CHAPTER II

RELATED LITERATURE STUDY

2.1 Warehouse in automotive manufacturing

2.1.1 Definition

Warehouse building is basically a weather protection device to store invested capital in the form of goods and to provide work space for the people and equipment who must handle these goods and deliver them to customers or to manufacturing operations (Sims, E. Ralph (Tompkins, James A., 1998: P.295)). In this study, warehouse is designed for storing raw material and delivering to automotive manufacturing operations.

2.1.2 Objective

The objectives must be met for a warehouse to be successful are following (Tompkins, James A., 1998: P.11).

1) Maximize effective use of space
2) Maximize effective use of equipment
3) Maximize effective use of labor
4) Maximize accessibility of all items
5) Maximize protection of all items

2.1.3 Warehouse operation

The basic functions of warehousing in a manufacturing environment are four functions which define the raw materials warehouse (Cullinane, Thomas P.(Tompkins, James A., 1998:, P.44)).

2.1.3.1 Receiving raw materials

The ownership of raw material is transferred or control takes place in the receiving department and is identical to the receiving function in the warehouse. Inventory level reduction is recommended if materials are received at time of use.

2.1.3.2 Storing raw materials

In the theory of zero-inventory storage functions would not have to exist in the system. Instead, raw materials would arrive from the vendor in the time to be put directly into the manufacturing process. By the way, because of some limitations in machine and labor use, the storing process is still being performed.

2.1.3.3 Kitting raw materials

The task of filling a customer order by seeking out units stored in the warehouse and accumulating them for shipment is called picking. In terms of manufacturing, kitting is the forming of a handling unit of items from stock. In general terms procedures include sequential kitting, batch kitting, or zone kitting.

2.1.3.4 Releasing raw materials

The final task in the warehouse process, releasing or shipping raw material to the next process, in term of manufacturing, called line side.

2.1.4 Warehousing devices

Warehouses should use multiple types of storage devices and strategies in different zones, base on item volume, frequency of use and destination, or origin (Baudin Michel, 2004: P.73).

2.1.4.1 Type of storage system

In today's warehouses, there are a lot of storage module applications. The general designs storage systems are introduced below.

2.1.4.1.1 Floor storage (Baudin, Michel, 2004)

The materials are placed on the floor.

2.1.4.1.2 Racks (Baudin, Michel, 2004)

In a racking system, most of the materials are packed in pallets or bulky style. There are various types of racking system as detailed below in **Figure 2.1:** Pallet storage options. These can be manual or automatic storage and retrieval system (AS/RS) for this kind of rack.

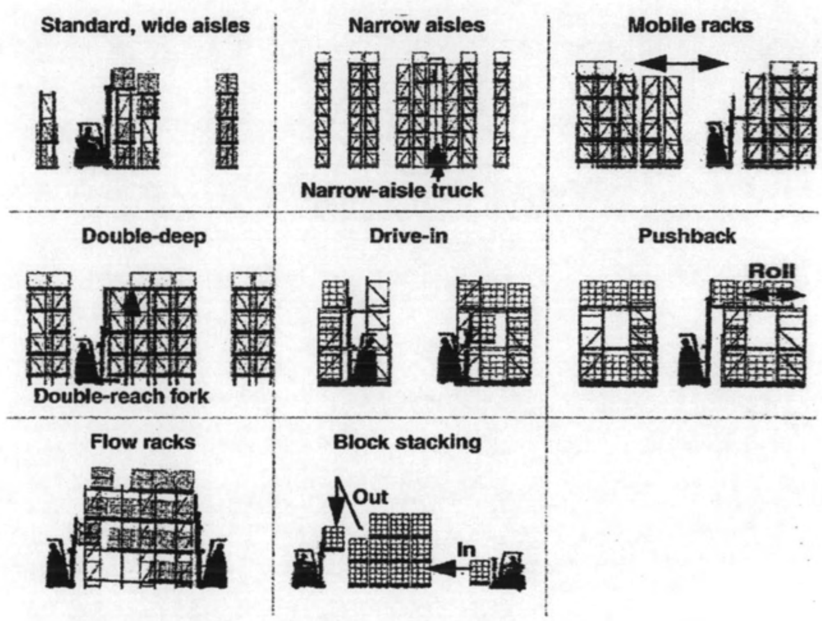

Figure 2.1: Pallet storage options (Baudin, Michel, 2004: P.82)

1) Standard, wide aisles or Selective racking system type: The main feature is it allows the storage of many different types of load and heights, also a wide range of palletized loads, containers, drums, coils and barrels with direct access to every unit (sometimes called Drive through racks in the case of mobile equipment driving into racks).

2) Narrow aisles: They support a high storage density and are processed with the mobile equipments for narrow aisles.
3) Double-deep / Drive-in / Push back: These types of rack are designed to store pallets for more than one deep with the purpose of increasing storage density. They also, require some especial equipment such as double-deep reach truck. The last-in-first-out (LIFO) system will happen in these kinds of rack.
4) Flow racks: They are for items with dedicated storage space and support first-in-first-out (FIFO) basis.
5) Block stacking: The main attraction is it requires no investment in racking and relies on the same forklifts the plant uses for other purposes. It requires pallets to be stackable. It is the most labor-intensive method and it can be identified with floor storage in item 2.1.4.1.1

2.1.4.1.3 Shelves and flow rack (Weiss, Donald J. (Tompkins, James A., 1998))

These types are used to store small parts. It is effect in item picking and frequent usages. Shelving is a basic storage method with flexibility and low capital investment. By the way, some systems have inefficient space utilization due to limitations of poor use of vertical space and many shelves are being occupied by more than one product. A flow rack is usually equipped with rollers, to take advantage of gravity in order to always have the material at the front of the shelf. Flow racks are popular in manufacturing and similar to shelving. Both types require efficient warehouse planning to enhance space utilization.

2.1.4.1.4 Bin (Weiss, Donald J. (Tompkins, James A., 1998))

Bins are also recommended to store small parts. They are lighter in weight, dust-free and adjustable. They are fabricated of wire or metal sheet depending on the material load.

2.1.4.1.5 Automatic storage and retrieval system (AS/RS) (Allred, James K. (Tompkins, James A., 1998)).

Automatic storage and retrieval system (AS/RS) are technologies for improving material flow and control in factories and warehouses. They are highly accurate, secure, space efficient and offer real-time management of inventory because they keep precise records of all items. These AS/RS computers are connected to systems which manage production to provide precise real-time knowledge of inventory on hand. They can utilize horizontal space without the need of a new building. It is high investment but it can save labor costs, carrying costs and security system costs.

The guideline of selection the proper storage module is shown in **Table 2.1:** Inventory profile and corresponding storage module (Sisko, G., 2003. Cited in Elenbark, 2006)

Table 2.1: Inventory profile and corresponding storage module

Range of Numbers of Pallets per SKU	No. of SKUs	Total No. of Pallets	Average No. of Pallets per item	Applicable Storage Module X = Preferred Storage Module O = Workable But Not Preferred						
				Pallet Load				Less than Pallet Load		
				Floor Storage	Drive-In Racks	Double Deep Racks	Single Deep Racks	Case Flow Racks	Shelves	Bin Drawers
> 100	2	350	175	X	X	O	O			
51 to 100	18	1,100	61	X	X	O	O			
21 to 50	40	1,000	25	X	X	X	O			
11 to20	160	2,200	14	X	X	X	O			
6 to 10	330	2,300	7	O	O	X	X			
2 to 5	500	1,600	3			O	X			
0.5 to 1	750	750	1				X	X		
0.25 to 0.49	900	270	0.3					X	X	
0.24 or less	1,300	65	0.05					X	X	X

2.1.4.2 Type of mobile equipments (Baudin Michel, 2004: P.51).

- **Forklifts truck**
- **Reach truck**
- **Tow tractor**
- **Stacker**
- **Pallet jacks**
- **Push carts**

2.1.5 Warehouse management system (Reed, Carla (Tompkins, James A., 1998))

The objective is maximizing the use of warehouse resources while exceeding the customer's requirements. Warehouse management system (WMS) supports high inventory accuracy and minimized uncertainty by supporting order checkers, pickers, and the proper paperwork in warehouse activity. The system offers a competitive advantage in organization by using tools such as Electronic Data Interchange (EDI) communications, bar coding requirements and other customer-specific packaging and labeling requirement to drive the system.

2.2 Literature reviews

2.2.1 Warehouse design

Warehouse design model attempt to optimize such things as the orientation of storage racks, the allocation of space among competing uses according to Cormier, 1997, problems which will be addressed can be classified into three major categories: warehouse design models, throughput capacity models, and storage capacity models.

Feng, and friends, 2006 present a periodic review inventory model with multiple delivery modes and generalize the notion of the base-stock policy for inventory systems with multiple delivery modes.

Warehouses once served almost exclusively as storage facilities. Raw material arrived or finished products left, and companies made improvements only when problems occurred, or space become constrained. According to Nash, 2006, converting to lean warehousing requires a significant change in the warehouse operations, plus a dedication at each level of the organization to always be looking for ways to do everything better, faster, with fewer errors and with minimal waste.

The process of designing the warehouse in the proper way for distribution center was described by Elenbark, 2006 as below which may be adapted in general design terms. The first step in designing a warehouse is the collection of historical data for the company's products and customers. This data is used for determining the types of storage methods and modules suitable for different products. The second step is to establish an inventory profile for each product group. These profiles should be calculated in terms of unit load per item, and the type of storage modules suited for each product. The other factors also explained are movement analysis, order characteristics, receiving and shipping characteristics, forecast factors and interpreting the data for design. These requirements are expressed in the following expected terms.

1) Number of trucks arriving
2) Times of arrival
3) Loading and unloading times
4) Volume be product lines
5) Volume by mode of transportation

With these requirements met, storage, order processing, shipping and receiving requirement will gain.

In the Lean concept, Lee, 2003 defined that, in the evolution of Lean Manufacturing from the Toyota Production System, the design of cells has, unfortunately, taken on a prescriptive, formula driven and imitative approach. The high volume and low variety of automotive production lends itself to certain types and configurations of cells. Now that Lean Manufacturing is spreading to other industries, the Toyota approach to cell design often creates problems. By the way this is for the workplace design but task can be applied elsewhere the four major tasks are:

1) Select The Products
2) Engineer The Process
3) Plan The Infrastructure
4) Design The Layout

From "Lean", a philosophy of production which focuses on reducing lead time by eliminating waste since customer order through logistic (Alukal, 2003). And waste is the non-value added activity or customers are not willing to pay. Warehouse is one of the 7 wastes which is included in lean wastes.

1) Overproduction
2) Inventory waste
3) Defective product
4) Over processing
5) Waiting
6) Motion
7) Transportation waste

Some sources include another waste which is not utilizing people as the eighth waste.

While excess inventory is waste, some stocks are necessary for production. Storage and retrieval in warehouses is needed when incoming and outgoing flow patterns differ (Baudin, Michel, 2004: P.73).

Warehouse should be designed base on current and future needs (Acker, 2006); to facilitate changes in business, warehouse space should be easily adapted. Material handling technologies and business such as JIT shall be implemented along with maximized utilization of space and optimized layout and configuration for warehouse operation.

Warehouse should be designed to maximize utilization of the space and optimize layout for effective operation process. Modern concepts provide value creation to customer by adding more value activity and minimizing waste between processes. Therefore, warehouse is designed to be as small as possible. In automotive manufacturing, it is easy to find the implementation in manufacturing processes in order to improve productivity and profitability. Warehouse is one of the business units and design should be focused to reduce the investment cost. By the way, design of the warehouse is depending on the business model. Through this study, it will be particularly implemented design to area of material handling in order to improve an efficiency and effectiveness.

Efficiency = Output = Yield

Effectiveness = Outcome = Yield + Customer satisfaction

One of the requirements in warehousing success is space utilization (Tompkins, 1998) which means the space will be more efficiently and effectively utilized.

In warehouse layout, there are processes of laying out a warehouse (Frazelle, 2002). The methodology requires as input the warehouse activity profile, performance operation, and the material handling and storage system. The methodology for warehouse layout includes five steps as presented below:

1) Space requirements planning: to determine the overall space requirements for all warehouse processes base on interrelationships between individual warehouse processes for example receiving, staging, pallet storage and etc.
2) Material flow planning: to specify a U-shape, straight-thru, modular-spine, or multistory flow pattern.
3) Adjacency planning: to locate functions with high adjacency requirements close to one another based primarily on material flow patterns.
4) Process location: to assign processes with low labor costs.

5) Expansion/contraction planning: Document expansion and contraction strategies for each warehouse process.

Design Strategies, Phillips, Ed, (http://www.strategosinc.com/warehouse.htm) described that one key to effective design is the relative dominance of picking or storage activity. These two warehouse functions have opposing requirements.

The **Table 2.2:** Storage requirements and technologies in different design concepts, below shows how different transaction volumes, storage requirements and technologies lead to different design concepts.

Table 2.2: Storage requirements and technologies in different design concepts

High Pick & High Storage This indicates a large and active warehouse such as a Distribution Center (DC). In these situations, high technology automated picking combined with mechanized handling and high density storage justifies itself.	**High Pick & Low Storage** With high picking activity but low storage, the picking area should be compact and dense and storage is simple. Some automation of picking may be justified.
Low Pick & High Storage Here the requirement is for high density storage with high bays, multi-levels and dense packing. Low turnover means that picking can be manual or semi-manual.	**Low Pick & Low Storage** A simple, small warehouse requires neither automation or sophisticated storage devices. Stacked pallets, floor storage or simple racks and shelves suffice. Handling is manual.

Techniques that maximize space utilization tend to complicate picking and render it inefficient while large storage areas increase distance and also reduce picking efficiency. Ideal picking requires small stocks in dedicated, close locations. This works against storage efficiency.

Automation of picking, storage, handling and information can compensate for these opposing requirements to a degree. However, automation is expensive to install and operate.

2.2.2 Warehouse operation assessment

An operations assessment is a process that evaluates ten categories of performance in the warehouse (Tompkins 1998). The ten categories in the operations assessment are as follows:

1) Customer service
2) Control systems
3) Inventory accuracy
4) Space utilization
5) Labor productivity
6) Facility layout
    a. Effective space utilization
    b. Efficient material handling
    c. Economic storage relative to cost of equipment, use of space, damage to materials, and material handling labor.
7) Equipment methods
8) Equipment utilization
9) Building facilities
    a. Dock capacity
    b. Lighting
    c. Personnel services (Offices, restrooms, break areas, etc.)
    d. Fire protection
    e. Outside space (Truck aprons, service areas, etc.)
10) Housekeeping and safety

Those are the guide indicators to identify the efficiency of the warehouse design at both the baseline stage and the after improvement. It can determine the efficiency by rating on a scale and calculate the performance index.

Lucansky 2003, identifies 'value to ultimate customer/consumer' in all its products and services and his analysis focuses on the value stream. Assessment can be defined as utilization beginning from implementation time. This time comes from the beginning of the process (unloading) through the finished put-away of the material. The measurement comes with measures for each of the Lean wastes, (Bodek, 2004).

The paper from Par Ahlstrom, 2004 shows the investigation into the contingencies to the applicability of lean production to service companies. A framework for lean production is described and translated into service companies, using an empirical base consisting of descriptions of lean production applications in the service sector, made by practitioners from service companies. The findings indicate that lean production is applicable to service operations, although there are contingencies to the application. The contingencies stem from the characteristics of services. There are also instances where lean production is perhaps more applicable to services than manufacturing, again due to the nature of services.

In order to apply lean manufacturing concept, Apte and friend, 2004 were review how the lean manufacturing principle can be beneficially applied to the insurance claims handling process and argue that minimizing cycle time plays the same role as reducing inventory.

In Lean warehouse, Ackerman, 2000 defined that in studying the warehousing operations, one should identify every activity that absorbs resources without creating additional value. Shipping and receiving errors may be the most obvious example. How much more profitable could the warehouse be if we eliminated the errors accepted as normal today? Waste also is found in poor utilization of space. Space is money, and it is paid for every month. If extra space is acquired when the existing warehouses are not completely full, the waste is obvious. Achieving lean warehousing requires a certain mind set.