CHAPTER 2
LITERATURE REVIEW

This chapter aim to explain the previous research and methodology that related to this research.

2.1. Material Handling

MHI.org was said that material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption and disposal. Kulak (2010), said that material handling has occupied 30-75% Total Cost of the Products, however the efficient Material handling could be reduce the operation cost around 15-30%. This statement shows the importance of Material Handling on the competitive advantage segment for the company. Tompkins (2003), described the criteria of the effective material handling system. The material handling should be on the right of Material, Amount, Condition, Place, Time, Position, Sequence, Cost, and Methods.

This research will find the methods and the amount that should be required by the current system. Hence, the cost of the material handling will be decreased as appoint the correct methodology to know the requirement.

2.2. Simulation Analysis

Rosetti (2015), described that simulation model is a tool to observed the particular system to be collected as function as time. Refer to Schmidt and Taylor (1970), a system is collection of entities that act and interact toward the accomplishment of some logical end system that used in the simulation. The classification of the system could be seen on Figure 2.1.

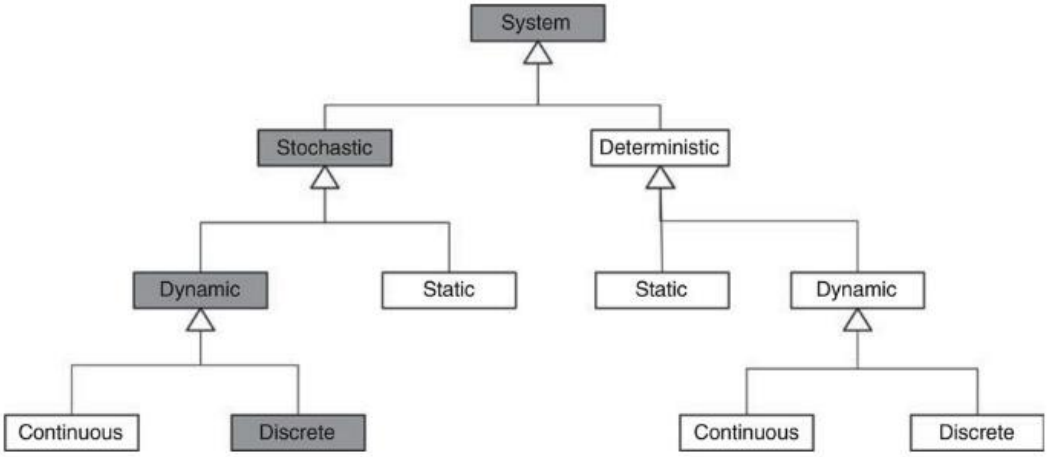

Figure 2.1. General Type of System

Simulation is one of the methods to describe the behaviour or characteristics on current system that implemented. However simulation also could be used as one of the tool to asses and revise the current system, based on the results. Therefore, Rosetti (2015) also was make the prescriptive modelling to tell how the simulation works for evaluate the current system.

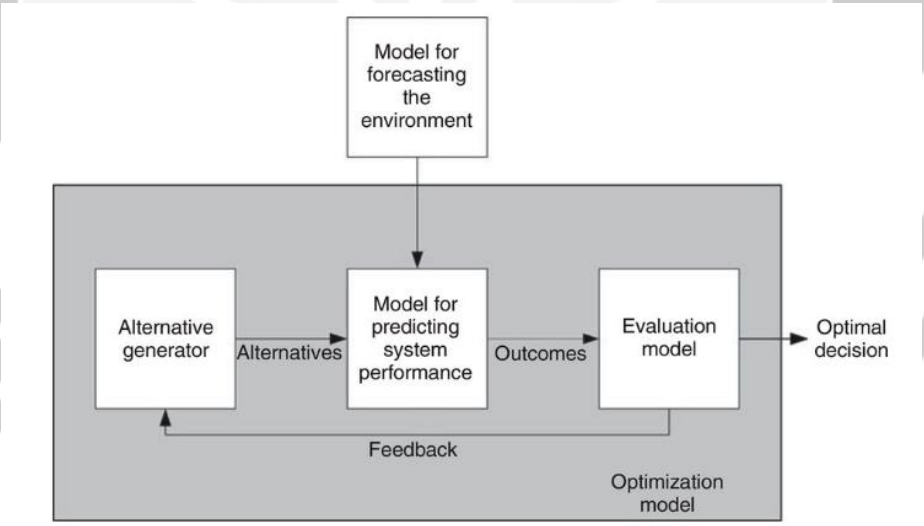

Figure 2.2. Using Simulation for Prescriptive Analysis

Rosetti (2015) also made a conceptual methodology to do the simulation that could be seen on figure 2.3. A based methodology that should be follow is :

- Define the problem
- Establish measure performance for evaluation
- Generate alternative solution
- Rank alternative solution

- Evaluative and iterate during process
- Execute and evaluate the solution.

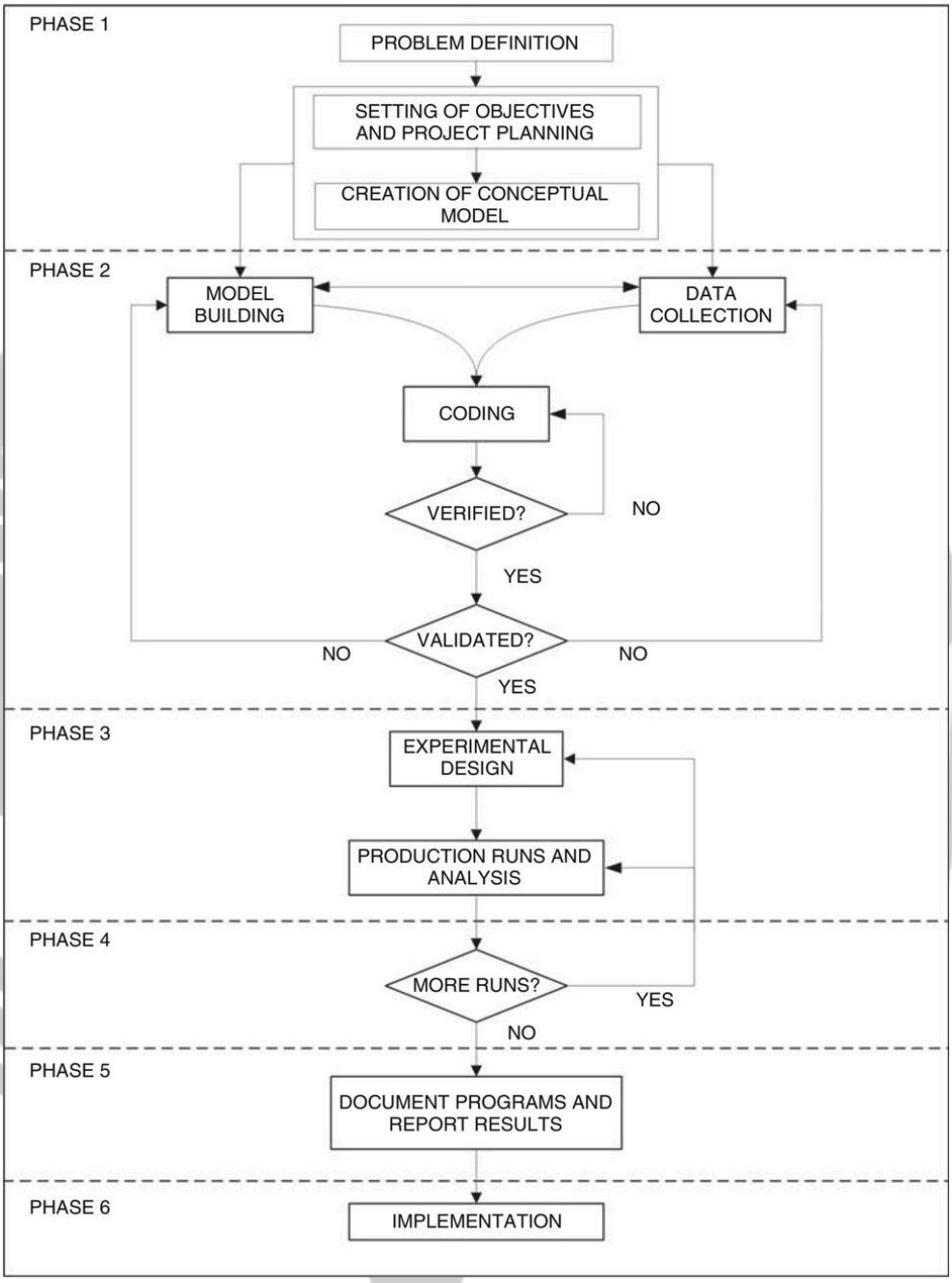

Figure 2.3. General Simulation Methodology

To know whether the simulation has been valid or not, the parameter that could be used is the number of replication that conducted. The point to estimate the number of replication could be seen on equation 2.1.

$$h=t_{\frac{\alpha}{2},n-1}\frac{s}{\sqrt{n}} \quad (2.1.)$$

where:

h = half-width

t = t-value

n = Number of current replications

α = Confidence interval

s = Sample standard deviation

For the number of sample that should be taken using this following equation. The equation 2.2. will performed for the current sample under 100, and for equation 2.3 for larger sample.

$$n \geq \left(\frac{t_{\frac{\alpha}{2},n-1}S}{E}\right)^2 \quad (2.2.)$$

$$n \geq \left(\frac{t_{\frac{\alpha}{2}}S}{E}\right)^2 \quad (2.3.)$$

where:

E= Expected half-width

t = t-value

z = z-value

n = Number of current replications

α = Confidence interval

s = Sample standard deviation

2.3. Statistical Analysis

In simulation method, there are no the exact result. Therefore, it is needed to do the replication for the model. After that, a statistical analysis was needed to validate the model that was performed.

The statistical method that used is ANOVA (Analysis of Variance) to know the significance difference between each variable using variance as the parameter. In ANOVA there are two different sample criteria that used. ANOVA was conducted based on hypothesis testing; therefore, there is assumption that was made during conducting the ANOVA. Here are the hypothesis testing for ANOVA

Ho: μ1 = μ2 = μ3 = … = μn (2.4.)

H1: At least one μn is different (2.5.)

Where:

μn= Means of sampe *n*

There are several software that could perform ANOVA analysis, i.e. Microsoft Excel, Mini Tab, and SPSS. The result of the ANOVA based on software will be shown on P-Value number (Montgomery, 2010). The definition of p-value is the smallest significance level that leads to null hypothesis rejection. Therefore, if the p-value less than the significance level then the null hypothesis should be rejected.

2.4. Time Study

Time study was used to determine the cycle time of each process that was performed by Operator. It was introduced by Frank and Lillian Gilberth (1868-1924).

To receive the proper data analysis based on the works needed proper methods that get the comprehensive sample. Niebel & Freivalds (2003) was explained the proper methods to do the time study started with identifying the job elements, selecting the operator, selecting the times to do the data gathering, record the time, and synthesizing the result from the data gathering.

The next step after do the time study is to make sure the data is valid based on the reality. Barnes (1980) was made the statistics equation to make sure the data that was taken is valid based on the assumption sufficiency and uniformity test.

Sufficiency test is the test to make sure that the sample data that was taken is enough based on the variance, and close to the population data. The data that was taken could be said enough if the number is larger than N' (the sample size should be taken), as seen on equation 2.6.

$$N' = \left[\frac{\frac{k}{s}\sqrt{N\Sigma Xi^2 - (\Sigma Xi)^2}}{\Sigma Xi}\right]^2 \qquad (2.6.)$$

Where:

k = Coefficient of confidence level

s = Precision level

N = Sample size

Xi = Standard time

While uniformity test is the test that makes sure that the data that was taken is uniform, and in control or lies between the upper and lower control limit. The equation of the upper and lower control limit could be seen on equation 2.7.

$$CL = \overline{x} + 3\sigma\overline{x} \quad (2.7.)$$

Where:

CL = Control limit

$\overline{X}$ = Grand mean

$\overline{\sigma X}$ = Variance of Data

2.5. Lead Time

Lead time in lean manufacturing is the whole time to process a product from the raw material to the finished product. It is included the process time, waiting time, and preparation time.

Shortening the lead time is one of the method that applied in lean manufacturing to reduce the waste. However in this research, lead time will be used as a based to calculate the number of trolley requirement.

2.6. Transportation Simplex Method

Transportation simplex method is a method to solve the transportation problem using Linear Programming, which has objective function to minimize the cost of transport or the distance between station. The parameter that should be known in this method is the supply and demand of the process, and the distance or cost-distance for each position supply and demand (Taha, 2010).

$$Minimize : Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} \quad (2.8.)$$

Subject to :

$$\sum_{j=1}^{n} X_{ij} = s_i \;\; i = 1,2,\ldots,m \quad (2.9.)$$

$$\sum_{i=1}^{m} X_{ij} = d_j \;\; j = 1,2,\ldots,n \quad (2.10.)$$

$$X_{ij} \geq 0 \; for \; i = 1,\ldots m \; and \; j = 1,\ldots n \quad (2.11.)$$

The simplex model build based to the mathematical model on equation 2.7. until 2.11. There are three method to solve the simplex model, Vogel approximation method, Least-cost method, and Northwest corner method. All of the method has

different result on their first starting iteration. However, all of the method final iteration will result to the same objective function.

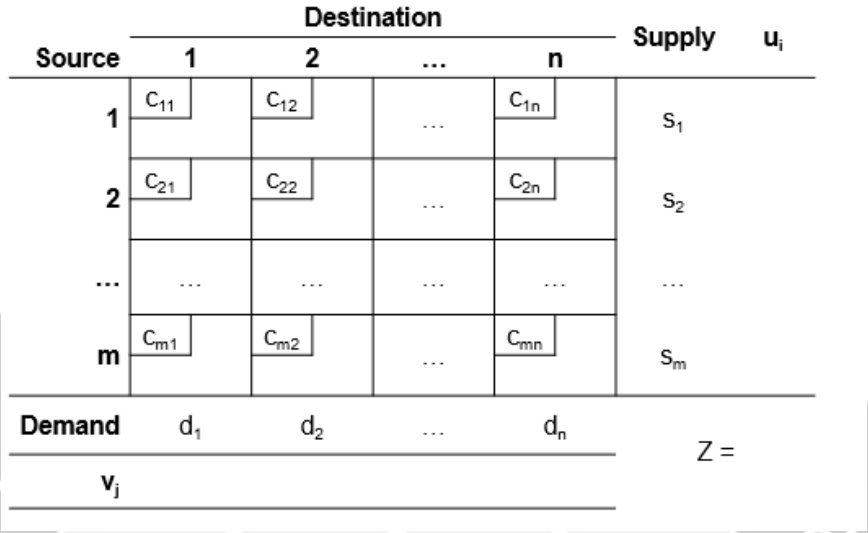

Figure 2.4. The Transportation Simplex Model

2.7. Previous Study in Fleet Sizing

Fleet size is the number of vehicle that available to transport the material in the shop floor. Fleet sizing was one of the four basic design elements in fixed-path material handling system design (Beamon, 1998). Fleet sizing research was introduced on 1950s, it was determined the optimum number of tank based on the schedule (Dantzig, et.al., 1954).

Ceder and Stern (1981) conducted a research to reduce the current fleet size using computational algorithm. It was also resulted the formula to identify the fleet size requirement based on the assumption of determined demand.

The usage of stochastic demand for the fleet-sizing problem was started by Parikh (1977). The approaching that was used is the queuing theory application, while the objectives are to conduct the fleet size and to minimize the delay, and the method to solve the problem was using the analytical method. Papier and Thomennan (2008) was performed a research to develop fleet size, fleet structure, and fleet leasing using the queuing methods.

The following previous research had complexity, and more than one aims. List et al. (2003) was determined the optimal fleet size using stochastic programming with the condition of uncertainty demand, travel times, and operational aspects. The complexity on the background was made this research easy to approach the other

problems. Beujon and Turquist (1991) was identify fleet sizing to make the decision for the management of the empty vehicle. This model optimized both of the fleet size and the decision simultaneously using uncertain condition. Because of the complexity, the works was assuming one of the parameter using deterministic to obtain the solution. K¨ochel et al. (2003) was proposed another problem with the stochastic data using simulation optimization approach. On this research, were considering the stochastic demand and travel times on the customer order batching. This model also was allowing the substitute between different vehicles.

Song and Earl (2008) were doing the research on vehicle repositioning and fleet size for two-depot service system using stochastic model. The model that they develop was identified the vehicles and repositioning the empty vehicle to be reusable again. Vahed et al., was developing the research for multiple depot and periodic vehicle. This research was resulted the algorithm to solve the problem of the fleet size regarding the constraint such as vehicle capacity, route, and budget constraint.

Multiple objective fleet sizing could be the decision making tool. Hence, List et.al (1991) was started the usage of fleet sizing problems to solve the multiple goal and objective problem. That research purpose is to minimize risk, minimize cost, and maximize the equity. Other research was started by Sayarshad et.al (2010). The objective of the research was to optimize fleet size and capacity, optimize of both quality and profit, and the ability to satisfy constraint will become useful in fleet size planning problem.

Compare to all of the previous research, this research is the only research that discussed the manual material handling that operate with man power. While the research objective is to find the optimum fleet size number in the company. Moreover, this research combine both of the analytical method and simulatio method; the alternatives developed using analytical method first, then it would be simulated on the simulation model.

Table 2.1. Previous Research Comparison

No	Author	Year	Title	Material Handling Type			Method	
				Manual	Automatic	Trasnportation	Analytical	Simulation
1	Beamon and Deshpande	1988	A Mathematical Programming Approach to Simultaneous Unit-Load and Fleet-Size Optimisation in Ma terial Handling Systems Design		✓			✓
2	Dantzig, Fulkerson, Johnson.	1954	Solution of a Large-Scale Traveling-Salesman Problem			✓	✓	
3	Ceder and Stern,	1981	Deficit Function Bus Scheduling with Deadheading Trip Insertions for Fleet Size Reduction			✓		✓
4	Parikh	1977	On a Fleet Sizing and Allocation Problem		✓		✓	
5	Papier, Thonemann,	2008	Queuing Models for Sizing and Structuring Rental Fleets		✓		✓	

No	Author	Year	Title	Material Handling Type			Method	
				Manual	Automatic	Trasnportation	Analytical	Simulation
6	List, et.al	2003	Robust optimization for fleet planning under uncertainty			✓		✓
7	Beaujo and Turnquist	1991	A Model for Fleet Sizing and Vehicle Allocation	✓	✓	✓		✓
8	Köchel, Kunze, Nieländer	2003	Optimal control of a distributed service system with moving resources: Application to the fleet sizing and allocation problem			✓		✓
9	Song and Earl	2008	Optimal empty vehicle repositioning and fleet-sizing for two-depot service systems			✓	✓	
10	List, et.al	1991	Modeling and analysis for hazardous materials transportation: Risk analysis, routing/scheduling and facility location			✓	✓	

No	Author	Year	Title	Material Handling Type			Method	
				Manual	Automatic	Trasnportation	Analytical	Simulation
11	Saryashad	2010	Solving multi-objective optimization formulation for fleet planning in a railway industry		✓			✓
12	This research	2018	Manual Material Handling Fleet Sizing using Simulation Model	✓			✓	✓