ANALYSIS OF REDUCING THE DEFECTS OF INDIVIDUAL TOY PACKAGING IN TOY MANUFACTURER, CIKARANG

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A Thesis presented to the
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THESIS ADVISOR
RECOMMENDATION LETTER

This thesis entitled "**ANALYSIS OF REDUCING THE DEFECTS OF INDIVIDUAL TOY PACKAGING IN TOY MANUFACTURER, CIKARANG"** prepared and submitted by **Nadila Nurul Fitri** in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering has been reviewed and found to have satisfied the requirements for a thesis fit to be examined. I therefore recommend this thesis for Oral Defense.

Cikarang, Indonesia, May 9th, 2017

Anastasia L. Maukar, ST,. MSc., M.MT

DECLARATION OF ORIGINALITY

I declare that this thesis "**ANALYSIS OF REDUCING THE DEFECTS OF INDIVIDUAL TOY PACKAGING IN TOY MANUFACTURER, CIKARANG"** is, to the best of my knowledge and belief, an original piece of work that has not been submitted, either in whole or in part, to another university to obtain a degree.

Cikarang, Indonesia, May 9th, 2017

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ABSTRACT

PT. X is one of the largest toy manufacturers in the world. For PT. X, the process of shipment to distribution center often leads to defect products during the trip and the defect products often end up in the distribution center's warehouse and not being handled. Both the distribution center and PT. X consider this as a loss of $361,290 but there is still no follow-up on this issue. In order to help the company to find out the options for this issue and define what factors which significantly affect the number of defect, this research is conducted. By using fishbone diagram and analysis of variance, the factors can be defined that temperature and average speed of truck become the significant factors towards the number of defect occurred, while the length of shipping time does not really affect. The proposed options of defects that occurred are stated and calculated. It is found that the best solution of this issue is to reship and rework the defect products occurred and it costs $73,615. It is way cheaper if it is compared with the reproduction cost, which is $367,990.

Keywords: *Shipment, Defect after Shipment Process, Factorial Design, Three-Way ANOVA, Fishbone Diagram, Reshipping*

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ACF	:	The Autocorrelation Function is a graph used to see whether the data has a correlation or not.
Cargo Load Sheet	:	The sheet that contains of the product details that is requested and sent to each country, where one sheet is for one country.
Defect	:	The product that has visual and physical problem that make the product does not meet the standard specification that are set by the company.
Final Packaging	:	The packaging process of the toys is where the toys are done putting in the individual cartons, then the individual cartons are put into a master carton.
Packaging I	:	The process where the toys are attached in individual carton and the plastic packaging.
Reproduce	:	The production process of products that defected as same as the amount of the number of defect occurred.
Reship	:	The shipping process that is done from place A to place B and deliver back to the place A.
Rework	:	The correction process of defect products that do not meet the standards.
RFID	:	RFID (Radio-frequency Identification) is used to simplify the tracking of shipping process by sending the signal and transmitting the data to the information system in the company to know and to track the whereabouts of products being shipped.
RTS	:	Return to Stock is the process where the data of the product details are input as archives and data collection before the products are place in the warehouse.

SOP	:	Standard Operating Procedure, the written steps or procedure that has been made to be the standard of a certain working process in order to control the same treatment.

CHAPTER I
INTRODUCTION

1.1 Problem Background

The higher business competition these days requires the company to adjust the strategies for daily business. The higher competition between companies is based on how a company can implement the invention and innovation process of product or services to be cheaper, and better than another companies. The effort to create that process is not the target during the course only, but is dynamic. It means that it should be pursued continuously and sustainably. As far as the company is still able to continue working to improve its performance, as far as was then that the company can survive in the tight global competition.

PT. X is one of several largest toy companies in the worldwide. As a specialty manufacturer of toys products which distribute all the products to almost all over the world, PT. X is also focused on getting maximum profit but still using the better material. Since the establishment of the factory of PT. X in Indonesia, PT. X has always been using PVC plastic as the main material for packing the products. As the company wants to make a new change, some policies are made. One of them is the company replaced PVC plastic with PET plastic, which the PET plastic is more economic and environmentally friendly than PVC.

However, after the change in packaging materials, when the products are delivered using the containers, some problems arise and cause significant losses for the company. The packaging of the product that has been changed using PET plastic material is defect, such as the plastic packaging is warping, curved and wavy (Appendix 2). Whereas, before all the products are shipped, the quality of the products has been checked by the quality department. The defect of the products might occur during the shipping process to the distribution center using containers.

This problem is quite influential and lead to substantial losses for the company, because of the fact that the products which are shipped using PET plastic as the packaging are defect. By this problem, the company had to loss $361,290 within 2016. For the reason that quite a distance between the production plant and the distribution center, the distribution center party quarantined all defect products in the warehouse, did not take any action and was still considering the appropriate action. Both of parties, the distribution center and PT. X want to reconsider and decide what better actions should be taken toward this issues and want to know what factors that significantly affect the defect product packaging.

In accordance with the problems that have been outlined, the research was conducted and focused on how to analyze the causes of defects and reduce the defects that occur but still using PET plastic for packaging materials. Several observation and analysis are also expected to be conducted in order to know the factors that cause the defect after shipping.

1.2 Problem Statement

The following problem statement is based on the background of the problem which has been mattered leads to statements as follow:

- What factors that are significantly affect the defect of the product packaging?
- What is the best action that should be taken to overcome the defect products that are quarantined in distribution center warehouse?

1.3 Problem Objective

The main objective of this research is as the following:

- To define the factors that significantly causes the defect of product packaging.
- To find out the best option to overcome the defect products that are quarantined in distribution center warehouse.

1.4 Scope and Limitation

Due to the limitation of time and resources in conducting this research, there will be some scopes in the research:

- The data that were taken is from January until December 2016.
- The research is only focused on data of a distribution center in Fort Worth, TX.
- The cost of shipping is given from the third-party, which is the logistic company.
- The cost of all products is same.

1.5 Assumption

Some assumptions have to be made in order to run and support this research properly as follow:

- The flow of production process is not changing.
- The trucks and containerships are in the same condition.
- There is no catastrophe and it is dry weather.
- The truck route is Cikarang – Tol Jakarta/Cikampek – Jakarta Inner Ring Road – Tj. Priok Port.
- The truck is delivered at 9 p.m.
- The population is a normal distribution.

1.6 Research Outline

The systematic way to conduct this research is described as follow:

Chapter I **Introduction**

This chapter provides the background of problem occurred, problem statements, research objectives, scopes, assumptions, and description of research outline as introduction for this project.

Chapter II **Literature Study**

This chapter contains the theoretical study, and previous study, which are books, journals, thesis used as reference in order to support this project.

Chapter III **Research Methodology**

This chapter delivers a detail process flow and explanation of every single step used to conduct this project, starts from problem identification until conclusion.

Chapter IV **Data Collection and Analysis**

This chapter consists of the data which is taken during the project will be analyzed and processed. The result of data analysis is a new improvement and result of application improvement which is expected to eliminate the defect product after shipping.

Chapter V **Conclusion and Recommendation**

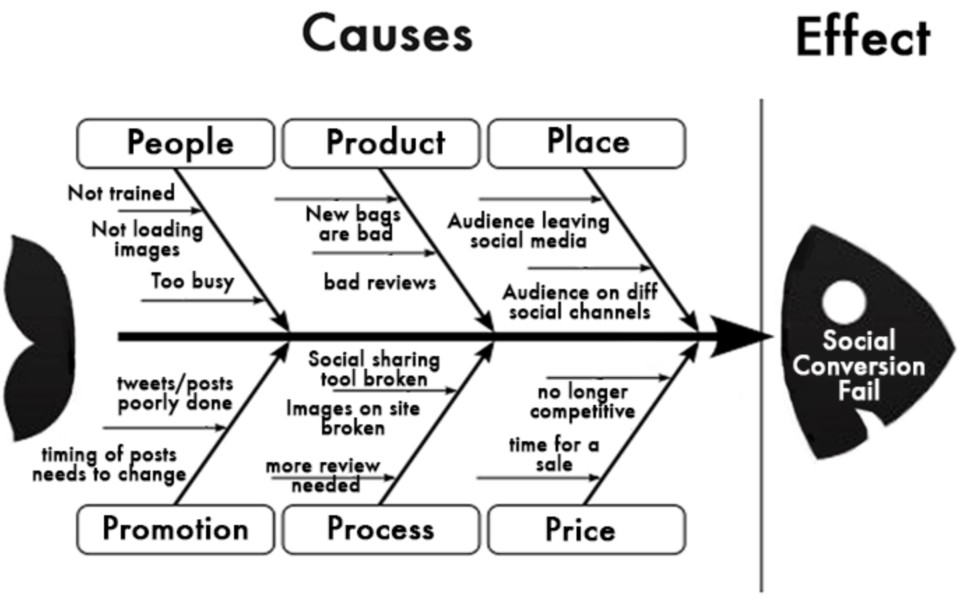
This chapter contains the conclusion of this research to achieve the goals of this research. Recommendations are also given for further research.

CHAPTER II

LITERATURE STUDY

2.1 Cause and Effect Diagram

One of the tools used to conduct the analysis in this thesis is cause and effect diagram. This tool is often used to analyze a certain problem systematically, therefore letting the users acknowledge what factors cause and contribute to the problem (Mitra, 2008). Cause and effect diagram is also known as the fishbone diagram, for the shape that looks like a fishbone, with the effect or problem as the head and the causes as the bones. This tool is first founded by a Japanese quality control statistician named Dr. Kaoru Ishikawa, from which the name Ishikawa diagram is given (Tri, 2006). The Cause-Effect diagram is used as a tool to identify the root causes of quality problems.



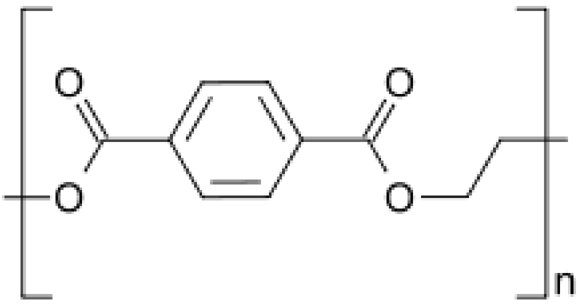
Source: marketgizmo.com

Figure 2.1 Cause-Effect Diagram

Figure 2.1 shows an example of a cause-effect diagram. Commonly, there are 5 categories of causes, which are material, methods and/ or measures, machine, man or people, and Mother Nature or environment. Material refers to the raw materials used in the production process, including information or data of all kinds involved in the production process. Methods and/ or measures refers to the procedures, work instructions, problem solving methods, and also quality inspection methods. Machine refers to all kinds of tools and equipment used in the production process. Man or people refer to all human resources involved in the production process, including customers, managers, government, employees, even the owner of the company. The last but not the least, Mother Nature or environment refers to the state of the surrounding environment.

2.2 Polyethylene Terephthalate (PET)

Plastic is one of the most commonly used materials ever since the year 1600 BC to this day (Andrady, 2011). The early uses of plastic were mainly processed natural rubbers used to manufacture rubber balls, bands, and figurines. Throughout the development of plastic, many additives were added into the polymer for many reasons, such as safety. One of the different types of plastics is Polyethylene Terephtalate (PET), or also known as PETE, PETP, or polyester. Two British chemists, John Rex Whinfied and James Tennant Dickson in 1941, first patented PET. In 1952, conglomerate company named E.I DuPont de Nemours or also known as DuPont in Delaware USA coined the use of Mylar, or also known as the household name for polyester film nowadays, in June 1951, thus received the registration of Mylar in 1952. In 1973, an inventor named Nathaniel Wyeth coined the use of PET bottle that was able to hold the pressure resulted from carbonated liquids that were lighter than glass and virtually unbreakable. The chemical formula of PET is $(C_{10}H_8O_4)_n$ with a melting point of 260^oC (van der Vegt, 2006).



Source: http://www.ks.uiuc.edu/

Figure 2.2 Carbon Structure of PET

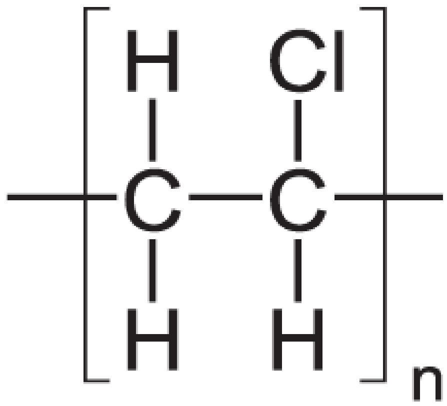
Figure 2.2 shows the carbon structure of PET. Can be seen that there are eight carbons in the structure. In daily life, PETs are often found in plastic bottles for soft drinks due to the strong property—specifically excellent water and moisture barrier material. When mixed with other materials like glass fiber or carbon nanotubes, PET can even be used as engineering plastic due to the enhanced strength of the material. Naturally, PET is colorless and semi-crystalline resin-like material and virtually indestructible, therefore the famous well-known myth about the indestructible nature of plastics. This indestructible nature of PET can be both an advantage and drawback, because since PET is indestructible, then PET can be used for a very long time without worrying the material to break or shatter due to excessive pressure. On the other hand, the indestructible nature can be a problem when the material is about to be disposed. PET can be a toxic pollutant when burnt and when disposed, the best way to dispose of PET is to bury PET instead of just dispose PET into the trashcan like any other types of trash. The purpose of burying the PET is to enable the soil to decompose the PET over time. Virtually the decomposition phase can take hundreds of years, which is why nowadays there are so many plastic-free movements. Although plastics, especially PET are indestructible, relatively cheap, and somewhat low-maintenance, there is a cost that should be borne, which is the tedious effort to decompose the material and having piles of plastics in the disposal centre. Aside from that, there are many advantages possessed by PET, such as chemical resistant (therefore commonly used as consumable packaging), water resistant, high strength to weight ratio, shatterproof, relatively inexpensive, and recyclable nature (Tripathi, 2002).

Source: https://www.creativemechanisms.com
Figure 2.3 Example of PET Usage as Water Bottle

Figure 2.3 shows an example of PET usage as water bottle. However, compared to other plastics, PET is not ideal for personal reuse because unlike glass, the sidewalls of PET bottles have a permeable quality that allow small molecules, for example flavor liquids of raspberry juice, to migrate into the wall, then out again when the juice is replaced by mineral water that essentially possess zero concentration of the flavor liquids. This causes the water to taste like raspberry juice, and not only that this causes a drawback in taste-wise, but can also be harmful to health if the molecules are toxic (Ashurst, 2016). Also, due to the thermoplastic nature, PET can also be used to make packaging trays and blister packs (Erwin, 2007).

2.3 Polyvinyl Chloride (PVC)

One of the oldest synthetic materials of plastic is Polyvinyl Chloride (PVC), which was discovered by at least two occurrences in the 19^{th} century by a French physicist and chemist, named Henri Victor Regnault and a German named Eugen Baumann. From those two discoveries, PVC was originally known to be a white solid and difficult to yield. In 1913, a German inventor named Heinrich August Klatte patented PVC for he founded a yielding method of polymerization of vinyl chloride with sunlight. During the 1950's, many companies started to use PVC, due to the early discovery of PVC through an experiment by an industrial engineer named Waldo Semon. The chemical formula of PVC is $(C_2H_3Cl)_n$ with a melting point of 100°C to 260°C (Wilkes, et al.).



Source: http:/quora.com/

Figure 2.4 Carbon Structure of PVC

Figure 2.4 shows the carbon structure of PET. Can be seen that there are two carbons in the structure. In daily life, PVCs are often found in pipes, electric cables, signs, clothing, furniture, healthcare, flooring, and knive handles (Biron, 2016). When fully chlorinated, typically having the chlorine level of 67%, PVC will have an enhanced heat resistance (known as CPVC) and therefore can be used as the material for hot pipes and fittings (Allsop, et. al). Naturally, PVC is white-colored, solid, and difficult to process.

PVC is a very versatile thermoplastic resin for the ability to take in various additives, such as plasticizers, stabilizers, fillers, and many other additives. Generally, the advantages of PVC depend on the type of compound. For example, rigid PVC is resistant to chemicals, rigid at room temperature, relatively inexpensive price, fireproof, and ease of joining and welding (Biron, 2016). These qualities enable the use of PVC in pipes, food containers, to medical gloves and clothing fabrics.

Source: https://blogs.babycenter.com

Figure 2.5 Example of PVC Usage as Food Container

Figure 2.4 shows an example of PET usage as food container. In regards of the sustainability, PVC is manufactured from petroleum and the process of producing PVC sodium chloride is also used. When PVC is recycled, the material will be broken down into small chips, have the impurities removed, and then the product will be refined to make pure white PVC. PVC can be recycled approximately seven times and typically has a lifespan of around 140 years. The attempts of recycling plastics, specifically PVC are widely known in the world, for example in the UK, where there was approximately 400 tons of recycled PVC monthly. Compared to other plastics, PVC has a specific health risk, which is the exposure of phthalates, which are the ingredients to soften the PVC (Hanser, 2005). Due to the heavy chlorine content of PVC, dioxins are released during the process of manufacturing, burning, or landfilling of the PVC. Dioxins, or also known as Tetrachlorodibenzodioxin (TTCD) is a transparent and odorless solid that include polychlorinated biphenyls (PCBs) that are known for the persistence as organic pollutants and endocrine disruptors.

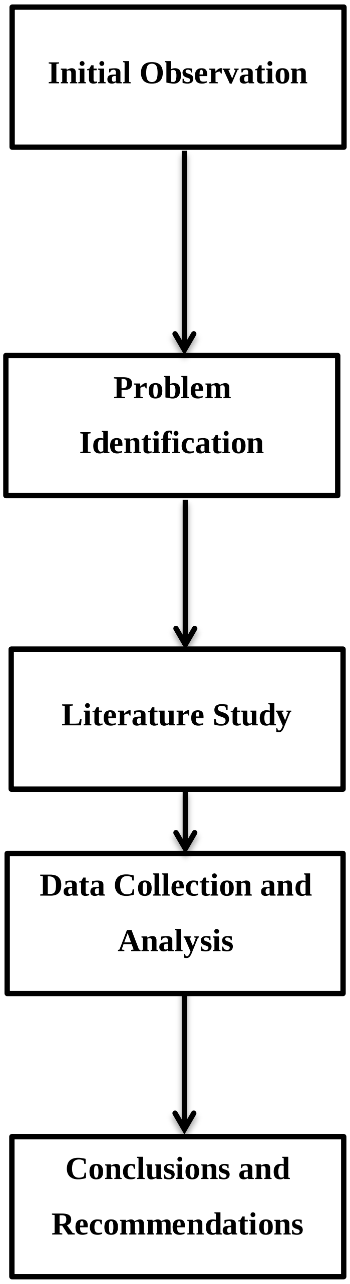
2.4 Three-Way Analysis of Variance (ANOVA)

Among numerous other ANOVA designs, although all of the ANOVA designs have different ways, all of them possess the same logic as the one-way and two-way ANOVAs. Depending on the complexity of the design, a researcher can make a more complex N-way ANOVA designs. In two-way ANOVA, a researcher can acknowledge both the main and interaction effects. However, the two-way ANOVA is less sensitive compared to the one-way ANOVA in regards to the moderate violations of the assumption of homogeneity and therefore, a researcher needs to acquire the approximate equal variances (De Muth, 2014). This practice is and can be widely used in various types of industries depending on the problem faced during the case. For instance, when a study consists of three independent variables, there will be three main effects, three two-way interactions, and one three-way interaction to analyze and therefore be acknowledged as a three-way ANOVA (Jackson, 2009). The procedures of performing three-way ANOVA is basically the same with the other ANOVA calculations, which are to describe the data, make assumptions and models, formulate the hypothesis, conduct test statistic, then the distribution of test statistic, perform the decision rule, calculation of test statistic (which is then summarized in the ANOVA table), make statistical decision, then finally formulation of the conclusion along with the determination of the p-value.

The main effects of the three-way ANOVA depend on the methods at each level of one of the factors, averaging over the other two. A two-way interaction is the normal of the different two-way interactions (basic association impacts) at each level of the third factor. A two-way interaction depends on a two-way table of means made by averaging over the third factor. The error term of the three-way ANOVA or also known as $MS_{w,}$ is simply an extension of the error term used for a two-way ANOVA. When a two-way ANOVA involve repeated measures, then the calculation should be analyzed as a three-way ANOVA, with the different subjects serving as the levels of the third factor. The advantage of using three-way ANOVA is to have an increased efficiency for comparing different levels of several independent variables or factors at a certain time instead of just having several separate single factor experiments. However, along with the enhanced sensitivity of the three-way ANOVA, the complexity of the analysis is also increased. This might be considered as one disadvantage of three-way ANOVA, which is the complexity. For instance, with a two-way ANOVA, there are two tests of the main effect and one interaction to interpret. On the other hand, with three-way ANOVA, these are added to three tests of the main effect, tree two-way interactions, and one three-way interaction (Jackson, 2003). However, through the help of statistical software like MINITAB or SPSS, this complexity can be tackled.

CHAPTER III

RESEARCH METHODOLOGY



Initial Observation:

- Initial observation in the packaging process in PT. X.
- Initial observation on defect occurrence and related factors in PT. X.
- Current problem in the distribution center.
- Interviewing the senior staffs regarded to the problems.

Problem Identification:

- Identifying the factors that cause the products defect.
- Defining the problem statement and research objective.
- Set the scope, limitations, and assumptions.

Literature Study:

- Cause and Effect Diagram
- Analysis of Variance

Data Collection and Analysis:

- Conducting the direct observations in production packaging line.
- Collecting all the supported data.
- Conducting the root cause analysis.
- Conducting the analysis.
- Analyzing the result.
- Comparing the before and after improvement.

Conclusions and Recommendations:

- Drawing the conclusion of the research.
- Giving some recommendations for future research.

Figure 3.1 General Research Framework

In this chapter, the framework of the research mechanism is described in order to help finding out the better solutions of the problems. This research used qualitative and quantitative method to acquire the research objectives. The detail of research flowchart is also represented to direct the researcher defining the objectives of the problems. Figure 3.1 showed and explained the general research framework.

3.1 Initial Observation

The initial observation of this study is done by conducting the direct observation in the packaging process in PT. X. Observing in production floor directly is useful to understand the detail activities regarded to packaging process. The observation is started from the process of the first packaging until the shipment of the products, defining the problem and determining the issues analyzed by seeing in fieldwork directly, understanding the current problem in distribution center, and collecting the data needed from company's data history. The observation is conducted accordance with the objectives that have been made.

3.2 Problem Identification

After done the initial observation and reviewing all the data related during 2016, the problems of this research has been found out that the packing material for the product might defect during the trip to distribution center inside the container. Several factors might cause the packaging warping and curved. The company does not want to change the material of the product packaging due to some confidential reasons. So, it can be defined that the main objective of this research is to determine what actions should be taken and find out the factors that significantly influence the issues without changing the material of the product packaging. Thus, PT. X considers some options of improvement to solve this issue to prevent loss of the company. In addition, the scopes and assumptions of this research are determined. The purpose of scopes and assumptions is to limit the research, so the result of research is valid and acceptable.

3.3 Literature Study

For this research, the literature study is by conducted a study of the literature of various books that correlate with the issues observed in the company. The references as this research basis are based on textbooks, e-books, journals, and website. It is used to provide an overview of the literature on the theories and rationale used as the basis of discussion and problem solving. Cause and Effect Diagram and ANOVA are used to help this research analysis.

3.4 Data Collection and Analysis

This section will provide all the data needed to support the research. It is gathered from the direct observation, interviewing the senior staffs, the company's data history, etc. After gathered all required data, appropriate methods are used to help the analysis and calculation for this research in order to achieve the objectives of this research. This research used qualitative and quantitative research as a reference.

The required data that are being gathered are such as the production data during 2016, the business flow information, the product shipping data, the defect data after shipment, and supporting data like shipping cost and rework cost that are collected. The data collection is gathered from the company historical data that have been collected from January to December 2016, not the experiment.

There several steps in order to compute and analyze the data, which are:

1. To create the cause and effect diagram. The diagram is created to visualize and show the causes that affect defect packaging after shipment.
2. To define what better improvements for each caused stated in fishbone diagram.
3. To calculate the data and analyze the results.

3.5 Conclusion and Recommendation

Based on the previous section, the conclusion of the research is listed in this last stage. The recommendations for future research are also given in order to conduct the further research. The conclusion that stated will answer the objectives of the research.

3.6 Detailed Research Framework

The detailed research framework is visualized in order to help the reader's understanding more about this research. The detailed research framework is drawn in Figure 3.2. This detailed research framework is formed systematically in order to simplify to understand the flow of this research. Not much different from general research framework, the detailed research framework consists of the problem identification which is the defects after shipment, literature study, calculation of reshipping, reworking, and reproduction cost, root cause analysis, calculation using statistical method, before and after improvement, and conclusion and recommendation.

As it can be seen on Figure 3.2, the research is started from problem identification. The problem identification is the defects after shipment. Problem identification is defined by conducting the initial observation directly, reviewing on the data that are collected, and by interviewing the staffs at PT.X.

When the observation is still going, it is found that the packaging process is running in accordance to the standard operating procedures. The operators pack the products properly. The materials that are used for the individual packaging are the plastic sheet packaging from PET (Polyethylene Terephthalate) material and the single corrugated cardboard.

By observing the packaging process, there is no problem occurred during the process. The next process after the packaging process is quality checking. Quality check process is conducted after the packaging process. This process is to ensure that there are no defect products coming out from the production line. Quality check process is done by inspecting the product packaging, the seal, and ensuring the plastic itself is not wavy. When the products are put in the warehouse, in order to maintain the quality of products to remain good after going through a long process until quality inspection, the company used a dehumidifier and temperature controller to prevent the occurrence of defects on the finished product.

After reviewing the data and all the process in the factory, the problems arise after the products arrived at the destination, in a distribution center. The packaging of the toys is defect. The plastic packaging becomes warping, curved and wavy when it arrived at the distribution center (Appendix 2). The defects that occurred are significant and the company had to loss around hundred thousand dollars because of this. By interviewing several staff related to this matter, it is confirmed that there are no further actions that are taken by both the company and the distribution center. The products are just kept in the warehouse of distribution center. It is unknown until this day what decision that both PT. X and the distribution center will be taken.

According to the matters described above, it is needed to do the further observation and analysis to find out the better solution for this problem. The observation will be focused on defining factors that significantly cause the defect of the products after shipment to the distribution center.

After conducted the observation, the problem identification is known as defect after shipment which is caused by several factors that will examined further. PT.X and distribution center also do not take any action to solve this issue for the defects that occurred. This research will be focused only in a distribution center that has the highest defects occurred, not the highest percentage of defects occurred, since the highest number of defect will give a loss impact for both parties.

After all the data is gathered and the problem identification is defined, the literature study is selected as reference and to help this research to process the data. The literature studies that will be used are 7 Basic Quality Tools (Cause and Effect Diagram) and Three-Way ANOVA. As the most important factor after Health, Safety, and Environment, Quality is becoming the second more important factor after health, safety, and environment. Every industry who wants to compete in global business competition has to maintain the quality of the products and services remain good. In order to maintain the quality of the products and services remain good, the company's management have to monitor and control the quality by using the measurements. So, it is needed to use 7 basic quality tools. If the company implements one of the 7 basic quality tools, the products and services consistency and quality can be maintained. The 7 basic quality tools are fishbone diagram, checklist/check sheet, control chart, scatter diagram, histogram, pareto chart, and flow chart. The tool from 7 basic quality tools that will be used in this research is cause and effect diagram. It is used to determine the potential factors that affect the number of defects. The second is Three-Way ANOVA, it is the method that used in order to determine the effect from three nominal estimated variables on a constant result variable. It analyzes the impacts of the independent variables on the result alongside the relationship to the result itself.

After defining the literature studies, the fishbone diagram is created to visualize and show the causes that affect defect packaging after shipment. After the fishbone is made, the next step is to define what better improvements for each caused stated in fishbone diagram.

The next step is to find out the factors that have a possibility to influence the defect packaging. After the factors are known, the factors will be selected as the independent variables. When the factors are already defined, the next is to gather the data from the factors mentioned.

As the data gathered, the next step is to conduct the calculation and analysis of the data. This research is conducted in order to find out the actions that can be taken to solve the defect product packaging that has not taken any action and only quarantined the defect product in the warehouse and to find out the factors that are significantly affect the defect of the product packaging. The calculation will be conducted by using statistical software to find out the standardization of the factors. The factorial design and analysis of variance will be used to analyze what significant factors that affect the number of defects and to find out the better and new parameter setting with expectation it will minimize the number of defects that will occur in the future.

After all the calculation is done, the analysis is conducted by analyzing the results of the processing of the acquired data that got from the analysis of variance calculation.

The data comparing is also conducted to know the before and after improvement from the factors that first mentioned causing the defect products. The result is being analyzed by seeing the effect of factors (the independent variables) and the combination between one to another independent variables. It can be done by examined the coefficients values, the p-values, and analyzed the statistical graphs.

The next step after the calculation and analysis is done is to form the proposed improvements for each factor, such as to set the new parameter settings for the factors. The calculation of reshipping, reworking, and reproduce cost also will be calculated as the options giving for the company. After all the research has been processed and the goals are attained, the conclusion that answered the problem identification can be listed and the recommendation for future research is also made. The summary of this research flow is summarized on Figure 3.2.

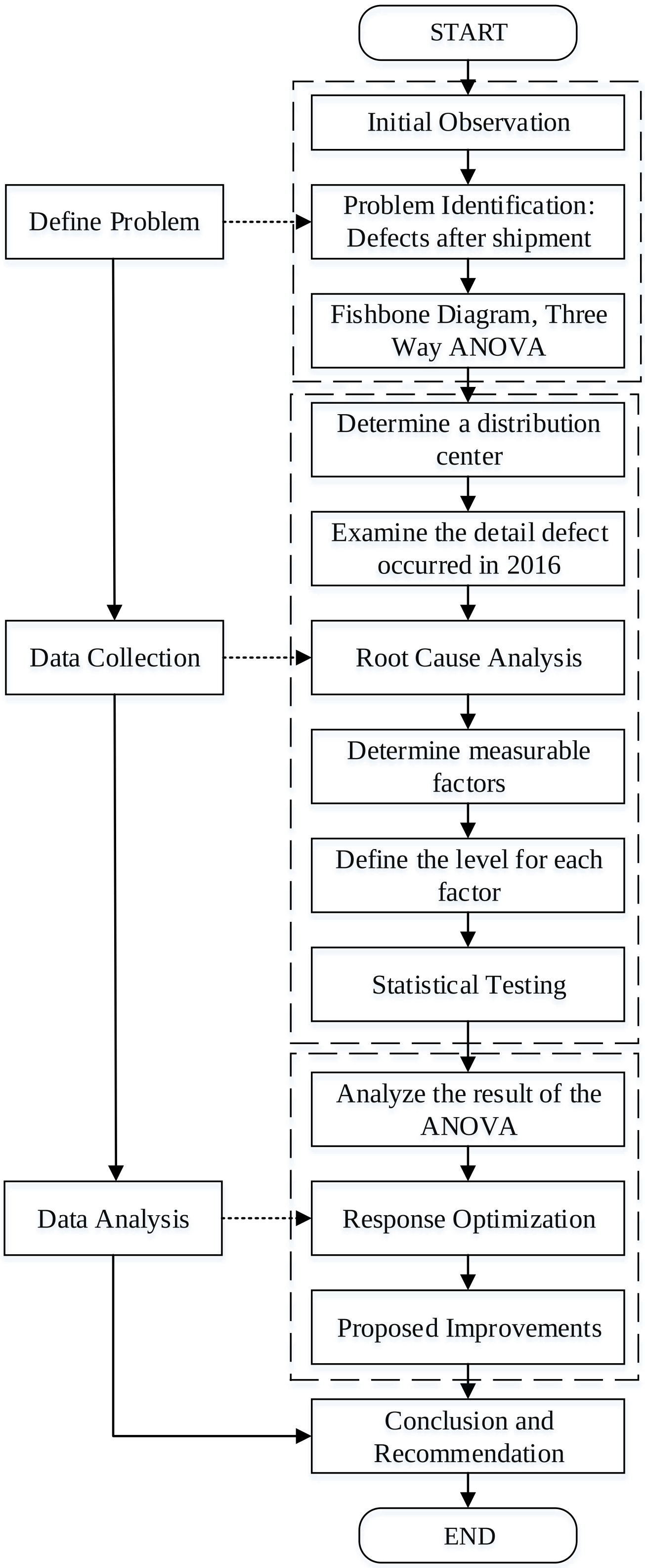


Figure 3.2 The Detailed Research Framework

CHAPTER IV
DATA COLLECTION AND ANALYSIS

4.1 Initial Observation

To start the analysis and the calculation, it is very needed to collect all the data and information regarding to it. The data needed in this research is from the initial observation, the experiments in PT.X, interviewing the related staffs and the operators who related with this matter, and re-evaluating the whole data in January to December 2016.

The initial observation was started in January 2017. The first step of the initial observation for this research was to know all types of toys in PT. X and the packaging flow process. PT. X is one of the largest toy companies in the world. In Indonesia, the factory has been producing many types of toys to fulfill the demands from all over the world. The products that are observed are varied. The research only focused on certain toys. The toys are divided into four types from a product brand. The data is shown in Table 4.1. There are C, NC, and other types called as AH and MH.

Table 4.1 Toys Categories

No.	Types of Toys	Quantities (pcs)
1	C	>1,000,000
2	NC	>2,000,000
3	AH	>1,000,000
4	MH	>1,000,000

Table 4.1 above represents the minimal quantities of each toy produced. C, AH, MH toys are produced more than one million pieces. NC toys production quantities are different with C, AH, and MH, which is more than two million pieces since the NC toys becomes the most favorite than the three others. The price of C, NC, AH, and MH are same, $30, because the four of products mentioned are made from the same materials. What distinguishes the four types of the toys is the apparel of the toys is made with the different color each other, the

different color of the toy itself, and its appearances. All of the products mentioned are produced in large quantities or mass production. The mass production toys are made for all consumers, so that the consumers around the world can have it. Four of the toys can be found in many stores worldwide, since the products do not have the limit quantities to produce. It is at least produced two millions and more.

It is known that in order to maintain the quality remains good, it is needed to use good material and also affordable. In a few months ago, the factory made some new policies in the toy production process. One of the new policies is to replace the plastic of packaging materials, from material Polyvinyl Chloride (PVC) into Polyethylene Terephthalate (PET), in which PET material is cheaper when it compared to PVC. This policy is applied to all toy products in mass production and some collector toys.

During a year, from the month of January to December 2016, the factory tries to run and applies the policy in several months. The following Table 4.2 shows the total production during the months of January to December, 2016.

Table 4.2 The Number of The Production in 2016

Year	**Month**	**Production (pcs)**
2016	January	3,122,624
	February	3,836,900
	March	4,095,200
	April	4,518,400
	May	4,576,500
	June	3,239,100
	July	3,257,300
	August	3,069,900
	September	3,642,800
	October	4,274,200
	November	4,896,300
	December	4,306,700
Total Production		46,835,924

Table 4.2 shows the total production. The total production data is collected from January to December 2016. It is stated that from January to December 2016, PT. X produced in the range of around three millions to almost 5 million toys. As it

can be seen, the total production of toys in PT.X of the last three months in 2016 was increasing. In October to December, there are peak seasons or the time of the year where the demand is highest. It includes collector toys production, non-collector toys in mass production, AH and MH. The detail information of the production in 2016 is presented in Table 4.3 below.

Table 4.3 The Detail Information of Toy Production for Each Category in 2016

Month	NC	C	AH	MH	Total (pcs/month)
January	2,284,100	103,424	397,700	337,400	3,122,624
February	2,547,200	182,900	734,900	371,900	3,836,900
March	2,787,700	186,100	775,000	346,400	4,095,200
April	3,126,900	175,700	796,500	419,300	4,518,400
May	3,071,100	135,200	930,700	439,500	4,576,500
June	2,050,200	66,300	763,800	358,800	3,239,100
July	2,084,672	97,719	781,752	293,157	3,257,300
August	2,148,930	92,097	613,980	214,893	3,069,900
September	2,367,820	109,284	837,844	327,852	3,642,800
October	2,692,746	192,339	983,066	406,049	4,274,200
November	3,133,632	186,059	979,260	597,349	4,896,300
December	2,842,422	163,655	904,407	396,216	4,306,700
Total Production	31,137,422	1,690,777	9,498,909	4,508,816	46,835,924

The detail information of the toy production is explained in Table 4.3. As it can be seen, the production for each type of toys to others was varied. The highest number of production of NC occurred in November which was 3,133,632 toys a month. The lowest production of NC was in June which is 2,050,200 toys. The C toys were produced mostly around one hundred thousand less or more in a month. The highest production of C toys is 192,339 toys in October and the lowest production of C toys was 66,300 toys which was in June.

Meanwhile, the AH and MH toys were produced around two hundred thousand to nine hundred thousand pieces in a month, depending on the demand. AH toys have the highest production in October with the total production of 983,066 in a month and it has the lowest production in January which is 397,700 pieces. For MH toys, the lowest production is happened in August with the total production of 214,893 a month and the highest production is 597,349 in November. The highest total production in a month for all types of toys within 2016 is 4,896,300 pieces occurred in November and the lowest production quantity happened in August with the number of 3,069,900 pieces.

4.2 Business Process

After the production process done in the factory line before, there are several steps to finish the process until finish goods and send to the retailers or distribution center. It is mentioned and described in order to find out the existing problem. All the data are gathered by doing some interviews and from the record of the company. Figure 4.1 represents the flow process chart from the packaging process until the shipment.

The business process is explained only after production process done and focused only in packaging process until the shipment. After the production process done, the first process is started from Packaging I. Packaging I is the process where the toys are attached in individual carton and the plastic packaging one by one. In this process, the material that used is the plastic packaging material (PET material), carton, and hot glue. During the observation it is known that the Packaging I workstation is already run appropriated with the standard operating procedure.

The second process is Final Packaging. In Final Packaging, the packaging process of the toys is where the toys are done putting into the individual cartons, then the individual cartons are put into a master carton. A master carton that used is a single wall corrugated carton. One master carton consists of 4 toys. The toys that are already packed in individual carton are put into the master carton and later will be wrapped by using packaging tape.

The next process is Quality Check. Quality Check is the inspection process in which the process is conducted by Quality Control department. All the individual cartons are being checked and ensured to meet and are compliance with standards that exist.

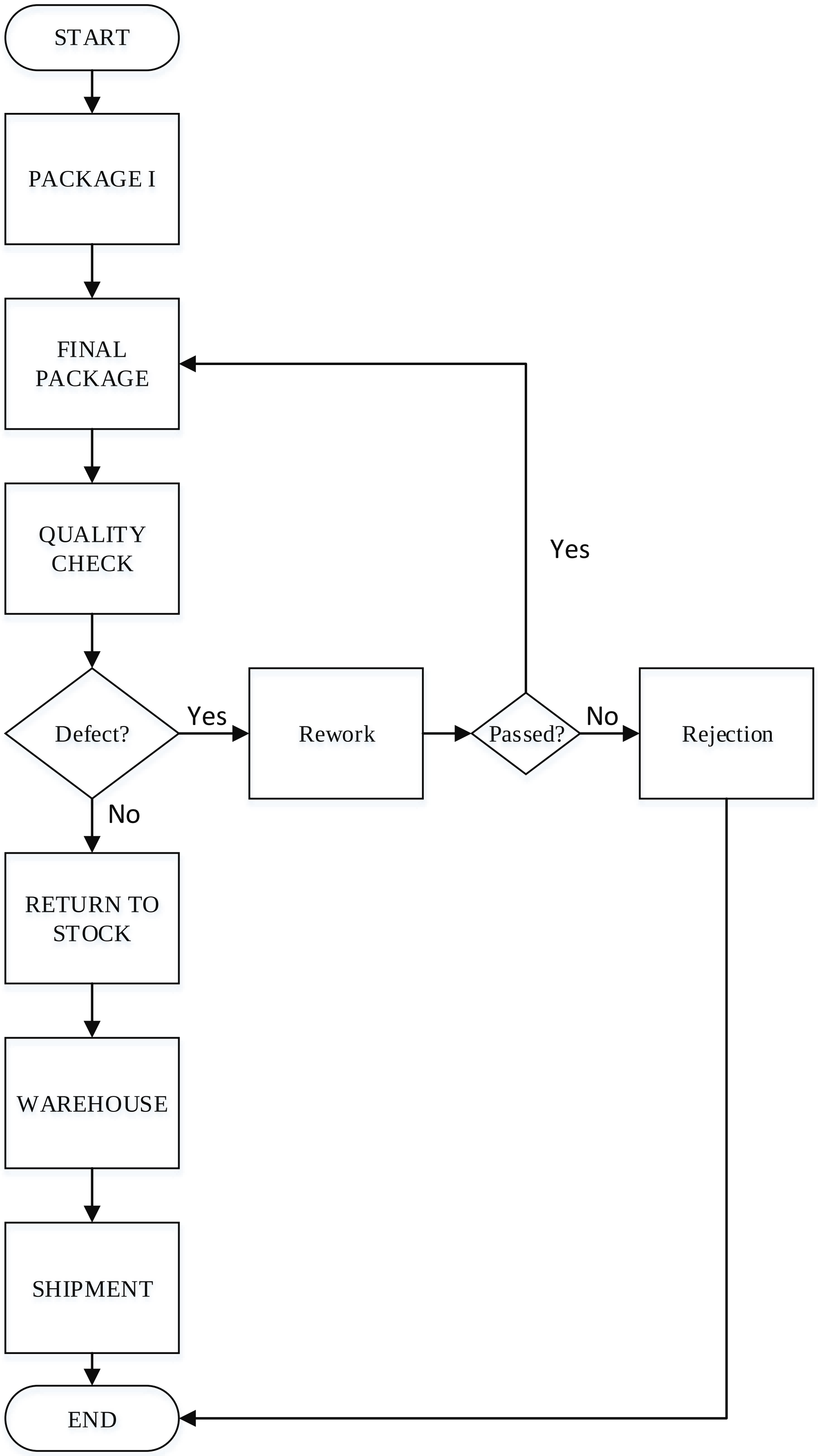


Figure 4.1 Flowchart of Packaging and Shipment

The process is conducted by taking the master cartons randomly, with the condition, every multiple of 2000 pieces, 4 cartons or 16 individual cartons are taken randomly to be sampled to check whether if the product packaging are appropriated with the standard or not. If the products are defect and do not meet with the standards, the products will be separated and placed at designated area near Return to Stock area. The QC staff will decide whether products will be reworked or rejected and the products will be moved to the rework or reject station. If the products are rejected, the products will be recycled to be raw material again. If the products can be reworked, the products will be sent to the rework station and will be returned through the packaging process again. So, in this process, the products will be ensured and determined whether this product is in accordance with the standard and worth selling or not.

After passing the inspection, for all products that have passed the inspection, RTS (Return to Stock) is the process where the data of the product details are input as archives and data collection before the products are place in the warehouse. The master cartons are stacked in the pallet before placed in the warehouse; with condition one stack consists of ten master cartons that arrange vertically. Every toy code is input and processed the data of the number of finish goods.

Source dspallets.com
Figure 4.2 Pallet

The following step is Warehouse. After the products are listed in database, the products are placed in the warehouse at the factory. The products are placed to some areas accordance with the place which is predetermined by warehouse staffs. In order to maintain the quality of products to remain good after going through a long process until quality inspection, the company used a dehumidifier and temperature controller to prevent the occurrence of defects on the finished products in the warehouse. After the locator of the product is determined and the products are placed in the rack locator, the data of locator is input into the company's database.

The last is Shipment. Shipment process is conducted based on the shipping plan and product loading plan. Shipping plan is made based on demand, inventory, and daily production schedule that have been made before by PPIC staff. The shipping plan that is made consists of two types, PT.X shipping plan where the products are directly from PT.X and MAPS shipping plan where the products are imported from PT.X that based on other country. In this research, it is only focused on the shipping plan of the C, NC, AH, MH products. Products that have been in shipping plan data are put into container and done the cross-checking. The products that will be shipped are prepared and recalculated. Later, the products are loaded into the container as it seen on Figure 4.3.

Figure 4. 3 Product Loading Process

The shipment process is conducted by the third party, which is the logistic company. For the inland delivery, it is sent by using a truck with a 40" container. The truck route is Cikarang – Tol Jakarta/Cikampek – Jakarta Inner Ring Road – Tj. Priok Port with a distance of 57.2 km. The delivery time for the truck is at 9 p.m. with the arrival estimation to Jakarta's toll booth at around 10 p.m. or more, since there is the rule of government that stated that the allowable time for the truck passes the high way or around Jakarta is from 10 p.m. – 5 a.m and to avoid the traffic jam.

Figure 4.4 The Logo of Maersk Line, Hapag Lloyd, Green Line

After arrived at the port, the products are placed in depot for days depends on the busy condition of shipping process in port before the containers are being shipped to the shipping destination by using containership. Depot container is an area or place in the port that is used to store the containers by conducting the process of expenditure, acceptance, maintenance and repair of empty containers. In this process, the possibility of products exposed to the sun is high. The products are delivered using freight services such as, Maersk Line, Hapag, and Greenline. The shipment process to America continent usually takes 25 to 40 days of shipment. The logo of the freight services is shown in Figure 4.4. For the shipment for Asia and Australia continent, PT. X use Greenline, while the shipment for America continent uses Maersk Line. The last, for the Africa and Europe, the shipment use Hapag Lloyd.

After reviewing all of the processes, the working activities and conditions that can be observed are from Packaging I, Final Packaging, Quality Check, Return To Stock, and Warehouse. The observation is already conducted and there is no problem found out during the observation. The shipment process can be controlled only from the product loading process until the inland delivery, while from the shipment process by containership; it only can be monitored by reports from the logistic services.

4.3 Problem Identification

After conducting the initial observation and reviewing the business flow information, the next following step is problem identification. The problem identification includes the problems that have been found during the initial observation, defect data, total loss cost, and re-shipping cost. Each data that have been collected will be elaborated in Figure 4.5 below.

While doing the observation, it was discovered that after the shipment process done and the products were delivered and arrived to the destination, named as distribution center. Some problems arouse and caused significant losses for the company. It was found that there were some significant defects on toy packaging after shipment.

The defects of product shipping that occurred during 2016 are shown in Figure 4.5. The detail data on Figure 4.5 are stated in Appendix 1. As it can be seen on the bar chart above, the highest defects within 2016 are occurred at the distribution center in Fort Worth, Texas. During January until December 2016, the highest defects that occurred after the products arrived in Fort Worth, Texas are 12,043 pieces of product defect.

This condition means that the company needs to improve and fix up this issue and find the better what better actions should be taken towards the defect product that are being quarantined warehouse and not being handled. Thereby, the research and analysis will be focused on the defect occurrence in Fort Worth, Texas, since it has the highest number of defect products.

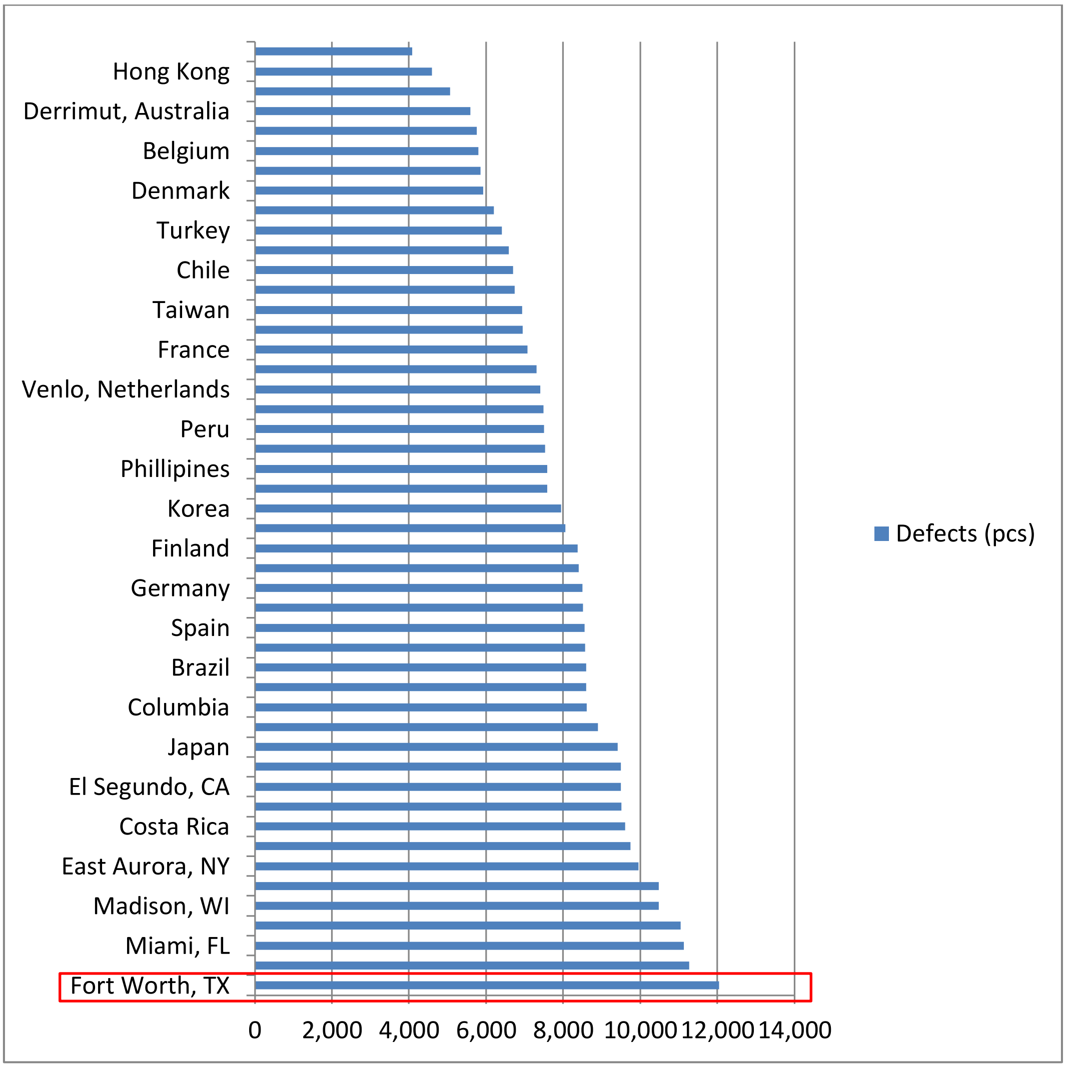


Figure 4.5 Defects of Product Shipping at All Distribution Centers in 2016

The defect occurred in the individual packaging of toys. It alleged, is likely to occur due to the new policy, with the replacement of the product packaging material of PVC into PET. Defect occurred in transparent plastic packaging, which is warping defect, curved and wavy. The example of the defect packaging is shown in Appendix 2. Whereas, before all the products is being shipped, the quality of the products are passed and already meet the standards, and it has been inspected by the quality control department. To conduct further research, observing and reviewing the data are needed. The data are taken from the history record of the company. The supporting data is presented in Table 4.4.

Table 4.4 The Product Shipping Details to Fort Worth, Texas

Date	NC	C	AH	MH	Total Product Shipping	Total Defect in DC	Total Loss ($)
January	30,157	7,826	16,920	15,345	70,248	702	21,060
February	32,746	9,375	17,033	19,034	78,188	1,173	35,190
March	32,845	8,059	16,407	17,093	74,404	967	29,010
April	27,872	6,352	16,244	17,125	67,593	811	24,330
May	27,064	8,160	14,597	15,830	65,651	985	29,550
June	30,287	6,670	12,424	14,908	64,289	1,093	32,790
July	25,057	8,730	16,677	11,552	62,016	1,178	35,340
August	31,361	5,035	13,991	15,290	65,677	1,248	37,440
September	30,635	8,851	15,983	16,850	72,319	940	28,200
October	31,291	9,118	16,102	15,594	72,105	1,009	30,270
November	34,391	9,857	15,261	19,184	78,693	944	28,320
December	27,757	9,417	16,670	17,089	70,933	993	29,790
Total Shipping in 2016 (pcs)					842,116		
Total Defects After Arriving at DC in 2016 (pcs)						12,043	
Total Loss Cost in 2016							$361,290

As it is stated in Table 4.4 above, the total shipping to a distribution center in Fort Worth, TX during 2016, from the month of January to December is 842,116 products, where each month PT. X delivered around more than sixty thousand pieces of toys. In November 2016, the company delivered 78,693 products to a distribution center in which this is the highest total shipping within 2016, but it has the total defects in the number of 944 products or 7.84% of defects in 2016. The company had to loss $28,320, where each toy is cost $30.

Based on the data above, the highest defects after the products arrived at destination occurred in August, 2016. It caused enough substantial loss for the company, which is $37,440 from 1,248 defect products in which 10.36% of defects in 2016 is occurred in August. The delivered products were the toys which were packed using new packaging material, which is PET material, not PVC. After twelve months that being sent, it has known that after the products arrived in a distribution center, there was a total number of $12,043 pieces of defected. Thus, it caused the company lost around $361,290 in the year 2016.

The smallest defects occurred in April 2016, the company loss $24,330 caused by 811 numbers of defects after shipping 67,593 pieces of toy products to the same distribution center or 6.73% of defects occurred in 2016. After observing further, it seemed that the company has not realized yet that it might happen due to the change of packaging material after the company conducted annually evaluation. Therefore, the factors that cause the defect of product packaging should be defined and examined in order to know what factors that potentially influence the defect of product packaging.

4.3.1 Root Cause Analysis

According to the previous section, it can be defined that the defect in packaging of toys after arrived at a distribution center are often occurred during 2016. In order to find out what things that can cause this problem, therefore analyzing the root cause is needed. Fishbone diagram from one of seven basic quality tools is used. The major categories of fishbone diagram that may lead to the problem are man, method, material, and environment. The defects are only occurred in the product packaging. The types of defect product packaging can be divided into 4 types such as warping, curved, melted, and wavy. All of the defect types are considered the same, since the packaging defect looked like melting but with different levels. The cause and effect diagram is made after conducted the initial observation from the packaging process until the shipment. As it can be seen in Figure 4.2, it can be concluded that the process from the Packaging I until Warehouse, there is no problem found out, since it is already controlled by the quality check process after the packaging process and before the shipment the products are placed in warehouse where the products are controlled by a dehumidifier and temperature controller to prevent the occurrence of defects on the finished products in the warehouse. It can be said that the defects might occur during the shipment in inland delivery and in depot, while from the shipment process by containership only can be monitored by reports from the logistic services. The detail fishbone diagram of defects in packaging material after shipment can be seen in Figure 4.6.

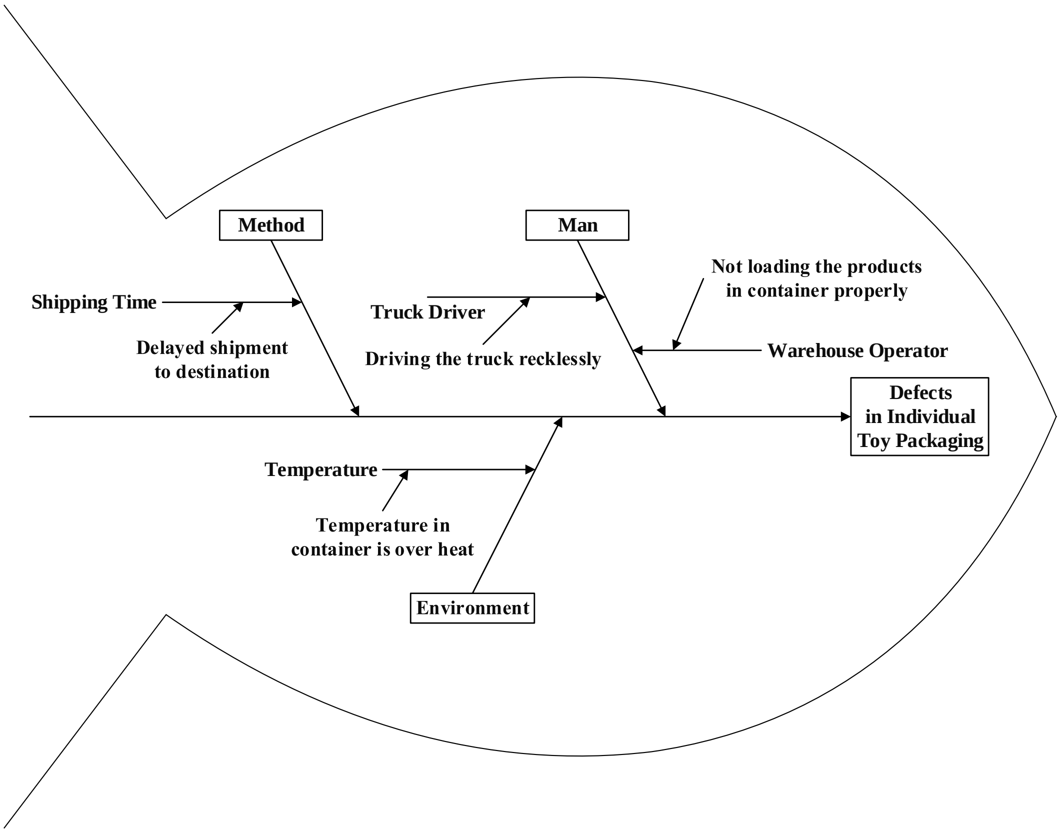


Figure 4.6 Fishbone Diagram

Fishbone diagram of the defects in packaging material after shipment's root cause detail is represented in Figure 4.6. This fishbone diagram describes major causes of the problem. It can be seen, there are three major causes which are man, material, and environment. Every major cause is described into several secondary causes.

The first main cause that will be elaborated is man. It is still divided into two secondary causes, warehouse operator and truck driver. After the packaging process and the quality check are done and the shipment process will be on going, the warehouse operators take chart to load the products into container. If there are warehouse operators who recklessly load the products into container and not handle the products carefully and if there is no standard operating procedure, it can cause the product defects. As one of the biggest toy manufacturer in the world, PT.X is selective to recruit the people who will work and involve with their business, from the highest level position into the lowest level position. It can be denied, even after the rigorous selection, the performance of the people may be up and down. By asking the senior staff who takes in charge to manage the working shift of the truck driver and monitor the truck driver, some of the truck drivers have been driving the truck recklessly. The situation on the road to the port also can be considered whether there is any traffic jam or not. It may lead to and cause the product defects inside the container of truck. The company has recorded the average speed monthly during a year in order if there is any future research regarded to it. Each delivery by truck is recorded as average speed of truck.

The cause of method is the shipping time. The length of time of shipment may occur during the bad weather at sea shipping or inland delivery. Although the weather can be predicted, but not all will be conformed to the weather forecast, bad weather can occur anytime and can hinder the process of cargo delivery to the destination. The longer shipping time, the more possibility to affect the defect products is. Therefore, the company has recorded the data of how long each products delivery spent for many years. In this research, the data delivery time is only focused during 2016. This could be one of several factors that cause the defect of the products after shipment. Therefore, the future observation and analysis will be conducted later in the next section.

The last main cause from fishbone diagram in Table 4.3 is environment. The cause from environment category of this fishbone diagram is temperature. The company wants to ensure if the temperature in container is over heat or not when the products are delivered by truck to a port. To help this research running well, the company has already recorded the temperature along the way to the port. Temperature data logger is used to measure and record the temperature inside container. The data is taken from the company’s history data. Therefore, it required further analysis whether the factors that are mentioned affect the defect problem significantly.

4.4 Proposed Improvement

After outlining the roots of cause above, all factors are described and it can be concluded that several improvement should be defined and taken as options. Each of main cause are elaborated what action should be taken and considered for this research. Table 4.5 represents the proposed improvements based on the Fishbone Diagram in previous section.

Table 4.5 List of Proposed Improvement

No.	Root Cause	Potential Failure Mode	Potential Failure Causes	Improvement
1	Man	Truck Driver	Driving the truck recklessly.	Defining the standard speed of truck.
		Warehouse Operator	Not loading the products into container properly.	Doing regular inspection and make the Standard Operating Procedure.
2	Environment	Temperature	Temperature in container is over heat.	Defining the standard temperature inside container.
3	Method	Shipping Time	Delayed shipment to destination.	Make a contract with third-party to always report if there is any delay of shipment, the usage of RFID.

According to Table 4.5 above, it is described the possible improvements for each main cause. The proposed improvements for each factor are explained below.

4.4.1 Proposed Improvement in Man

The potential failure causes in man are the truck driver and warehouse operator. If the truck driver who drives the truck that brings the container has been driving the truck recklessly or in a high speed, it will cause the unstable condition inside the container and may cause defect product packaging. As it is explained in business flow information section, the products are delivered at 9 p.m. where the truck route is Cikarang – Tol Jakarta/Cikampek – Jakarta Inner Ring Road – Tj. Priok Port with a distance of 57.2 km, to avoid the traffic jam along the way and to follow the road rule of the government which is the allowable time for the truck passes the high way or around Jakarta is from 10 p.m. – 5 a.m. Thus, it is needed to define the standard average speed of truck since there is a possibility of the truck driver to drive up to 60 km/hour.

The second cause is the warehouse operators do not load the products into container properly. A person's work performance can sometimes decrease and increase. To maintain the operator's performance in good condition, regular inspection by person in charge or quality department is required. Regular inspection can be done by monitoring the working steps of operators and ensure that it is already appropriate with the standard operating procedure if any. Since there is no standard operating procedure (SOP) for this workstation, it is also needed to make the standard operating procedure (SOP) of the product loading process. The proposed standard operating procedure is made and can be seen in Appendix 7.

4.4.2 Proposed Improvement in Method

The potential failure causes in method is the shipping time. The shipping time is generally 25 – 40 days. If there is any delayed shipment to destination that will take much longer than the usual shipment, it may cause the product packaging defect. The longer the shipping time, the more probability of defect packaging occurred. It can affect the number of defect packaging since if the products are on a longer shipping time than usual, it is possible that the products inside the container are exposed to sunlight or the surrounding hot air causing the product defects during the shipping.

Hence, it is needed to know further if the factor of shipping time influence with the number of defects occurred. The other improvements that can be proposed are to make a contract with third party to always report if there is any delay of shipment, to make allowable maximum shipping deadline, like the shipping time is 30 days and the allowable additional shipping time 5 days. If the third party exceeds the shipping deadline, it will be sanctioned in accordance with the contents of the agreement letter made. It also can be solved by the usage of RFID (Radio-frequency Identification). RFID is used to simplify the tracking of shipping process by sending the signal and transmitting the data to the information system of the company to know and to track the whereabouts of product being shipped.

4.4.3 Proposed Improvement in Environment

The potential failure causes in method is the temperature. If the temperature is high, it will affect the material of the packaging becomes warping. The warping and wavy condition of the packaging material can be seen in Appendix 2. The temperature problem can be solved by using thermostat. It can be used by setting the desired temperature. Thereby, to know the desired temperature and to set the standard temperature is needed to conduct the calculation and analysis based on the company's historical data that have been recorded before.

From all the main causes are stated and the proposed improvements are mentioned, the research will focus and prioritize only to the factors that can be measured. By seeing the Table 4.5, the main factors that can be measured and the data of the main factors that are available in the company are temperature, average speed of truck, and distance time. It can be concluded that the speed of truck, temperature, and distance time should be analyzed in order to find out if these parameters have the big impact that cause the defect of the products. Therefore, the further calculation is needed. The factorial analysis will be conducted to help facilitating the finding of the better solution from the selected parameters. The detail calculation and explanation will be elaborated below.

4.5 Statistical Testing

After defining the factors, the next step is to define the levels for each factor. The calculation and analysis of the factors will be elaborated in this section.

4.5.1 Parameters

All the required data that have been collected for the research are from the field observation and taken from the company's historical data, not conducting the experiment. This research is set by three variables, which are temperature, average speed of truck, and shipping time.

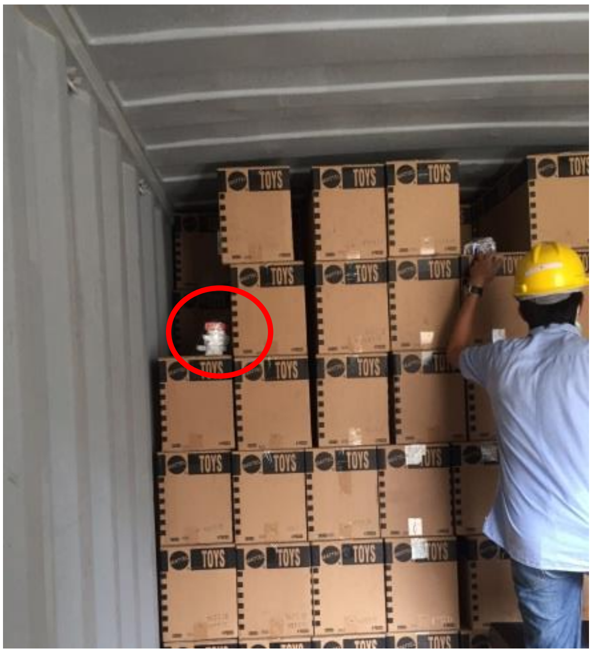


Figure 4.7 Temperature Data Loggers Inside Container

The temperature data are taken from the temperature data loggers, the temperature recorder that are placed inside container during 2016 as it is seen in Figure 4.7. The data of shipping time are concluded from how long every shipment time spent in 2016, while the data of average speed of truck are recorded by using GPS tracker. All of the data are concluded and made in range for each level of factors, but the detail data cannot be stated due to company's policies. These three variables become the main factors of causing the defect packaging after shipment. Each factor has different number of levels. All levels of factors consist of three levels of temperature, two levels of average speed of truck, and two levels of shipping time. The levels are made as 3 x 2 x 2, so the levels can be fit with the dependent variables which will required minimum 12 dependent variables. The levels of temperature are stated in Table 4.6.

Table 4.6 Level of Temperature

Level	Temperature Range (^{o}C)
1	32 – 36
2	37 – 41
3	42 – 46

Each level is defined from the company's record. As it can be seen, the first level is in range 32 – 36^{o}C. The second level is 37 – 41^{o}C the third is in range 42 – 46^{o}C. The range of temperature in each level is defined after seeing the result of the record of temperature data logger. If the temperature inside container is too high, it will affect the products packaging becoming warping and wavy.

Table 4.7 Level of Average Speed of Truck

Level	**Average Speed of Truck (km/h)**
1	<50
2	≥50

As it is presented in Table 4.7, there are two levels of average speed of truck. The first one is below 50 km/h and the second level is greater or equal to 50 km/h. The more speed the truck rises, the more likely there is any defect packaging due to the unstable condition inside container due to the high speed.

Table 4.8 Level of Shipping Time

Level	**Shipping Time (days)**
1	<32
2	≥32

Table 4.8 is the level of shipping time. The shipping time factor is selected in order to know if the length time spent in shipment affects the problem, which is the defect of products after shipment. There are two levels that are made for distance time. The first level is in range below 32 days and the second is greater or equal to 32 days of shipment.

All the range of each level is defined by concluded the data range of shipping time, average speed of truck, and temperature in company's data record. The data of shipping time, average speed of truck and temperature cannot be stated in this research due to the company data is confidential. The data of number of defects were occurred with the every level of each factor that has been recorded by the company. Table 4.9 below is the data of defects occurred that is affected by the temperature, average speed of the truck, and the shipping time.

Table 4.9 The Number of Defect That Caused by The Factors

No.	Temperature	Average Speed of Truck	Shipping time	Number of Defects
1	1	1	1	102
2	3	2	1	600
3	3	1	1	734
4	2	2	2	439
5	1	2	2	504
6	1	2	1	463
7	1	1	2	214
8	3	1	2	597
9	3	1	1	662
10	1	2	2	323
11	2	2	1	630
12	1	2	1	463
13	2	2	1	573
14	3	1	2	605
15	3	2	2	702
16	2	1	1	546
17	2	1	1	533
18	2	1	2	407
19	2	1	2	469
20	2	2	2	540
21	1	1	1	176
22	3	2	1	768
23	1	1	2	180
24	3	2	2	813

In this research, the statistical testing is conducted. The company shipped the products to a distribution center twice a month. So, the data stated in Table 4.9 is from twenty four times of shipment within 2016.

4.5.2 Normality Test

Generally, a group of random variables is identically and independent distributed normality (IIDN) if each random variable has the same probability distribution as the others and all are mutually independent. Normality test is conducted in a data distribution in order to demonstrate statistically whether the group of data is normal or not.

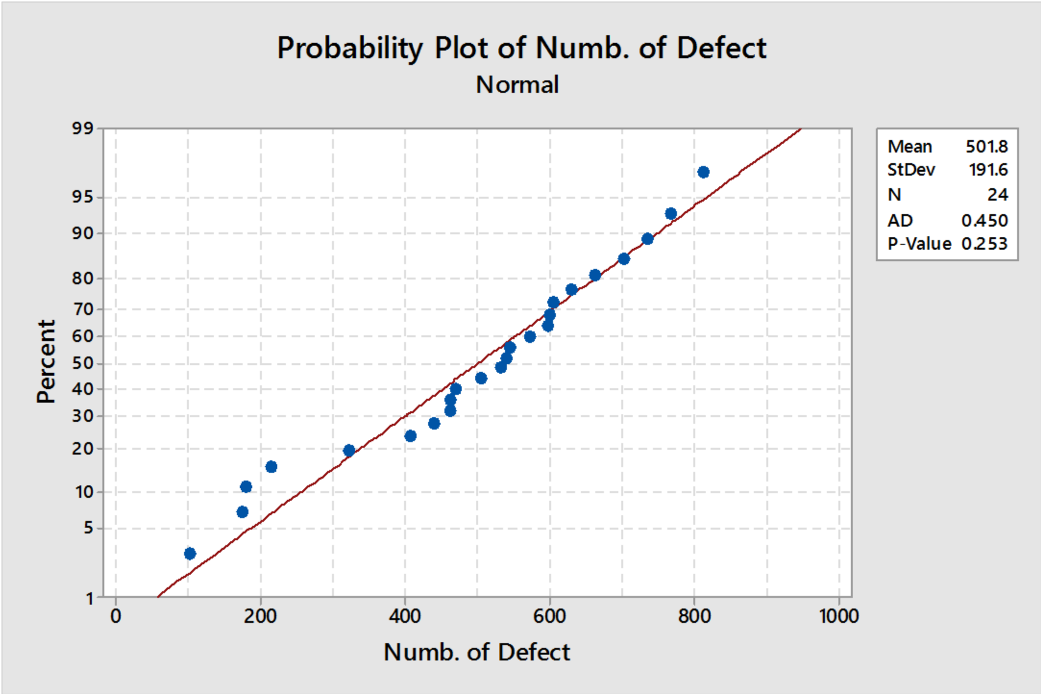


Figure 4.8 Probability Plot for Number of Defect

The null hypothesis can be set that if the p-value is equal or greater than α (α = 0.05), it can be interpreted that the data is normal, with 95% of confidence interval. The normality test is conducted using statistical software. Figure 4.8 shows the probability plot for number of defect. By seeing the result, since the p-value is 0.253 and greater than α, which means the null hypothesis is accepted. It means that the probability of the data being normal and is greater than 95%.

4.5.3 Autocorrelation Function (ACF)

The Autocorrelation Function (ACF) is used to see whether the data has a correlation or not. It is generally used to check the randomness in data set. This randomness is discovered by computing autocorrelations for data values at different time lags. If random, such autocorrelations should be near zero for any and all time-lag separations. If non-random, then one or more of the autocorrelations will be significantly non-zero.

H_0: The residual is independent.

H_1: The residual is not independent.

With α equals to 0.05, the hypothesis is made above. The graph of autocorrelation function is shown below on Figure 4.9.

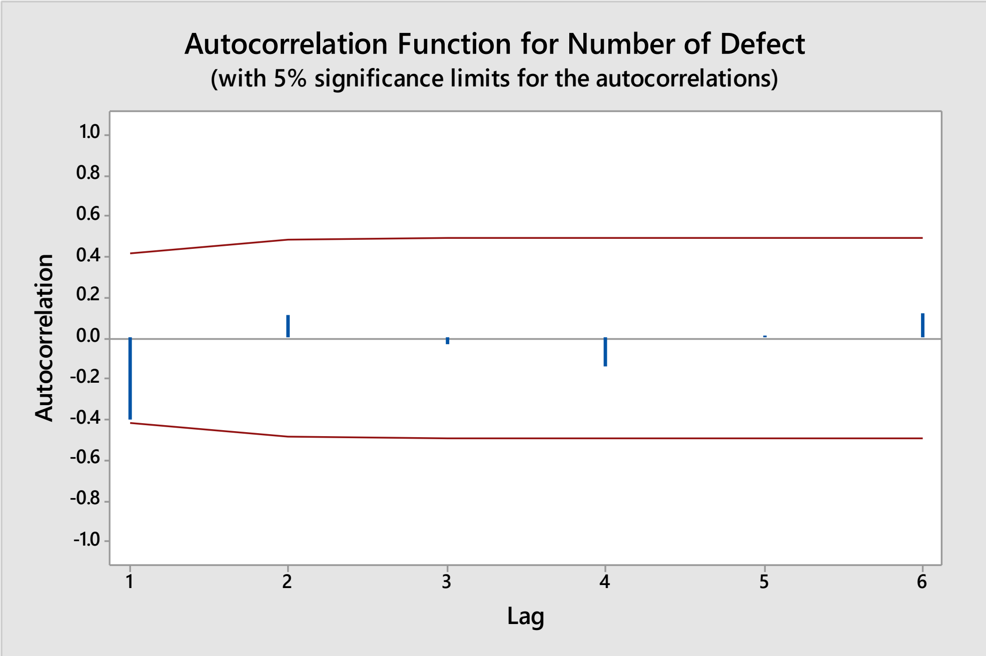


Figure 4.9 Autocorrelation Function

Since there is no lag (blue lines) that exceeds the significant limits (red line), so, the H_0 is accepted in which the residual is independent.

4.5.4 Factor Effect Estimation and Coefficients

The next step is to analyze the data by using the statistical software in order to define the factor effect estimation to response optimization result is attained. The objective of the factor effect estimation is to provide the information of statistical analysis.

```
Model Summary

      S    R-sq  R-sq(adj)  R-sq(pred)
65.3991  93.92%     88.34%      75.67%
```

Figure 4.10 Factor Effect Estimation

After calculating the data using the statistical software, the model summary is defined on Figure 4.10. The result of R-Square is 93.92%. It can be mean as the percentage of the ability to describe the independent variables which are temperature, average speed of truck, and shipping time. Meanwhile the adjusted R-Square that has value of 88.34% is used to compare the explanatory power of regression models that contain diverse numbers of predictors. The adjusted R-squared is a modified version of R-squared that has been adjusted for the number of predictors in the model. The adjusted R-squared increases only if the new term improves the model more than would be expected by chance. It decreases when a predictor improves the model by less than expected by chance. The adjusted R-squared is always lower than the R-squared.

Figure 4.11 is the result to see how the factors have any impact on the defect packaging. The impact of each factor is defined by the coefficients. The values of coefficient can be concluded if the factor is significant or not. Thereby, p-value will be studied also in which to find out the factors that have significant impact to the defect packaging of the products. If the p-value is less than 0.05, it can be said that the factor affects the defect packaging after shipment.

Coefficients

Term			Coef	SE Coef	T-Value	P-Value	VIF
Constant			501.8	13.3	37.59	0.000	
Temp.							
1			-198.7	18.9	-10.52	0.000	1.33
2			15.3	18.9	0.81	0.433	1.33
Avg. Speed							
1			-66.4	13.3	-4.97	0.000	1.00
Ship. Time							
1			19.0	13.3	1.43	0.179	1.00
Temp.*Avg. Speed							
1	1		-68.7	18.9	-3.64	0.003	1.33
2	1		38.0	18.9	2.01	0.067	1.33
Temp.*Ship. Time							
1	1		-21.2	18.9	-1.12	0.284	1.33
2	1		34.3	18.9	1.82	0.094	1.33
Avg. Speed*Ship. Time							
1	1		4.4	13.3	0.33	0.749	1.00
Temp.*Avg. Speed*Ship. Time							
1	1	1	-31.3	18.9	-1.66	0.124	1.33
2	1	1	-7.0	18.9	-0.37	0.717	1.33

Figure 4.11 The Coefficients of Factors

The factors that influence the defect packaging are known, which are temperatures on level 1 (32 – 36^{o}C) and the average speed of truck on level 1 (40 – 50 km/h). There is an influence on defect packaging in two factors interaction which are between temperatures on level 1 (32 – 36°C) and the average speed of truck on level 1 (40 – 50 km/h). Meanwhile, in three factors interaction, there is no influence. For Variance Inflation Factor (VIF), if the VIF value is more than 5 to 10, it is multi-collinearity or highly correlated between predictors (the factors).

4.5.5 Initial Model of Response

After the values of the coefficients are known, it is needed to build the initial model. Figure 4.12 shows the initial model of response that built by estimating the coefficients and factors to describe the response.

```
Numb. of Defect = 501.8 -198.7 Temp._1 -66.4 Avg. Speed_1 -68.7
Temp.*Avg. Speed_1 1
```

Figure 4.12 Initial Model of Response

The initial model of response on Figure 4.12 can be interpreted as follows:

- The defect of the product packaging will be diminished by 198.7 when the temperature inside the container is set or in range of 32 – 36°C, with the condition there is no factor affects the defect.
- The defect of the product packaging will be diminished by 66.4 when the average speed of truck that brings the container is drove in range of 40 – 50 km/h, with the condition there is no factor affects the defect.
- The defect of the product packaging will be diminished by 68.7 when the temperature inside the container is set or in range of 32 – 36°C and the average speed of truck that brings the container is drove in range of 40 – 50 km/h, with the condition there is no factor affects the defect.

4.5.6 Analysis of Variance (ANOVA)

From Figure 4.13, ANOVA calculation is presented. The calculation employed the statistical software. The objectives of analysis of variance are to compute and to know the effect of factors and the interaction direct the response in the numerical model. If the p-value is less than α (α=0.05), then H_0 is rejected and if the p-value is greater than α (α=0.05), then the H_1 is rejected.

Not like the first result table, the analysis of variance calculation is not used to represent the impact of the factors. This analysis of variance will be used to see if there is any difference in the influences/impacts of factors levels of causing the defect packaging, like if there is any difference in factor influence level of temperature in range of 32 – 36^{o}C, 37 – 41^{o}C, and 42 – 46^{o}C, between average speed of truck in range of 40 – 50 km/h and 50 – 60 km/h, and shipment time between range 25 – 32 days and 33 – 40 days of shipment.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	11	792653	72059	16.85	0.000
Linear	4	700955	175239	40.97	0.000
Temp.	2	586517	293259	68.57	0.000
Avg. Speed	1	105735	105735	24.72	0.000
Ship. Time	1	8702	8702	2.03	0.179
2-Way Interactions	5	71790	14358	3.36	0.040
Temp.*Avg. Speed	2	56929	28465	6.66	0.011
Temp.*Ship. Time	2	14401	7201	1.68	0.227
Avg. Speed*Ship. Time	1	459	459	0.11	0.749
3-Way Interactions	2	19909	9955	2.33	0.140
Temp.*Avg. Speed*Ship. Time	2	19909	9955	2.33	0.140
Error	12	51324	4277		
Total	23	843978			

Figure 4.13 Analysis of Variance Calculation

By referring on Figure 4.13 above, the values of the ANOVA result that can be analyzed are p-value and F-value. The factors that have the impact to the defect packaging can be defined by seeing the ANOVA p-values. If the p-value is less than α (α=0.05), then it can be interpreted that there is difference in the influence from treatment to the defect packaging. The further interpretation is stated as follows:

- The model of linear of temperature factor has p-value less than α (α=0.05), it can be defined that there are differences of impacts of three levels of temperature for the defect packaging.
- The model of linear of average speed of truck factor also has p-value less than α (α=0.05), it can be defined that there are differences of impacts of three levels of temperature for the defect packaging.

- For the two factors interaction, there are differences of impacts of interaction type 'temperature and average speed of truck', since the p-value is less than α (α=0.05) toward the defect packaging.

Based on Figure 4.13, the null and alternative hypothesis of each model can be created in Table 4.10 below.

Table 4.10 Hypothesis Table

No.	H	Hypothesis	P-Value
1	H_0	There is no significant effect of temperature on defect.	0.000
	H_1	There is significant effect of temperature on defect.	
2	H_0	There is no significant effect of average speed of truck on defect.	0.000
	H_1	There is significant effect of average speed of truck on defect.	
3	H_0	There is no significant effect of shipping time on defect.	0.179
	H_1	There is significant effect of shipping time on defect.	
4	H_0	There is no significant interaction between each level of temperature and each level of average speed of truck.	0.011
	H_1	There is significant interaction between each level of temperature and each level of average speed of truck.	
5	H_0	There is no significant interaction between each level of temperature and each level of shipping time.	0.227
	H_1	There is significant interaction between each level of temperature and each level of shipping time.	
6	H_0	There is no significant interaction between each level of average speed of truck and each level of shipping time.	0.749
	H_1	There is significant interaction between each level of average speed of truck and each level of shipping time.	
7	H_0	There is no significant interaction between each level of temperature, each level of average speed of truck, and each level of shipping time.	0.140
	H_1	There is significant interaction between each level of temperature, each level of average speed of truck, and each level of shipping time.	

Table 4.10 above shows the p-value of each model that calculated in analysis of variance. The hypothesis decision to find out what models that are being chosen will be elaborated in the next section.

4.5.7 Hypothesis Testing

As the analysis of variance interpretation is done in the previous section, the next step is to analyze the hypotheses for the parameter settings. The hypothesis is built and consist of the null hypothesis (H_0) and H_1. If the result shows the p-value is less than α (α=0.05), then H_0 is rejected. The result of hypothesis testing is shown in Table 4.11.

Table 4.11 Hypothesis Testing

No.	H	Hypothesis	Decision
1	H_0	There is no significant effect of temperature on defect.	Reject H_0: 0.000 < 0.05
	H_1	There is significant effect of temperature on defect.	
2	H_0	There is no significant effect of average speed of truck on defect.	Reject H_0: 0.000 < 0.05
	H_1	There is significant effect of average speed of truck on defect.	
3	H_0	There is no significant interaction between each level of temperature and each level of speed of truck.	Reject H_0: 0.011 < 0.05
	H_1	There is significant interaction between each level of temperature and each level of speed of truck.	

According to the result of analysis of variance on Figure 4.9 and Table 4.10, there are three selected models that have significant effect on defect, which are temperature, average speed of truck, and the interaction between each level of temperature and each level of speed of truck, since the p-value is less than α (α=0.05) and H_0 is rejected.

4.5.8 Residual Analysis

In residual analysis, it consists of graphs that are used in order to see if the assumptions from analysis of variance calculation are achieved or not. It all is presented on residual plots. Residual plots consist of normal probability plot, versus fits, histogram, and versus order.

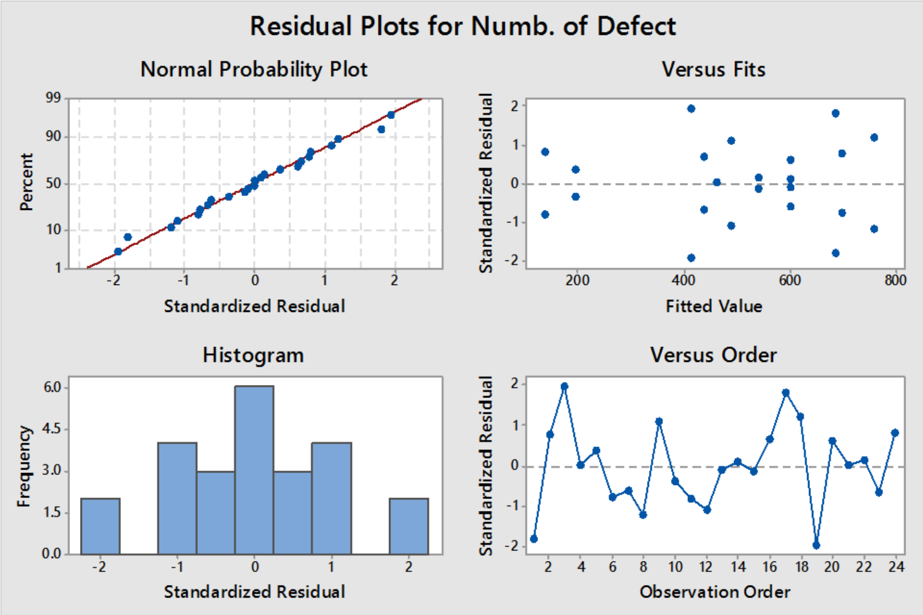


Figure 4.14 Residual Plots

The assumption of normality can be seen in Figure 4.14. The graph of normal probability plot shows a pattern of points that are around and follow the linear pattern. It can be defined that the residual is normally distributed. The second graph represents the residual versus fits in order to see the residual homogeneity. Since the points are spread out and not showing any pattern, can be defined as homogenous. The third graph shows the histogram that has bell-shaped, so it is normally distribution. The fourth graph is spread randomly and not forming any pattern. The residual versus order graph shows the independency of all residual, so it can be concluded that the independent assumptions is achieved. It can be concluded that all the assumptions are achieved.

4.5.9 Main Effects Plot

The main effect plot is made also by using statistical software. It is done by plotting the means of each level value of each variable. From point to other point, it is connected with line. The overall mean is also stated in a reference line. The line can be interpreted as follows:

- There is no main effect present if the line is formed horizontally. The response mean is as same as it is pass all factor levels.

- There is main effect present if the line is formed vertically and not horizontally. The response mean is not as same as it is pass all factor levels. The more significant the line slope, the bigger the enormity of the major effect.

Figure 4.15 below shows the main effect plot for number of defect for each factor. The dotted line shows the mean of all runs in analysis. The main effect plot consists of three factors which are shipping time, average speed of truck, and temperature. The main effect plot of shipping time factor shows that the shipping time level 2 (33 – 40 days) has better effect to minimize the number of defect packaging than the level 1 (25 – 32 days). Since the line that connects shipping time level 1 and level 2 is not so steep, so, it is not significant statistically. Shipping time factor will not really affect the number of the defect packaging.

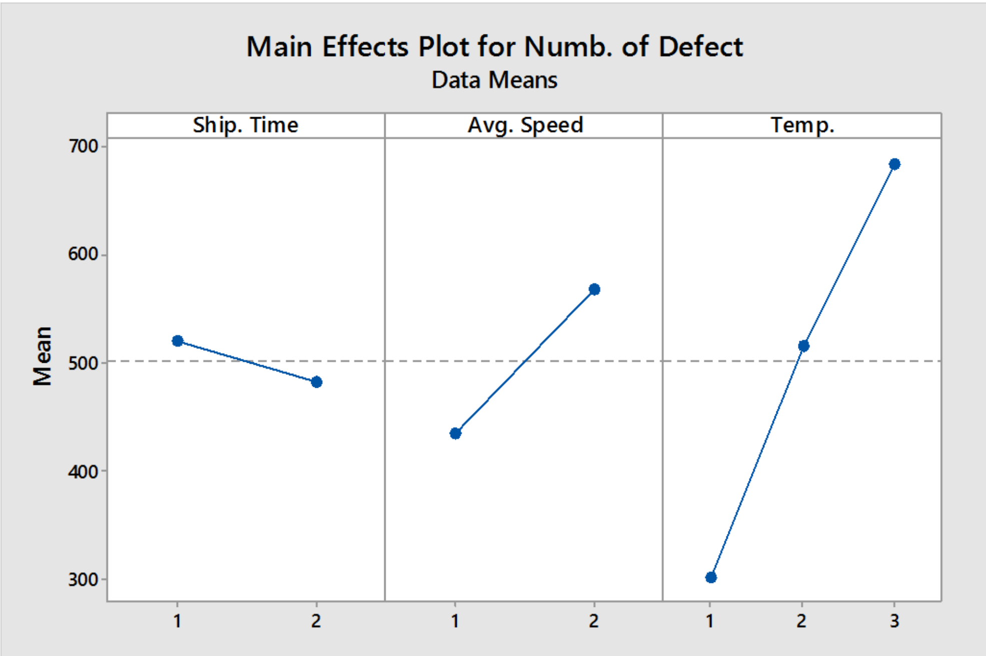


Figure 4.15 Main Effects Plot for Number of Defect

The main effect plot for average speed of truck quite affected the response (the number of defect), since the slope of the line is quite steep. It can be defined that the average speed of truck factor level 1 (40 – 50 km/h) which has the better impact to the response. The more vertical the line the more significant the factor influence the response. As it is seen, the temperature is significant and will influence the response (the number of defect) since the line slope is the steepest among other factors. The temperature in level 1 (32 – 36^{o}C) has a possibility to affect significantly the number of defects to be reduced.

Since the shipping time factor is not significantly affected the response. It can be remove from the model. As it is already explained above, it can be concluded that the best level of factors toward the response mean (number of defect) are temperature in level 1 (32 – 36^{o}C) and the average speed of truck factor level 1 (40 – 50 km/h).

4.5.10 Interaction Plot

The main effects plot that is explained in the previous section cannot be the only one reference since the interactions between factors according to analysis of variance test. Therefore, the interaction plot is needed to be examined in order to know if there is any interaction between on factor to other factors toward the response (number of defect). The interaction plot for the response is formed on Figure 4.16 below.

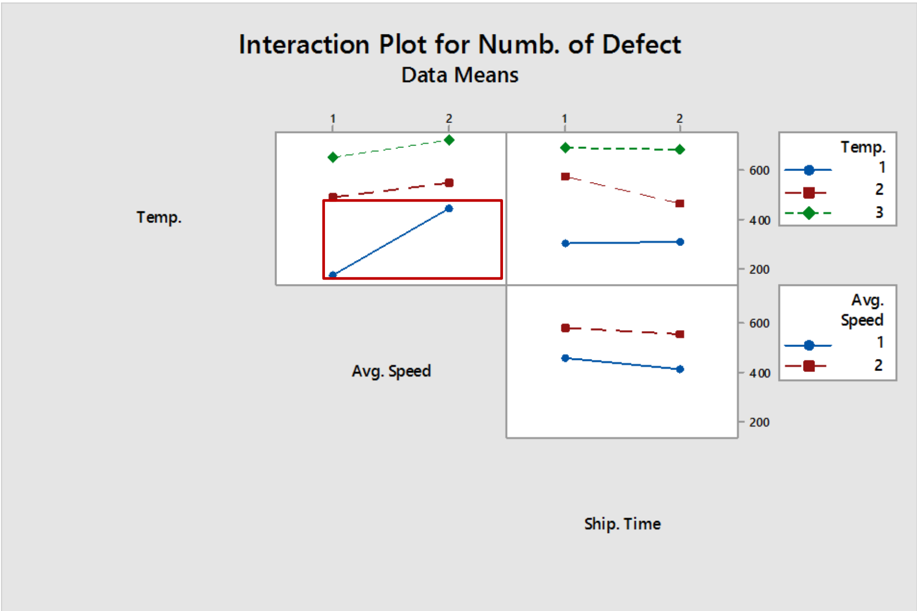


Figure 4.16 Interaction Plot for Number of Defect

The interaction plot above shows the interaction between temperature - average speed of truck, temperature – shipping time, and average speed of truck with shipping time towards the response (number of defect). By seeing all of the interactions, it can be concluded that the best interaction between factors toward the response is temperature in level 1 (32 – 36^{o}C) and the average speed of truck factor level 1 (40 – 50 km/h).

Table 4.12 Response Optimization for Minimum Number of Defects

Response Optimization: Numb. of Defect

```
Parameters

Response          Goal      Lower  Target  Upper  Weight  Importance
Numb. of Defect   Minimum             102    813       1           1


Solution

                                      Numb. of
          Ship.  Avg.                   Defect     Composite
Solution  Time   Speed  Temp.              Fit  Desirability
1         1      1      1                  139      0.947961


Multiple Response Prediction

Variable     Setting
Ship. Time   1
Avg. Speed   1
Temp.        1


Response            Fit  SE Fit       95% CI            95% PI
Numb. of Defect   139.0    46.2  (38.2, 239.8)  (-35.5, 313.5)
```

After all of the tests have been proved, the next step is to find out the optimum parameter setting for response. The minimum defects will be considered as the new parameter setting. Based on the result in Table 4.12 above, the minimum defects occurred will be in the combination of temperature in level 1 (32 – 36^{o}C), the average speed of truck factor level 1 (40 – 50 km/h), and the shipping time level 1 (25 – 32 days) with the minimum number of defect is 139 products.

4.6 Before After Improvement

Based on the analysis in previous section, in order to reach the minimum defects packaging, it is needed to implement the proposed improvements. As it is already explained in Table 4.5, the causes that affect the number of defect packaging after shipment from the factor of Man, Environment, and Method are such as the driver drives the truck recklessly, the warehouse operators do not loading the products into container properly, the temperature inside container is over heat, and there is delayed shipment to destination. The number of defects can be minimized by these detail proposed improvements below.

4.6.1 Result On Proposed Improvements in Man

According to the calculation and analysis, the average speed of truck is significantly influence of the cause of the product packaging defect. The minimum defects will be occurred in the average speed of truck factor level 1 (40 – 50 km/h). With reference to this parameter setting, therefore, it is needed to propose the improvements such as conducting the regular training for truck drivers, in order to make and remind the truck drivers always get used to drive the truck in range 40 – 50 km/h.

The second cause is the warehouse operators do not load the products into container properly. A person's work performance can sometimes decrease and increase. Therefore, the regular inspection is needed. The regular inspection can be done by monitoring the working steps of operators and ensure that it is already appropriate with the standard operating procedure if any. Since there is no standard operating procedure (SOP) for this workstation, it is also needed to make the standard operating procedure (SOP) of the product loading process. Therefore, the proposed standard operating procedure is made and can be seen in Appendix 7.

4.6.2 Proposed Improvement in Method

The potential failure causes in method is the shipping time. After the statistical testing is done in previous section, it can be concluded that the factor of shipping time is not significant and not really affected toward the number of defects that occurred. But, the proposed improvement is still needed, which are to make a contract with third party to always report if there is any delay of shipment, to make allowable maximum shipping deadline, like the shipping time is 30 days and the allowable additional shipping time 5 days. If the third party exceeds the shipping deadline, it will be sanctioned in accordance with the contents of the agreement letter made.

It also can be solved by the usage of RFID (Radio-frequency Identification) since the shipment report is still conducted manually by mail. RFID is used to simplify the tracking of shipping process by sending the signal and transmitting the data to the information system of the company to know and to track the whereabouts of product being shipped. The standard of shipping time also should be set to 25-32 days in accordance with the result of statistical testing.

4.6.3 Proposed Improvement in Environment

After conducting the analysis of the statistical testing, it can be concluded that the temperature factor is significantly affect the number of defect. The best temperature that helps minimizing the defects is in range 32 – 36^{o}C. It can be realized that the usage of thermostat is needed in order to maintain the temperature inside the container in range 32 – 36^{o}C. The usage of thermostat also should be used since the new proposed standard of temperature is already determined, which is 32 – 36^{o}C.

4.6.4 Comparison of Current Condition and Proposed Improvement

After conducted the root cause analysis, statistical testing, and analysis, the proposed improvements are made and the comparison table of current condition and proposed improvement is formed to easily see the differences. The comparison between the current conditions and proposed improvements of all factors are listed in Table 4.12.

Table 4.13 Comparison of Current Condition and Proposed Improvement

No.	Factor	Potential Failure Mode	Current Condition	Proposed Improvement
1	Man	Truck Driver	Driving the truck in high speed up to 60 km/h	Training and making a standard to drive the truck in range 40 – 50 km/h.
		Warehouse Operator	Not loading the products into container properly.	Regular inspection and making the Standard Operating Procedure (Appendix 7).
2	Environment	Temperature	Temperature in container is over heat up to 46^{o}C.	Using thermostat to control the temperature inside container, make the range of 32 – 36^{o}C as the standard.
3	Method	Shipping Time	Delayed shipment to destination.	Making a contract with third-party to always report if there is any delay of shipment and defining the allowable maximum shipping deadline or the usage of RFID (Radio-frequency Identification).

4.6.5 Defining The Best Option

After the defects occurred during 2016, the distribution center neglect and has been doing nothing to this problem. Distribution center is not doing anything to repair the defect packaging of toys. The toys are quarantined in a warehouse inside the distribution center in Fort Worth, Texas and PT. X does not know what further actions carried out by the distribution center. This research is conducted to help both the company and distribution center to find out if there is any option that can be taken to solve this issue.

In the previous section, the distribution center has not taken any action of this issue occurred. The options that has been made to be considered are to choose reshipping and reworking the defect packaging of the products and it means that the distribution center has to deliver the defect products back to the factory of PT. X and may spend pretty much money for the reshipping and rework costs, or to reproduce and deliver the new products.

As it is seen on Figure 4.17, the distance between Fort Worth, Texas where the distribution center is and Cikarang, Bekasi, Indonesia where the factory of PT. X is, is 25,709 km in which the cost for one time shipping for one container is $6700. For the inland delivery in Indonesia, the delivery time for the truck is at 9 p.m. with the arrival estimation to Jakarta's toll booth at around 10 p.m., since there is the rule of government that stated that the allowable time for the truck passes the high way or around Jakarta is from 10 p.m. – 5 a.m. The truck route is Cikarang – Tol Jakarta/Cikampek – Jakarta Inner Ring Road – Tj. Priok Port with a distance of 57.2 km.

Figure 4.17 Distance Maps from Factory to Distribution Center

As the problem described above, it might be solved by reshipping and reworking the defect products itself. All the costs are calculated as follows

- Reshipping Cost

  Before the calculation is conducted, there are some data and information to be known. The shipment process is done by the third-party, logistic company. The requirement of shipment is minimal one container. As per one container, the shipping cost from the third-party from Indonesia to USA and vice versa with the distance of 25,709 km as shown in Figure 4.17, is $6,700. Based on the company's historical data, the container that used is 40" Container with the capacity of 18,659 products. The shipment process of the defect products will be considered to be shipped by the end of the year and the products will be sold and distributed for the high season. So, the total reshipping cost will be:

$$Reshipping\ Cost = 'USA\ to\ ID\ Cost + 'ID\ to\ USA'Cost$$
$$= 6700 + 6700$$
$$= \$\ 13{,}400\ /year$$

- Rework Cost

  Based on the company information, the rework cost for each toy is $5, including the material cost and labor cost per toy. The calculation of rework cost of defect products in 2016 at distribution center in Fort Worth, TX is as follows:

$$Rework\ Cost = Rework\ Cost\ per\ toy\ \times Number\ of\ Defects\ per\ year$$
$$= 5\ \times 12{,}043$$
$$= \$\ 60{,}215$$

So, if PT. X chooses to rework all the defect products, in 2016 the company will spend the costs as follows:

$$Total\ Rework\ Cost = Rework\ Cost + Reshipping\ Cost$$
$$= 60{,}215 + 13{,}400$$
$$= \$\ 73{,}615$$

- Reproduction Cost

  If the company chooses to reproduce the number of products that defect in 2016 with the cost $30 each, it will be:

$$Reproduction\ Cost$$
$$= (Production\ Cost\ \times Number\ of\ Defects\ per\ year) + Shipping\ Cost$$

$$= (30 \times 12{,}043) + 6{,}700$$

$$= 361{,}290 + 6{,}700$$

$$= \$\ 367{,}990$$

The shipment process of the defect products will be considered to be shipped by the end of the year and the products will be sold and distributed for the high season. If PT. X prefers to rework the defect products and the products are returned to the production plant, it will be costly reshipping and reworking with the amount of $73,615 dollars in which the company should pay the shipping cost double, from USA to Indonesia and vice versa. While, if PT. X prefers to produce new toys and send the products, it will cost $367,990.

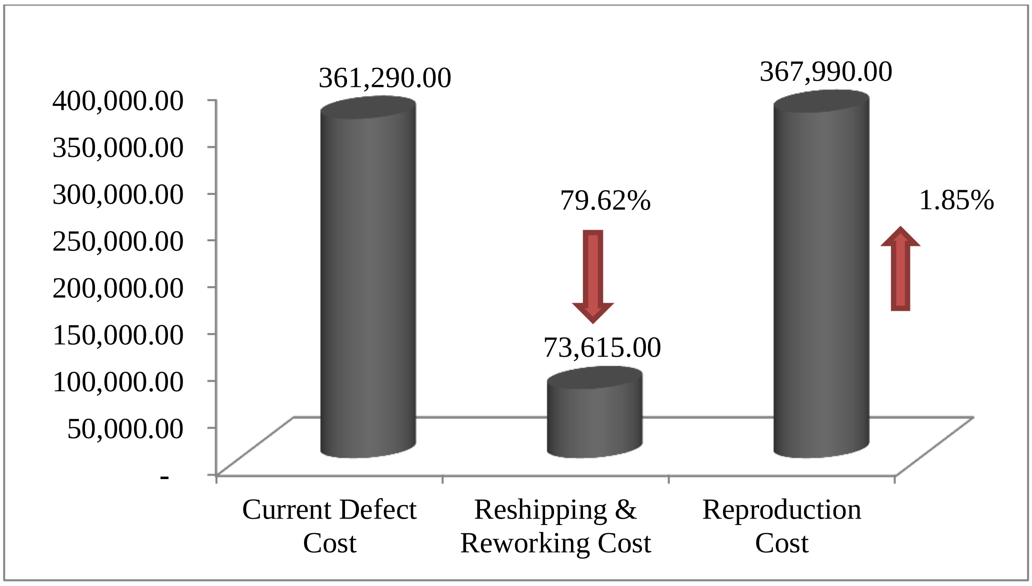


Figure 4.18 The Comparison of Option Costs

As if it is compared in Figure 4.18, it can be concluded that it is better to select the option to reship and rework the defect products rather than to reproduce and deliver the new products. For the reshipping and reworking option, it is known that the cost to solve this issue is way cheaper since the cost is $ 73,615 in which it costs only 79.62% of the current defect cost if it is compared with the reproducing option. If the company chooses to reproduce and deliver the new products, it will cost much money as it is compared with the reworking cost since the reproduction cost is 1.85% more expensive in comparison with the current defect cost.

CHAPTER V
CONCLUSION AND RECCOMENDATION

5.1 Conclusion

According to the analysis of the research, there are several conclusions that can be made. The conclusions below contain the research objectives that have been attained after conducting the research. The research conclusions are stated and elaborated as follows:

- The factors that significantly affect the number of defect product packaging are known. The factors are temperature and average speed of truck and there is interaction between both factors. Meanwhile the factor of shipping time is not really affected of causing the number of defects. The new parameter settings are also defined as the proposed improvement for the company and the distribution center. There are temperatures in range of 32 – 36^{o}C and the average speed of truck that should be drove in range of 40 – 50 km/h, with the expectation it can minimize the number of defects.
- There are two options to solve the defect products that have been quarantined in the distribution center warehouse at Fort Worth, Texas, which are to reship and rework the products or to reproduce the products. Based on the two options that have been stated and analyzed in previous section, the option of reshipping and reworking the products becomes the best solution that should be chosen by both parties, since the cost to reship and rework the defect products is way cheaper with the amount of $73,615 if it is compared with the reproduction cost which is $367,990.

5.2 Recommendation

After the data calculation and analysis have been concluded. The recommendation for future research is defined in order to still conduct the continuous improvement. It is recommended to conduct the further research by identifying other factors that cause the defect products, conduct the experiment of the PET packaging material in laboratory towards the significant factors that already defined in previous section. It is also recommended to conduct research to find out the new and the better packaging material without ignoring the eco-friendly aspect and easy to recycle, and last but not least is to examine further and deeper on the shipping handling process as the future research.

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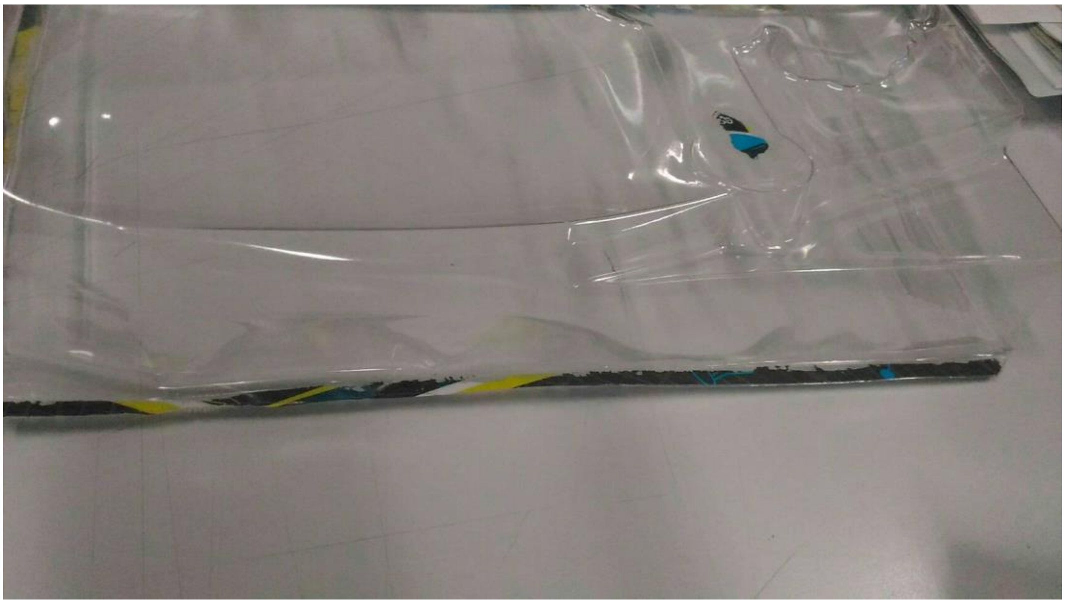
APPENDICES

Appendix 1 – Data of Product Shipping at All Distribution Centers in 2016

No.	Country	Product Shipping (pcs)	Defects (pcs)
1	Fort Worth, TX	842,116	12,043
2	Chicago, IL	908,582	11,263
3	Miami, FL	949,572	11,126
4	Laredo, TX	987,398	11,049
5	Madison, WI	902,953	10,485
6	New York, NY	1,714,900	10,485
7	East Aurora, NY	983,640	9,953
8	United Kingdom	1,169,808	9,740
9	Costa Rica	856,356	9,602
10	Los Angeles, CA	960,284	9,506
11	El Segundo, CA	983,078	9,503
12	Austria	906,684	9,491
13	Japan	1,223,491	9,408
14	Romania	849,582	8,904
15	Columbia	996,804	8,607
16	Switzerland	949,330	8,603
17	Brazil	949,536	8,596
18	San Bernardino, CA	992,502	8,573
19	Spain	959,205	8,553
20	New Zealand	967,840	8,509
21	Germany	1,037,505	8,496
22	Greece	930,529	8,406
23	Finland	967,035	8,375
24	Puerto Rico	907,508	8,058
25	Korea	956,353	7,950
26	Norway	969,055	7,591
27	Phillipines	958,308	7,588
28	Canada	909,313	7,535
29	Peru	910,800	7,506
30	India	956,308	7,495
31	Venlo, Netherlands	957,395	7,402
32	Portugal	937,582	7,309
33	France	1,096,540	7,068

No.	Country	Product Shipping (pcs)	Defects (pcs)
34	Venezuela	995,750	6,950
35	Taiwan	894,757	6,940
36	Hungary	996,204	6,745
37	Chile	903,899	6,704
38	Czech Republic	963,957	6,592
39	Turkey	902,951	6,413
40	Italy	919,475	6,209
41	Denmark	938,062	5,927
42	Poland	964,550	5,853
43	Belgium	969,305	5,795
44	Argentina	996,658	5,760
45	Derrimut, Australia	1,047,294	5,597
46	Mexico	905,830	5,069
47	Hong Kong	905,395	4,593
48	Singapore	983,945	4,085

Appendix 2 – Defect Packaging




Barbie
DREAMTOPIA

Appendix 3 – Defect Percentage

Month	Product Shipping	Product Shipping Detail	Defect/ Shipping	Defect/ Month	Percentage
January	70248	14,050	102	702	5.83%
		56,198	600		
February	78188	54,372	734	1173	9.74%
		23,816	439		
March	74404	48,363	504	967	8.03%
		26,041	463		
April	67593	13,519	214	811	6.73%
		54,074	597		
May	65651	39,391	662	985	8.18%
		26,260	323		
June	64289	36,645	630	1093	9.08%
		27,644	463		
July	62016	24806	573	1178	9.78%
		37210	605		
August	65677	49258	702	1248	10.36%
		16419	546		
September	72319	47007	533	940	7.81%
		25312	407		
October	72105	32447	469	1009	8.38%
		39658	540		
November	78693	15379	176	944	7.84%
		63314	768		
December	70933	14187	180	993	8.25%
		56746	813		
Total	842116			12043	

Appendix 4 – Product Shipping and Defect Details

No.	Product Shipping Details				Product Defects Details			
	NC	C	AH	MH	NC	C	AH	MH
1	5,382	1,820	3,720	3,128	38	15	24	25
2	24,775	6,006	13,200	12,217	208	72	183	137
3	20,134	6,325	12,438	15,475	285	91	177	181
4	12,612	3,050	4,595	3,559	213	39	108	79
5	27,480	3,749	8,049	9,085	384	35	48	37
6	5,365	4,310	8,358	8,008	81	77	171	134
7	5,506	1,504	3,059	3,450	117	19	50	64
8	22,366	4,848	13,185	13,675	223	83	131	160
9	16,634	3,060	8,954	10,743	294	58	135	175
10	10,430	5,100	5,643	5,087	138	81	79	25
11	17,495	2,950	7,508	8,692	278	75	176	101
12	12,792	3,720	4,916	6,216	228	49	103	83
13	11,255	4,145	5,077	4,329	217	93	124	139
14	13,802	4,585	11,600	7,223	227	92	187	99
15	25,150	3,748	10,385	9,975	308	68	190	136
16	6,211	1,287	3,606	5,315	255	37	139	115
17	20,355	5,822	10,890	9,940	274	71	107	81
18	10,280	3,029	5,093	6,910	153	48	114	92
19	10,390	4,970	8,137	8,950	146	93	132	98
20	20,901	4,148	7,965	6,644	297	64	103	76
21	5,750	1,967	3,893	3,769	76	29	37	34
22	28,641	7,890	11,368	15,415	299	124	158	187
23	5,801	2,350	3,877	2,159	67	37	44	32
24	21,956	7,067	12,793	14,930	284	106	196	227

Appendix 5 – Factorial Design Calculation

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Correlation: Temp., Avg. Speed, Ship. Time, Numb. of Defect

	Temp.	Avg. Speed	Ship. Time
Avg. Speed	0.000		
	1.000		
Ship. Time	0.000	0.000	
	1.000	1.000	
Numb. of Defect	0.832	0.354	-0.102
	0.000	0.090	0.637

Multilevel Factorial Design

```
Factors:       3     Replicates:     2
Base runs:    12     Total runs:    24
Base blocks:   1     Total blocks:   1
```

Number of levels: 3, 2, 2

Design Table (randomized)

Run	Blk	A	B	C
1	1	1	1	2
2	1	1	2	1
3	1	1	1	1
4	1	1	2	2
5	1	3	1	2
6	1	1	2	1
7	1	3	2	1
8	1	2	2	2
9	1	3	1	2
10	1	3	2	1
11	1	1	1	1
12	1	2	1	1
13	1	2	1	1
14	1	3	1	1
15	1	2	2	2
16	1	2	1	2
17	1	2	2	1
18	1	2	2	1
19	1	3	1	1
20	1	2	1	2
21	1	3	2	2
22	1	1	2	2
23	1	3	2	2
24	1	1	1	2

General Factorial Regression: Numb. of Defect versus Temp., Avg. Speed, Ship. Time

Factor Information

Factor	Levels	Values
Temp.	3	1, 2, 3
Avg. Speed	2	1, 2
Ship. Time	2	1, 2

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	11	792653	72059	16.85	0.000
Linear	4	700955	175239	40.97	0.000
Temp.	2	586517	293259	68.57	0.000
Avg. Speed	1	105735	105735	24.72	0.000
Ship. Time	1	8702	8702	2.03	0.179
2-Way Interactions	5	71790	14358	3.36	0.040
Temp.*Avg. Speed	2	56929	28465	6.66	0.011
Temp.*Ship. Time	2	14401	7201	1.68	0.227
Avg. Speed*Ship. Time	1	459	459	0.11	0.749
3-Way Interactions	2	19909	9955	2.33	0.140
Temp.*Avg. Speed*Ship. Time	2	19909	9955	2.33	0.140
Error	12	51324	4277		
Total	23	843978			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
65.3991	93.92%	88.34%	75.67%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	501.8	13.3	37.59	0.000	
Temp.					
1	-198.7	18.9	-10.52	0.000	1.33
2	15.3	18.9	0.81	0.433	1.33
Avg. Speed					
1	-66.4	13.3	-4.97	0.000	1.00
Ship. Time					
1	19.0	13.3	1.43	0.179	1.00
Temp.*Avg. Speed					
1 1	-68.7	18.9	-3.64	0.003	1.33
2 1	38.0	18.9	2.01	0.067	1.33
Temp.*Ship. Time					
1 1	-21.2	18.9	-1.12	0.284	1.33
2 1	34.3	18.9	1.82	0.094	1.33
Avg. Speed*Ship. Time					
1 1	4.4	13.3	0.33	0.749	1.00
Temp.*Avg. Speed*Ship. Time					
1 1 1	-31.3	18.9	-1.66	0.124	1.33
2 1 1	-7.0	18.9	-0.37	0.717	1.33

Regression Equation

Numb. of Defect =

501.8 - 198.7Temp._1 + 15.3Temp._2 + 183.3Temp._3 - 66.4 Avg. Speed_1

```
+ 66.4 Avg. Speed_2 + 19.0 Ship. Time_1 - 19.0 Ship. Time_2
- 68.7 Temp.*Avg. Speed_1 1 + 68.7 Temp.*Avg. Speed_1 2
+ 38.0 Temp.*Avg. Speed_2 1 - 38.0 Temp.*Avg. Speed_2 2
+ 30.7 Temp.*Avg. Speed_3 1 - 30.7 Temp.*Avg. Speed_3 2
- 21.2 Temp.*Ship. Time_1 1 + 21.2 Temp.*Ship. Time_1 2
+ 34.3 Temp.*Ship. Time_2 1 - 34.3 Temp.*Ship. Time_2 2
- 13.2 Temp.*Ship. Time_3 1 + 13.2 Temp.*Ship. Time_3 2
+ 4.4 Avg. Speed*Ship. Time_1 1 - 4.4 Avg. Speed*Ship. Time_1 2
- 4.4 Avg. Speed*Ship. Time_2 1 + 4.4 Avg. Speed*Ship. Time_2 2
- 31.3 Temp.*Avg. Speed*Ship. Time_1 1 1
+ 31.3 Temp.*Avg. Speed*Ship. Time_1 1 2
+ 31.3 Temp.*Avg. Speed*Ship. Time_1 2 1
- 31.3 Temp.*Avg. Speed*Ship. Time_1 2 2
- 7.0 Temp.*Avg.Speed*Ship. Time_2 1 1 +7.0 Temp.*Avg. Speed*Ship. Time_2
1 2 + 7.0 Temp.*Avg. Speed*Ship. Time_2 2 1
- 7.0 Temp.*Avg. Speed*Ship. Time_2 2 2
+ 38.3 Temp.*Avg. Speed*Ship. Time_3 1 1
- 38.3 Temp.*Avg. Speed*Ship. Time_3 1 2
- 38.3 Temp.*Avg. Speed*Ship. Time_3 2 1
+ 38.3 Temp.*Avg. Speed*Ship. Time_3 2 2
```

Response Optimization: Numb. of Defect

Parameters

Response	Goal	Lower	Target	Upper	Weight	Importance
Numb. of Defect	Minimum		102	813	1	1

Solution

Solution	Ship. Time	Avg. Speed	Temp.	Numb. of Defect Fit	Composite Desirability
1	1	1	1	139	0.947961

Multiple Response Prediction

Variable	Setting
Ship. Time	1
Avg. Speed	1
Temp.	1

Response	Fit	SE Fit	95% CI	95% PI
Numb. of Defect	139.0	46.2	(38.2, 239.8)	(-35.5, 313.5)

Appendix 6 – Cost Comparison

	Current Defect Loss Cost	Reshipping & Reworking Cost	Reproducing Cost
Cost	$ 361,290	$ 73,615	$ 367,990

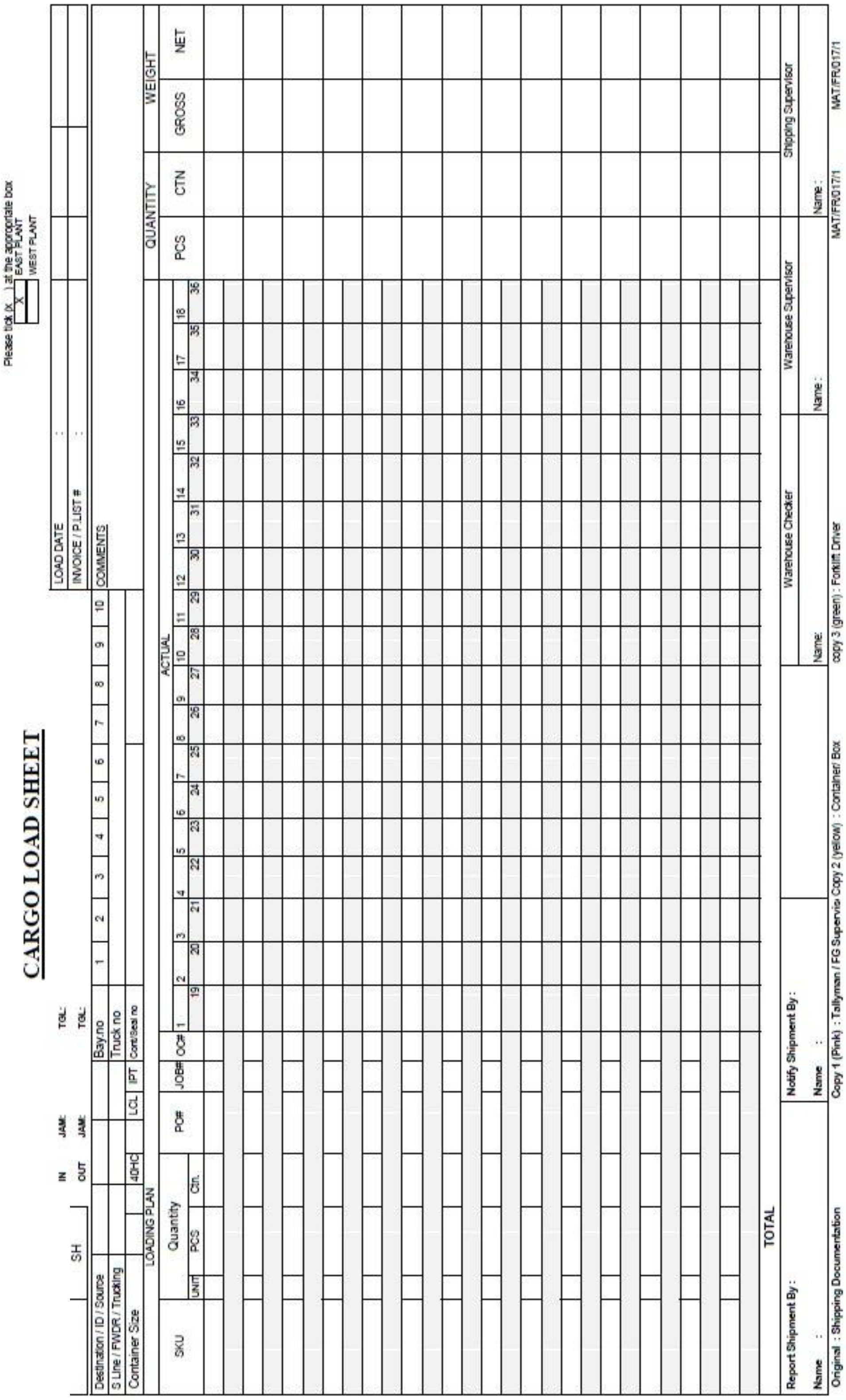
Appendix 7 – Standard Operating Procedure of Product Loading Into Container

<table>
<tr><td>Tanggal Efektif: 27 Mei 2016</td><td colspan="2" rowspan="4">PT.X LOGO</td><td>Disetujui</td><td>Diperiksa</td><td>Dibuat</td></tr>
<tr><td>Seksi : Warehouse</td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td></tr>
<tr><td>Nama Proses : Loading Toy</td></tr>
<tr><td>Referensi Prosedur : Prosedur Pengiriman Barang Jadi</td></tr>
<tr><td>No. Dokumen : -</td><td colspan="2">INSTRUKSI KERJA</td></tr>
<tr><td>Halaman: 1/1</td><td colspan="2">PELAKSAAN LOADING BARANG PENGIRIMAN</td></tr>
</table>

No.	Langkah Kerja	Gambar	Keterangan
1	Siapkan barang yang akan di proses untuk dimasukkan ke dalam container pengiriman.		
2	Pastikan barang yang akan di kirim jumlah dan kodenya sesuai dengan Cargo Load Sheet.		
3	Barang yang akan dimasukkan ke dalam kontainer di ambil 20 pieces dari setiap kelipatan 5000 produk untuk di cek kualitasnya.		
4	Setelah lolos quality check, barang dikemas kembali.		
5	Pasang label untuk kardus yang berada ditumpukkan paling atas.		
6	Masukkan barang ke dalam container menggunakan hand stacker.		

<table>
<tr><th rowspan="2">Safety</th><th rowspan="2">Type Part</th><th colspan="5">Pokok Pemeriksaan</th><th colspan="3">Perbaikan</th></tr>
<tr><th>Subject</th><th>Item</th><th>Std/Spek</th><th>Alat</th><th>Oleh</th><th>Isi Perbaikan</th><th>Tanggal</th><th>Oleh</th></tr>
<tr><td>Helm Safety, Sepatu Safety</td><td>Toy X</td><td>Quality & Quantity</td><td>Label, Card Load Sheet</td><td>OK</td><td>Hand Stacker</td><td>PIC LOADING WAREHOUSE</td><td></td><td></td><td></td></tr>
</table>

Appendix 8 – Cargo Load Sheet



Please tick (x) at the appropriate box
X EAST PLANT
WEST PLANT

CARGO LOAD SHEET

SH | IN JAM: TGL: | OUT JAM: TGL:

LOAD DATE :
INVOICE / P.LIST # :

Destination / ID / Source
S Line / FWDR / Trucking
Container Size | 40HC | LCL | IPT
Bay.no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10
Truck no
Cont/Seal no
COMMENTS

LOADING PLAN

SKU	Quantity UNIT	Quantity PCS	Quantity Ctn.	PO#	JOB#	OC#	ACTUAL 1 / 19	2 / 20	3 / 21	4 / 22	5 / 23	6 / 24	7 / 25	8 / 26	9 / 27	10 / 28	11 / 29	12 / 30	13 / 31	14 / 32	15 / 33	16 / 34	17 / 35	18 / 36	QUANTITY PCS	QUANTITY CTN	WEIGHT GROSS	WEIGHT NET
TOTAL																												

Report Shipment By :
Name :
Notify Shipment By :
Name :
Warehouse Checker — Name:
Warehouse Supervisor — Name :
Shipping Supervisor — Name :

Original : Shipping Documentation | Copy 1 (Pink) : Tallyman / FG Supervis Copy 2 (yellow) : Container/ Box | copy 3 (green) : Forklift Driver | MAT/FR/017/1 | MAT/FR/017/1