UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

TABLE OF CONTENT

Title i

Ratification ii

Statement of Works Originality iii

Preface iv

Abstract vi

Intisari vii

Table of Content viii

List of Tables xii

List of Figures xiii

List of Equations xiv

List of Attachment xv

CHAPTER 1 INTRODUCTION

1.1 Background 1

1.2 Problem Statement 4

1.3 Research Questions 5

1.4 Research Objectives 5

1.5 Research Contributions 5

1.6 Scope of Research 6

1.7 Systematic of Research 6

CHAPTER 2 LITERATURE REVIEW

2.1 Layout Definition 10

2.2 Concept of Layout Design 11

UNIVERSITAS GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

2.3 Types of Processes 13
2.3.1 Project Processes 14
2.3.2 Jobbing Processes 14
2.3.3 Batch Processes 15
2.3.4 Mass Processes 15
2.3.5 Continuous Processes 16
2.4 Types of Layout Design 16
2.4.1 Fixed-Position Layout 17
2.4.2 Functional Layout 18
2.4.3 Cell Layout 18
2.4.4 Product Layout 19
2.5 Layout Planning Method 20
2.5.1 String Diagram 20
2.5.2 Line Balancing 22
2.5.3 Load Distance Method 27

CHAPTER 3 RESEARCH METHODS

3.1 Research Design 29
3.1.1 Research Strategies 29
3.1.2 Extent of Researcher Interference 30
3.1.3 Study Setting 30
3.1.4 Unit of Analysis 30
3.1.5 Time Horizon 30
3.2 Operational Definition 31

UNIVERSITAS GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

3.2.1 Operational Definition of Precast Concrete Production 31

3.2.2 Operational Definition of Layout 31

3.2.3 Operational Definition of Line Balancing 32

3.3 Data Collection 32

3.3.1 Types of Data..... 32

3.3.2 Data Collection Method..... 33

3.3.3 Validity and Reliability..... 34

3.4 Data Analysis Method 34

CHAPTER 4 DATA ANALYSIS

4.1 Company Profile..... 36

4.2 U-Ditch Production Process 36

4.3 Result 38

4.3.1 Cycle Time of U-Ditch Production..... 39

4.3.2 Minimum Number of Workstations Needed 40

4.3.3 Workstations Grouping Alternatives 40

4.3.4 Tasks Grouping in Every Workstations..... 41

4.3.5 Idle Time and Efficiency Level 44

4.3.6 Cost Benefits..... 47

CHAPTER 5 CONCLUSION

5.1 Conclusion 49

5.2 Limitations..... 50

5.3 Suggestions for Future Research 50

5.4 Managerial Impacts..... 51

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

References 53

Attachments 55

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

List of Tables

Table 2.1 Layout Types for Every Process Type..... 16

Table 2.2 Line Balancing Heuristics..... 24

Table 4.1 Tasks Duration in PT Rahayu Bhuana Karya..... 38

Table 4.2 Minimum Number of Workstations in PT Rahayu Bhuana Karya.. 41

Table 4.3 Workstations Tasks Grouping in PT Rahayu Bhuana Karya 42

Table 4.4 Line Balancing Summary 46

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

List of Figures

Figure 4.1 Precast Concrete Production Precedence Diagram 37

Figure 4.2 Update Precast Concrete Production Precedence Diagram..... 39

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

List of Equations

Equation 2.1 Cycle Time 23

Equation 2.2 Cycle Time 23

Equation 2.3 Theoretical Minimum Number of Workstations 23

Equation 2.4 Idle Time 25

Equation 2.5 Idle Time 26

Equation 2.6 Idle Time 26

Equation 2.7 Efficiency Level 26

Equation 2.8 Efficiency Level 27

Equation 2.9 Load Distance 28

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

List of Attachments

Attachment 1 Task Duration of U-ditch Production..... 55

Attachment 2 PT Rahayu Bhuana Karya Layout..... 56

Attachment 3 Production Data..... 56

Attachment 4 Interview 1 Transcript..... 57

Attachment 5 Interview 2 Transcript..... 60

Attachment 6 Interview 3 Transcript..... 62

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

CHAPTER 1

INTRODUCTION

1.1 Background

Business competition is getting tougher from time to time. In order to survive in the market, businesses must be able to strive and grow in the uncompromising market. In facing the tough competition, businesses should be able to manage the operation well. Good operation management will improve a firm's overall performance. One of the key roles of having a good operation management is by having good facility layout. Managing facility layout is an important concern, especially for manufacturing firms, and it will really affect the efficiency of the manufacturing process (Zhenyuan et al. 2011). Layout planning plays a very important role in impacting the profitability and manufacturing process of a company (Lad and Telsang, 2017). Layout design is also one of the keys in getting long-term efficiency in a business operation (Heizer, Render, and Munson, 2017). Siregar, Tarigan, and Nasution (2018) mentioned that ineffective layout design will cause the company's performance to be under the optimum level, hence a properly designed layout is needed for every workstation in the company to ensure a smooth operation.

Drira, Pierreval, and Hajri-Gabouj. (2007) stated that layout design is the arrangement of everything needed for production of goods or delivery of services. Having a good facility layout means to arrange the physical equipment within a workshop to help the facility work in a productive way, which will contribute to the overall efficiency of the firm's operation (Zhenyuan et al. 2011). Kadir et al. (2015) also stated that one of the elements that can change a manufacturing company's

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

performance is its selection of the layout design. Profitability of the firm will also get impacted by the implementation of effective layout design. Effective layout design minimises the material flow which leads to cost reduction and also improvement in cycle time (Lad and Telsang, 2017). Total operating expenses in manufacturing can be reduced for 10% to 30% annually with effective facility layout (Singh and Sharma, 2006).

In the recent years, the infrastructure development in Indonesia has progressed very quickly. Indonesian government has assigned 223 projects and three strategic national programs since the year 2016 (Koordinator Bidang Perekonomian Republik Indonesia, 2019). Infrastructure development has been the priority of Indonesia's development program which also pushes the growth of the construction industry in Indonesia (Adi, 2019). This shows that the competition in the construction industry is very relentless. Companies must be able to move fast and efficiently in the market.

One of the businesses that is affected is precast concrete business. The concrete industry contributes to about 40 percent of the total materials used in Indonesian projects, thus the government encourages the capacity enhancement of precast concrete to be 50 percent up to the year 2019 in order to fulfil the target (Indopos, 2019).

Problems like skyrocketing demand of the precast concrete also came up and exceeded the supply capacity (Himawan and Hapsari, 2017). Based on Kementrian Keuangan Republik Indonesia (2019), the government keeps increasing the state budget for infrastructure building from year to year. In 2017, the budget is 388.3

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

trillion Rupiah, which then increased to be 410.7 trillion Rupiah in 2018. The budget has been increased again to 415 trillion Rupiah for the year 2019 which means that the demand for precast concrete will keep going up. Based on Asosiasi Perusahaan Pracetak dan Prategang Indonesia (2019), there are only 42 concrete companies registered in the association. Out of those 42 companies, the author found out that 11 companies operate in Central Java. Because of this, the competition is joined by a few companies selling a fairly similar product. In order to be able to compete and fulfil the increased target of production capacity, precast concrete business must be able to operate much more efficiently.

These conditions also affect PT Rahayu Bhuana Karya, which is one out of two precast concrete manufacturers in Magelang. The company was established in 27 September 2019. Although it is recently established, the people behind the company already have previous experiences with precast concrete since the year 2014. As a newly established and relatively small company, the company must be able to quickly adjust itself and operate very efficiently in order to match the number of demand and also the national production target stated by the government while also competing with the already established bigger companies.

Nuryanto, the Director, stated that since the company is still operating at the very early stage, thus it is still open to ideas that can help the company to cope with the stated problems before. One of the ways to overcome the aforementioned problems is by having a good layout design. Good layout design can help the company to reduce production time which leads to better efficiency. It also means that the company can produce higher amount of output with similar time.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

Based on the previously stated matters, a research is conducted in PT Rahayu Bhuana Karya to analyse its layout design and the improvements needed to maximise the performance of the plant.

1.2 Problem Statement

In order to be able to fulfil the skyrocketing demand while also competing with other manufacturers, the company needs to operate with good efficiency and performance from the very beginning. One of the factors that affects the firm's performance is the layout design. Kikolski and Ko (2018) stated that production efficiency depends largely on layout design of production equipment in the plant. Layout planning plays a very important role in impacting the profitability and manufacturing process of a company (Lad and Telsang, 2017). It means that a layout design evaluation is needed for the firm in order to be able to improve its performance.

To improve the layout design, line balancing method will be used. When the workstation size or the number of workstations used is physically modified for balance purposes, this line balancing method will impact the layout design of the firm (Jaggi, Patra, and Chaubey, 2015). With line balancing method, PT Rahayu Bhuana Karya can evaluate its layout design and then find the least number of workstations needed that can produce the highest efficiency possible.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

1.3 Research Questions

Based on the background and problem statement, there are several questions raised for PT Rahayu Bhuana Karya, which are:

1. How is the current layout design of PT Rahayu Bhuana Karya?
2. What is the result of line balancing the production in PT Rahayu Bhuana Karya?
3. Which layout is better for PT Rahayu Bhuana Karya?

1.4 Research Objectives

The objectives of this research are specified as below:

1. To identify the current layout design of PT Rahayu Bhuana Karya
2. To determine the proper layout design that is balanced for PT Rahayu Bhuana Karya
3. To determine the better and more proper layout for PT Rahayu Bhuana Karya

1.5 Research Contributions

This research is expected to make some contributions for several parties as explained below:

1. For researcher, this research will be useful as a media to apply the knowledge about layout design that has been learned throughout the study in university.
2. For academician, the result of this research can be used as a reference to help future research with related topic.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

3. For the company, this research can be used as a consideration in managing the layout design of the working station and as a suggestion to further improve the company.

1.6 Scope of Research

The research is conducted in PT Rahayu Bhuana Karya, which is located in Jl. Saragan 1 No. 15, Saragan, Mertoyudan, Magelang, Jawa Tengah 56172. The research inspected the production of precast concrete starting from making the mould up to finished product. The focus will be on measuring the production efficiency level using the line balancing method which gives the least number of workstations with highest efficiency level for precast concrete production. The research is done in March 2020.

1.7 Systematic of Research

The writing of this thesis will be divided into five chapters. The chapters consist of Introduction, Literature Review, Research Methods, Results and Discussion, and Conclusion and Suggestions.

Chapter I: Introduction. This chapter discusses that business competition is getting tougher from time to time. One of the industries that is affected is precast concrete industries in Indonesia. The demand of precast concrete in Indonesia is rising significantly with just a few players in the market. Because of this, the government encourages production capacity enhancement. To be able to do so, precast concrete manufacturers should be able to produce with higher efficiency thus reducing the production time and produce more output. Line balancing method will be used to analyse the efficiency level of the company. This method can then

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

be used to obtain the least number of workstations with the highest efficiency level possible for the company.

Chapter II: Literature Review. This chapter explains the theory used as a reference for this research. The layout definition in this research is the arrangement of facilities needed for production of good. A good layout design is wanted to maintain flexibility for future changes. This will enable the company to adapt to changes without sacrificing the performance while also maintaining the competitiveness. As a rule of thumb, layout design can be based on the type of processes of the production. Thus, types of processes and types of layout design will be elaborated in this chapter. In order to evaluate the layout, some planning method can be used. The planning method discussed in this chapter consists of string diagram method, line balancing method, and load distance method.

Chapter III: Research Method. The research strategy used in this study is case study thus the research focuses on collecting information about an activity in an organisation. In this case, the research focuses on collecting information about U-ditch production in PT Rahayu Bhuana Karya. The researcher maintains a minimal interference in order to preserve the normal flow of events. The study is conducted as a field study with non-contrived settings in PT Rahayu Bhuana Karya from 5 March 2020 to 13 March 2020. In this study, the types of data collected consist of primary data and secondary data. The primary data collected are the production stages and the time duration in producing the U-ditch in PT Rahayu Bhuana Karya. The secondary data collected is the production data of PT Rahayu Bhuana Karya.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

In collecting the data, structured interview and observation are used. The data is then analysed using line balancing method.

Chapter IV: Results and Discussion. The U-ditch production process consists of ten different steps that consist of mould assembly, rebar preparation, release agent application, rebar laying, concrete mixture pouring, curing, mould disassembly, product removal, mould cleaning, and branding. Omitting the curing process, all those steps take 65 minutes to be done. By using line balancing, the U-ditch production has a cycle time of 15 minutes. With 15 hours of daily working hour and 60 units of daily production target, the minimum number of workstations needed is 5 workstations. In grouping the tasks, several heuristic methods are used. The longest task time and least number of following tasks are used since both of the methods produce the same best solution. This 5 workstations setup will result in an idle time of 13.33% and efficiency level of 86.67%. Line balancing will also save the company from unwanted costs like extra labour cost and transportations cost while also maintaining the competitiveness of the company. The risk of getting fined due to lateness in completing a governmental project is also minimised.

Chapter V: Conclusion and Suggestions. The conclusion of this research is that with line balancing, PT Rahayu Bhuana Karya has a cycle time of 15 minutes and the minimum number of workstations needed is 5 workstations. With this setup, the company will get an efficiency level of 86.67% and idle time of 13.33%, which is about 1 hour and 59.97 minutes of the daily working time. Line balancing also enable the company to avoid unwanted while also maintaining the competitiveness. However, there are some limitations in the research. It only focuses on U-ditch

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

production activity in PT Rahayu Bhuana Karya even though the company also produces other kinds of precast concrete. Things like optimal number of employees and distance between workstations are also ignored in the research. As the managerial impacts, the line balancing is suggesting PT Rahayu Bhuana Karya to modify its layout in order to be able to cope with the daily production target. The number of workstations should be changed to 5 and also some of the activities should be moved from its current place. However, not all of the suggestion can be applied due to some limitation in the company. However, it is hoped that the line balancing can help the company when building new plants in the future.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

CHAPTER 2

LITERATURE REVIEW

2.1 Layout Definition

Based on Cambridge Dictionary (2019), layout means the way something is designed or arranged. Drira, Pierreval, and Hajri-Gaboui (2007) stated that layout is the arrangement of facilities needed for production of goods or delivery of services. The facilities can be a machine tool, a work centre, a manufacturing cell, a machine shop, a department, a warehouse, etc. (Heragu, 1997). Naik and Kallurkar (2016) stated that facility layout is an integration of the physical arrangement of departments, workstations, machines, equipment, materials, common areas, etc., in an existing or proposed industry. The most complete definition of layout is it is a plan or an act of planning the optimum arrangement of industrial facilities, which includes personnel, operating equipment, storage space, materials-handling equipment, and all other supporting services, along with the design of the best structure to contain these facilities (Moore, 1962).

Moore (1962) proclaimed that a good layout is crucial to the operation of an efficient industrial organisation. Having a good facility layout will contribute to the overall efficiency of the firm's operation (Zhenyuan et al. 2011). It can be concluded that layout is the arrangement of equipment, workstations, and other supporting facilities that are needed in a production or delivery process, which is crucial to the operation of an efficient industrial organisation.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

2.2 Concept of Layout Design

Companies manage a good layout with specific objectives in mind, Based on Kulturel-Konak (2007), the objective of managing a good layout design is to maintain flexibility for future changes, so the firm can readily adapt to changes without having significant performance change, while also maintaining robustness to uncertainty, so the firm can still perform well under a variety of scenarios and outcomes. Heizer, Render, and Munson (2017) stated that the objective of layout strategy is to develop an effective and efficient layout that will meet the firm's competitive requirements. Chase, Jacob, and Aquilano (2006) stated that the objectives of managing facility layout is to ensure a smooth work flow or a particular traffic pattern in the arrangement of departments, work groups within departments, workstations, machines, and stock-holding points within a production facility. From these previous studies, it can be inferred that the efficiency is the main goal of managing the layout.

Zhenyuan et al. (2011) found out that facility layout has an impact on the efficiency of a firm's manufacturing process, thus managing facility layout is an important concern, especially for manufacturing firms. Other than efficiency, layout planning plays a very important role in impacting a firm's profitability (Lad and Telsang, 2017). Tompkins et al. (2010) had found that 20% to 50% of the manufacturing costs are due to the material handling parts which is affected by facility layout and good layout can help to reduce 10% to 30% of the material handling cost. This is also supported by what is stated by Singh and Sharma (2006)

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

that total operating expenses in manufacturing can be reduced for 10% to 30% annually with effective facility layout. Productivity is also improved with effective facility layout design as it reduces manufacturing lead time, increases the throughput, and thus increases the overall productivity and efficiency of the firm (El-Baz, 2004). Based on Heizer, Render, and Munson (2017), benefits of proper layout for the firm are:

1. Higher utilisation of space, equipment and people;
2. Improved flow of information, materials, or people;
3. Improved employee morale and safer working condition;
4. Improved customer/client interaction;
5. Improved productivity and efficiency.

On the other hand, bad layout design will give bad impacts too that cannot be ignored. Siregar, Tarigan, and Nasution (2018) mentioned that ineffective layout design will cause the company's performance to be under the optimum level. Muhammad Zulfikri Mamat and Rosli Mohamad Zin (2016) found out that poor site layout design will double the material handling cost, increases accident rate, increases chance of material loss, increases distance travels in site, increases cost of project, increases completion time of project, and reduces the quality of works.

Heizer, Render, and Munson (2017) mentioned in their book that a good layout requires determining the following:

1. The material handling equipment that will be used, such as conveyors, cranes, automated storage and retrieval systems, and automatic carts to deliver and store material, must be decided first.

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

2. Personnel, machines, and equipment requirements must be known first before layout and space for each component can be designed. Allowances for requirements that address safety, noise, dust, fumes, temperature, and space around equipment and machines must also be considered.
3. Layout concerns often require decisions about environment and aesthetics, like positioning of windows, planters, and height of partitions to facilitate air flow, reduce noise, and provide privacy.
4. Flow of information is important to any organisation and must be facilitated by the layout to prevent any possible future communication issue.
5. Cost of moving between various work areas must be considered since there may be unique considerations related to moving materials or to the importance of having certain areas next to each other.

Zhao and Tseng (2007) mentioned that in a fast-changing world, a facility may find itself in a situation where its existing functions have become out of date, thus changes are needed. Due to this problem, it may be desirable that the facility layout can be flexible, which means it can be adapted to changing circumstances. Therefore, in designing a layout, the possible future needs must be considered.

2.3 Types of Processes

In deciding the suitable layout for a firm, Ertay, Ruan, and Tuzkaya (2006) mentioned that the consideration can be somewhat based on the types of the company's process design. Based on Slack, Brandon-Jones, and Johnston (2016),

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

there are five different manufacturing process types which are project processes, jobbing processes, batch processes, mass processes, and continuous processes.

2.3.1 Project Processes

Greasley (2008) stated that a project process is used to make a one-off product to a customer specification. He also mentioned that a feature of a project process is that the location of the product is stationary. Slack, Brandon-Jones, and Johnston (2016) explains that project processes deal with discrete, usually highly customised products, where the products are usually low volume and high variety. They mentioned that project processes often have a relatively long timescale between the completion of each item, where each job has a well-defined start and finish. It is also mentioned that transforming resources may have to be organised especially for each item because each item has different resources. Activities involved in the process can be complex, because they are ill-defined, uncertain, and involve significant discretion to act according to professional judgement (Slack, Brandon-Jones, and Johnston, 2016).

2.3.2 Jobbing Processes

Just like project processes, jobbing processes also deal with high variety and low volumes (Slack, Brandon-Jones, and Johnston 2016). The difference with project processes is that the product moves to the location of the transforming resources instead of the other way around (Greasley, 2008). Slack, Brandon-Jones, and Johnston (2016) stated that in project processes, each item has resources devoted more or less exclusively to it while in jobbing processes, each product has to share the operation's resources with many others. It is also stated that many jobs will

UNIVERSITAS
GADJAH MADA
WORKING STATION LAYOUT EFFICIENCY ANALYSIS IN A PRECAST CONCRETE MANUFACTURER USING LINE BALANCING METHOD
REINALDO HADISURYA D, Wakhid Slamet Ciptono, MBA, MPM, Ph.D.
Universitas Gadjah Mada, 2020 | Diunduh dari http://etd.repository.ugm.ac.id/

probably be one-offs that are never repeated. Jobbing processes could be pretty complex, but they usually produce smaller size products and involve fewer unpredictable circumstances (Slack, Brandon-Jones, and Johnston, 2016).

2.3.3 Batch Processes

In batch process, the products are grouped as they move through the design process (Porter, 2009). The products are grouped into batches which can range from two to hundreds of products (Greasley, 2008). Batch processes have a relatively wide range of volume and variety combination, but is not in the same degree as jobbing processes (Slack, Brandon-Jones, and Johnston, 2016). Porter (2009) stated that in a batch process, the product moves to the location of transforming resources such as equipment, thus resources are shared between the batches. It is also mentioned that instead of setting up machinery between each product, like in jobbing process, setups occur between batches, leading to a higher utilisation of equipment. A feature of batch processes is that it is difficult to predict when a batch of work will arrive at a machine, thus a lack of coordination can lead to a queue of products waiting for a machine at any one time which will dramatically increase the time the product takes to progress through the process (Porter, 2009).

2.3.4 Mass Processes

Mass processes are those which produce items in high volume and relatively narrow variety in terms of its fundamentals while maintaining the same production process (Slack, Brandon-Jones, and Johnston, 2016). Porter (2009) mentioned that it is cost effective to use specialised labour and equipment due to the high-volume production. He also mentioned that due to the low product variety, setting up of