CHAPTER I INTRODUCTION

I.1. Background

PT XYZ is a plastic manufacturing company that operates in Bandung. Registered as a company in 1993, the company had been a supplier of high-quality product, in-time delivery, and high customer satisfaction. Its quality is guaranteed through certification from ISO 9001: 2015 that has been given in 2020. The company's vision is to provide molds & plastic products, dies, jigs, & fixtures, precision parts, and general mechanics of the highest quality and secure product for the satisfaction of the customer. Figure I.1.1 shows the sample product that the company produce.

Figure I.1.1. Sample Product

The company does not do forecasting. The production system that was implanted by the company is make-to-order (MTO). The order is received by the company in advance, where the customer specifies the amount of product they require and when the product should be delivered. The company had four injection molding machines to support the production process. These four machines are the same type with the same capabilities and capacity. Therefore, all jobs that were received by the company can be processed by those four machines.

The injection molding machines can shape plastic according to its mold. Before the production, the mold is mounted on the machine. The operator will then operate the machine where it will mold the plastic into the desired shape. The result of the molding is the final product that will be packed and delivered to the customer. Figure I.1.2 shows the machine that was used in the company's production floor.

Figure I.1.2. Injection Molding Machine

Based on the above explanation, the system in the company is single-stage production in an identical parallel machine system. This kind of problem falls into NP-hard problems with *m* machine and *n* jobs (Amini et al., 2011). The company uses the First Come First Serve (FCFS) scheduling system. The current scheduling system on the company's production floor can be seen on Figure I.1.3.

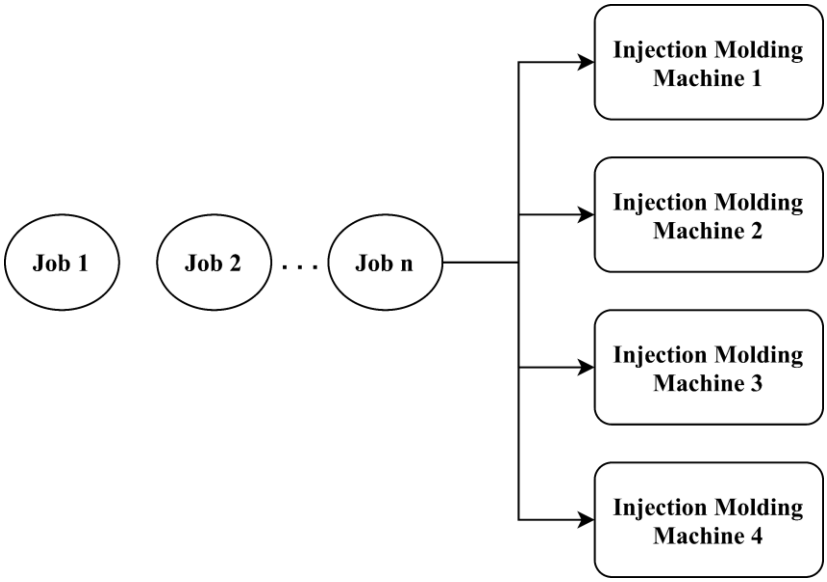

Figure I.1.3. Current Scheduling System

In May 2021, the company did not manage to meet all the customer's due dates. Out of 145 jobs in that month, the number of tardy jobs is 26 with total tardiness is 64. Table I.1.1 below shows the summary of tardiness in May 2021 within the company.

Table I.1.1. Tardiness Summary on Injection Molding Machine in May 2021

Machine	Number of Jobs	Total Tardiness (Days)	Tardy Jobs	Completion Time (Days)
1	40	6	3	20
2	37	5	4	19
3	36	32	11	22
4	32	21	8	24
Total	**145**	**64**	**26**	**85**

Tardiness is an indicator of how well the company could meet the demand's due dates. The tardiness itself is influenced by the company's capacity and the company's scheduling system. Sufficient capacity is required to meet the customer's demand in time (Kumar & Suresh, 2009). While tardiness is one of scheduling's performance measures. Table I.1.2 contains the details of potential root cause that may induce the problem in the company.

Table I.1.2. Symptoms and Root Cause

Symptoms	Possible Root Cause
Tardiness in fulfilling demand	Undercapacity
	Inadequate scheduling system

Both capacity and scheduling are part of an integrated system in production planning and control, where it manages human, materials, information, and machines. The potential solution and research method will be further explained in the following chapters.

I.2. Alternative Solution

The problem that will be the focus of the research is a complex problem. This is evidenced by the existence of several alternative solutions to the problems in the object of research. Table I.2.1 lists the potential solutions for the problem.

Table I.2.1. Alternative Solution

Root Cause	Solution
Undercapacity	Increase the company's capacity
Inadequate Scheduling	Design a better scheduling system for the company

The problems mentioned in Table I.2.1 have multiple solutions that can improve the condition. To determine which alternative solution that will be selected, an analysis is made on the root causes and their alternative solution.

1) Undercapacity

   If a company does not have the required capacity, it is impossible to meet the customer's demand in time. Based on the data provided by the company, a rough capacity calculation was made and compared with the required capacity for May 2021. The workdays for machine operators are from Monday to Saturday, where every day there are three shifts available, each shift lasting eight hours. If there is an influx in demand, the company will use Sundays for overtime when necessary. Figure I.2.1.

shows the comparison between the required capacity and the available capacity in May 2021.

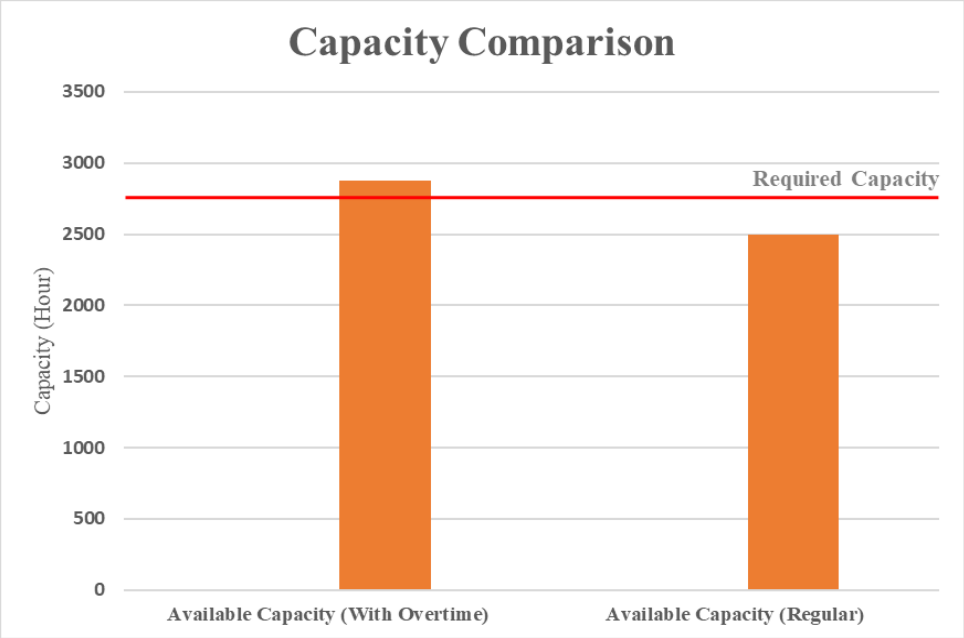

Figure I.2.1. Capacity Comparison

Based on the Figure I.2.1, the company had enough capacity to fulfill the required demands by using available capacity with overtime. Capacity increase speeds up the production process to meet the customer's demand faster. Increasing capacity could be done by a few alternatives, such as adding more machines and workers. However, capacity increase will require substantial investment by the company.

2) Inadequate Scheduling

Scheduling performance can be measured through certain parameters such as tardiness and makespan. Since the capacity is sufficient, then the tardiness in the company reflects the existing scheduling performance.

In scheduling, there are several methods that can be used to improve the scheduling. Each method has both advantages and disadvantages. While choosing the method for scheduling, it is important to consider the constraint and the objective at hand. The problem addressed in the research is how to reduce total tardiness. Table I.2. 2 shows the

alternative solution method for scheduling along with its definition, advantage, and disadvantage.

Table I.2. 2. Alternative Solution in Scheduling

	Alternative Solution		
	Heuristic	**Metaheuristic**	**Optimization**
Definition	Heuristic is any approach to problem solving or self-discovery that employs a practical method, not guaranteed to be an optimal goal, but still enough to reach the goal (Wong & Ming, 2019).	Metaheuristic algorithms is a form of stochastic optimization algorithm which does not depend on the surface gradient for optimization (Wong & Ming, 2019)	Optimization tried to use formulation to find a solution in a simplified version of the problem using approximation and assumptions (Sarker & Newton, 2008).
Advantage	For NP-Hard problems, heuristic methods can yield results close to optimal with acceptable calculation time (Adhi et al., 2018). Heuristics is also easy to implement and efficient (Tsai & Chen, 2014).	Metaheuristic algorithms can provide the global best solution and can be used as an efficient trial and error in complex problems (Gandomi et al., 2013).	Optimizations can provide the global optimal solution (Sarker & Newton, 2008).
Disadvantage	Heuristic method usually finds the solution in local minima and therefore not the most optimal solution (Wong & Ming, 2019).	Application of metaheuristics to a specific problem will require a calibration on a set of numerical instances of the problem as well as testing on an independent set of instances (Silver, 2004).	Processing time will increase in factorial manner for NP-Hard problem when using optimization (Adhi et al., 2018).

As mentioned in the background, the system in the company is identical parallel machines systems, where the jobs to be processed is over a

hundred jobs, and identical parallel machine problem are categorized as NP-hard problems. Based on Table I.2. 2, the best approach to solve the tardiness problem is from scheduling, particularly scheduling using a heuristic method where the solution provided is simpler to calculate and can be implemented without additional cost required.

I.3. Problem Formulation

Based on the background provided, the following is the problem formulation that can be drawn: how to design a method that could reduce total tardiness to be applied in PT XYZ?

I.4. Objective of Research

The objective of the research is to design a method that could reduce total tardiness to be applied in PT XYZ.

I.5. Benefit of Research

This research can be a reference for future improvements in the company, especially in the production planning and control process. Particularly to help in increasing effectiveness and efficiency in the production in reducing tardiness in the company to reach production target delivery.

I.6. Writing System

The following is the writing system for this research:

Chapter I **Introduction**

This chapter contains research background, problem formulation, research's objective, research objective, and writing system.

Chapter II **Literature Study**

This chapter contains literature study and theories that relate to the topic of research that was done in this paper. Those theories and studies are used as a base for this research.

Chapter III **Problem Solving Methodology**

This chapter contains the methodical step of the research that will be done. It explains what the input of the research is, what method will be used to process those inputs, and what output is expected through the research.

Chapter IV Integrated System Design

This chapter contains the data that are needed for the research. It also explains the source of the data and related information about the data that could be relevant to the research. The data that are collected is also processed by a specific method that has been determined before.

Chapter V Validation and Evaluation of Design

This chapter is the result of the solution design and the explanation about the research that has been done. It will compare the result of the research with the existing condition or with another past research in a similar topic.

Chapter VI Conclusion and Suggestion

This chapter contains the conclusion of the research that has been done and gives constructive suggestions. The suggestion could be to readers, other researchers, or the company.