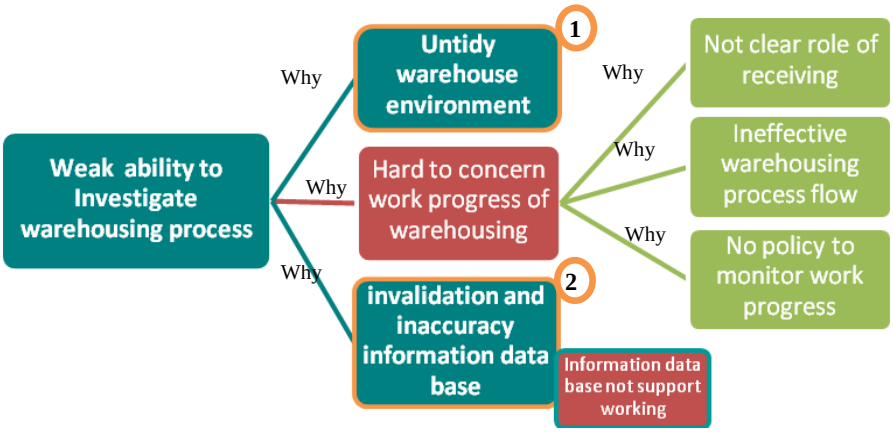


Figure 4. 16 The why-why tree of weak ability investigate problem (3rd root problem)

There are three main reasons which lead to difficulty in investigating warehouse situation. First and second are the untidy warehouse environment and the invalidation and inaccuracy information data base which lead to difficulty of investigating process. These two reasons had already evaluated their root cause in the previous part. Third reason is the hard to concern work progress of each order instruction or each warehousing stage. There are three root causes that lead to hard in concerning warehousing progress which are the unclear role of receiving process, the unlinking of overall warehousing activities flow and the no policy for monitoring product stock and work progress in warehouse.

As the "make-to-order" strategy, the overall manufacturing process, which starts at the order coming from customer until the loading out, is like one project that the result is already clear.

Not clear role of receiving

The current receiving process of warehousing is no responsibility and unclear the work instruction. This is lead to many difficulties in investigation. Moreover, the unclear role of receiving is also relate to the storage stock update then the error checking difficulty and also relate to blocking the picking product in warehouse then the order picking difficulty. This cause is one root cause of warehousing fail problem as it relate to the weak warehouse investigating process and it may lead to the product missing, hard to reach to required product and longtime searching which are the main problem symptoms of warehousing fail.

Ineffective warehousing activities process flow

The warehousing activities process flow in this case warehouse is ineffective because it cannot refer to the real detail of the finished good product flow. The previous warehouse activity always base on the experience and skill of the shop floor warehouse stuffs and not transfer to the next generation so the warehousing process is rely on only a few stuffs. Then, if this stuff is out of work with any reason, the warehousing will be sensitive to build problem symptoms and may lead to warehousing failure. The warehousing activities process is lack of link point between each activities step. It also leads to not awareness of the bottle neck point that is sensitive to make the overall warehousing process failure. This is also obstacle to the warehouse evaluate for improving process as cannot investigate warehouse profiling.

No policy to monitor work progress

There is still not the rule for monitor the work progress of order instruction through the warehouse system so that the failing problem will not be aware until nearly the ending step of warehousing process. All products that come from production will be sent into warehouse for storage with no any concerning order instruction or where it should be at the end of product flow. The order-picking usually not be started until near to the loading date and all products in order list available in warehouse. To monitor work flow to follow loading time is part of risk management.

Ability to monitor work flow in warehouse is weak. Warehouse cannot tell the order working status such as 60% of order list come in warehouse or 50% is already picking. To see progress of each order status is the way to manage risk as the work lead or lag to the suitable plan. If the process failing happens, it should take action as fast as it can to increase ability to get rid of the failing warehouse process risk. Example of the product missing case, it should be aware as there are no required product in the coming list from production plan and also no in the stock inventory not just be aware at the picking period near to loading time. As no monitor policy, the warehouse investigation will be weak.

This cause is one root cause of the weak warehouse investigating process and it may lead to the warehousing fail problem as it relates to create the warehousing problem symptoms at the picking process which is usually the bottle neck warehousing process and has a critical time frame.

The Why-Why analysis diagram of Mistake in loading process

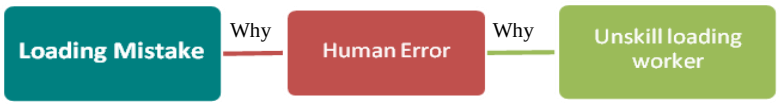


Figure 4. 17 The why-why tree of loading mistake problem

This above figure is the root cause analysis of the loading mistake. The loading mistake is usually come from human error which is arrange the carton in the wrong way and have to re-loading again. The human error of loading control stuff is cause from unskilled worker. This problem usually occurs when supervisor stuff out of working and while the working stuffs that are new. So, the root cause of loading mistake problem is unskilled of working stuff.

Unskilled in loading process of stuffs

The loading process control needs the calculation and the 3-dimension-model imagination skills to design the loading pattern. This cause is rarely to be happened so it is the low impact to the main problem.

The Operation and Procedure Root Cause

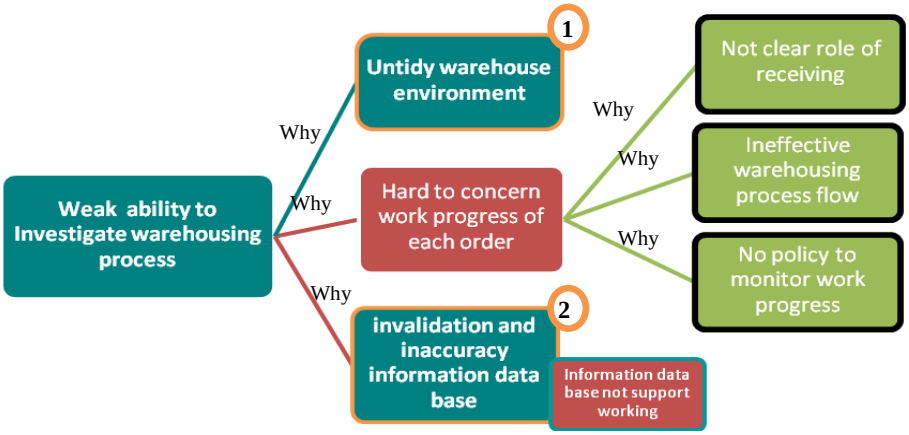


Figure 4. 18 The why-why tree of weak ability monitor problem (3rd root problem) after evaluation

In conclusion, the evaluate shows that weak ability to Investigate warehousing process problem are three root causes. First is the unclear receiving which are no work instruction defining. Second is the unlinking of overall warehousing activities flow root cause. Lastly, the third root cause of this problem is that warehouse doesn't have the monitor process in concerning work progress.

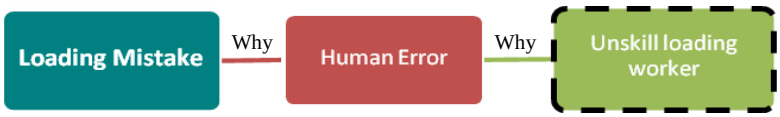


Figure 4. 19 The why-why tree of loading mistake problem after evaluation

The root cause of this loading mistake problem is unskilled loading of stuffs but the loading mistake is not always happening.

4.7 The Problem Solving Analysis

This part is problem solving analysis by using the how-how analysis technique. The previous part analysis and evaluate the root causes of the warehousing fail problem by using the why-why analysis tool and the current warehousing process background. After the evaluating of the previous part by separate into three main topics, the physical structure has two root causes. The two root causes which relate to the main problem as warehousing fail are lack of warehouse area and unorganised warehouse. The information system has three main involving root causes which are human error in data recording, no balancing with in & out data and not relating to warehousing of data base. The operation and procedure has four root causes which are not clear role of receiving, ineffective warehousing process flow, no policy to monitor work progress and unskilled loading stuffs. It is three root causes of the picking operation and one the loading operation respectively.

The How-How analysis diagram

How-how tree diagram start by setting the root cause problem at the left side and ask with the How? question such how it become the problem root cause or how to get rid of the root cause of the main problem, and then define the solution of root cause solving.

The solution evaluation factors

This research is the warehousing process improvement which is focusing on the warehousing process fail problem. From the root cause analysis, it show many root cause relating to the main problem focusing so to choose the result way of improvement have to set the evaluate factors firstly. These are the main factors which using in considering the solution choices of the warehousing process fail problem.

- Cost of investment

  The cheaper is the better choice. The company is running the investment in product development and production improvement so that the management policy is still no budgets investment for warehouse improvement in this period. This is the second importance evaluation factors for this warehouse problem solution analysis.

- The effectiveness

  The effectiveness is the most importance evaluation factors as it relate to the target result for this warehousing process improvement by reducing process failing problem. The effectiveness is considered by the relating of root cause of the problem and the weight of each root cause effect.

- The future benefits

  Even though the company isn't approval investment for a warehouse improvement project in this period but the management is still interesting in warehouse improvement project in future such as new technology implement or re-building warehouse area. If the solution choices are more benefit for future developing project, it will be better in considering.

- Easy to implement

  This factors concern in the impact to existing work flow. The warehouse improvement solution should not be interrupt to overall manufacturing process.

The root causes analysis with how-how technique will be placing follow the why-why analysis from the previous part to create the Why-How chart for each warehousing problem symptoms. After that all of the root-cause analysis will be put into the total table hierarchy of root cause analysis for clear the overall picture of warehousing cause and effect problem analysis. Lastly, each root cause will be evaluated by the evaluate factors.

The Physical Structure Root Cause

The root causes that found in the physical structure topic are the unorganised area and insufficient warehouse area which are the cause of the untidy warehouse

environment problem. The unorganised warehouse area is higher priority than insufficient warehouse area.

The solving of insufficient warehouse area is to increase warehouse area. It is many ways to increasing the warehouse utilize space such build the new warehouse structure for expanding area or implement pallet rack and shelf or other warehouse equipment for increasing the usage area.

As unorganised warehouse area root cause is the situation that there is no any policy in warehouse to group total warehouse holding products into sub-groups and lead to difficulty in warehousing process so that to organize warehouse area is the solving of this root cause. If ask the question how warehouse area are not organizing, the answer will be there are no any policy of zoning, categories and positioning in this total warehouse area. To organize warehouse is three main methods which is the activities zoning, product grouping and customer grouping.

The physical structure root cause result will be shown in the below chart which is using the Why-How question analysis method. In the chart, the purple box refers to the problem solving method while the green refers to the root cause.

The Why-How analysis diagram of untidy warehouse environment

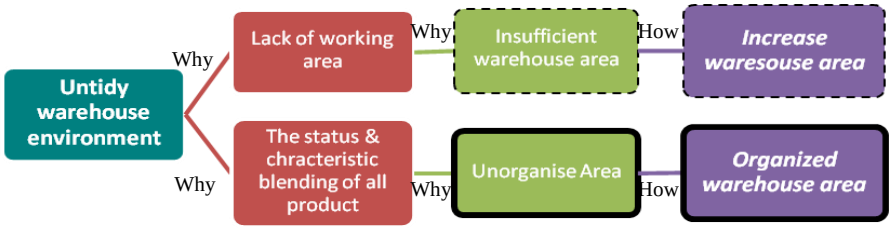


Figure 4. 20 The why-how tree of untidy warehouse environment problem

The Information System Root Cause

The root causes of invalidation and inaccuracy information data base problem are the no in-and-out recording of balancing data and the unrelated data base to warehousing process while the human error in data recording is also the root cause of this problem but its effect is low compare to the two before causes. These root causes will be asked the how it can be reduce or disappear to find the problem solution method.

Human error in data recording root cause is come from the lower skill in accounting and computer office excel program basic so that one method to reduce this root cause is to set up training program for the office stuffs.

No balancing with in and out data is cause to an easy to error of stock balance recording. This root cause can be cut out by set the new balancing with in and out recording back ground history by set the keeping history period such for 1 month in example.

Data base not relating to warehousing root cause is solving by set the data base recording system in detail which can relate to warehousing stock. Even though it is already define the way to solve this root cause, but to design the warehouse data base detail needs to define the detail warehousing flow before.

The overall conclusion of information root cause analysis is shown in the figure 4.20

The Why-How analysis diagram of invalidation and inaccuracy information data base

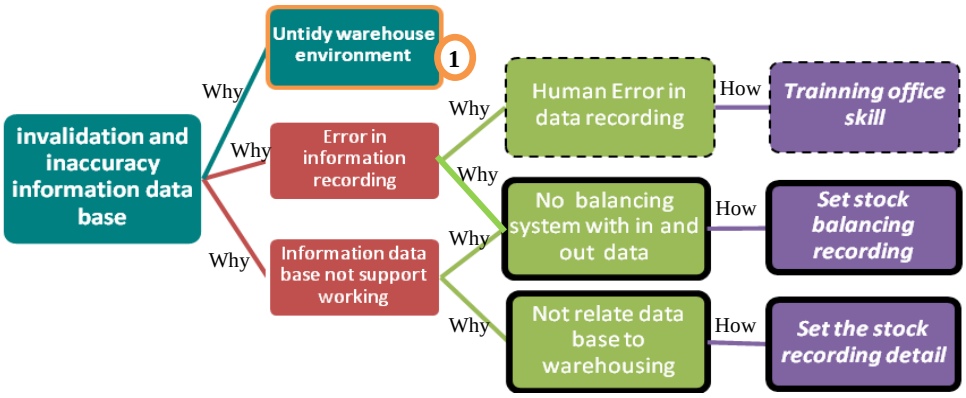


Figure 4. 21 The why-how tree of invalidation and inaccuracy information data base

The Operation Root Cause

The topic of why-why operation shows that there are four root causes. Three is come from the weak ability to investigate warehousing process problem while another is come from mistake loading problem. The weak ability investigation warehousing process problem are the unclear receiving which are no work instruction defining root causes, the unlinking of overall warehousing activities flow root cause and lastly the no monitor process in concerning warehouse work progress. The root cause of the loading mistake problem is unskilled loading of stuffs but the loading mistake is not always happening so this cause is the low impact to the main problem.

The first root cause in this topic is the not clear role of receiving process which its solving is to set the receiving work instruction.

An ineffective warehousing process flow is the root cause which is unlinked between each sub-processes of warehousing activities. The overall warehouse work

process flow is the main four ordering activities processes (receiving, storage, picking and loading). The receiving and storage which are not concern the link to the picking process create to the critical situation in picking process. To solving this root cause is to revise the warehousing process flow for improving overall process.

No monitor policy in warehousing process is another root cause of warehouse investigation problem under the warehouse operation topic. As the higher sale volume each year the warehouse also has to managing under the more work load so the monitor policy is become more important. Set monitor policy in warehouse is the solving method for this root cause.

Lastly, the unskilled warehouse loading stuff root cause is the situation that the loading stuff is lack of experience in the loading process then cannot control loading process to be finished in time. The training course for warehousing stuff in the loading skills is required in cutting out this root cause. However this is low impact to the main problem.

The conclusion of root cause in operation topic will be separate into two Why-How analysis chart bellowing.

1

The Why-How analysis diagram of weak ability to investigate

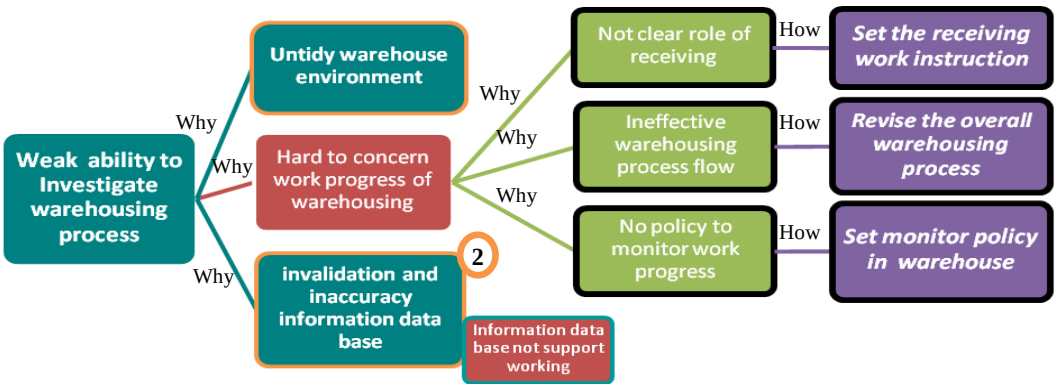


Figure 4. 22 The why-how tree of weak ability to investigate

The Why-How analysis diagram of Mistake in loading process

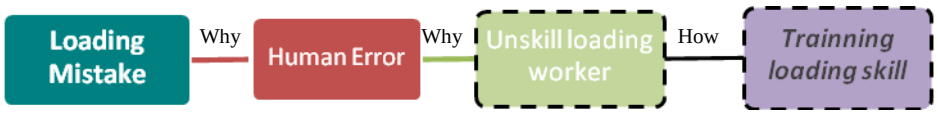


Figure 4. 23 The why-how tree of loading mistake problem

4.8 The Problem Solving Evaluate

From the Why-How analysis diagram, it can be concluded that there are 9 possible ways to solving the 9 root causes that involve to solving the warehousing process fail problem. The 9 problem solving way are To organize ware house area, Increase warehouse area, Training office skill, Set stock balancing recording, Set the stocking status, Set the receiving work instruction , Revise the overall warehousing process ,set planning process in warehouse and Training loading skill.

First evaluation cutting out the low interesting solving choices.

For the first evaluation, the nine root causes solving methods will be choose to be only six solving methods by cutting out the root cause solving methods which are the low impact to the main problem and is not relate to the significant root problem of the main improvement focusing. The cutting three root causes solving are increase warehouse area, training office skills and training loading skills.

Increase warehouse area

- The reasons to cut out this root cause solving out are the high investment need in this implement and the low impact of its root cause. The warehouse overflow comes from a little volume of demand above the warehouse capacity and it also only two month that it trend to be happened.

Training office skill

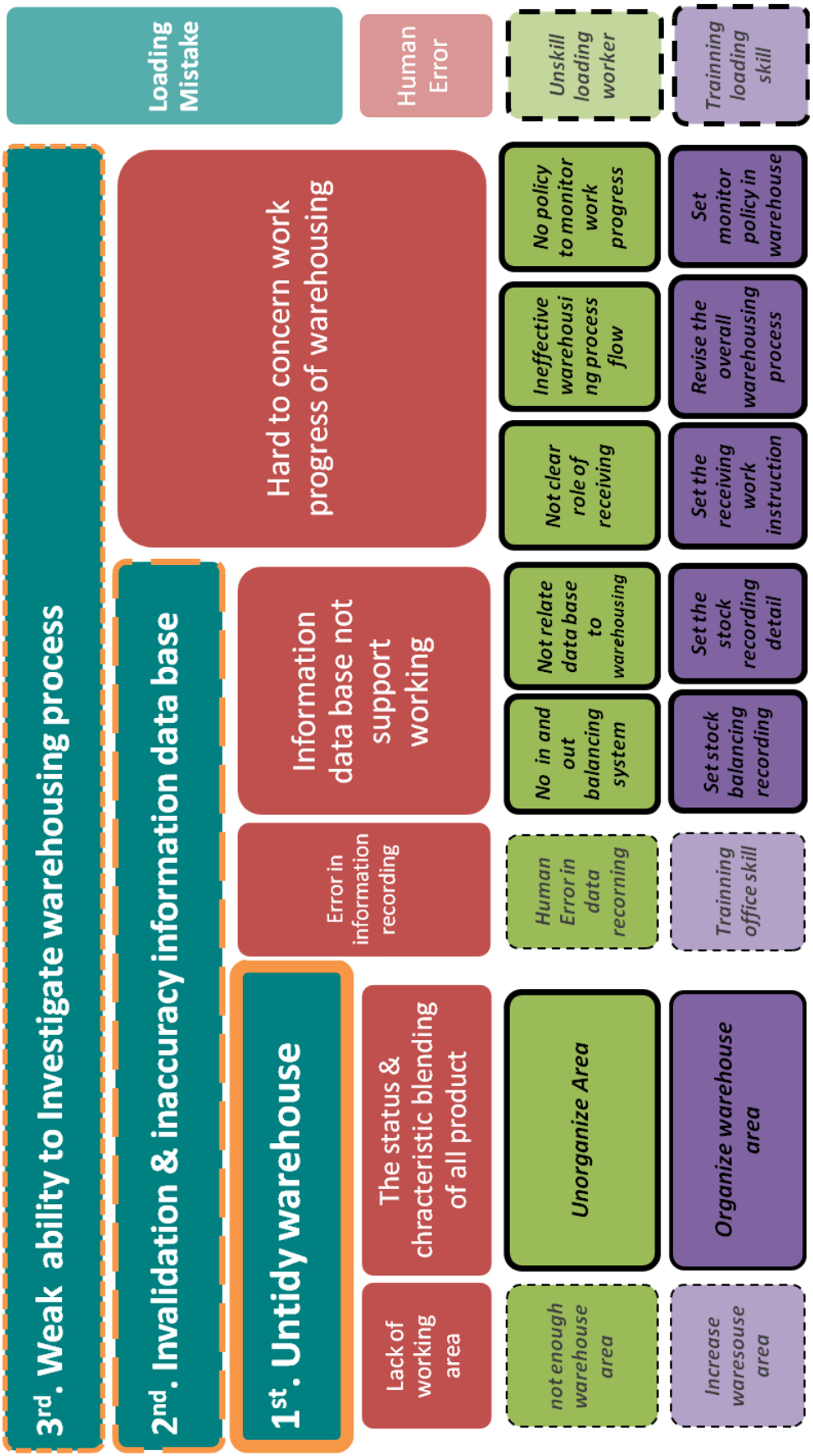
- The human error is related to man more than method. Moreover, this case the recording error is also get a lot effect from the bad data system so it will be more important to get rid of the effect from the method in information recording first.

Training loading skill

- The human error is related to man more than method. Moreover, this case is under the loading process which is low effect to the main problem compare to the pre-loading warehousing process. The mistake during loading process is also not the significant root problem in this case study.

The three cutting and six passing of root cause solving will be shown next in the hierarchy table of conclusion.

Table 4. 1 Overall hierarchy of warehousing problem analysis



The overall problem solving result

The overall problem solving result, which is concluded in previous problem analysis and evaluation, is shown in the overall hierarchy table of root problem analysis (Table 4.1). The table hierarchy of root problem analysis shows the relationship of all root problems, its causes and its solutions. The upper problem statements are the effect that causes from their under lower level statements.

Second evaluation to find out the detail for the passing solving choices.

The next step evaluation is the objective considering of the passing six root cause solving choices. The six passing solving choice will be discussing as their individual conclusion concepts bellowing.

- ***To organize warehouse area***

This is about to create the guideline structure in warehouse area utilisation. The guideline structure' objective is the benefit managing in the outgoing warehouse product flow. It relates to reducing the waste time of searching or reaching step in picking process.

- ***Set stock balancing recording***

This is about to create the history of stock balancing recording which is the error prevention and the backward number validation checking whereas the existing detail balancing database in excel file is just the short note. This solving choice is the adjusting of balancing recording method to have the history background.

- ***Set the stocking recording details***

This is about to link the stock information to the actual warehousing stock. This solution approach in the previous part shows its objective in control and checking the warehousing stock and situation. This is going to depend on the warehousing control policy.

- ***Set the receiving work instruction***

Not considering work role of receiving and also storage leads to the untidy warehouse environment then the problem at the order-picking especially the searching and checking process. This solving is to set the work principle for paying attention on the inbound warehousing management which is receiving process. This purpose

relates to how to manage inbound pattern for supporting the product reaching, checking of the outbound or picking process.

❖ ***Set monitor policy in warehouse***

This is about to set some policy for monitoring overall warehouse profile by divided it into sub channels such as the product category or warehousing status or customer grouping. The method using of this solution will be related to the method for organised warehouse area solution. This creates the pattern of warehousing profile flow which is benefit to the warehouse investigation while any warehousing products in the current warehouse can be move to any position of warehouse area and it can be any warehousing status.

❖ ***Revise the overall warehousing process***

The previous warehouse activity always base on the experience and skill of the shop floor warehouse stuffs and not transfer to the next generation worker so it is necessary to develop the standard work flow for making the warehousing process more stable to control.

Third evaluation to find out the overall solution concept.

The last evaluation is the opportunity considering of the solution from the concept of six passing solving choices.

The choice of organised warehouse area is the most significant influence in this case study as it affect to all three significant root problems and it is the only one relating to the first significant untidy warehouse problem. Another four choices also have to concern their concept association to this choice first choice unless the stock balancing recording which only relates to the number error problem. So that, the organising warehouse area topic will be analysis more in the detail to find the main concept for overall solution direction.

There are three main methods for organize warehouse area to improve the searching process which relate to the significant warehousing problem.

- Firstly the activities zoning policy to separate overall warehouse area into the sub-zone reduce area boundary in the product searching and reaching process.

- Second is the product category policy such as the product type or product code or customer base.
- Third method is the position allocation policy to reducing the searching time but this method need to recording the position of all finished goods warehouse holding stocks.

To evaluate these three methods for the main warehousing improvement concept selection need to analyst the warehouse flow profile.

The product profiling in warehousing process analysis

As the product is the main flow in warehouse department so the product profile in warehouse is the best picture to represent the actual warehousing process. There are two main factors influence to the flow inside warehouse that are the customer demand and the production. This product profiling analysis will be show by the demand characteristic analysis in the beginning then the production detail and the history product flow.

The demand characteristic analysis

The demand characteristic will be show on the sale characteristic and the customer characteristic order.

Table 4. 2 Table of total demand distribution

DESCRIPTION OF GOODS	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
1000ml UHT (12x1000ml.)													
200ml UHT (36x200ml.) A													
200ml UHT (36x200ml.) B													
240ml. CANNED (30x240ml.)													
240ml. CANNED (24x240ml.)													
315ml. CANNED (24x315ml.)													
250ml CANNED (24x250ml.)													
200ml Glass Bottle (12x200ml.)													
720ml Glass Bottle (12x720ml.)													
Grand Total													

Table of total monthly demand distribution shows the demand distribution by using the product main package type and the monthly time line in categories data and using the pallet as the analysis unit. This total demand in pallet unit table creates from collecting the demand from domestic and export. Firstly, demand quantity will be

summarized in carton units as the unit of order history recording then use the factors as unit transfer from chapter 3 to transfer to pallet unit as the unit base in the warehouse storage system. The overall picture of the demand will be divided by the main package type firstly to see the ratio of the package type then the size of package. The quantity bar chart in each cell comes from setting the conditional formatting rule to compare each monthly sale volume of the same packaging types.

From this table chart, it shows that the demand is usually seasoning in each product package along monthly timeline. Moreover, the ratio of the package in each month always changes.

Table 4. 3 Total monthly demand distribution

DESCRIPTION OF GOODS	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Grand Total													

The total demand is seasoning. In the period of April to June is the high peak period. The demand on this peak period is 5 times (at level 5) compare to the October to January period which is the low period and the demand at level 1. This show that the warehouse have to support the vary demand capacity along the year.

Table 4. 4 Total package type demand distribution

DESCRIPTION OF GOODS	TOTAL
1000ml UHT (12x1000ml.)	
200ml UHT (36x200ml.) A	
200ml UHT (36x200ml.) B	
240ml. CANNED (30x240ml.)	
240ml. CANNED (24x240ml.)	
315ml. CANNED (24x315ml.)	
250ml CANNED (24x250ml.)	
200ml Glass Bottle (12x200ml.)	
720ml Glass Bottle (12x720ml.)	
Grand Total	

This table shows the total yearly demand of each product package. It shows that the major demand is the can package. The most level demand is the caned 240ml. and 315ml.. The demand package volume ordering is bottle, UHT and Can respectively. The bottle demand is very low compare to UHT and can.

Anyway, the table 4.5 shows that the total monthly demand of each package type is also seasoning. For example, the Can product is usually high during Feb to July and also Sep. The 1000ml UHT demand is high in DEC and Mar while it is low in Apr to June.

Table 4. 5 Demand distribution of each package

Table 4. 6 Total customer demand distribution

Customer	Number of Container													frequency	% Accumulate
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total		
A9		46	44	64	64	64	24	1	48		1	4	360	360	44.2%
D1	14	5	8	8	5	6	7	6	6	10	9	10	94	454	55.8%
A6	6	7	7	7	7	7	7	7	7	7	6	5	80	534	65.6%
A3	2	3	6	5	7	8	4	4	2	2	1		44	578	71.0%
B19	1	3	2	3	1	3	3	2	1	2	2	1	24	602	74.0%
B18	2	2	2	2	2	1	2	1	1	2	2	2	21	623	76.5%
B17	2	2	2	1	2	1	2	1	1	1	1		16	639	78.5%
B24	2	1	1	1	2	1	1	1	1	2	1	1	15	654	80.3%
B21	1	1	1	1	1	1	1	1	1	1	1	1	12	666	81.8%
B22	1	1	1	1	1	1	1	1	1	1	1	1	12	678	83.3%
B23	1	1	1	1	1	1	1	1	1	1	1	1	12	690	84.8%
A10		2	2				2	1	1				8	698	85.7%
B27	1	1		1		1		1		1	1		7	705	86.6%
A1	1		1		1		1		1		1		6	711	87.3%
A2	3				2			1					6	717	88.1%
A11		1		1					1	1	1	1	6	723	88.8%
B20			1	1		1		1	1			1	6	729	89.6%
B25		1		1	1		1			1		1	6	735	90.3%
A7		1				1		1	1				4	739	90.8%
B30	1						1			1		1	4	743	91.3%
A12				1				1	1				3	746	91.6%
A13	1							1	1				3	749	92.0%
A14			1		1				1				3	752	92.4%
B31			1				1				1		3	755	92.8%
A5				2									2	757	93.0%
B26		1					1						2	759	93.2%
B28					1							1	2	761	93.5%
B29				1						1			2	763	93.7%
A4									1				1	764	93.9%
A8			1										1	765	94.0%
A15											1		1	766	94.1%
A16	3	3	3	3	3	3	3	3	3	3	3	3	36	802	98.5%
B32	1	1	1	1	1	1	1	1	1	1	1	1	12	814	100.0%
Sum	43	83	86	106	103	101	64	37	83	38	35	35	814		

The total customer demand distribution table (5.4.5) show the monthly seasoning of containers loading out. As Pareto theory, it shows that there are only 8 customer accounts hold the 80% of the total containers quantity loading out of warehouse from the total of about 33 customers (A16 and B32 is customer code refer more than one casual customers). The first eight significant customers have the

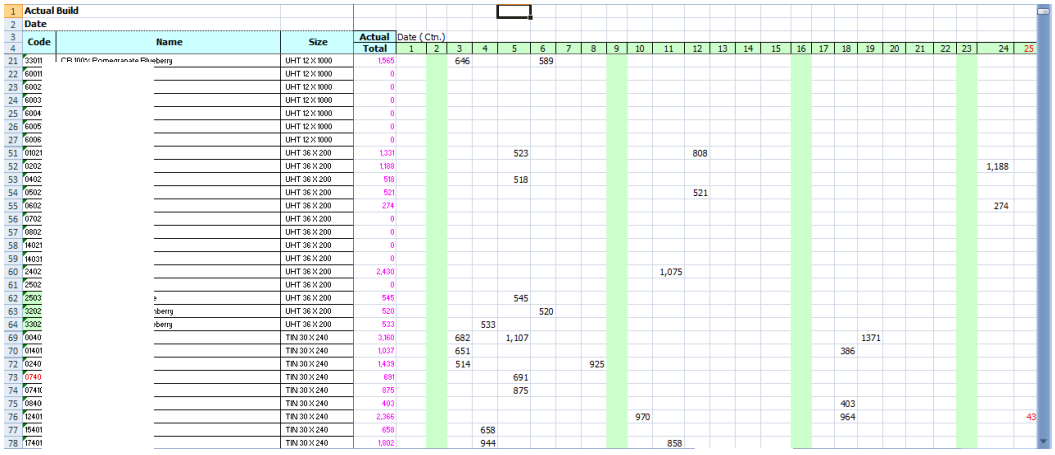
seasoning monthly demand showing in containers numbers. In conclusion, the loading out container, which refer to warehouse out flow, is seasoning in the number and the customer pattern.

The Production characteristic analysis

The production plan is created by considering of many manufacturing's factors under production manager's discretion and also management agreement. The factors that have to be concerned are the conditions of the material supply condition, the manufacturing capacity, the demand of customer and the cost management. Not including delivery timeline, the two main concerning points in production plan are to enlarge production batch size and to be smooth the manufacturing capacity required rate as much as possible. The production schedule come from merge the same product code of each customer together then sequencing the group of product variance by production factors consideration. By the ways, the production plan and its schedule are created under by scoping time period, it starts like filling each piece of jigsaw until become the picture for each production period.

Bellowing figures show the example of production, one production lot mean to the quantity of one product code of the onetime production.

The product inbound to warehouse is daily and vary from about 35 to 200 pallets per day. The frequency of warehouse inbound pallet numbers is 55 to 90 pallets per day.



	Actual Build																									
	Date																									
	Code	Name	Size	Actual Total	Date (Ctn.) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
21	33011	OR 100% Pomegranate Blueberry	UHT 12 X 1000	1,585			646			589																	
22	60011		UHT 12 X 1000	0																							
23	6002		UHT 12 X 1000	0																							
24	6003		UHT 12 X 1000	0																							
25	6004		UHT 12 X 1000	0																							
26	6005		UHT 12 X 1000	0																							
27	6006		UHT 12 X 1000	0																							
51	01021		UHT 36 X 200	1,331					523							808											
52	0202		UHT 36 X 200	1,188																						1,188	
53	0402		UHT 36 X 200	518					518																		
54	0502		UHT 36 X 200	521												521											
55	0602		UHT 36 X 200	274																						274	
56	0702		UHT 36 X 200	0																							
57	0802		UHT 36 X 200	0																							
58	14021		UHT 36 X 200	0																							
59	14031		UHT 36 X 200	0																							
60	2402		UHT 36 X 200	2,430											1,075												
61	2502		UHT 36 X 200	0																							
62	2503		UHT 36 X 200	545					545																		
63	3202	berry	UHT 36 X 200	520						520																	
64	3302	berry	UHT 36 X 200	533				533																			
69	6040		TIN 30 X 240	3,160			682		1,107													1371					
70	01401		TIN 30 X 240	1,037			651															386					
72	0240		TIN 30 X 240	1,439			514					925															
73	0740		TIN 30 X 240	691					691																		
74	0741		TIN 30 X 240	875					875																		
75	0840		TIN 30 X 240	403																		403					
76	12401		TIN 30 X 240	2,398										970								964					43
77	15401		TIN 30 X 240	658				658																			
78	17401		TIN 30 X 240	1,802				944							858												

Figure 4. 24 The production pattern example of some variant products.

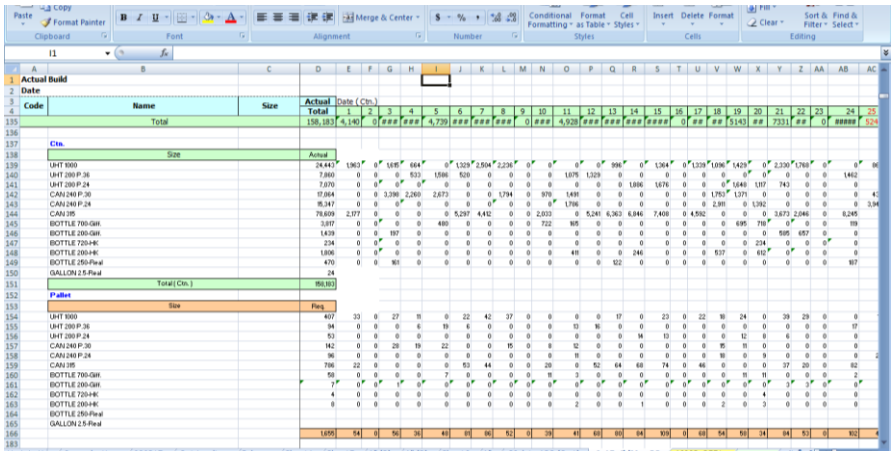


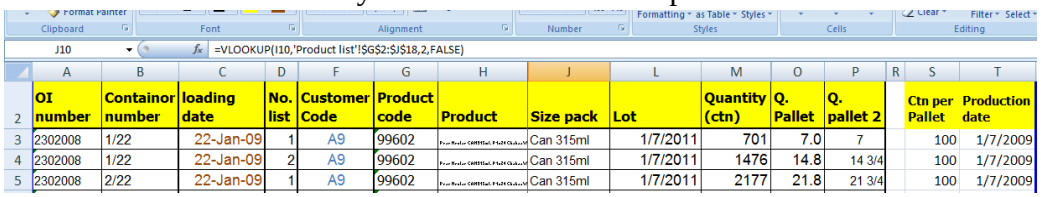
Figure 4. 25 The production pattern example in estimate total pallet unit.

The product profiling characteristic background analysis

To analysis the product profiling in warehouse, the authors create the historical recording document data base in warehouse by focusing the detail of each product loading out of every container under the SKU unit. If the data is different in any one list header, it is the different SKU.

The classification header lists are

- Order number is the number order placing code
- Container number is the order and number of container in each order code. 1/22 is mean to the first container of twenty two containers in that order.
- Loading date is the day of container loading out.
- Number list (No. list) is the ordering number of product detail list in each container.
- Customer detail is the customer code and name
- Product detail id product code and name
- Lot is the production lot which relates to the producing date as same as the warehouse inbound receiving date
- Quantity is the number of product in that ordering list of the container in carton units
- Pallet is the estimate full pallet unit of product quantity which is converted by the table unit from chapter 3.



	OI number	Containor number	loading date	No. list	Customer Code	Product code	Product	Size pack	Lot	Quantity (ctn)	Q. Pallet	Q. pallet 2	Ctn per Pallet	Production date
3	2302008	1/22	22-Jan-09	1	A9	99602		Can 315ml	1/7/2011	701	7.0	7	100	1/7/2009
4	2302008	1/22	22-Jan-09	2	A9	99602		Can 315ml	1/7/2011	1476	14.8	14 3/4	100	1/7/2009
5	2302008	2/22	22-Jan-09	1	A9	99602		Can 315ml	1/7/2011	2177	21.8	21 3/4	100	1/7/2009

Figure 4. 26 The header of historical detail data base.

The result analysis will be described bellowing.

- The product in flow from production is daily coming while the product out flow isn't loading out daily but it load as weekly that mean there is usually loading activities every week but some day is no product loading. The customer order lead time is about 1-2 months and at least one month after placing order.
- The customer that placing order every month is also order seasonal product variety in package type, variant flavors and product volume.
- As the warehouse policy set that product holding storage one week before loading, but the actual situation shows that it is always crossing product flow in warehouse. That means the order picking usually collect the product lot from the same week of the loading date (recent coming product lot). Anyways, in the order picking is also collecting product lot from last week and last month and until last 6 months (a rarely case) in some case for finish one order. (showing in figure 4.26)

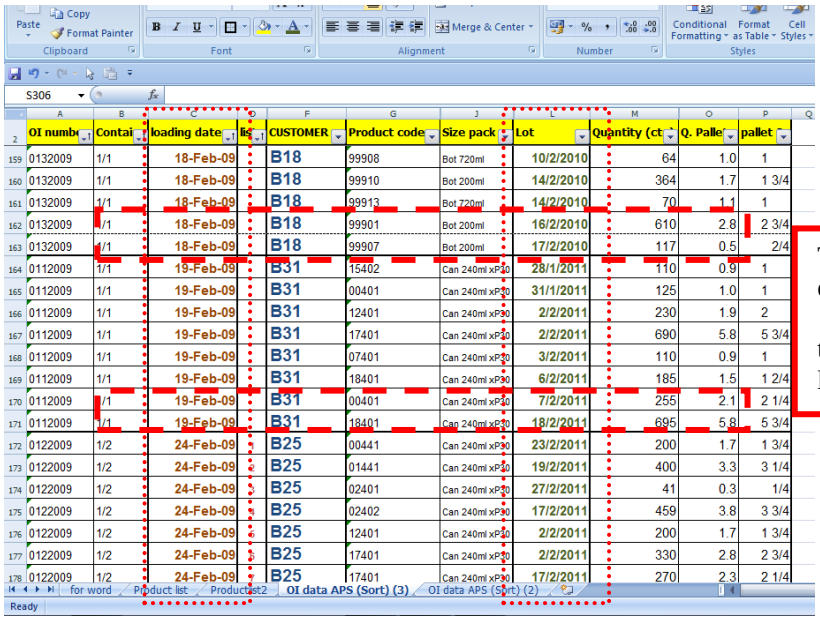


Figure 4. 27 The example of detail data base historical data with crossing flow.

- The product order from the significant customers of company with more than 20 containers per month is usually loading one or a few mixing product per one container while all other customers usually loading a variety product mixing in one container. Moreover, some order need to collect product from more than 20 product lots. (figure 5.27 and 5.28)

- The product profiles show that there are both long-term storing and short-term cross movement required for this case warehousing product line.

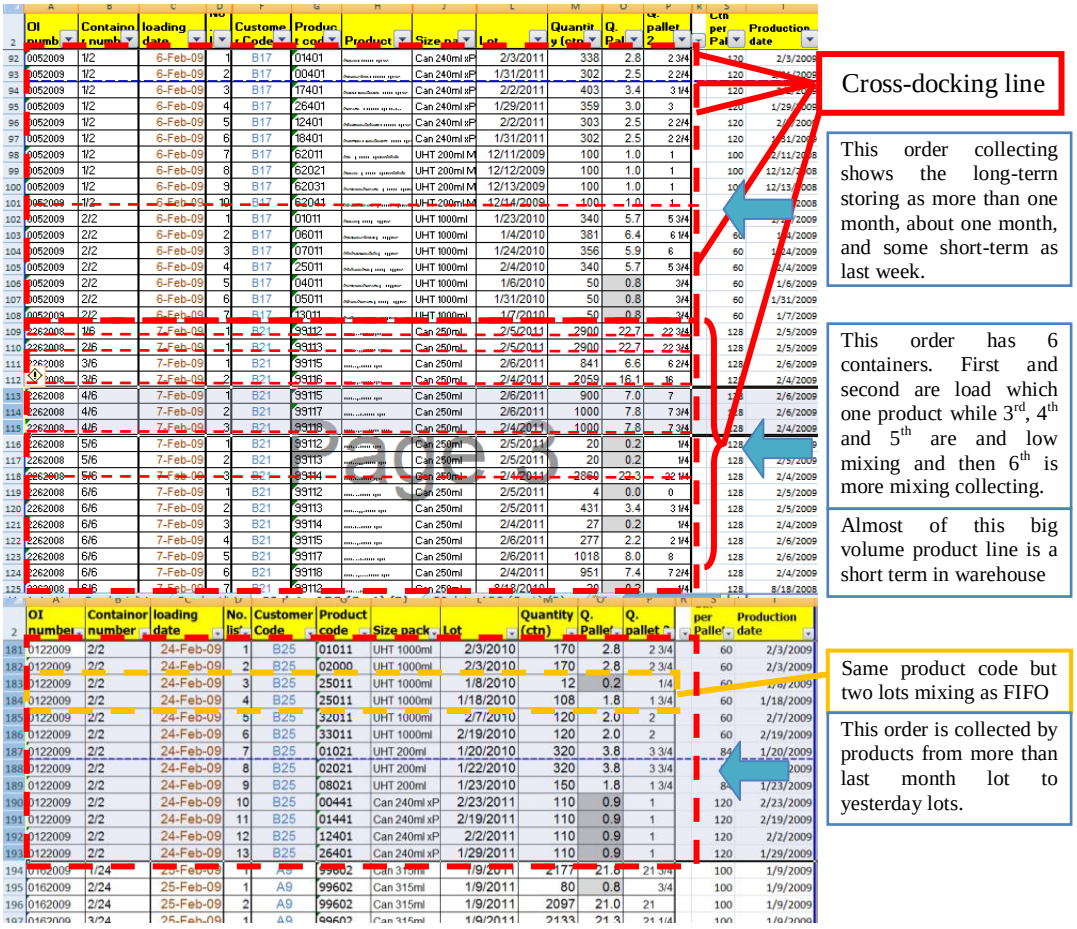


Figure 4. 28 the example of detail data of the general container loading

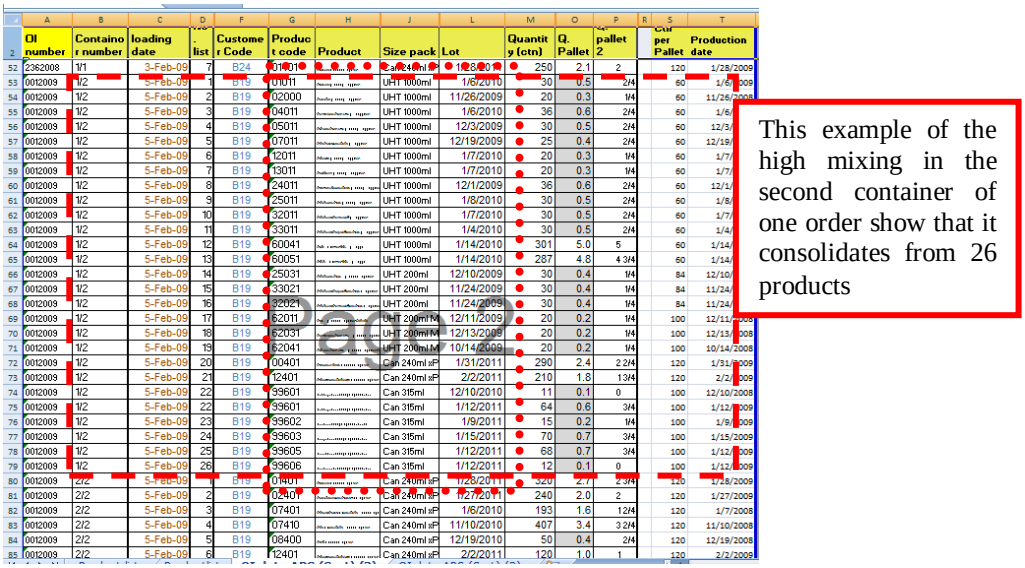
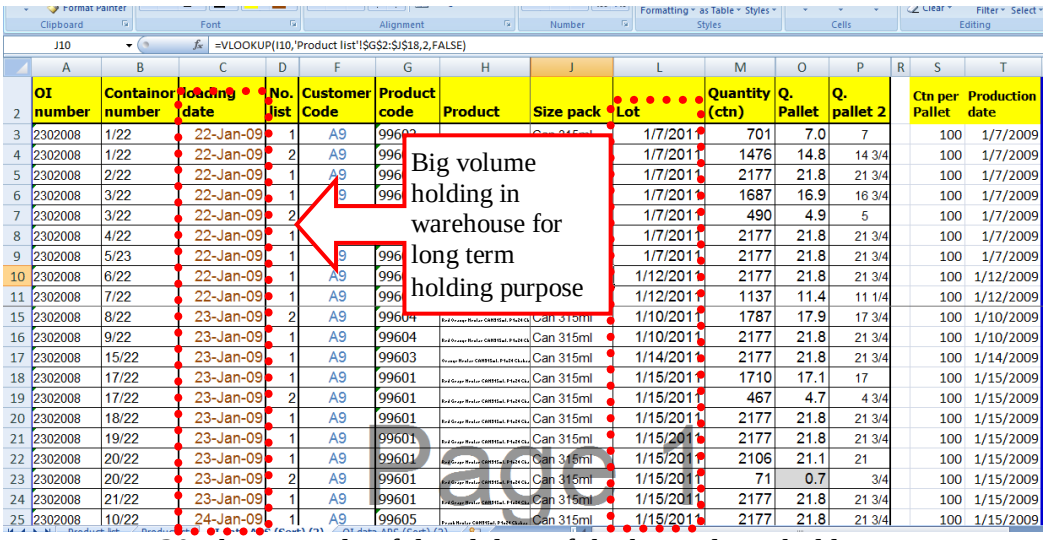


Figure 4. 29 The example of detail data of the high mixing in container loading

- Although, the biggest one customer hold about 40% of total product sale volume and usually loading under one or a few product code per container but under the unorganised policy of warehousing this big size can cause the difficulty in warehousing process for picking process of other order as an barrier of inside warehouse perspective view. In this case, the big size volume of order is usually produced near to the loading time but sometime it will be placed in warehouse for a long holding period which may cause from the high density order in nearly period and the production plan factors.



	OI number	Containor number	Loading date	No. list	Customer Code	Product code	Product	Size pack	Lot	Quantity (ctn)	Q. Pallet	Q. pallet 2	Ctn per Pallet	Production date
3	2302008	1/22	22-Jan-09	1	A9	99602			1/7/2011	701	7.0	7	100	1/7/2009
4	2302008	1/22	22-Jan-09	2	A9	996			1/7/2011	1476	14.8	14 3/4	100	1/7/2009
5	2302008	2/22	22-Jan-09	1	A9	996			1/7/2011	2177	21.8	21 3/4	100	1/7/2009
6	2302008	3/22	22-Jan-09	1	9	996			1/7/2011	1687	16.9	16 3/4	100	1/7/2009
7	2302008	3/22	22-Jan-09	2					1/7/2011	490	4.9	5	100	1/7/2009
8	2302008	4/22	22-Jan-09	1					1/7/2011	2177	21.8	21 3/4	100	1/7/2009
9	2302008	5/23	22-Jan-09	1	9	996			1/7/2011	2177	21.8	21 3/4	100	1/7/2009
10	2302008	6/22	22-Jan-09	1	A9	996			1/12/2011	2177	21.8	21 3/4	100	1/12/2009
11	2302008	7/22	22-Jan-09	1	A9	996			1/12/2011	1137	11.4	11 1/4	100	1/12/2009
15	2302008	8/22	23-Jan-09	2	A9	99604		Can 315ml	1/10/2011	1787	17.9	17 3/4	100	1/10/2009
16	2302008	9/22	23-Jan-09	1	A9	99604		Can 315ml	1/10/2011	2177	21.8	21 3/4	100	1/10/2009
17	2302008	15/22	23-Jan-09	1	A9	99603		Can 315ml	1/14/2011	2177	21.8	21 3/4	100	1/14/2009
18	2302008	17/22	23-Jan-09	1	A9	99601		Can 315ml	1/15/2011	1710	17.1	17	100	1/15/2009
19	2302008	17/22	23-Jan-09	2	A9	99601		Can 315ml	1/15/2011	467	4.7	4 3/4	100	1/15/2009
20	2302008	18/22	23-Jan-09	1	A9	99601		Can 315ml	1/15/2011	2177	21.8	21 3/4	100	1/15/2009
21	2302008	19/22	23-Jan-09	1	A9	99601		Can 315ml	1/15/2011	2177	21.8	21 3/4	100	1/15/2009
22	2302008	20/22	23-Jan-09	1	A9	99601		Can 315ml	1/15/2011	2106	21.1	21	100	1/15/2009
23	2302008	20/22	23-Jan-09	2	A9	99601		Can 315ml	1/15/2011	71	0.7	3/4	100	1/15/2009
24	2302008	21/22	23-Jan-09	1	A9	99601		Can 315ml	1/15/2011	2177	21.8	21 3/4	100	1/15/2009
25	2302008	10/22	24-Jan-09	1	A9	99605		Can 315ml	1/15/2011	2177	21.8	21 3/4	100	1/15/2009

Figure 4. 30 The example of detail data of the big volume holding inventory

<u>The conclusion of the organised warehouse concept from the 3rd evaluation</u>

The characteristic of warehouse profiling also widely pattern types depend on the production plan factors. Some order is mixing from many product line some are a few, furthermore some of coming product line flow passing warehouse slow while some are so fast. This means to difficulty in setting the policy for controlling warehouse activities by product characteristic or order customer or even the time period. By the ways, it shows that this warehouse also perform the significant role of the fast movement as the cross-docking line showing.

In conclusion, the demand analysis shows that it is seasoning in both product and customer so that the category product grouping policy cannot use in this case. Moreover, the major product is usually fast flowing through warehouse or always moving in warehouse as the ‘make-to-order’ policy and the row-on floor keeping style

so the position policy is also not suitable in this case. The organize warehouse policy from the methods defining in the previous part that can be appropriate to apply is only the activities zoning policy.

4.9 The Conclusion of Problem Solving

This chapter was describing in the problem symptoms or small incidents that lead to the main problem of situation that cannot loading out product. Then, the root cause was defined by the why-why technique after that the solving choice was define by the how-how technique. Lastly, the significant factors were applied in the solution evaluation before the product profiling analysis to find the suitable solution approach.

The root cause statement of the main problem

By the overall of this chapter analysis and the previous chapter analysis background, it can be concluded that the significant problem, which is hard to control and monitor warehouse, comes from the weakness of warehousing management which refer to two founding points from the problem analysis.

First is the root cause of the unorganised warehouse area utilization to support overall warehousing process. This creates the obstruction in warehousing operation as the crowd mixing product environment lead to difficulty in receiving, put away, picking and checking.

Second is the root cause of the inappropriate warehousing process flow. As it is not related to the actual material handling flow inside warehouse, the warehousing process and operation is emphasis on the picking process while ignore the role of receiving then the worker usually face with the problem of long time searching and the problem of cannot finding required product.

In additional, it is another significant found which is the root cause of information data base and this is also the obstacle in the research. However, this relate to the error of information problem more than the warehousing failure problem. Furthermore during the researching manufacture has hired the new office staff for especially responding in the stock balancing process in warehouse and also adjust the balance recording methodology to have the history background by including the

opening stock, the stock changing and the ending of stock balance. The root cause of information is reducing its character in this research by the previous reason so that author will not pay attention in this area.

The solution approach concept

The result of warehousing problem analysis shows that to prevent the situation that cannot loading product out of warehouse, it need the reform of warehousing work flow and warehouse area utilization to be suitable to the real product flow in warehouse.

The warehouse product profiling analysis show that "cross-docking" is one significant paying in this warehouse role unless the inventory holding role so that this warehouse has to perform both inventory holding role and cross-docking role. Even the picking process is the significant process that relate to the most cost of general warehouse, it should not be an only main significant process in this case study warehouse especially concerning the "Make-to-Order' model of this manufacturer. Each warehousing processes cannot be separated out from each other as same as the overall manufacturing process which is actually start at the production plan of the Make-to-Order model.

In conclusion of problem solving analysis, the solution approaching concept is the controlling and managing warehousing flow under the activities category policy. The actual warehousing in this case should be form the warehousing flow at the starting inbound warehousing which is receiving process. To manage the warehousing flow at the receiving for the benefit in picking and warehouse operating, it needs to concern the cross-docking concept as the separate line at the beginning.

The warehousing improvement proposal

For the cross-docking concept, the warehouse planning is a design tool which is applied in this case for helping receiving process to set the starting warehouse profile form. There are three designs in this warehouse improvement proposal

1. The design of warehousing planning is to develop the algorithm of warehousing planning work flow. The objective of the warehousing planning is to predict cross-docking activities in warehouse and support in warehousing control and monitor.

2. The revise of warehousing process flow is to redesign the work flow of warehouse to appropriate to the actual product flow and relate to the warehouse plan setting. This emphasis on the receiving role to concerning the easy to access product of order picker.
3. The design of warehouse layout by activities zoning method is to support the warehousing activities. Moreover, this way is used in organised warehouse area by separating the available and picked product out of each other so the boundary of searching area will be narrowed while the warehouse operation will be easy.

The previous performance measurement

For the warehousing performance measure method to compare before and after of warehousing process improvement in this case, it have to concern some of these reason.

As this study focusing on the main problem of situation that cannot loading out of product. The measurement index should be related to this objective which is the quality performance of warehousing not the productivity performance. The completeness of order fulfilment is chosen as the key performance index in this case because it is related to warehouse process from receiving to picking which is the focusing area and can be refer to picking accuracy.

Even though, the most common measurement in picking performance is the pick rate which refer to the number of pick per working time. Nevertheless, this indicator is sensible in the case like this study case which have an incentive scheme of operation as the distribution of order characteristic, the high range of number mixing per order so that this indicator is not suitable for this study case as each order picking is the different of operating and material handling required. For example, the picking time required for each product pallet is depending to the total product volume inside warehouse or warehouse environment condition and the difficulty to find and reach each of it and also further one order picking may collect for just a few big batch or a small variety product code lots. Each period time is different in the total quantity of warehouse handing material. By the ways, the warehouse productivity of this case is not straight varies to the volume of material handling or workload, it have to including the complicate variable factors from each order in the productivity

performance calculation. These are some limited factors excluding the hardness of calculation without information supporting shows that why this thesis will not measure the warehouse productivity performance.

The completeness of order fulfilment is defined by the container loading bill that can be complete the picking process before the loading time. The complete picking is also to pick the right of the required product with the right quantity as in the order list.

As it is easy to counting the failure than completeness and the failure percentage is more obviously refer to warehousing process improvement objective. The most of warehousing out bound is usually loading product into container so that order fulfilling process is done by the container bill too. The result will be calculated in the number of container failure in order fulfilment.

The calculation is

$$\%\ \text{failure of pre} - \text{loading} = \frac{\text{Num. fail CTNs}}{\text{Total CTNs load}} \times 100$$

The meaning of factors:

% failure of pre-loading	- the failure percentage of all loading product
Num.fail CTNs	- the counting number of container failing month
Total CTNs load	- the total containers loading out in each month

The result of calculation shows in the bellowing table.

Table 4. 7 the warehousing measurement before the improvement

Info.	Before (Inprovement)	
	Jan	Feb
Total Monthly container loading	**45**	**71**
total Pre-load fail	**3**	**3**
% Con Pre-loading fail	**6.67%**	**4.23%**
% Average	5.45%	

The average percentage of order fulfilment failure = (6.67+4.23)/2 = 5.45%

In summary of the previous condition, the percentage of the preloading process failure in Jan and Feb are 6.67% and 4.23% respectively. The average of order fulfilment failure percentage before warehouse improvement is 5.45%.

Chapter V
THE WAREHOUSING PROCESS IMPROVEMENT

The methodology for this case warehousing process improvement has three main approach processes. First is to design the warehousing planning process flow. Second is to redesign overall warehousing process flow. Third is the design of warehouse layout by zoning warehousing activities.

5.1Design Warehousing Planning Process

The design for the warehousing planning process flow has two main steps which start by the design for total available forwarder checking and then follow with the design of warehousing activity.

Actually warehousing in this case study is performing under the frame of input and output determinants. The input determinant refers to the production plan of manufacturing while the output determinant refers to the loading schedule and order requirement. Warehousing is just the linking station to process the required value adding of each small material flows. The planning tools purpose to create the track of SKU line inside warehouse by using benefit of the production plan and order instruction information which is providing before the actual finished goods come into warehouse.

First of all the objective of the planning design will be define.

a) Objective of the warehousing operation
   - To guideline for monitoring warehousing process

b) Objective to warehousing plan
   - Reduce risk of the warehousing failure
   - Define the cross-docking line activities
   - To check the product available in advance

5.1.1 Planning for Product Available

This plan step is the pre-stage to check product available which is should be doing two weeks prior and should be revised weekly or information changing.

The product available checking plan:

Three main information data need in planning

1. The order instruction of the next two weeks loading in schedule
2. The production plan cover for the next two weeks
3. The stock balance at the present

Instruction of the pre-planning

1. Revise order instructions and stock balance to order the queue of container loading and the present status stock balance
2. Compare the product requirement from order list to the stock balancing
3. Fulfil order with the stock product by filling the detail lot of product in the order list memo then adjusting the total stock balance
4. Revise the order that uncompleted fulfilling of the previous step and revise the production plan of incoming product
5. Compare the order requirement of the uncompleted fulfilling OI to the incoming product from production plan
6. Fulfil order with the incoming product by filling the detail lot of product in the order list memos then adjusting the total stock balance for the next two week forecasting.
7. Inform the production about the product that might be lack if there are the orders that might not be completed at the loading time.

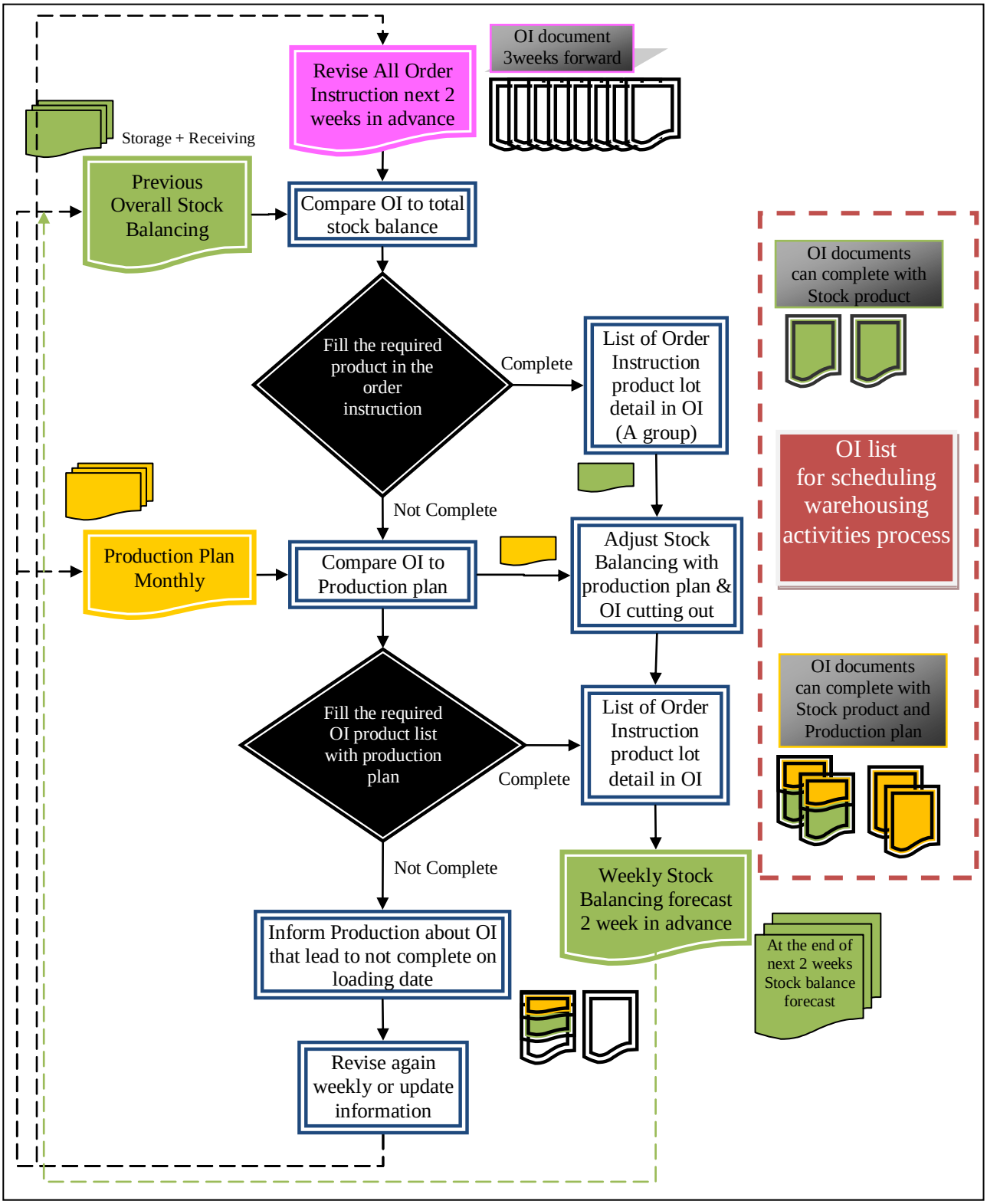


Figure 5. 1 The pre-planning process

5.1.2 Planning for Warehousing Activities

This plan step is the post-stage to forecast the cross-docking line in each week which is should be doing one weeks prior and should be revised weekly or input information changing.

The warehousing activities plan:

Three main information data need in planning

1. The order instruction of the next two weeks loading in schedule which is draft in the product detail by the pre-planning.
2. The production plan cover for the next week
3. The stock balance at the present

Instruction of the post-planning

1. Revise the order instructions and the present stock balance to sequent the queue of container loading and the present status stock balance
2. Compare the product requirement from order list to the stock balancing
3. Fulfil order with the stock product by filling the detail lot of product in the order list memo then adjusting the total stock balance
    - Create the picking memo for the picking from storage (more than one week holding)
    - Create the picking request memo for the direct picking of receiving (the incoming during the loading week)
4. Revise the order request of this next one week loading and the production plan and receiving stock(short term holding of receiving product)
5. Compare the product requirement from the picking request of receiving to the incoming product from production plan and receiving stock
6. Fulfil order with the incoming product by filling the detail lot of product in the order list memos then scheduling draft memo for receiving

- Create the draft memo for scheduling receiving from (including the direct put away and cross-docking)

7. Determine the product lot in receiving holding to put away to storage grouping
    - Create the put away memo for the move product lot from receiving to storage (this week receiving stock that not include in the loading plan list)
8. Adjusting the total receiving stock balance and forecast the total stock balance for the next order planning
9. Conclude the schedule of all relating picking memo and some draft check
    - Check the special process requirement if have. This step is just informing the head staff of special process and draft confirming the in-time scale because it usually consider this factor at the production plan.
    - Check the activities area. This is just the draft checking for the suitable total area management to for all activities such as the waiting group product for loading lists that should be place to warehouse room 3.1.

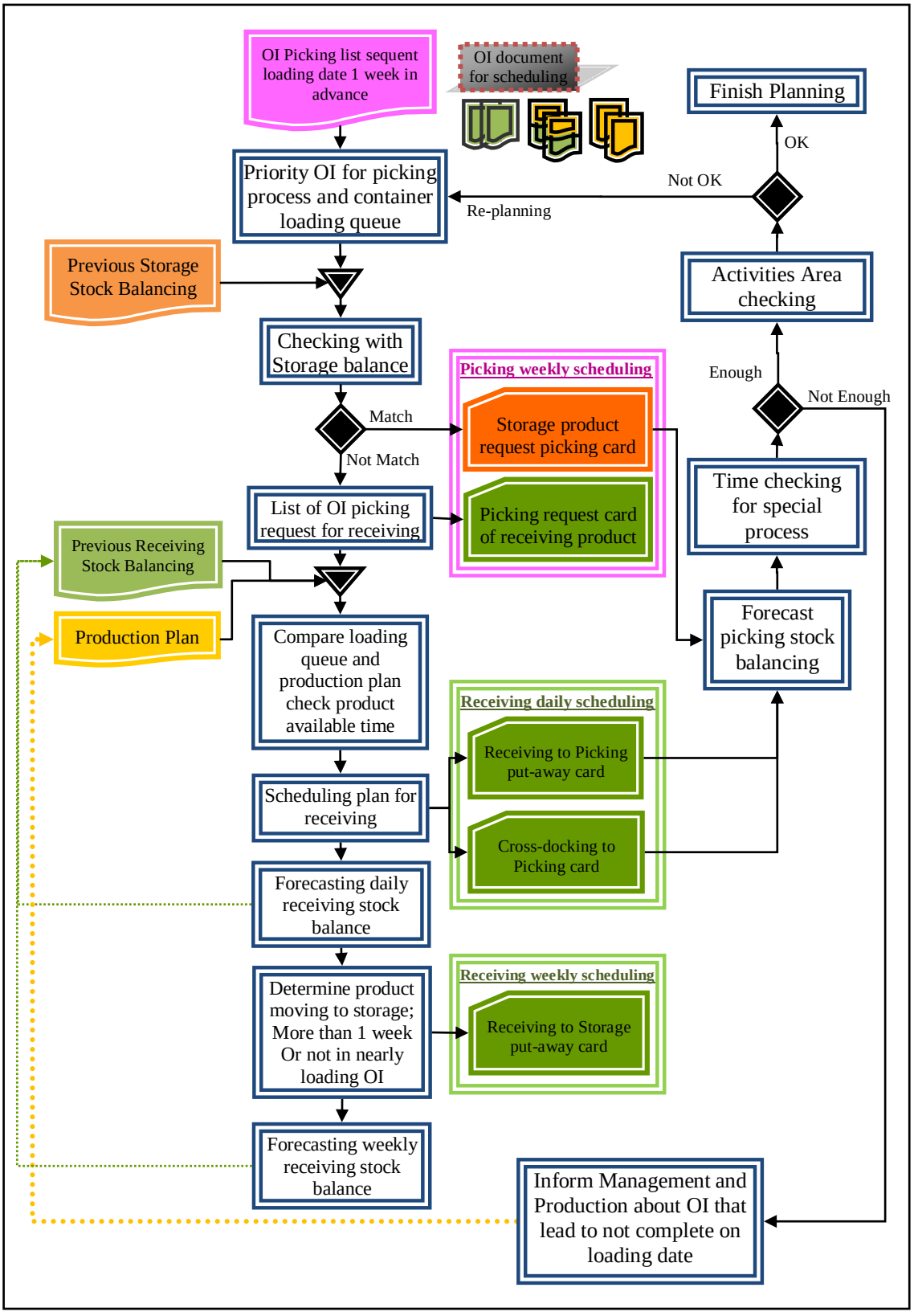


Figure 5. 2 The post-planning process

5.2 Redesign Overall Warehousing Process

The redesign for the warehousing process flow starts by the revise of warehousing activity and then the design of suitable new warehousing flow for warehousing activity. Firstly, the warehousing process should be designed to support the material handing and its flow profile. Second, the warehousing process should consistent to the warehousing planning design. This warehousing process flow will show the links between sub processes as the small intersection line. As the old warehousing process does not pay attention to cross-docking line, the picking process of cross-docking material is hastened in the shop floor, which is searching for incoming overall warehouse area, and then lagging overall process.

First of all the objective of the planning design will be define.

a) Objective of the warehousing operation
   - To be easy to control warehousing process
b) Objective to warehousing plan
   - Reduce using time in searching

Warehousing process workflow is redesigned by applying cross-docking concept. Warehousing process flow can be separated into two main flows which are inbound flow and out bound flow. The inbound flow is starting from the ending of production line going to receiving process for checking and arranging product input then sending into storage. In the other hand, the outbound flow, which refers to picking process, is starting at the firstly picking from the long-term stock in storage as the FIFO policy and then following the picking from the short-term products in the receiving area then lastly collecting the incoming product as cross-docking line after that the loading process is running. The picking flow direction is the return of inbound receiving to storage flow. Anyways, the loading process is the same as the existing warehouse process.

The detail of warehousing process flow design is shown in figure 5.3. Warehousing process is separated into four main activities processes which are Receiving, Storage, Picking and Loading.

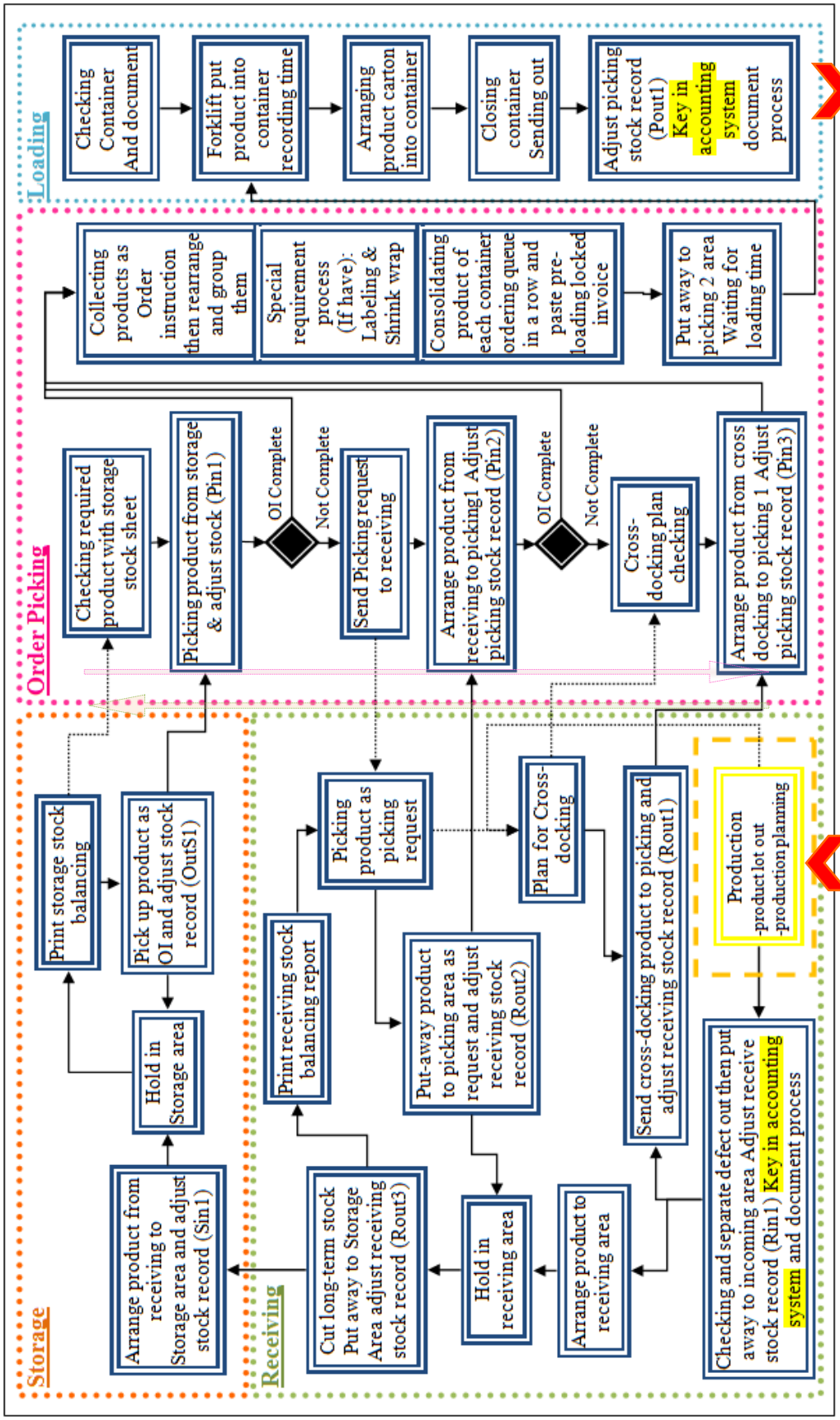


Figure 5. 3 The overall warehousing process workflow

The overall warehousing process workflow; 1. Receiving 2. Storage 3. Order picking 4. Loading

Receiving

1. Bring the products from production to place into receiving area of warehouse after check the quantity and quality matching with production report.
2. Key in the information system and document process and adjust the balance excel file
3. Check the picking request product for receiving product and the cross-docking memo
4. Distinguish and Put away the request product as in the cross-docking memo to the picking
5. Arrange the other remaining product of the incoming product lot to group with the previous receiving product pile
6. Determine the longest term product holding to put away from receiving to storage. It is including the product in the put away memo for moving the receiving to storage
7. Adjust the excel balance stock then conclude the receiving stock and print out
8. Receive and revise the product request memo from picking, high light the cross-docking memo
9. Arrange and Put away the request product as in the put away receiving to picking memo to the picking

Storage

1. Bring and arrange the products from receiving zone into storage zone.
2. Adjust the stock balance of excel file Key in the information system and document process and adjust the balance excel file
3. Hold the product in the storage zone for the picking process

Order Picking

1. Receive order instruction, the picking from receiving memo and the cross-docking memo.
2. Check the required products with the storage stock
3. Pick the required products from storage zone to place in the picking zone then lock and label it
4. Revise the request products memo and cross-docking memo for receiving
5. Pick the product from receiving zone
6. Receiving the product as the cross-docking line from the receiving direct put away
7. Collect the products as the order instruction and run the special process if it is required
8. Consolidate and arrange the products grouping pile follow the container loading queue then put away to picking zone 2 (warehouse room3.1) to wait for loading

Loading

1. Check the container condition and the document preparation.
2. Bring out and Put the prepare product into container and record time on loading document
3. Arrange the product cartons into container
4. Check and close container
5. Record the loading document
6. Key out stock in the information system and document process and adjust the balance stock excel file.

5.3 Layout Zoning

The warehouse layout is set by applying the activities zoning policy. The objective of this layout design considers the convenient of accessibility and the smoothing warehousing flow. Figure 6.4 shows the activities zoning in warehouse layout area. There are three significant activities inside warehouse. Receiving refers to handle the incoming product from production. Storage refers the long-term stock keeping and arranging in warehouse. Picking refers to collect and group the required product as in each order instruction list to prepare for loading process. The area for each activity will not be specific in size as the holding product volume of each activity is change along the period time between the peaks of loading activities. The main warehouse room three is the area for all warehousing activities while the warehouse room 3.1 is specific using for holding only the picking product, which are be locked or waiting for loading, because of the loading area nearly location.

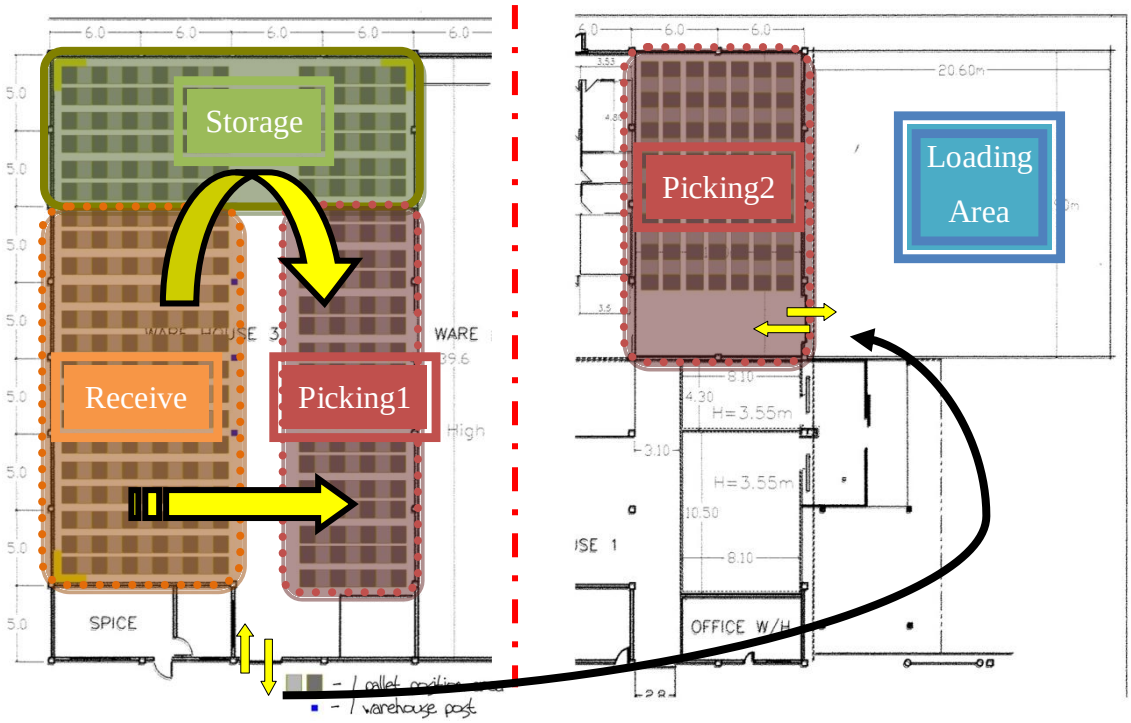


Figure 5. 4 The activities zoning layout of warehouse

The main material handling and movement is in the main warehouse area which is warehouse room 3. The layout design use the U-shape policy because the appropriate for the mechanism of material flow which have a high cross-docking line.

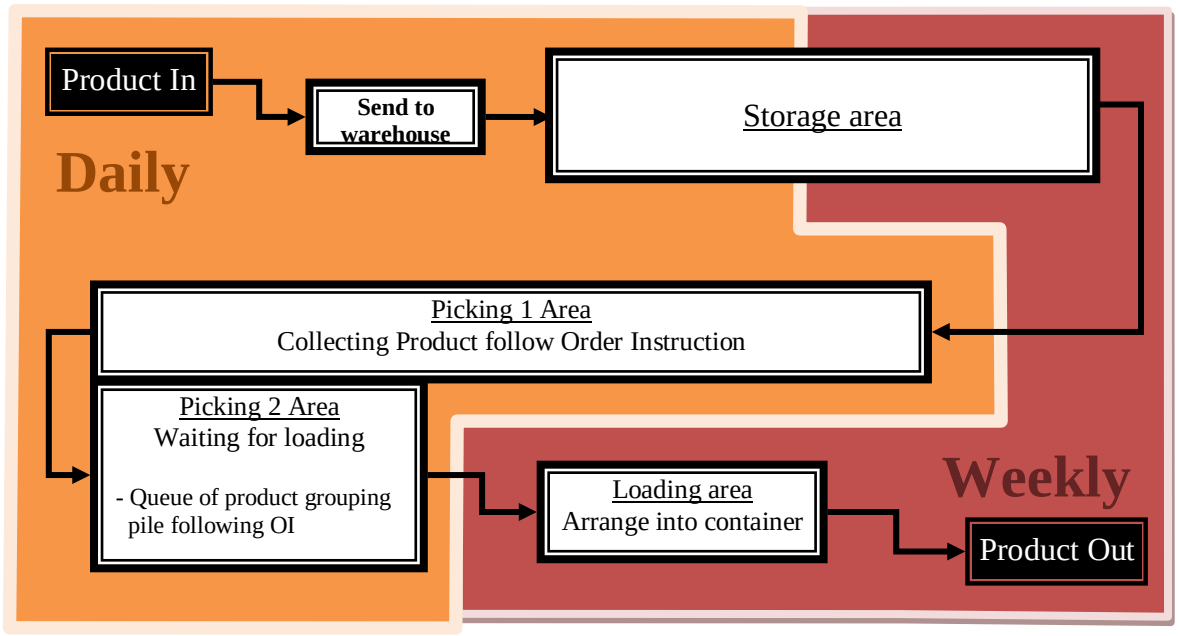
The U-shape layout design is supporting the three direction movement between the three main warehousing activities and especially direct put away from receiving area to picking area and also the in and out flow movement which links to outside warehouse room. Moreover, the existing warehouse structure building has only one entering door so that the u-shape design is benefit in no requirement for reconstruction.

5.4 The Warehousing Improvement Evaluation

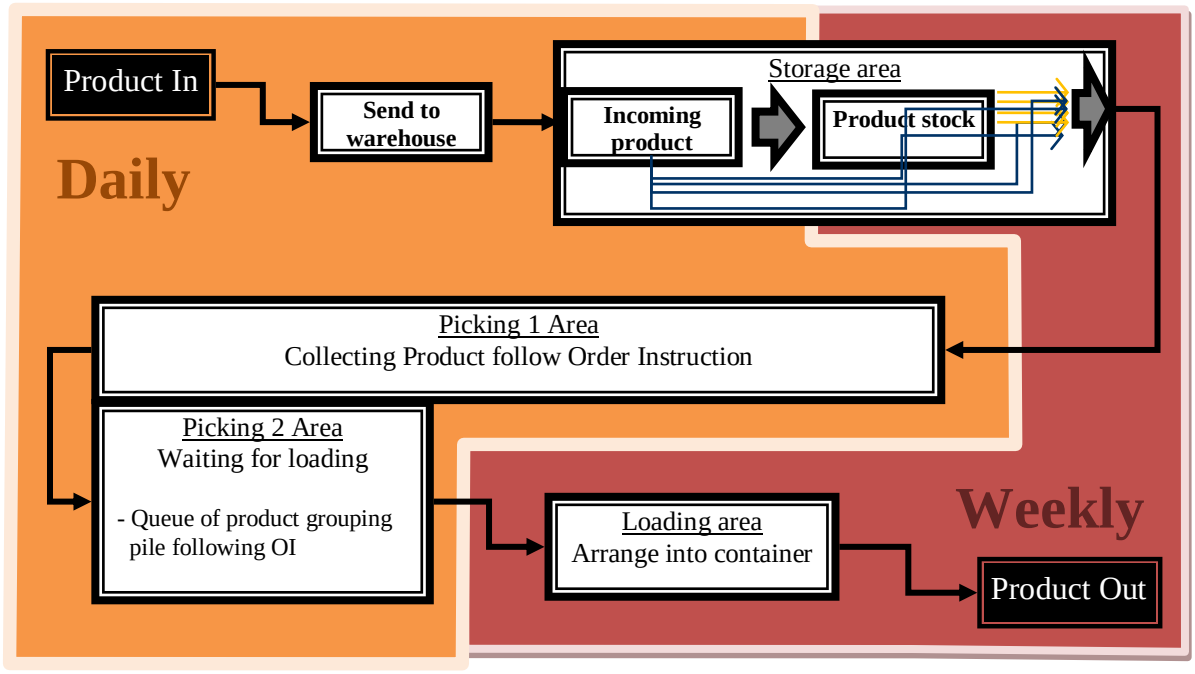
The changing of warehousing at the previous stage and the behind stage of this warehousing improvement is shown as bellowing pictures. Figure 6.5 and figure 6.6 are represented the previous and the behind of warehousing improvement respectively.

The previous warehousing look like no receiving role in the warehouse material flow as it is only the post-checking done by warehouse office staff. As all products that came out from production line will be sent to warehouse and placed into any available area as storage concept. After product was placed as the storage, it is picked to collect for the order then it will be loaded out. The existing warehousing flow are designed to accommodate for only the specific storage product line but actually there are some of the incoming product line that have to fast forward moving to the picking as shown in figure 5.5 (b).

The figure 5.5 (b) shows that the material flow line was going to be jam at the link position between storage and picking. The product is crowded as the activities step of picking from storage. These make usually picking activities have to work under the force condition to hurry up as dense of work and to more intend as the dynamic and complicate of storage material.



(a)



(b)

Figure 5. 5 The picture of warehousing before improvement

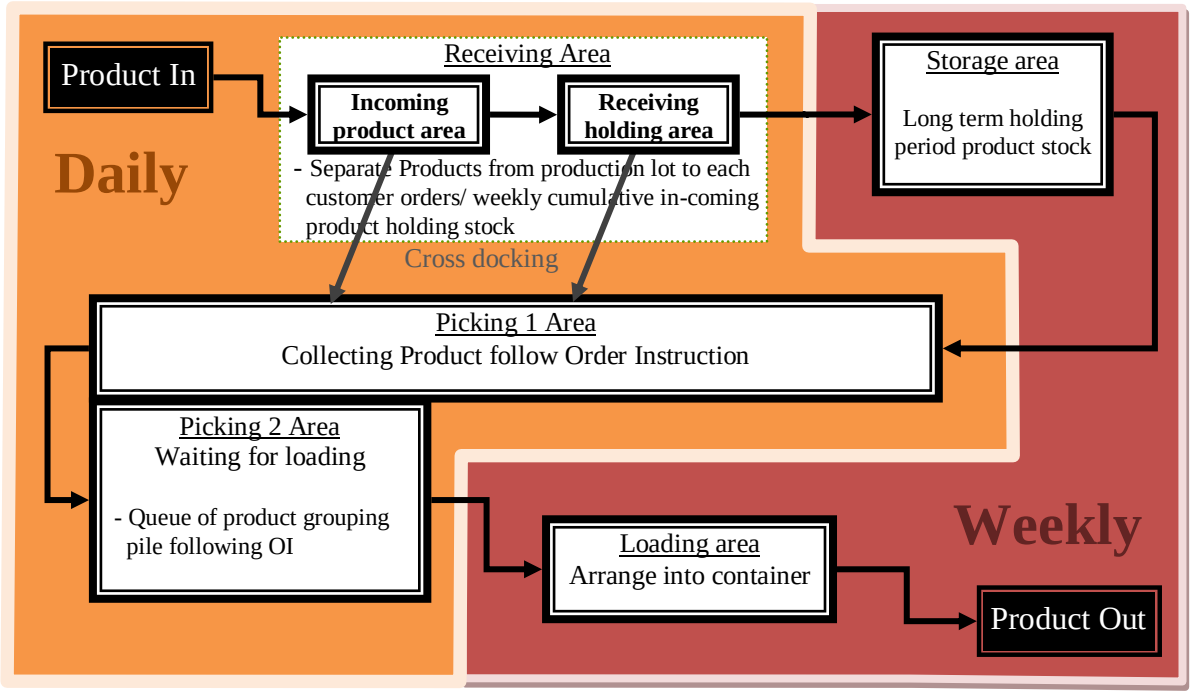


Figure 5. 6 The picture of warehousing after improvement

Receiving and order picking in this warehouse should be not completely separated from each other. They should be linked together since the significant performances of this warehouse are a sorting the product lots from production and a consolidating to fulfill customer order. However, the initial existing warehouse process receiving and order picking are separated by storage step as every product will firstly push into storage status

From these diagram chart, the improvement reduce the dynamic crowd of material flow lines between the storage and the picking by setting the receiving and building the bridge between receiving and picking. The product of cross-docking line will be assume that it is automatic appear to pick so that the waste time in searching for product in waiting list will be disappear.

In conclusion, this warehousing improvement changes the cross-dock finished goods line handling from “searching and checking” to “forwarding and presenting”. This warehousing flow design will reduce time of searching the short-term finished goods while the layout zoning will organize warehouse and reduce searching area boundary by separate the picked and locked products out of the overall warehousing holding products.

The result of performance comparing

Table 5. 1 Summary of result of before and after improvement

Info.	Before (Improvement)		After (Improvement)				
	Jan	Feb	Mar	Apr	May	Jun	Jul
Total Monthly container loading	**45**	**71**	**91**	**138**	**79**	**97**	**63**
total Pre-load fail	**3**	**3**	**3**	**2**	**1**	**1**	**0**
% Con Pre-loading fail	**6.67%**	**4.23%**	**3.30%**	**1.45%**	**1.27%**	**1.03%**	**0.00%**
% Average	5.45%		1.41%				

The warehouse improvement is starting implement in Mar. The average percentage of the preloading process failure in the before and after period of warehousing redesign proposal is 5.45% and 1.41% respectively. The percentage of warehousing improvement is about 4.04%. The percentage of failure is dramatically reducing to be 3.3% in March from the average value of two previous months at 5.45%. After the first month of improvement, the failure is gradually reducing to be about 1.45%, 1.27%, 1.03% and then 0% at the last month of researching period. It can be say that the failure trend will be about 0-1.5% in the future as the trend line is shown in figure 5.7.

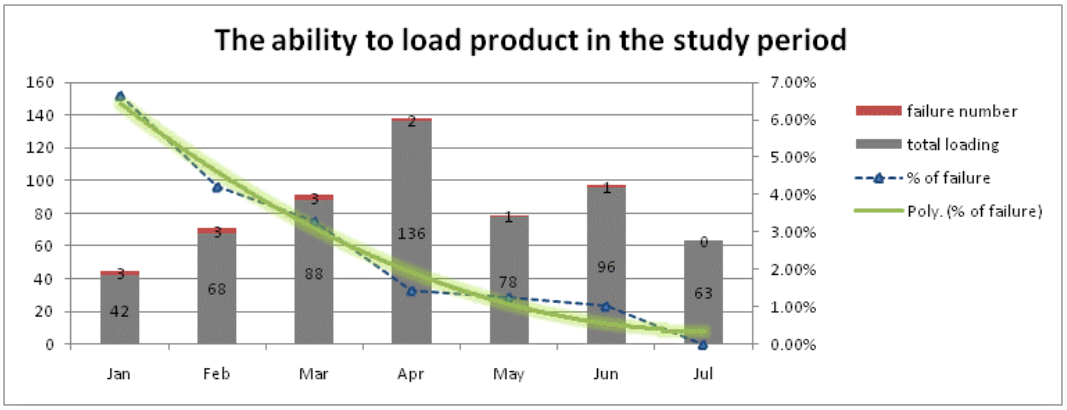


Figure 5. 7 The chart of warehousing improvement

In conclusion, the result shows that the warehouse improvement proposal is effective by reducing of the number of container that fails in the order fulfilment process. In addition, warehousing flow is smoother in operation and investigation. The cross docking is well managing by being identified and directly sent to picking at the beginning of inbound receiving stage. Warehousing activities are also reducing time of area scanning process as the boundary guideline is clearly defined.

Chapter VI
CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Warehouses play a significant role in today's supply chain as their increasing value-adding because of manufacturing evolution. Not just the inventory holding purpose play the significant role in warehousing process as in the past, but also the movement handling became the new significant role. As concepts of JIT, Supply Chain Management, Lean, and Agile, the warehouse is asked to be more assembly operating, more product handling, more cross-docking, and more customizing. As there are many warehouse classifications, each warehouse has a specific role at each position of the supply chain and also the business warehouse item characteristic. Juice manufacture is used as a case study for this research of warehouse improvement, and only juice finished goods product under the studied company's brand name are in focusing. The scope area covers just the boundary of warehouse department area.

Many challenges were found during this study, this manufacturer case study has ***'Make-to-Order'*** as an overall manufacturing business model. The juice finished goods are high variety by classification of flavor in fruits and concentrations, package types and product sizes. The main package types of product are cans, UHT boxes and bottles. Each package type can also have various pack sizes. The variety of package sizes causes the difference in the transferring units of standard pallet. This is another key creating the complicated factor in warehousing flow. As the company sells product through domestic and international export, the destination for product delivery is at the distribution center of both domestic and international company's partners in different countries. Each company's customers prefers to high different range in order characteristic.

The production holds 'Mass production' and 'Just-In-Time' as their strategy concept. This refers to a material requirement planning (MRP), a production plan and a large batch size of continuous production line. Manufacturer needs to produce

product at least the minimum batch size and tries to enlarge the batch size as much as possible for the cost benefit. In conclusion of the product limited factors effecting to warehouse, the product comes into warehouse as a large size batch with the sequencing of production cost benefit not the out-going queue of delivery order.

This warehouse case study should be described as a ***distribution*** although it is called as juice finished goods manufacturing warehouse. It needs to perform the assembly operation for order fulfilment because its manufacturing department implements JIT combined with mass customization. By the reason of manufacturing requirement in warehouse capability, this warehouse not only holds the inventory holding role of product between production time and customer delivery time, but also holds the items movement handling role as isolating, dispatching, accumulating, sorting and consolidating. The order fulfillment process is to collect the specific product codes and the first-in-first-out of product lots which should follow the order requirement until the order list is completed.

From the preliminary observation, *the main problem of warehousing process effective failure as warehouse cannot load product out to respond the customer's requirement especially in the peak demand*. This problem shows in the situation that there were all required products in the stock but cannot load them out from warehouse. As a result, this reason above is the main focusing in this research to find how to improve the warehousing process effectively and the ability to deal with the risk of warehouse processes failure during the high peak demand period.

This research starts at the current warehousing analysis:

Existing warehousing flow process is the common concept as the general warehouse. There are four main warehousing activities in the overall process which are receiving, storage, picking and shipping. The overall mechanism concept is to bring the product for keeping in warehouse area then going to pick the required products as order list by searching and checking for loading and finally delivering to customer.

The warehousing analysis shows the main founding problems, which lead to the main problem of warehousing failure, in the picking process. These are the high time consumed searching and the difficulties to find the required product. It is found that these problems were also related to the overall warehousing process not just the picking but also the information database system and the utilization of warehouse area.

The conclusion of problems found in the current warehousing analysis:

a) The warehousing process and operation

The picking process

- Long time searching process
- Hard to reach the required product
- The product missing

The loading process

- The mistake during loading steps

The overall warehousing

- Weak ability to investigate warehouse: this include stock checking and warehousing tracking back in picking, receiving and storage.

b) The warehouse information

- Invalid and inaccurate information of warehouse stock

c) The warehouse physical structure (layout and area)

- Untidy warehouse environment

Then, the problem solving analysis is applied to find the approach of warehousing improvement:

From the overall of current warehousing and problem analysis, it shows the significant problem that leads to the main focusing situation refers to the difficulties in warehouse controlling and monitoring by the two weak management root causes.

1) The unorganised warehouse area utilization: This creates the obstacle in warehousing operation as the crowd mixing product environment will lead to difficulty in receiving, putting away, picking and checking.

2) The inappropriate warehousing process flow: The warehousing process is not related to the actual material handling flow inside warehouse, the warehousing process and operation is emphasis on the picking process while ignore the role of receiving so the shop floor worker usually face with the problem of outbound accessibility.

In addition, there is another significant finding, which is the poor information database, and also resulted in the obstacle in the research. This causes to the error of information problem more than the warehousing failure problem. Furthermore, during the research, the significant of this root cause is reduced by the new office worker who was hired especially in responding in the stock balancing and the adjustment of balance recording methodology. So, this research will not pay attention to this area.

Finally, the warehousing improvement is designed and evaluated:

As all products from production line will be sent to warehouse as storage purpose by placing into any available area, it shows that there is no concern in the inbound receiving role which is a significant factor of the outbound failure. The category policy is required to reform of the inbound warehousing flow policy. From the product profiling analysis referred to warehousing profile, it was found that the suitable category is the activity controlled policy. The classification policy base on product or customer characteristics and also the identification location policy are not appropriated because of the sensitivity of demand and the dynamic motion inside warehouse. Moreover, the warehousing profile analysis also shows that 'Cross-docking' is appearing to be another significant line in the warehousing flow so that the receiving activities have to be redesign by including the activities concept of this flow line.

For the cross-docking concept, the warehouse planning is an applied tool for forming the starting profile of warehouse at inbound receiving process. There are three methods including in this warehouse improvement proposal

4. The design of warehousing planning

   This is to develop the algorithm of warehousing planning work flow. The objective of the warehousing planning is to predict cross-docking activities in warehouse and support in warehousing control and monitor.

5. The revision of warehousing process flow

   This is to redesign the work flow of warehouse to be more appropriate to the actual product flow and relate to the warehouse plan setting. This emphasizes more on the receiving role to the concerning of the easy to access product for order picking.

6. The design of warehouse layout by activities zoning method

   This is to support the warehousing activities. Moreover, this way is used to organise warehouse area by separating the available and picked product out of others. So, the boundary of searching area will be narrowed while the warehouse operation will be easy.

For the measurement method of the warehousing performance to compare before and after of warehousing process improvement in this case, the completeness of order fulfilment is chosen as the key performance index of the outbound warehousing. This study focused on the effective of warehousing process in term of the quality performance not the productivity performance. Moreover, the warehouse productivity performance is sensitive in the case like this research which has an incentive scheme of operation as the distribution of order characteristic and the high range of number mixing per order. These reasons are not excluding the difficulties of calculation without information supporting.

The completeness of order fulfilment is defined by the completed container loading bill, which is the right of the required product with the right quantity as in the order list, before the loading time. It is easy to count the failure than completeness and the failure percentage is more obvious referring to warehousing process improvement objective. The result will count the number of container failure in order fulfilment and calculate in percentage.

It was found that the average percentage of the preloading process failure in the period before and after warehouse improvement was 5.45% and 1.41% respectively. In conclusion, the result showed that the warehouse improvement proposal was effective by the reduction of the number of containers that failed in the order fulfilment process.

6.2 Recommendation

From the research of this warehousing case study, there are some recommendations provided during the research as the followings.

1. The study is related to the finished goods warehouse of juice manufacturing, which is operated under the 'Make-to-order' strategy. Hence, this warehousing improvement method from this study is able to be applied as reference for other warehouses which have similar operations and material characteristics. To be more clearly, this warehousing case performs for both the inventory holding in a period time and the material movement handling as the short-term of cross-docking.

2. The research was limitedly focused in the production plan and loading schedule which are one of the significant external factors in this warehouse system. So, the future developing improvement research may be conducted in other factors in this interesting area.

3. It was recommended that the material density inside warehouse and the information system are the obstacles to increase the performance of warehouse activities. Examples of the future improvement topic are to study the opportunity and benefit of each increasing handling capacity by applying the information technologies such as RFID, scanner/barcode or WMS (warehouse management system) to increase the speed and reliability in information tracking. In addition, increasing area capacity is another choice. For instance. There are the racking system or the re-construction or outsource warehouse strategy to

increase the capacity support the peak demand. The storage benefit of container is another interesting policy choice. The calling of containers to be waited for loading in advance which the company can benefit by using these containers to increase warehouse area capacity. However, it needs further feasibility study and evaluation on additional Pros and Cons on this concept such as the transportation partner collaborate and the operation, the cost benefit and the infrastructure requirement such the crane and dock implementing design.

4. Setting the standard sizes of quantity in customer order to be related to pallet size may reduce the workload and make the workflow of warehousing activities more smoothly. The standard size of order means to a full or a half or a quarter of pallet. This needs the collaboration from sales persons to convince their contacted customers to be concerned on the detail of package size and loading size pattern.

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APPENDICES

Appendix A: Warehouse Organization Chart

ABC manufacturing warehouse is respond to entirely inventories of all manufacturing process. The overall warehouse organization structure of ABC manufacturing is the flat-wide. One head warehouse manager respond to manage all activities pass 7 responsible team subsidiaries following the criteria of inventory and functional. Seven teams are Jam raw material, Juice raw material, Cold storage, Ink code, Jam product, Juice product and Shrink wrap.

Raw material team for both jam and juice is divided into two sub parts; one is respond to receiving process of raw material from suppliers including quality checking and another is respond to preparing for, sending to, and checking return back from production line. Raw material for juice is under the same idea as raw material warehouse team of jam yet change from jam to juice line. Ink code label responds in producing and preparing ink code label for all product lines. Cold-storage responds in the cold stock controlling and managing. Jam product team is taking care Jam product since receiving in from production line to loading out. Juice product is similar to jam product warehouse team. Lastly, Shrink-wrap/Label packing is respond to shrink wrap, special product label and re-packing process.

The overall organization structure in manufacturing warehouse system

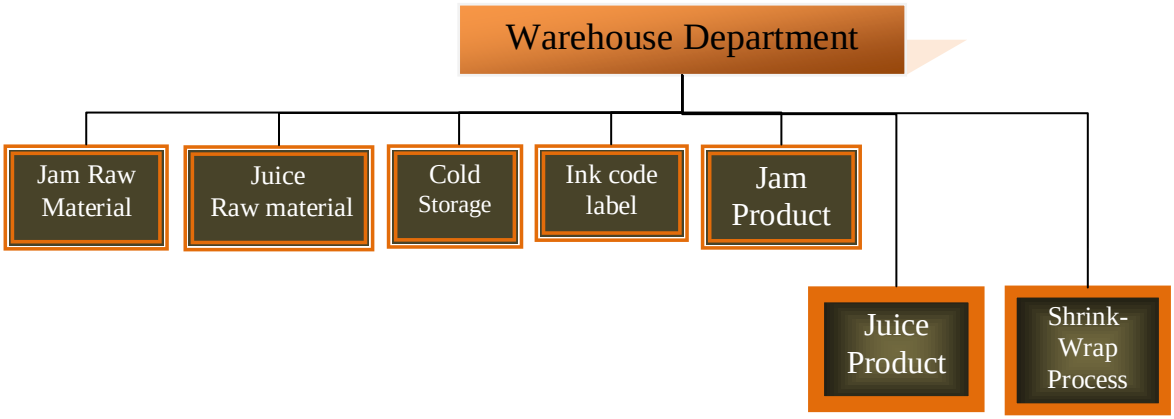


Figure A. 1 Sub-teams in warehouse department

The warehouse processes of the raw material direct respond to the MRP planning team. The JIT strategy and suppliers collaboration of MRP department bring the advantage to the raw material warehousing work process as the low inventory on hand and an up-to-date schedule plan.

The above part shows the picture of the entire warehouse department which the juice warehouse process is part of it. The warehouse organization structure is obviously divided Juice product items from jam product line and raw material line. Even it separates the working team and area dual to the product item and working role but all activities in warehouse system also have to share some resources such as a fork lift truck, the shrink-wrap machine, main path area and etc.

As this research is scope on the juice product, the warehouse organization structure of will be provided next in the relating detail of juice finished goods.

The organization structure in manufacturing warehouse system that involve in juice finished-good product area.

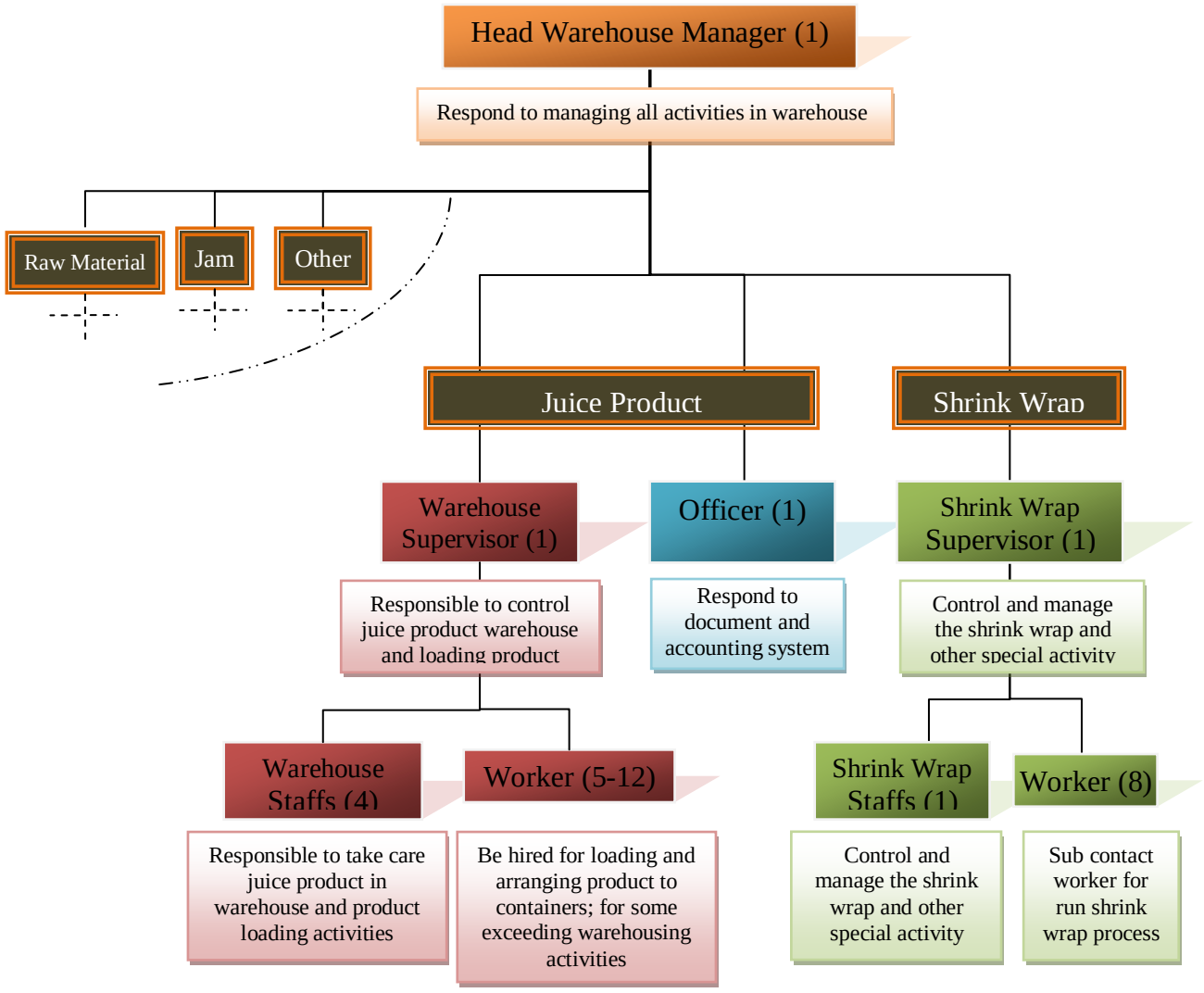


Figure A. 2 Organization structure chart of juice product teams in warehouse

The highest level is a head warehouse manager who is responsible for managing all activities in warehouse area from the beginning pack material & raw material to the final finish good of both juice and jam line including contacting with the transportation partner and supplier. For juice product, warehouse manager is directly responsible for dealing with customer commitment and sale department information exchanging. Warehouse manager responsibility also includes the transportation planning and the collaboration with the transportation partner.

Sub-team of juice product can be divided to two parts which are the warehouse room stuffs and the office accounting staffs.

Warehouse room team is five staffs which are one supervisor and four main warehousing staffs. There are also part time workers who are hired to loading product to container as cartons unit and also doing some exceeding warehouse activities. The number of part-time workers in this part will be depended on the work load of each period. Warehouse room supervisor is responsive for managing, planning and checking the loading out product and driving fork-lift truck to truck or container. Four warehouse room stuffs are one damaging-product worker, who is responsive for checking, taking care and reprocessing a damaged package product and managing the product for special sale activities, and three workers, who are responsive for warehousing activities in warehouse room including controlling product loading activities.

Warehouse officer is responsive for all documents of juice product such as tax-invoice, lock-product paper and bills and also the accounting information system.

Shrink wrap team consists of two full time stuffs. One is shrink wrap supervisor is responsive for controlling and managing all shrink wrap process for both juice and jam product. Another staff is the shrink wrap machine controller who is responsive for monitoring and maintenance the shrink wrap machine. Shrink wrap team's job inculdes repacking process and special labeling process. There are also more than 8-12 part-time workers in this team as to run the shrink wrap machine usually using at least 8 workers.

Appendix B: The Warehouse Operation

Warehousing operation can be separated into five main jobs which are inbound receiving, put away and storage, order picking, loading, and stock checking. Each warehousing activities can be divided into several procedure steps as the following.

1. Inbound finished goods receiving

This is the receiving step of product from production line.

Table B. 1 Procedure of inbound receiving finished goods

Order	Procedure	Worker	Document	Equipment
1	Products Quality investigate	QA staff	Quality checking form	-
2	Arrange product upon pallet	Production workers	-	-
3	Pallet of product waiting for moving to warehouse	-	-	Hand pellet jack
4	Recording the production lot quantity and time in report	Pallet recording staff	Production lot report	-
5	Send the production report to warehouse office	Production staff	-	-
6	Warehouse officer go to investigate product as the report	Warehouse Office Staff	Production lot report	-
7	Key in the information accounting system	Warehouse Office Staff	-	Computer
8	Keep the document in file	Warehouse Office Staff	Production lot report	-

1.1.) Products Quality investigate

The product that come out from production line will be random investigate the quality of product and its package by QA staff. The defect product is separated to reprocess or destroy.

1.2.) Arrange products on upon pallet

The product come out from production line as the unit of UHT box or can or bottle. The production workers will put it into carton box and arrange its carton upon the standard pallet following the pattern is shown in chapter 3.

1.3.) Pallet of product waiting for moving to warehouse

The product pallets will be pile and wait at the production out area before moving to warehouse area.

1.4.) Recording the production lot quantity and time in report

The product pallet arranging will be done one by one until finish. One production batch is different carton quantity so it will come up to different number of full-pallets and fraction cartons too. The 352 cartons units of 1000ml UHT will be recording as 5 pallets and 52 cartons in the production pallet arranging report.

1.5.) Send the production report to warehouse office

After each production batch is done, the production worker will send one copy of production report to warehouse office.

1.6.) Warehouse officer go to investigate product as the report

Warehouse officer receive the production report from production department. The officer will bring that report and go to investigate the coming product by matching actual product to the report quantity and lot detail.

1.7.) Key in the information accounting system

Warehouse officer key in the production detail as warehouse inbound receiving stock update then save this action of accounting system. The key in details are product detail and quantity receiving.

1.8.) Keep the document in file

Warehouse sign the production report for confirm investigation then copy and send it back to production, accounting and keeping in warehouse file one copy.

2. Put away and Storage

This is about the moving and holding of finished goods during the storage inside warehouse period

Table B. 2 Procedure of warehouse finished goods put away and storage

Order	Procedure	Worker	Document	Equipment
1	Area allocating	Warehouse staff	-	Fork lift car
2	Bring the product pallet to place in warehouse	Warehouse staff	-	Fork lift car
3	Put away the product	Warehouse staff	-	Fork lift car

2.1.) Area allocating

Warehouse staff uses the experience and memory to find the area for allocating the new coming product. The moving product into warehouse starts at the free area observation. Warehouse staff looks for available area while he driving the forklift around warehouse area, then calculates the area required and the available area. It may need some put away of existing product in warehouse to clear the row before bring coming product in.

2.2.) Bring and arrange products pallet into warehouse area

Warehouse store the finished goods product in available area with no any policy and no position access record so that one product code may be found around the warehouse and also the locked products of picking process may be placed in many warehouse area alternately with in-coming and long-term storage products.

2.3.) Put away the product

Warehouse staffs put away product out the aisle or rearrange or change the position area by the suitable and their consideration.

3. Order picking

Order picking is the picking and arranging products as customer's order instruction.

Table B. 3 Procedure of order picking

Order	Procedure	Worker	Document	Equipment
1	Receive OI from sales and marketing	Warehouse manager	Order instruction	-
2	Check the stock balance from the computer	Warehouse officer	Stock balance	Computer
3	Investigate the required product in warehouse	Warehouse staff	-	-
4	Confirm the product detail with Sales and marketing	Warehouse officer	-	-
5	Prepare the document for loading	Warehouse officer	Order instruction	-
6	Pick the product as the OI list	Warehouse staff	Locked product	Fork lift car
7	Arrange the product pallet as the container list	Warehouse staff	Loading prepare	Fork lift car
8	Pile product group and wait for loading	Warehouse staff	-	-

3.1.) Receive OI from sales and marketing

The order instruction document (OI) will be sent from sale and marketing department to warehouse manager after the order receiving. If the OI is updated or changed in detail, warehouse office will be informed from sales and marketing. The export OI usually sent to warehouse about 1 month before loading time while the domestic sale department is usually updating the schedule delivery plan every two weeks. By the way, the loading detail and date is defined about 1-2 weeks before loading time. Warehouse manager revises the order instruction nearly the loading time. The OI revise is about one week or a few days before loading for the main purpose of checking OI loading date. Each OI details are the customer detail, customer code, OI number, loading detail, loading date, list of product code and its quantity, and the special requirement if have.

3.2.) Check the stock balance from the computer

Warehouse manager or warehouse officer will check the stock information detail in the accounting system and the excel balance sheet. The purposes of stock checking in computer are “Is the required product following the OI in warehouse?”, “How much quantity of each product list?”, “Is the lot detail of required product stock should be pick out first as FIFO?”

3.3.) Investigate the actual product in warehouse

Warehouse manager assigns warehouse staff to find the required product in the warehouse area. If warehouse staff cannot find the required product as the specific detail, warehouse staff will check the lot and quantity detail of all relating product codes in all warehouse area then short note and report to warehouse manager.

3.4.) Confirm the product detail with Sales and marketing

Warehouse office informs the detail of the product list in order instruction to sale after that sale will check and approve the OI with product lot detail. The approval OI will be processing the next steps which are picking and loading.

3.5.) Prepare the document for loading

Warehouse office will prepare all documents for both the picking and loading processes. The documents are the locked label and OI checking for the picking and loading and checking documents for the loading process.

3.6.) Pick the product as the OI list

Warehouse staff picks the required product as the OI list detail. This step including rearranging the carton of product upon pallet if it necessary such as the splitting of one full product pallet to be two fraction pallets. This process includes put away activity.

3.7.) Arrange the group of product as the container list

Warehouse staff brings picked products follow the OI to place together and paste the locked label on it. The lock label is the customer and OI detail inside. This also includes the consolidating process of some

product fragment together for becoming a full pallet. This is for reducing the transport times from warehouse area to loading area.

After finish this step, warehouse staff will send the finished OI picking detail document back to warehouse then warehouse office will cut the stock out in the excel balancing sheet.

3.8.) Waiting for loading

After collect the product as the OI, the lock product will be piled together and wait until the loading time.

4. Loading

Loading operation is to arrange all products as OI list into containers.

Table B. 4 Procedure of loading

Order	Procedure	Worker	Document	Equipment
1	Check the container	Warehouse staff	Container checking form	
2	Find and move the OI picking product to load	Warehouse staff	Order instruction	Fork lift car
3	Lift the product pallet up to container	Warehouse supervisor	-	Fork lift car
4	Arrange the product cartons into container	Outsourcing worker	-	
5	Record the loading document	Warehouse staff	Loading form	Camera
6	Closing container	Warehouse staff	-	Camera
7	Key in system and document process	Warehouse officer	Loading document	Computer

4.1.) Check the container

Warehouse staff checks the environment inside container at the first step of loading when truck terminal drive the containers into manufacture and park at the loading area. The container checking bases to the checking form list. Warehouse staff may underlay the thick paper, if it need for preventing the carton of product damaging.

4.2.) Find and move the OI picking product to load

The products as the OI loading list should had be already picked for loading prepare. This step is only to find the position of the grouping pile of required product and to move ordering to the loading area.

4.3.) Lift the product pallet up to container

The product pallets will be transfer from warehouse area to loading area then lift up to the container one by one. The ordering of product pallet depends on the loading arranging pattern and some requirement of product code position in container. The product, that will be place in the innermost container, should be lift up in the first place. The arranging design can be separate to inner, middle and ending sections. Each section also has many layers and each layer also has to design arranging pattern of it depending on the mixing product.

4.4.) Arrange the product cartons into container

Warehouse staff controls the outsource workers to transfer cartons of product upon each pallets into container. This step will be done one by one pallet that lifted up into the ending of container until finish all as customer's order.

4.5.) Record the loading document

Warehouse worker, who controls the loading process at the container, has the duty to all loading document recordings. QA staff also is collaborator in this step to random checking the loading product and to sign the loading document for approval. Warehouse staff also has to take a photo for attaching with the loading document during this loading step.

4.6.) Closing container

Warehouse staff, loading controller, check the completeness then close the door of container and lock all door latches before insert the seal lock at the last stage.

4.7.) Key in system and document process

After loading activities is done, the complete loading documents are sent to warehouse office. Warehouse office key out stock as the loading products list then keep the loading report into its file. This also includes the invoice document process with the accounting.

5. Stock checking

This activity is to investigate the actual stock matching with the number. This process is two pattern methods. One is the random product checking which manager will specific the product code for staff to check. Another is a full stage checking overall warehouse area then summary and compare to the information system.

Table B. 5 Procedure of stock checking

Order	Procedure	Worker	Document	Equipment
1	Assign the checking to warehouse staff	Warehouse manager	Checking memo	-
2	Investigate product in warehouse area	Warehouse staff	Checking list	-
3	Compare the checking result to the information	Warehouse office	-	Computer
4	Adjust the number in system	Warehouse manager	-	Computer

5.1.) Assign the checking to warehouse staff

Warehouse manager assign warehouse staffs to check actual product in warehouse by specific the product items code in the memo or separate area checking respond for checking warehouse team members for overall warehouse product checking.

5.2.) Investigate product in warehouse area

Warehouse staffs walk around warehouse to scan for the specific items or scan the assigning warehouse area then write the details of product finding and send back to warehouse manager.

5.3.) Compare the checking result to the information

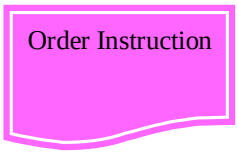
Warehouse manager collect all checking reports from warehouse staffs then summaries the actual stock checking report. The actual stock checking report will be brought to compare with the information system. The comparing result should be matching but if it not matches, the checking process may rerun again.

5.4.) Adjust the number in system

If second time checking result is not equal, it will need the adjusting number in the accounting system.

Appendix C: The Tables of Planning Information

The order instruction:



Header data

- Number of order instruction, Customer detail, Loading date and detail.

Table C. 1 Order instruction information

Container order	No.	Product code	Product name	Quantity (ctn)	Loading Date	Lot production
1/2	1	002341	acb	xxx	x/x/x	
1/2	2	022156	bba	xxx	x/x/x	
2/2	1	002245	cab	xxx	x/x/x	

The order instruction after fill the product details:

Header data

- Number of order instruction, Customer detail, Loading date and detail, Revise date.

Table C. 2 Order instruction information with product lot detail

Container order	No.	Product code	Product name	Quantity (ctn)	Loading Date	Lot production
1/2	1	002341	acb	xxx	x/x/x	12022010
1/2	2	022156	bba	xxx	x/x/x	06012011
2/2	1	002245	cab	xxx	x/x/x	10022010

The production plan:

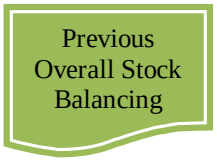
Header data

- Date of revising plan, Production plan period.

Table C. 3 Production plan information

Production Date	Product code	Product	Lot production	Quantity

The stock balance:



Header data

- Date of revising plan, Production plan period.

Table C. 4 Stock balance information

Product code	Product	1		2		3		4		5		Total Quant.
		Lot	Quantity	Lot	Quantity	L	Q	L	Q	L	Q	

Appendix D: The Measurement Result

The container loading result of 2009

Before the warehouse improvement implement

Table D. 1 Result of warehousing process recording before improvement

Month	Jan					Feb			
Week of Year	1	2	3	4	5	6	7	8	9
Week of Month	1	2	3	4	5	1	2	3	4
Ending date of the week	1/2/2009	1/9/2009	1/16/2009	1/23/2009	1/30/2009	2/6/2009	2/13/2009	2/20/2009	2/27/2009
Num. of Containers		**8**	**11**	**5**	**21**	**12**	**6**	**16**	**37**
No. Con that not ready to load			**1**		**2**			**1**	**2**
Total Monthly container loading					**45**				**71**
total Pre-load fail					**3**				**3**
% Con Pre-loading fail					**6.67%**				**4.23%**

After the warehouse improvement implement

Table D. 2 Result of warehousing process recording after improvement

Month	Mar				Apr				
Week of Year	10	11	12	13	14	15	16	17	18
Week of Month	1	2	3	4	1	2	3	4	5
Ending date of the week	3/5/2009	3/13/2009	3/20/2009	3/27/2009	4/3/2009	4/10/2009	4/17/2009	4/24/2009	4/30/2009
Num. of Containers	**7**	**44**	**25**	**15**	**8**	**34**	**2**	**62**	**32**
No. Con that not ready to load	**1**	**1**	**1**					**1**	**1**
Total Monthly container loading				**91**					**138**
total Pre-load fail				**3**					**2**
% Con Pre-loading fail				**3.30%**					**1.45%**

Month	May				Jun				Jul				
Week of Year	19	20	21	22	23	24	25	26	27	28	29	30	31
Week of Month	1	2	3	4	1	2	3	4	1	2	3	4	5
Ending date of the week	5/7/2009	5/15/2009	5/22/2009	5/29/2009	6/5/2009	6/12/2009	6/19/2009	6/26/2009	7/3/2009	7/10/2009	7/17/2009	7/24/2009	7/31/2009
Num. of Containers	**19**	**5**	**51**	**4**	**19**	**27**	**9**	**42**	**9**	**15**	**26**	**2**	**11**
No. Con that not ready to load			**1**					**1**					
Total Monthly container loading				**79**				**97**					**63**
total Pre-load fail				**1**				**1**					**0**
% Con Pre-loading fail				**1.27%**				**1.03%**					**0.00%**

BIOGRAPHY

Miss Apaasorn Prairajata was born on 17 February, 1983 in Bangkok, Thailand. She has obtained her Bachelor degree in Chemical Engineering Science from Chulalongkorn University in 2005. While she is working for ILS department Aspec Oil Thailand, Co., Ltd, she enrolls for Master degree in Engineering Business Management at Regional Center for Manufacturing System Engineering, Chulalongkorn University and University of Warwick.