

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL BACKGROUND

In this chapter, some journal reviews having similar type with the research's topic are discussed as well as some theories to give the basic needs to analyze current problems.

2.1. Literature Review

The first research is from Zuluaga et al (2012), about the heuristic simulation for configuring a selective pallet rack system to install a normal pallet rack optimized for the company's pallet's size (L x W x H). This research can only be used for the normal pallet rack and shows only the method. The method of simulating the selective pallet rack will produce a conclusion whether the size is maximized or not in the warehouse.

The other researcher is William (2008) wrote about warehouse pallet flow storage system, goods loaded into the rack and then each moves by itself with an engineered-calculated angle to the out area far back. He discusses most of the things, except there is no further explanation about his method and there is no cost associated.

Perme et al (2011) discuss about using discrete simulation to calculate the efficiency and flow of the warehouse, and also to look for the constraints. But it can only be used along with the warehouse that has already equipped with WMS. Despite the WMS, efficiency calculation is one important aspect to be seen for configuring a racking system to ensure a smooth flow inside the storage.

Zeng et al (2002), use ABC analysis for analyzing the type of goods (which one should come first) and the journal compared 3 racking system for the best rack in the warehouse based on the number of pallets can be stored inside. Unfortunately there is no cost associated for the racking system and this method is designed to make a whole new layout.

Gue and Meller (2007) tell about aisle configurations for unit-load warehouses. Their objective is to minimize the travel distance of the lift truck for one Pick and Deposit point. Building a warehouse layout is necessary to use this, and it is

being used as a project in a traditional layout design. This calculation is needed to configure the international standard aisle for a storage facility.

Then there is a strategic inventory optimization written by Shapiro and Wagner (2009). This journal is one of the business logistics journals telling us about integrating the inventory model and simulation to get the output and the holding cost within the supply chain of the inventory. From this journal, some information about optimizing the storage without abandoning the cost aspect could be taken to support the research.

Dekker et al (2004) wrote a research about order-picking response time. This research is good to be used in this project to calculate the inventory accuracy and to optimize the picking of goods inside a warehouse. One of the methods used by writers is heuristic simulation which simulates the choices of route that was calculated through several steps.

In a book written by Mulcahy (1994), planning analysis has two steps: data collection and development of alternative layouts. The first step is divided into five methods, they are: identifying and listing existing material handling equipment, measuring, classifying each warehouse function, projecting SKU inventory levels, and reviewing alternative material handling concepts. The second step, development of alternative layouts, has an objective to build alternatives for several key warehouse functions. According the equipment selection procedure from Apple (1972), reviewing alternative material handling concepts has another steps, they are: make a tentative selection of equipment type, narrow choices, evaluate the alternatives, check the selection for compatibility, select the specific type of equipment, prepare specifications, and procure the equipment.

Lu and Gelman (2003) combines several methods to develop steps for estimating sampling variance of survey estimates. It gives a brief explanation of using weighting method as the first step which is crucial at the scoring system to achieve a correct design and proper comparison in quantitative analysis.

Afshari et al (2010) explains the selection of personnel using statistical calculation with weighting method. The main objective of this article is to show how the weighting method is briefly calculated to achieve the final score for the selection.

In spite of that, supporting articles are found to get the latest information about the topics referring to current study. The first article is from Clymer Enterprise (1998), it is about the benefit of using drive-in pallet rack placed in the center of the warehouse (aisle in four corners are the same), but unfortunately there is no cost associated in this article. There is also an explanation about modular racking system. This article, made by Frazier Industrial (2008), offers a non-built racking allows us to build by ourselves.

The next article from Beverage Industry (2006) is explaining about the bolted drive-in racking system that allows company to easily build and take the racks out. Konstant Storage Systems (2011) gives a tip to choose the right pallet rack for a company. But the company gives no further explanation about the choices of racks offered. The other journal of Phelan (2009) explains about the three most popular racking systems in the world for warehousing, but there is no cost associated to compare one to another.

Cisco-Eagle (2013) gives a method to calculate the rack estimator for a warehouse using the detailed measurement of the warehouse. This data then calculated and the cost come out is came from the average price of each product needed for the warehouse. SSI Schaefer (2012) describes its mobile pallet racking system to increase the warehouse efficiency.

Mecalux (2013) offers a LIFO or FIFO installation for drive-in pallet rack system. It gives a specific design for the specific strategy that we are going to use for the warehouse, but there is no cost associated. A Canadian manufacturing company (2011) gives a specific design for storage with the single-deep rack, unfortunately the company only gives the design without further explanation. Slip sheet as an option in nowadays industry also discussed by Johnson (1980). The researcher gives the benefit and also negative aspects by using this slip sheet rather than standard pallet.

Pickvance (2001) explains the varieties of comparative analysis to help understanding the widely spread comparative method. This article gives several explanations about achieving procedures and analytical results depend on some assumptions mentioned in the article.

Zhu et al (2005) gives example of calculating risk elements using weighting method. The study explains the importance of using weighting for each risk factor. It also gives a brief difference between 0-3 / 0-2 scoring and 0-1 scoring.

Scoring of 0-3 is being used when the risk elements need to be shown in a big difference rather than using 0-2 scoring, because every element could make a decision into the conclusion. The 0-1 scoring is used to calculate statistical data in overall score, which means every risk factor is combined into one condition.

Research with a complete analysis without leaving the cost as one of the decision-maker for companies nowadays can be done after evaluating the previous researches. The gap analysis for each research can be seen in table 2.1.



Table 2.1. Gap Analysis

Journal's title	Object	Method	Limitation	Design	Efficiency Measurement	Cost
A simulation-optimization heuristic for configuring a selective pallet rack system	✓	✓	✓			
A Model for Technical Optimization of the Distribution Centre	✓	✓	✓		✓	
Designing an efficient warehouse layout to facilitate order-filling process	✓	✓	✓	✓		
Aisle configurations for unit-load warehouses		✓				
Strategic Inventory Optimization	✓	✓	✓			✓
Order-picking Response Time	✓	✓	✓	✓		
Warehouse Distribution & Operations Handbook		✓		✓		
Material Handling Systems Design	✓	✓		✓		✓
Drive-in racks smooth flow for FIFO				✓		
Pallet flow racks boost capacity				✓		
Modular racking system			✓	✓		
supplier's marketplace (pallet racking)			✓	✓		
racking it up (Konstant storage system)			✓	✓		
choosing the right racking system		✓	✓			
Cisco Eagle Pallet rack	✓					✓
Mobile pallet racking				✓		
Mecalux : Drive-in racking	✓			✓		
Racking up a storage : Canadian Manufacturing				✓		
The Pros and Cons of Slip Sheets	✓		✓			
Four Varieties of Comparative Analysis		✓				
A Method for Estimating Design-based Sampling Variances for Surveys with Weighting, Poststratification, and Raking		✓	✓			
Simple Additive Weighting Approach to Personnel Selection Problem	✓	✓	✓			

2.2. Basic Theory

The basic theory will include warehouse and storage, material handling problem solving, and also the relationship between those two.

2.2.1. Warehousing and Storage

According to Apple (1972) Warehousing is an activity which is concerned with the storage and issuing finished goods or products between places, while storage is an activity that take attention to safekeeping of all materials in the plant, between production operations, and awaiting finished parts to assembly station in a good order. Storage and warehousing often interchanged in common practice, but the overall function of both is very much the same.

Rushton et al (2006) then explain warehouse is an integral part of the supply chain either to increase market volatility or to shorten customers' lead times. Moreover warehouse needs to be designed and operated in line with the specific requirements of the supply chain.

a. Warehouse Types

According to Wignjosoebroto (2003) warehouse can be divided into several types based on the materials stored, they are:

1. Raw Material Storage
Warehouse to store raw materials
2. Work in Process Storage
Warehouse to store unfinished good that has gone through one or two work stations
3. Finished Good Storage
Warehouse to store processed good that usually will be sold later
4. Supply Storage
Warehouse to store materials which supporting the production (example: packaging, safety equipment, etc.)
5. Finished Part Storage
Warehouse to store parts that is ready for assembling
6. Salvage
Warehouse to store defect products which can be reworked

7. Scrap and Waste

Warehouse to store defect product which cannot be reworked

b. Storage Arrangement

Other than that, according to Francis et al (1992), arranging a layout for a warehouse needs to be evaluated and re-do if necessary. Goods arrangement also needs to be considered. There are four methods in arranging storage, they are:

1. Dedicated storage method

Location of goods is divided according to its characteristics of the goods itself.

2. Randomized storage method

This method is used when the goods can be placed in any place which is available. Item placement depends on the closest distance to the storage with FIFO (First In First Out) system. However this system has limitation, mainly in organizing the goods, because characteristics are not necessary in this method.

3. Class-based dedicated storage method

This method is the combination between dedicated storage and randomized storage method. Goods are placed based on the type of goods in several section of the storage, but each place can be filled randomly if the goods have been set in the same characteristics or type.

4. Shared storage method

Shared storage method means that different goods can be placed in one storage slot. This method reduces the need of more storage space.

c. Warehouse Roles

Rushton et al (2006) explain that the prime objective of a warehouse is to assist the movement of goods. Many techniques are used to reduce the need of holding inventory, and encompassed with range of supply chain initiatives such as Just-In-Time (JIT), Efficient Consumer Response (ECR), etc., however it is often necessary to hold inventory in where the two conditions apply, they are:

1. The demand for the product is continual;
2. The supply lead time is greater than the demand lead time.

Holding inventory is only one of warehouse's roles taken from other common roles such as consolidation center, cross-dock center, assembly facility, etc. Warehouse often fulfill a mix of these different roles.

2.2.2. Material Handling Basic Concept

According to Apple (1972) material handling is the art of implementing movement, economically and safely. Material handling should be applied to move handler and materials needed. There are definitions about material handling, and none is universally acceptable while one said the primary function is to move materials. One new definition from Assauri (2008) says that material handling is an activity of moving goods from one point to another which involves picking, lifting, and putting materials or goods into the production processes. Some activities related to material handling are as follow:

- a. Packing at supplier's plant,
- b. Loading and shipping,
- c. Unloading activities,
- d. Storage,
- e. Issuing materials.

Those activities above need to have attention in several areas such as:

- a. Storage methods,
- b. Packing methods,
- c. Handling equipment feasibility,
- d. Equipment selection for both handling and storage,
- e. Material handling specifications and standards,
- f. Handling cost studies and cost control methods,
- g. Keeping up to date on handling equipment, methods, and procedures,
- h. Related communication systems.

Assauri (2008) explains that material handling cost will be high when the efficiency is low. Efficiency in material handling should be known by engineer to reduce the waste in handling material or goods. Some reason why the inefficiency of material handling could arise is:

- a. There is slow movement of material or goods inside the running production processes;

- b. Bad handling of scrap results in waste of time and cost;
- c. Slow transportation between departments;
- d. Waste in maintenance department because the lack of direct supervision.

Material handling also has some tasks to benefit the system in a company, such as:

- a. To do an investigation and analysis to determine an efficient material handling activities;
- b. To plan, and make a test of newly developed material handling equipment;
- c. To give recommendations in material handling methods and installation;
- d. To follow and make installation report of new material handling tools and equipment.

Material handling concepts are further explained below.

a. Material Handling Benefits

Attention to details can solve material handling problems, in the other hand men made tools and machines that can help them to do jobs. Building, carrying, or loading makes handling equipment improve either to speed up or to have better capacities. The handling improvement is significantly proven by higher labor cost. A company needs to think a good handling system in order to get the best results. The benefits of material handling can be explained below.

1. Reduced Cost

This act improves the cost of handling and handling tools or machines that could make job easier to do. Material handling is also needed in this problem, mainly to reduce cost of material handling or to reduce total production cost by improved handling procedures.

2. Increased Capacity

Other people also see increased capacity as improving handling system, because one company needs to increase output. Increased capacity is one of important factor to see a better handling system because increased capacity could mean better space utilization, reduce excessive waste of space, faster loading and unloading, and higher equipment utilization.

3. Improved Working Condition

Better material handling also means an improving working condition because it has higher safety to man, materials, and tools, makes job easier, makes work lighter, and reduces error in operation.

4. Improved Salability of a Product

Material handling can also increase the value of a product because customer's decision is important. It can increase the product's value by increasing speed of services provided by the company.

b. Material Handling Limitations and Negative Aspects

Any implemented method in this world is not perfect; furthermore handling system should be evaluated by looking not only the benefits but also the consequences before company makes changes.

1. Additional Capital Investment

Cost is always more attractive than other parts in the business, so the proposed new system needs to be compared with the best version of present practice not with the present practice.

2. Loss of Flexibility

Proposed handling system needs to be evaluated if it is flexible to be economically and quickly adapted or not. When the answer is no, the time loss and changeover cost should be included so the investment calculation could be satisfied.

3. Vulnerability to Downtime

System implemented or proposed new system is never run perfectly in time. Proposed new system needs evaluation in terms of getting back from its service, because breakdown can add costs.

4. Maintenance

Maintenance is an important part to be planned and executed well to ensure the system runs well. Maintenance becomes problem for new modernized handling system because more mechanization are used, and new maintenance methods need to be handled with specified skill.

5. Auxiliary Equipment Costs

Implementing new system needs to consider the new added cost beside the costs spend inside the system. There will be additional cost in some ways such as fuel, gas, pallet, and power supply.

c. Basis of Material Handling Analysis

Material handling analysis has its scope in the definition of material handling itself. Extended material handling activity is located in a specific enterprise with a number of characteristics of the enterprise such as type, product manufactured, and importance of material handling to the company. Material

handling keeps expanding and becomes more important and widely recognized. Material handling activity needs to fit one of the development stages below.

1. Conventional

Movement of materials from one to another is the main attention as the interpretation to material handling in this stage. The concern is engineer needs to find the best way of moving goods between two points.

2. Contemporary

Engineer needs to take attention in the overall flow of materials in the enterprise. Engineer will work to relate any possibility of using general material handling plan with all handling problems engineer could find. Generally we can say that engineer needs to find all problems and solve those problems in this stage. The objective of this stage is to get a totally integrated plan.

3. Progressive

Analyst needs to visualize material handling problems in some related activities such as movement and distribution of finished goods to get overall handling problem solution. This current stage is usually called as “theoretical idea system”.

Increasing material handling in one enterprise needs to be analyzed well because the options to develop are so many. Any possibility from conventional until modern or automated handling can be considered.

d. Unit Load Concept

Unit load in material handling is usually defined as container to get a proper connection between unit load and material handling. Two criteria for unit load are large number of units and size too large for manual handling. Large number of units or parts is considered as one unit to be handled. The basic way to move a unit load is by lifting and carrying, which usually go together in practice. This method is accomplished by some ways such as:

1. A lifting device to lift under the load;
2. Inserting lifting element in the unit load such as wheels, coils, and pipe;
3. Squeezing the load between two lifting surface such as stacked and squeezed cartons;
4. Suspending the load through a hook or a sling.

Above methods are needing basic unit load techniques to be implemented. The basic techniques and the example are written below.

1. Unit load on a platform (Skid and pallet),
 2. Unit load on a sheet (Flat sheet, molded sheet, or flexible sheet),
 3. Unit load on a rack (racking in desired position to hold unit load),
 4. Unit load in a container (box, bin, or crate),
 5. Self-contained unit load (Bundle, bale, fastened unit load, or interlocked unit load).
- e. Equipment Concept and Selection

Equipment is being used in companies, but equipment does not mean to solve a handling problem. Equipment shall be placed in one of the methods to solve material handling problem, which to simplify but economical. The work simplification should follow the general procedure:

1. Eliminate the move;
2. Combine the move with other function;
3. Change the sequence of activities;
4. Simplify the move to reduce waste.

Equipment needed for the handling can be either powered or non-powered. Powered equipment means mechanized equipment such as conveyors, trucks, and cranes, while non-powered equipment is manually operated such as man power.

Engineer should present an understandable explanation in considering equipment type. Pictures and drawings should be appropriately showed. Presentation and drawings would help companies to understand the future equipment in its facilities. Equipment and tools should be considered in all aspects for easier handling in safer conditions. Engineer should list the characteristics below in proposing the new equipment:

1. Advantages,
2. Uses,
3. Applications,
4. Limitations.

Pickvance (2001) explains that the selecting of equipment, one of decision-making problem, can be done with weighting scores that determined by using qualitative or quantitative measurement. Other research, according to Rushton

et al (2006), weighting of qualitative measurement can be achieved by using scoring of 1, 3, and 5, where 1 is the score for negative impact to the objective, 3 is the score of medium (can be changed or not), and 5 is the positive impact to the objective.

People need to understand that almost all material handling equipment have common advantages such as safer handling, reduce handling cost, increase production, reduce product damage, and relieving manpower. Selecting equipment does not ignore trends in industrial world. Early industries used a simple manually-operated handling system, but companies are using more mechanization nowadays. This makes equipment more sophisticated and more complicated, so engineer needs to consider the maintenance also when choosing the equipment. Equipment selection procedure is explained below.

1. Relate all factors

Determine all factors to get the proper background of the problem, including characteristics of material and the requirements to move it.

2. Determine degree of mechanization

Mechanization needs to be seen before selecting the equipment to know whether analyst should choose a higher or lower mechanization level for the system.

3. Tentative selection of equipment type

Significant factors in the current system will help analyst to determine some equipment types for the system.

4. Narrow the choice

Options for equipment are many, so choices need to be narrowed by comparing its characteristic to the system.

5. Evaluate alternatives

Evaluating alternatives means to compare the alternatives in terms of intangible aspects and cost.

6. Check selection for compatibility

Equipment under consideration should be checked for its compatibility to fit into the system.

7. Select specific type of equipment

After the compatibility has been checked, equipment should be selected based on the system's needs.

8. Prepare specifications

A study about the specification of the equipment that will be installed to search for suitable equipment which will fit the system, however it might be necessary to contact consultant who has more experience in its field.

9. Procure equipment

Procurement processes after the specifications of equipment have been determined.

f. Material Handling System Design Procedure

Material handling procedure has developed as time goes by. Apple (1972) said that this procedure is directed mainly for material handling problem, and this procedure can be followed without using in sequence method. The procedure of getting material handling problem solution shall be described below.

1. Identify the problem

Observe and analyze the problem to get a proper image of the problem being faced with the company. Some companies have already known the problems without identifying because it has already been concerned.

2. Determine scope of the problem

Analyst should review the complete scope of the problem to avoid mistakes in implementing new system, so there would not be a false investment

3. Establish objectives

Clearly stated the objective of the project based on the problem to look for the solution later.

4. Define the problem

Define the entire problem properly to review the previous thinking of solution.

5. Determine what data to collect

List all data that should be taken and recorded to get the material handling quotation needed.

6. Establish work plan and schedule

Plan the procedure and schedule to solve the problem identified before. The plan shall depend to the scope and complexity of the problem.

7. Collect data

Actual collection of all necessary data for making the solution, and should be recorded in order to get the actual and up-to-date data.

8. Develop, weigh, and analyze data

Study the facts from the data gathered before. Analysis can be done via some techniques such as assembly chart, process chart, from-to chart, and procedure chart.

9. Develop improvements

Comparing data to all other alternative solutions is usually a process to make the solution in material handling problem, but this is not always necessary to do. Technical work should be provided.

10. Prepare justification

Re-check and re-calculate the new method, then prepare for the justification for management review and approval.

11. Obtain approvals

Presenting the proposed new system to the board of the company, furthermore approval should be obtained after presenting the new system to the board.

12. Revise as necessary

Proposed system does not always be good directly. Disagreements and questions in the system should be changed or fixed immediately.

13. Work out procedure for implementation

After receiving approvals, it is important to make a procedure to install the new proposed system which depends on the complexity of the project without leaving an up-to-date purchase of new system, list of new equipment, select vendors of the new equipment, plan manpower and budget requirement, and establish time schedule for the installation.

14. Supervise installation

The engineer who made the system should supervise the installation to make sure the new method will go according to his/her plan.

2.2.3. Plant Layout and Material Handling Relationship

According to Apple (1972) plant layout takes attention in analysis, planning, and design of the physical facilities that is used in the production, while material

handling deals with that phase of operations which involves movement of materials used in carrying on the activities of the company. When physical facilities are designed, integration to the material handling plan is needed.

a. Objectives

Plant layout and material handling have a close relation. According to Apple (1972) there are some plant layout objectives can be associated with material handling objectives. Below are the objectives of plant layout with the objectives of material handling associated under the plant layout objectives.

1. Facilitate manufacturing process
 - a. Efficient flow of materials
 - b. Minimum of production bottlenecks
 - c. Faster delivery to customers
2. Minimize material handling
 - a. Larger unit loads
 - b. Less damaged materials
 - c. Better control of materials
 - d. Automatic or mechanized handling
3. Maintain flexibility of arrangement and operation
 - a. Flexibility of handling methods and equipment
 - b. Coordinated material handling system
 - c. Material handling planned for expansion
4. Maintain high turnover of work in process
 - a. Shorter production time cycle
 - b. Constant rate of production
5. Hold down investment in equipment
 - a. Less idle time per machine
 - b. Reduced handling between operations
6. Make economical use of floor area
 - a. Better space utilization
 - b. Higher production per square foot per employee
 - c. Use of material handling equipment not requiring fixed floor space
7. Promote efficient utilization of manpower
 - a. Minimize manual handling
 - b. Make effective use of containers
8. Provide for employee convenience, safety, and comfort

- a. Safer working conditions
- b. Less fatigue
- c. Improved personal comfort
- d. Upgrading of employees

A successful plant layout has an effective material handling system or vice versa. Both need attention to solve the problem in an appropriate way. Many activities in an organization are affected to material handling.

b. Relationships between Material Handling and Physical Facilities

Plant layout has an important effect to material handling system, so the facility planning for the plant should support the development of an efficient layout and workflow. Easy example for the importance between material handling and facilities is the consideration for transportation method. Transportation has a direct relation to material handling activities inside the plant such as loading, unloading, and shipping.

Other example is from designing the building itself. Spacing and aisle width can affect in selecting the handling equipment, design of the floor and surface finish also can affect the type of equipment. Designing the plant layout should consider the future development of the plant layout itself to catch up with the growth of the company.

Material handling analysis is not always using the same method day to day, because the variety of handling analysis, tools, and equipment are developing. Basic method will be used as the basis for analyst, but the practice could be different depending on the nature of the material handling problem.

2.2.4. Racking System

Racking system is one of the material handling aids that commonly called as pallet rack. Racking system is designed to store any palletized goods in horizontal rows with multiple levels. It is usually integrated with fork lift trucks as the main requirement to load pallet into a rack. Several types of racking system based on Apple (1972) and Rushton et al (2006) are explained below.

a. Selective Pallet Racking

Selective pallet racking is the most common pallet rack being used by companies nowadays. This racking system provides easy accessibility to all

products stored in the rack. It usually comes with either clip-in configuration or bolt-together configuration. This racking system is popular and easy to find, therefore a lot of rules and standards are given for a good set up for selective pallet racking.

b. Drive-in Racking

Drive-in rack is a racking system configuration that allows lift trucks to be driven directly into the stacked rows. Drive-in rack has a dense capacity with one entry only. This means that a lift trucks should go backward to exit the stacked rows, and most of the application of drive-in rack has Last In First Out (LIFO) method.

c. Drive-through Racking

Drive-through rack has similar system with drive-in rack, but drive-through rack uses First In First Out (FIFO) method which means to provide entries at both ends of the racking system for lift trucks.

d. Pallet Flow System

Pallet flow system is a racking system usually called as gravity flow or dynamic flow system. This system allows pallet to move to the end of the rack by using rollers in the rail. It has a complex motion and braking system which need to be maintained well. This system allows both First In First Out (FIFO) and Last In First Out (LIFO) configuration.

e. Push-back Racking

Push-back racking is a racking system that allows a pallet pushes pallet behind it. It uses a wheeled cart for each pallet, and one channel of push-back rack can consist of 6 to 7 pallets. It is known for Last In First Out (LIFO) configuration, though there is a First In First Out (FIFO) configuration for this type of pallet rack.

f. Compact Mobilized Pallet Racking

This racking system is motorized pallet rack which eliminates manpower and use full mechanization. This racking system has moving aisles and is usually integrated with the automation of picking pallets.

g. Slip Sheet

Slip sheet is a racking system which eliminates the use of standard pallets. Slip sheet is a name of the sheet, either plastic or metal, and commonly used to name the racking system. It utilizes a sheet which will be picked by lift truck using push/pull attachment, and can be stacked well in the storage without the

need of rack. Slip sheet is commonly used in distribution centers which act only as a transit area for goods.

Racking system decision should be seen from its characteristics such as FIFO vs LIFO configurations, the need of rack installation, degree of mechanization, capacity requirement, and automation level.

2.2.5. Cost Concepts

Cost is a necessary factor to propose a new system. Capital investment drives the agreement of a new proposal handed to the board. Cost should be determined from several areas such as activity cost and equipment cost. Company always hopes to get a huge benefit in investing a big project. According to Apple (1972) there are some reasons in determining material handling cost that will be listed below.

- a. Have an accurate record of production cost
- b. Recognize all material handling cost
- c. Serve as basis for economic evaluation and cost comparison
- d. To help minimize the material handling cost
- e. Basis for determination of material handling efficiency
- f. For budget purposes
- g. Justify installation of additional material handling equipment or personnel.

Factors affecting material handling cost in delivering the numbers from proposing a new system usually come from material handling development. These factors, which will be described below, are classified already based on their components.

a. Direct cost

Direct cost is commonly associated with the operation of one equipment or manpower. Some examples are installation cost, transportation cost, labor cost and depreciation cost.

b. Indirect cost

Cost which is associated with the investment or operation, measurable but not directly related, such as training, overtime, and downtime.

c. Indeterminate cost factors

This cost factor is vague, or frequently not known. This cost is still debatable in its nature. Some of the examples from this cost are lost production due to delay, space lost, and changes in product or material quality.

d. Intangible factors

Calculation of dollars value, and should not be included in a cost comparison.

The examples are quality of equipment, durability of equipment, manufacturer's reputation, financial policies, and improved customer service.

Rushton et al (2006) said that cost, as one of the constraint in planning material handling facilities, should be compared well with all options available. Several cost decision are made by qualitative result, but most of the result is achieved by calculation of total cost combined with comparative method to get the desired result.

