CHAPTER I
INTRODUCTION

This chapter includes the research background, problem formulation, research objectives, research scopes, and an outline of the research.

1.1 Research Background

In the current market, the price of a sheet of metal is relatively high, and its processing requires careful attention to minimize the number of defects in the resulting products. In light of this, companies operating in the metal work industry are keen on reducing the quantity of defective products within their overall production. Manufacturing firms aim to enhance their competitiveness by continuously improving productivity and quality (da Silva et al., 2019). Quality control must be consistently implemented to separate defective products from those that have passed the quality inspection. After conducting the quality inspection, if a significant number of defective products are identified, it is necessary to analyze the underlying causes of these defects (Gaspersz, 2007).

According to Björkman & Wisén (2020), since manufacturers conduct any kind of quality inspection and quality improving to find and separate nonconforming parts and products, one might infer that manufacturers are aware that their processes will result in flaws. The reputation, client loyalty, and financial performance of a company can all be negatively impacted by defective products. Customers may become less loyal to a company as a result of defective products because they may no longer have faith in its ability to provide high-quality goods. Defective products can also cause a company to incur higher costs, such as those related to product recalls, repairs, and legal fees.

Currently, the processing industry has become one of the largest contributors to Indonesia's GDP. According to Kementrian Keuangan Republik Indonesia (2022), the processing industry sector was one of the most impactful contributors to Indonesia's GDP during Triwulan III-2022, as can be seen in **Figure 1.1**. The growth of GDP for the processing industry experienced positive growth from Triw III-2022 to Triw IV-2022, which was from 4.83% to 5.64% (year-on-year). One of the industries included in the processing industry sector is the metal work industry, which majority is classified as Small and Medium Enterprises (Dudić & Cvijić, 2017). This industry processes raw metal sheets into finished products after being pressed using hydraulic press machines.

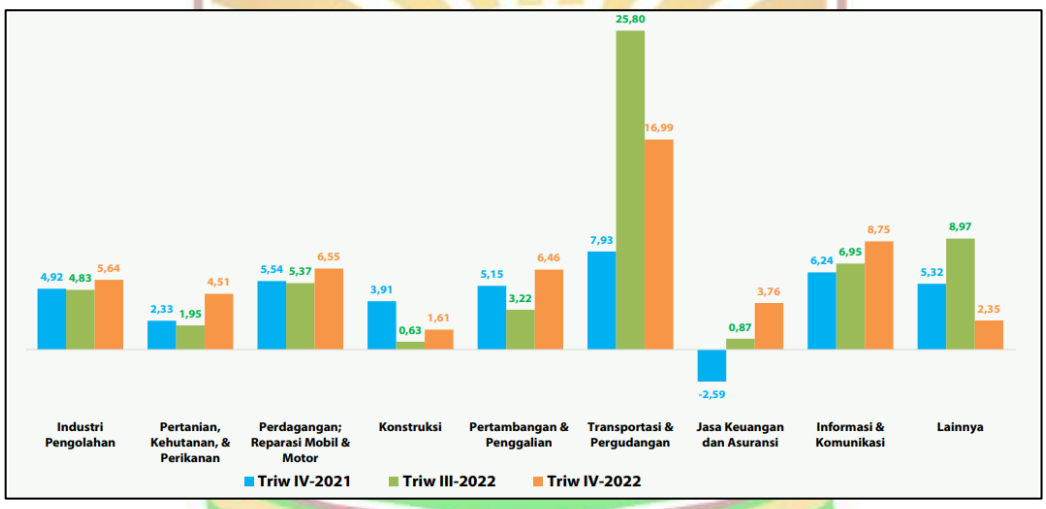

Figure 1.1 Growth of GDP in Some Business Fields (year-on-year) (percent)

(Source: Badan Pusat Statistik, 2022)

The global market for metal products increased from $2632.6 billion in 2022 to $2851.45 billion in 2023, representing a compound annual growth rate (CAGR) of 8.3%. The increase in sales of metal products is primarily due to the growing market demand for various types of metal raw materials. Aluminum, chromium, cobalt, cadmium, cerium, beryllium, bismuth, and several other types of metals are commonly used as raw materials. These metals find extensive application in construction, manufacturing, and various other industries (The Business Research Company, 2023). The rising demand for these materials has contributed to the overall increase in the sales of metal products.

PT Citra Interlindo is a manufacturing company specializing in the production of medium-voltage electrical equipment and metal work utilizing press machines. Established in 1984 and located in Tangerang, the company initially operated under the name PT Cahaya Inaba Electric. At that time, it functioned as a foreign direct investment (FDI) company between Indonesia and Japan, serving as a distributor for electrical component products manufactured by a Japanese company. After a few years, PT Citra Interlindo acquired shares from the foreign company and obtained production permits. Subsequently, in the following year, the company started manufacturing switchgear and load break switches. Recognizing its successful production of electrical components, the company changed into domestic investments and also changed its name to PT Citra Interlindo in 1989.

In 1990, the company obtained a license from Cooper Power System USA (McGraw Edition) to produce products such as surge arresters, fuse cutouts, fuse links, and disconnecting switches. In 1994, PT Citra Interlindo obtained a license from GE Company USA to assemble medium and low-voltage switchgear, expanding its product line to include lightning arresters, fuse cutouts, and disconnecting switches. In 1995, the company relocated its factory from Tangerang to a new location at Delta Silicon, Industrial Park Lippo Cikarang. A year later, PT Citra Interlindo agreed with PT Hitachi Power System Indonesia as a sub-vendor for metal sheets and parts. Currently, the company holds international standard certifications such as ISO 9001, ISO 45001, and SMK3 (Occupational Health and Safety Management System) certification awarded by the Ministry of Manpower of the Republic of Indonesia.

The company operates on a make-to-order business production strategy, where customers place orders for products before the company begins production to meet the specific demands of each customer. According to Hapsari, Azinar, and Sugiyanto (2018), Make to Order (MTO) is a production system in which products are manufactured after receiving an order. In this system, the company maintains a design for the product and a set of standard materials in its inventory, based on previously manufactured products. PT Citra Interlindo has three plants (phases)

used to produce several types of products. Each plant is interconnected with each other. Plant 1 is commonly used for the production of type 1 products, specifically metal work. It contains press machines, a machine shop, shearing equipment, welding stations, maintenance facilities, and quality control. Plant 2 houses an assembly area, bending machines, welding stations, and temporary inventory for materials and finished goods. Plant 3 consists of an assembly area, testing area, finishing area, and painting facilities. The overall layout of the company can be seen in **Figure 1.2**.

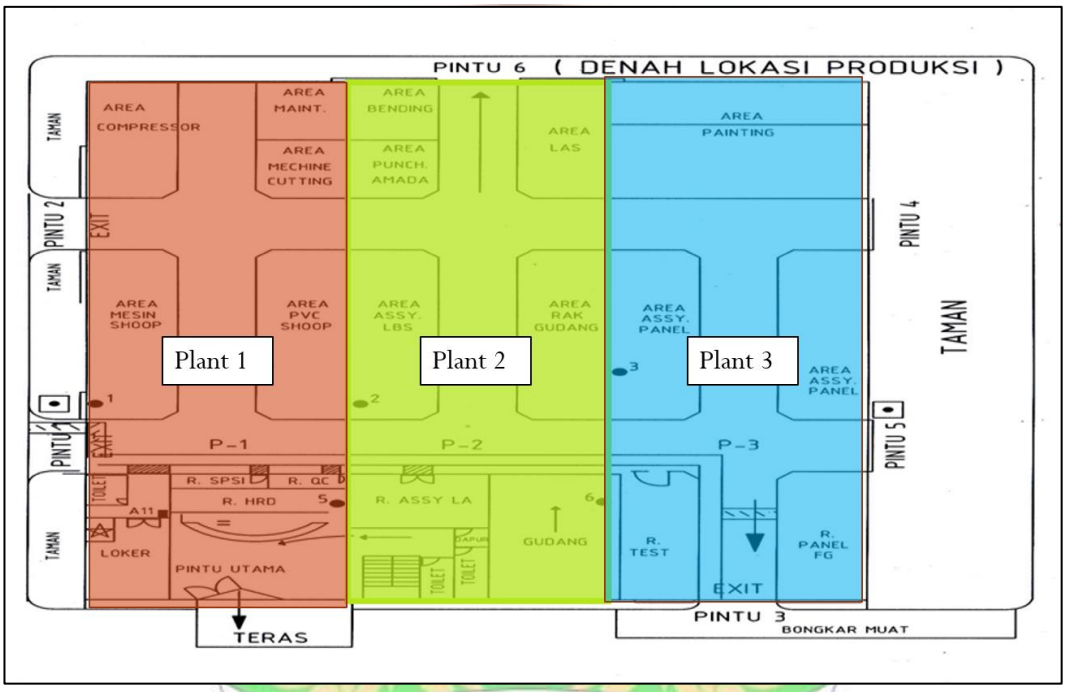

Figure 1.2 Layout PT Citra Interlindo

The company produces various products, including switchgear, MV electric equipment, motor control center, sheet metal, metal work, and relay & control panels. Among all the product types manufactured by PT Citra Interlindo, those that undergo the pressing process (metal work) have the highest number of defects. There are three types of defects often occur in the metal work production process. The first is a scratch defect referred to as Kizu. The second type of defect is wavy defect referred to as Nami. The third type of defect is sharp edges defect referring to Burry. The types of machines used in the production process of metal work are power press machines, punching machines, hydraulic guillotine shearing machines,

shearing machines, hydraulic press brake machines, and CNC turret punch press machines. **Figure 1.3** illustrates a board containing examples of defects that often occur in metal work products. **Figure 1.4** illustrates an example of a hydraulic press machine used to produce metal work products.

Figure 1.3 Defect Product Sample Board

Figure 1.4 Hydraulic Press Machine Used for Producing Metal Work Products

The production process of metal work begins with inspecting the quality of the raw materials, which are metal sheets. After the quality check, the next stage is shearing. During this stage, the metal sheets are cut according to predetermined size criteria and adjusted to the size of the available press machine. Following the shearing process, the process moves on to the press machine/stamp machine. At this

stage, the metal sheets are pressed using the appropriate type of press machine and dies according to the product design. During this stage, there are three steps that consist of blanking, punching, and bending. Blanking means the material will be pressed according to a predetermined product design. The punching step is used to cut off the excess sides or to make a hole in the surface. For the last step in the press machine stage, bending is used if there is a subsequent press process after making the hole.

After the press machine stage, there is a bending stage. This stage is using lathe machine for thread making, lathe processing, and finishing the product. The final stage in the production of metal work is quality control. During the quality control stage, defects are often found in metal work products. Based on the type of defect, the defective products are classified into two categories: those that can be reworked and those that are irreparable and considered scrap.

PT Citra Interlindo is strongly committed to reducing the occurrence of defects in their metal work products. This is primarily due to the significantly higher production volume of metal work products compared to other products such as switchgear, MV electric equipment, motor control center, and panels. Additionally, another reason is that the raw materials for metal work products are provided by the customer. Consequently, if there are defective products that cannot be reworked, the company would have to compensate the customer multiple times the cost of the material, according to the initial agreement made between the company and the customer.

The data shown in **Table 1.1** illustrates the percentage of damaged metal works over 24 months, from January 2021 to December 2022. As seen in **Table 1.1** below, the total defect in metal works consistently exceeded the maximum target defect set by the company almost every month. The company's predetermined maximum target for product defects is 1.5% per month. However, in reality, the average percentage of product defects is 2.18%. It is evident from the table that the

overall number of defects in metal works consistently surpassed the company's designated maximum target almost every month.

Table 1.1 Percentage of Defective Products from January 2021 – December 2022

No	Month	Total Products		Percentage NG		OT / NT
		Good	NG	Target	Actual	
		(pcs)	(pcs)	(%)	(%)	
1	Jan-21	20,197	438	1.50%	2.12%	NT
2	Feb-21	20,626	536	1.50%	2.53%	NT
3	Mar-21	27,928	734	1.50%	2.56%	NT
4	Apr-21	22,691	340	1.50%	1.48%	OT
5	May-21	14,202	467	1.50%	3.18%	NT
6	Jun-21	26,893	556	1.50%	2.03%	NT
7	Jul-21	32,752	360	1.50%	1.09%	OT
8	Aug-21	26,804	272	1.50%	1.00%	OT
9	Sep-21	21,298	341	1.50%	1.58%	NT
10	Oct-21	26,321	595	1.50%	2.21%	NT
11	Nov-21	22,837	623	1.50%	2.66%	NT
12	Dec-21	36,117	1,353	1.50%	3.61%	NT
13	Jan-22	64,027	1,704	1.50%	2.59%	NT
14	Feb-22	47,077	1,283	1.50%	2.65%	NT
15	Mar-22	56,958	1,130	1.50%	1.95%	NT
16	Apr-22	44,155	1,305	1.50%	2.87%	NT
17	May-22	27,184	527	1.50%	1.90%	NT
18	Jun-22	42,211	978	1.50%	2.26%	NT
19	Jul-22	48,099	769	1.50%	1.57%	NT
20	Aug-22	68,521	1,230	1.50%	1.76%	NT
21	Sep-22	55,740	879	1.50%	1.55%	NT
22	Oct-22	34,120	413	1.50%	1.20%	OT
23	Nov-22	67,329	2,379	1.50%	3.41%	NT
24	Dec-22	25,789	675	1.50%	2.55%	NT
TOTAL		**879,876**	**19,887**	**36%**	**52.32%**	**NT**
Average		**36,662**	**829**	**1.50%**	**2.18%**	**NT**

After reviewing the data on metal work products spanning from January 2021 to December 2022, it is apparent that defects are a common occurrence. From the table above, throughout January 2021– December 2022, December 2021 had the highest percentage of product defects, and only four periods of the month did not exceed the maximum target proportion of defects set by the company. It is posing a significant challenge that the company intends to tackle.

Table 1.2 Rework Component Cost Calculation

Product Type	**Cover Sink**
Component	**Cost/unit**
Rework Process Cost	Rp 1,675
Equipment and Supplies Cost	Rp 5,300
Machine Depreciation	Rp 750
Delivery Delay	Rp 1,275
Total	Rp 9,000

Table 1.3 Defect Compensation Cost Calculation

Product Type	**Cover Sink**
Component	**Cost/unit**
Returns Cost	Rp 4,884
Raw Materials	Rp 9,767
Process Cost	Rp 14,651
Machine Depreciation	Rp 2,442
Reshipment Cost	Rp 3,907
Total	Rp 35,650

Tabel 1.2 shows the assumption of the cost of losses that the company must incur. Based on the calculations in the table, the company must incur costs of Rp. 9,000.00 for one unit of cover sink products when carrying out the rework process. **Tabel 1.3** shows the assumed compensation costs that the company must incur. Based on the calculations in the table, the company must spend Rp 35,650.00 for one unit of defective cover sink product as compensation to the customer. The calculation of the components of the rework and defect compensation costs is adjusted to the total defective products from January 2021 - December 2022.

Table 1.4 Example of Estimated Losses for Metal Work Product in 2022

No	Month	Rework	Rework Cost	Defect	Defect Cost	Total Loss
1	Jan-22	712	Rp 9,000	992	Rp 35,650	**Rp 41,772,800**
2	Feb-22	496	Rp 9,000	787	Rp 35,650	**Rp 32,520,550**
3	Mar-22	437	Rp 9,000	693	Rp 35,650	**Rp 28,638,450**
4	Apr-22	900	Rp 9,000	405	Rp 35,650	**Rp 22,538,250**
5	May-22	220	Rp 9,000	307	Rp 35,650	**Rp 12,924,550**
6	Jun-22	209	Rp 9,000	769	Rp 35,650	**Rp 29,295,850**
7	Jul-22	197	Rp 9,000	572	Rp 35,650	**Rp 22,164,800**
8	Aug-22	628	Rp 9,000	602	Rp 35,650	**Rp 27,113,300**
9	Sep-22	112	Rp 9,000	767	Rp 35,650	**Rp 28,351,550**
10	Oct-22	301	Rp 9,000	112	Rp 35,650	**Rp 6,701,800**
11	Nov-22	993	Rp 9,000	1386	Rp 35,650	**Rp 58,347,900**
12	Dec-22	244	Rp 9,000	431	Rp 35,650	**Rp 17,556,573**
Total						**Rp 327,926,373**

Tabel 1.4 shows an example of estimated losses from the production of metal work products at PT Citra Interlindo in 2022. After calculating the number of defects that can be reworked and those that cannot be reworked, the company is estimated to experience a loss of Rp 327,926,373.00 during 2022. The loss cost provides additional costs that must be incurred by the company to carry out the rework process and also the production process again as a replacement for defective products that cannot be repaired. However, the actions taken by the company to reduce the rework process and defective products are still very minimal. As stated by Björkman & Wisén (2020), the reputation, client loyalty, and financial performance of a company can all be negatively impacted by defective products. Customers may become less loyal to a company as a result of defective products because they may no longer have faith in its ability to provide high-quality goods. Defective products can also cause a company to incur higher costs, such as those related to product recalls, repairs, and legal fees.

Therefore, considering these issues, the researchers intend to minimize the number of metal work defects by addressing the factors that affect the production process. In the realm of enhancing quality, lean manufacturing and Six Sigma have emerged as one of the most extensively validated methodologies. In this research, an attempt was made to easily integrate lean manufacturing with the Six Sigma

approach on metal work production lines in a manufacturing facility. As stated by Gaspersz (2007), lean is a continuous effort to eliminate waste and increase value-added in products (goods and/or services) to provide value to customers (customer value). The lean approach applied to manufacturing is known as lean manufacturing. Additionally, the Six Sigma approach aids in identifying and eliminating sources of variation and defects, to continuously improve the manufacturing process by reducing variation, minimizing defective products, and enhancing overall product quality (Rathilall & Singh, 2018).

Six Sigma is frequently employed as a benchmark for evaluating the excellence of goods manufactured by a company. The goal of Six Sigma is to enhance a company's profitability by minimizing variations, defects, quality issues, and wasteful practices that can negatively impact customer loyalty. In simpler terms, Six Sigma's main goals are to eliminate variation in products and processes and to increase a product's degree of quality. (Nandakumar et al., 2020). As a result, numerous companies strive to attain the optimal Six Sigma value. This is crucial as achieving the desired Six Sigma value signifies that the company has achieved a specific standard of quality for each of its products.

The primary objective of Six Sigma is to reduce variations in products and processes and to achieve quality levels of less than 3.4 defects per million opportunities (DPMO). The important point to be noted is reducing the defects involves measurements in terms of millions of opportunities instead of thousands. The term Sigma Quality Level is used as an indicator of a process's goodness. A lower Sigma quality level means a greater possibility of defective products, while a higher Sigma quality level means a smaller possibility of defective products within the process (Yadav & Sukhwani, 2016). Therefore, adopting the combination of lean manufacturing and the Six Sigma approach in the metal work production process at PT Citra Interlindo was chosen to reduce product defects and elevate the company's Sigma value.

1.2 Problem Formulation

Based on the background of this research, the following is the problem formulation in this study.

1. What is the Sigma level of the metal work production process at PT Citra Interlindo?
2. What are the factors that contribute to the frequent occurrence of defects in metal work products at PT Citra Interlindo?
3. How can we propose improvements to the factors that influence product defects by analyzing the aspects of man, machine, method, material, and environment Metal Wok Plant at PT Citra Interlindo?

1.3 Research Objectives

Based on the background and the problem formulation above, the research objectives of this study are as follows:

1. Determine the Sigma level of the metal work production process at PT Citra Interlindo.
2. Identify the factors that contribute to the frequent occurrence of defects in metal work products at PT Citra Interlindo.
3. Propose improvements to the factors that influence product defects by analyzing the aspects of man, machine, method, material, and environment at the Metal Work Plant of PT Citra Interlindo.

1.4 Research Scopes

To narrow its scope, this research is conducted under several limitations. The following are the research scopes:

1. The type of product chosen as the subject of this research is metal products that undergo a pressing process during the production stage.

2. The statistical data used in this research covers the period from January 2021 to December 2022.
3. The proposed improvements and recommended solutions did not reach the implementation stage.
4. The time other related to it are not discussed in this research.

1.5 Outline of the Report

The outline of this final project is reposted as follows:

CHAPTER I INTRODUCTION

This chapter comprises the background, problem formulation, research objective, research scopes, and outline of the research.

CHAPTER II LITERATURE REVIEW

This chapter contains the theoretical basis that supports this research consists of the theories of waste, quality control, lean Six Sigma, Six Sigma, tools or techniques employed in data processing, and the analysis of related earlier studies.

CHAPTER III RESEARCH METHODOLOGY

This chapter contains the steps of research consisting of preliminary study, literature study, preliminary observation, problem identification, problem statement, Six Sigma methodology, conclusion, suggestion, and research methodology flowchart.

CHAPTER IV SIX SIGMA METHODOLOGY

The Six Sigma methodology represents a detailed view of the data collection and data processing for this study. This chapter presents the methods or techniques used from the definition phase to the improve phase of the Six Sigma methodology.

CHAPTER V CONCLUSION AND SUGGESTION

This chapter contains conclusions and suggestions obtained by conducting this research.