REDUCE MANUFACTURING LEAD TIME THROUGH PDCA AND WASTE ELIMINATION IN METAL CASTING COMPANY: A CASE STUDY

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by

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DECLARATION

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ABSTRAK

Salah satu isu terbesar yang dihadapi oleh profesional faundri dan penyelidik dalam pengeluaran blok galas tuangan logam semasa proses tuangan. Menggunakan kitaran peningkatan berterusan PDCA adalah perlu kerana ia adalah alat penting untuk meningkatkan kualiti produk dari masa ke masa dan meminimumkan sisa. Untuk menjimatkan masa, ia digunakan dalam usaha untuk mempercepat kaedah pemutus logam untuk proses pembuatan blok galas. Tujuan utama dokumen ini adalah untuk mengurangkan jumlah pembaziran yang dihasilkan oleh jabatan pentadbiran, sehingga mempercepat penghantaran blok galas kepada pelanggan. Melalui pemeriksaan literatur yang relevan, potensi pembaziran yang mungkin terjadi selama masa pengeluaran produksi telah ditemukan, dan saat ini langkah-langkah sedang dilakukan untuk menguranginya. Untuk melakukan analisis punca pembaziran di dalam proses ini, "Fishbone Diagram" (juga dikenali sebagai " Ishikawa Diagram") digunakan untuk menghilangkan pengurangan. WITNESS Horizon Simulation digunakan sebagai penanggulangan yang berpotensi untuk melaksanakan pengubahsuaian yang dibuat terhadap penyelesaian perkhidmatan yang boleh dipercayai dan menjimatkan kos. Pengubahsuaian ini dilakukan sebagai tindak balas kepada penemuan simulasi. Di bahagian yang dikhaskan untuk perbincangan, hasil dapatan pencarian ditemukan, dan ia membuktikan bahawa kitaran PDCA adalah alat yang sangat baik.

REDUCE MANUFACTURING LEAD TIME USING PDCA AND WASTE ELIMINATION IN METAL CASTING COMPANY: A CASE STUDY

ABSTRACT

In the late 1900s and early 2000s, there were a few newly founded foundries that were better organized and used contemporary machinery to make high-quality iron and steel castings in small and medium-sized enterprises (SMEs). The late delivery of a particular product was one of the most important challenges experienced by foundry experts and researchers throughout manufacturing. Consequently, the customer experienced unsatisfactory service. Utilizing the PDCA continuous improvement cycle is necessary since it is a crucial tool for raising the quality of a product over time and minimizing waste. To save time, it was used in an attempt in this thesis study. The major purpose of this thesis is to reduce the manufacturing lead time of metal casting using the PDCA cycle and waste elimination in the administration department. The potential waste that might occur during the manufacturing lead time has been identified via a review of the relevant literature and the implementation of fishbone diagrams in the root cause analysis step. Then, as a potential countermeasure, the WITNESS Horizon simulation was used to examine and compare production line models with and without motion waste. This thesis found that the simulation model 3 showed the lowest lead-time compared to simulation model 1 and 2 with the elimination of all motion waste at the discussion section. It can be concluded that with the implementation of PDCA cycle in this thesis, the lead-time of metal casting process has been improved by 4.34% systematically. It was proven that the PDCA cycle is an excellent tool to reduce the metal casting process.

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENT

CHAPTER 1 : INTRODUCTION

1.1 Introduction

Strong industrial competitiveness nowadays is assessed not only by the capacity to manufacture high-quality goods at competitive prices, but also by the efficiency with which goods are supplied to consumers. (Kholil et al., 2020). Even though the materials used in the processes vary, the moulding techniques utilised in sand casting are generally the same (Kumaravadivel & Natarajan, 2013). Beginning with the design of the casting and ending with the finishing process, the casting process consists of a series of processes in the manufacture of metal castings. This can be thought of as a series of steps. The first step in the process of casting is making a design for the casting. Moulds are manufactured using a manual process, sometimes referred to as a handmade method of production (Susihono & Adiatmika, 2021a) After that, the design is turned into a pattern and a core box, which will be used to make the mould and the core mould. The metal is then melted, which can be done all at once or in several steps. After getting the liquid metal ready, it is poured into the mould. After a certain amount of time, the molten metal inside the mould will harden. The casting then needs to be cleaned and taken out of the mould. This is the end of the process (finishing)(Kholil et al., 2020).

In addition, every company that operates in the distribution industry and has the goal of being globally competitive is obligated to emphasize providing satisfactory service to its customers. However, for managers to successfully meet the requirements of their customers, a suitable product design process needs to be implemented. In this view, one of the primary demands of the client is a non-defective, high-quality product. This is because late product delivery leads to customer unhappiness, which in turn leads to a decline in sales, which leads to a loss in financial gains, which leads to an increase in the unit cost. Manufacturing companies rely on a wide variety of methods and techniques for production improvement, such as the PDCA cycle and lean tools.(Realyvásquez-Vargas et al., 2020a).

The primary issue in this study is that the bearing block product is not delivered to customers on time, as estimated in the delivery estimate. The bearing blocks are mounted bearings that carry the load on a rotating shaft. They are also known as pillow bearing blocks or Plummer block bearings. Bearing housings are typically fabricated from grey cast iron. However, various types of metals, such as ductile iron, steel, and stainless steel, as well as thermoplastics and polyethylene-based polymers, may be used to create the same product.

Figure 1.1 The Illustration of Bearing Block in The Metal Casting Company

Regarding to the delivery issue of the bearing block metal casting, it is possible that both administrative and production processes will generate waste. The delivery of the bearing block falls under the administrators' purview of responsibility. It can be difficult to change work systems because people want to preserve the traditions and methods of their forefathers This is particularly true in the cultural sector of metal casting, which has a long history and is considered a traditional industry (Susihono & Adiatmika, 2021b). Nevertheless, there is a possibility of waste during the administration process for metal casting, which may result in delays in the delivery of products from the manufacturing line. According to the findings of this research study, the performance of the premise is significantly impacted when deliveries are late. In light of this, the underlying reason is investigated further and confirmed by the research. The PDCA cycle and many lean technologies served as the research methodology for this particular investigation. As a consequence of this study, the lead time for producing bearing blocks will be cut down, which will result in improved performance for the firm as well as a more cost-effective approach.

1.2 Problem Statement

High customer satisfaction and significant profits are only achievable via the delivery of excellent products and services. To give customers maximum service, businesses must take considerable effort and forecast all potential needs and wants that may develop throughout the supply of goods or services. When a delivery is late, it reduces consumer trust and satisfaction. Thus, it reduces the possibility that dissatisfied consumers would employ the services in the future. This thesis found that there is problem due to high manufacturing lead-time that cause in late delivery to customers and suggest to reduce the manufacturing lead-time by using PDCA cycle and waste elimination.

1.3 Objectives

There are two objectives in this research study.

i. To identify the waste within planning process and manufacturing process of metal casting.
ii. To reduce the lead-time of metal casting manufacturing process.

1.4 Scope of Project

This project involves the metal casting production process. The manufacturing of metal casting usually the administration will have a discussion session with production department regarding to the estimation of the lead-time once the order has been received. This requires careful preparation and collaboration on the part of both departments. Therefore, this scope of project focusing to reduce the manufacturing lead time by using

PDCA cycle and waste elimination which are the key feature of this project. The scope of describes the area of interest, which is the metal casting production process, particularly the planning procedure. With the help of the PDCA cycle, the problems that cause waste can be found step by step and resolved. Elimination of waste can be observed by using the simulation software between the simulation model with and without waste. However, there are some constraints when using the simulation with least of tutorial. Thus, after several studies has been made, there are some assumption that have been made in order to reserve the model properly when running the simulation. The simulation has been accepted with the verification and validation step in the process to make sure the simulation models can be used. To demonstrate that a project has been satisfied, simulation results are being compared and discussed.

1.5 Thesis Outline

In this thesis study, there are six main chapters that explained the overall information and details obtained from the observation stage until this research concludes on this project. This chapter introduces the description of this project which include an overview of the manufacturing process, the problem statement obtained from the observation week, and the objective of the study.

Chapter 2 of this thesis report will be devoted to the Literature Review, which will mostly consist of a review of previous research conducted on this topic. This chapter gives a more detailed discussion of the origins and practical use of the PDCA cycle. In addition, there are a number of other reasons in favour of lean manufacturing, lean tools such as kaizen, and simulation research that support the benefits of employing simulation software in the manufacturing industry.

Chapter 3 gives up the conceptual underpinning for this investigation. It describes in full the methodology utilized to conduct this inquiry. This system consists of four steps: the planning stage, the doing stage, the check stage, and the act stage. In addition, it provides justifications for using this practice. This section describes the numerous stages involved in conducting the research, including how participants were selected, data were collected, and results were analyzed. This chapter provides a summary of the case study and describes the simulation method that will be employed in the following chapter. The use of this method will be the focus of Chapter 4.

In Chapter 4, three simulation model case studies that should be observed using a one-based model are described, along with instructions for installing the program WITNESS Simulation. This chapter then presents the results that were derived from the simulation data. The explanation of the findings may be found in the next chapter.

This study compared and contrasted the simulation modelling case studies in Chapter 5 in relation to the purpose of this study, which is to reduce the time required to start the manufacturing process. The simulation modelling case studies utilized as the basis for this chapter's discussion were those that showed the most development.

The findings and conclusions of this research investigation were provided in Chapter 6. This study also includes an overview of the accomplishments and execution of the project. In this chapter, the constraints are placed on the obstacles that need to be overcome in order to get some perspective and identify potential areas for advancement.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature review refers to the study that was done in the past that was relevant to the current issue and needed to be considered along with the notion to carry out this research. In this project, this study from the literature review focuses mostly on lean manufacturing on the application of the PDCA cycle, which is the vital key in eliminating the waste in project issue. The PDCA cycle and lean manufacturing were both used in the manufacturing industry, therefore that's where the examination of the relevant literature focused. Other service sectors were also considered. This chapter is a representation of a significant amount of research linked to this research study that was obtained from journals, online sources, and books.

2.2 Lean Manufacturing

Lean Manufacturing is a system of principles, processes, methods, and strategies for minimizing operational waste (Rodrigues et al., 2019c). To meet the needs for customers and shareholders eliminates loss caused by the whole value stream. The purpose of lean manufacturing is to eliminate waste and decrease non-value added to achieve the best performance of the production flow (Zahraee, 2016). Lean manufacturing includes the elimination of waste, unpredictability, and rigidity. Due to the ongoing shift in consumer expectations, entrepreneurs must be able to make sound judgments in order to grow and flourish, and an organization's future success rests on its capacity to adapt to these changes while maintaining its basic principles. Every industrial or service organization must boost efficiency by utilizing cutting-edge technologies. Quality and productivity improve a company's capacity to compete in the global market. As a result, a lean manufacturing strategy focuses on cutting costs and increasing turnover by systematically and continuously eliminating all non-value-added operations. Lean is "the solution" for the survival in the industries and development in a competitive industry. Lean manufacturing helps firms achieve targeted productivity by providing easy-to-implement, improve delivery time, reduce cost and improve the quality of a product (Pavnaskar et al., 2003). All operations are lucrative because of the company's emphasis on minimizing and eliminating waste. This Lean Production (LP) emphasizes the elimination of non-value-added occupations, the utilization of the least amount of space necessary for production by a smaller number of workers, and a smaller work-in-progress (WIP) for shorter stoppages. As a consequence, LP (Lean Production) has received an international reputation as a method of reducing waste, improving quality, improve employee engagement while increasing firm competitiveness, all of which contribute to the survival and success of a business (Marodin & Saurin, 2013).

Lean manufacturing is a management approach that encourages the elimination of inefficiencies and non-value-added occupations from the production process. This may be achieved via the removal of waste and inefficiency. It is feasible to attain this objective by reducing the number of needed manufacturing phases (Pereira et al., 2019). This method aims to make firms more competitive in their particular markets by increasing their productivity levels, reducing their operational expenditures, and concurrently increasing the quality of their products less time. This may be achieved by boosting their production and decreasing their operational costs with kaizen to support the lean production implementation (Deif & Elmaraghy, 2014). The connection between the two is founded on the need for the continuous expansion of its operations to be a condition for this kind of advancement. Companies that employ this style of production confront the substantial challenge of establishing a culture that will result in a long-term commitment to lean manufacturing practices, and this culture must also be maintained. This is a specific difficulty faced by organizations using this technique of manufacturing. One of the goals of creating a culture of continuous improvement is to use the PDCA cycle or a Kaizen, which is a strategy for a systematic approach that focuses on customer expectations, is process-oriented and encourages everyone to get involved and take the lead. Kaizen is a technique for a systematic approach that is customer-centric, process-oriented, and fosters the involvement of the staff during the improvement (Suárez-Barraza et al., 2011). The technique known as kaizen is a means to adopt a systematic approach that is centered on the needs of the consumers, focused on the process, and encourages the participation and initiative of everyone working together (Jain & Gupta, 2015).

Lean production minimises waste in the production process. Just-in-time (Kumar et al., 2022), poka-yoke and synchronous manufacturing (Shah & Naghi Ganji, 2017), cellular manufacturing (Chiarini, 2014), and supplier management are one of the techniques of lean production. Lean manufacturing strives to minimise waste in order to fulfil market demand. The Japanese automakers lacked material, financial, and human resources after World War II. In Japan, Eiji Toyoda and Taiichi Ohno were the origin of lean production at Toyota Motor Company (Carlos Hernandez-Matias et al., 2019). After the success of lean manufacturing in Japan, other organisations and industries, particularly in the United States, embraced it. Lean operating ideas in manufacturing are also known as lean manufacturing, lean production, the Toyota Production System, etc. Henry Ford, an American businessman, embraced Lean in the 1920s, claiming that shortening the production cycle helped keep Ford's pricing low. In certain industrial processes, non-value-added work may exceed 90 percent (Dhiravidamani et al., 2017a). Lean manufacturing offers a faster, more dependable production flow while decreasing waste, allowing workers to earn more, owners to earn more, and consumers to get higher-quality goods. Lean manufacturing is related with advantages, cost savings, and reduced lead times (Kumar et al., 2022).

2.2.1 Manufacturing Lead-Time

The production needs calculating process times (LT) while forecasts the load and output that are required for quotes with due dates and production control decisions. Lead Time (LT) estimation is complex and often imprecise (Pfeiffer et al., 2016). A short production lead time is recognised as being essential to achieving world-class manufacturing objectives of on-time delivery, quality, and flexibility. Today, shortening lead times is one of the most crucial factors in customer satisfaction (Dey et al., 2021). The improvement of the operational and financial performance in a premise mostly depends more on Lead Time (LT) reduction (Perona et al., 2016). A viable approach to shorten lead time will lower manufacturing costs and, over time, increase customer satisfaction. Choosing the optimum instrument for lead time reduction depending on product volume and product mix is never straightforward. Process mapping, SMED, 5S, Kaizen, Value engineering, and Seven-waste reduction are among the most common and adaptable lead time reduction strategies (Balaji et al. 2022).

2.3 PDCA Cycle

In 1950, Dr. W. Edwards Deming introduced the PDCA cycle to the Japanese. In Chinese history, handicraft industries and quality control date back to the sixteenth century B.C. Galileo is largely acknowledged as the founder of modern science and the scientific method. In other works, Aristotle is credited with creating the method. Ibn Al-Haytham (965-1040) is generally regarded as the world's first scientist. Figure 2.1 demonstrates the development of the scientific method.

2.3.1 Waste Elimination

The Lean manufacturing system identifies eight categories of waste because successful Lean management implementation results in intra- and interorganizational capacity building techniques and enhances time-based ability to compete. Waste encompasses any potentially flawed work/activities, not only damaged items, but as well as quality issues and management issues. The first table lists eight waste categories. The elimination of one waste stream may result in the elimination or reduction of others. JIT manufacturing lowers inventory and waste by producing the right product at the right time and location. "Lean thinking" emphasizes just-in-time inventory management, "pull" rather than "push" production, improved supplier relationships, and the elimination of waste and inefficiency. Waiting inefficiently is a waste of time. When products are not being moved or worked on, manufacturing waste occurs. This waste slows both products and employees. The optimal situation would have no waiting time, hence accelerating product flow. The waiting period may be used for training, maintenance, or kaizen, but not for overproduction. (Esfandyari & Osman, n.d.).

Table 2.1 The Eight Waste Description

Type of Waste	**Description**
Motion	Movement of people that does not add value
Waiting	Idle time created when material, people or equipment is not ready
Correction	Work that contains defects, errors, rework, mistakes or lacks something necessary
Over-processing	Effort that adds no value from the customer's viewpoint
Over-production	Producing more than the customer needs right now
Transportation	Movement of product that does not add value
Inventory	More materials, parts or products on hand than customer needs
Underutilization	The management does not fully utilize the employee talent and wasting hiring another staff.

In any production facility, trash will be generated. It is critical to adopt strategies to reduce waste production. Overproduction, defects, inventories, motion waste and transportation, waiting periods, over-processing, and underutilized are all examples of typical wastes in manufacturing operations. Observation have been made to grasp the current condition of the premise for better planning. Defects rate from the production is estimated from 5% to 10% where the number is quite high for the premise to bear the risk of loss in profit. Other than that, time is wasted to walk numerous time to inform the production for any information regarding to the product. Moreover, this resulting to late information being sent to the QC department to ready the product once the product are in standby to be delivered. This also might resulting the product to be stored in inventory to be rescheduled for delivery due to covid-19 cases as some premise may closed earlier than before. The reschedule may cause a little damage in the inventory. Thus, waste elimination is needed to maintain manufacturing stability and sustainability (Mostafa et al., 2015).

Manufacturing process often being delayed, over-budget from the delayed process, etc. due to bottleneck process which causes blockage in the workflow process. When a department receives more demands than its maximum capability to produce is considered as a bottleneck. This disrupts the workflow and creates delays throughout the manufacturing process. The bottleneck in the process might be a machine or computer, a person, a department, or an entire work cycle. This paper uses the lean tools which are Pareto charts to analyze and confirm the bottleneck from the simulation result. The root cause of the bottleneck was then identified using a cause-and-effect diagram and five whys. A cause-and-effect diagram is a straightforward method for identifying problem causes. It may be used to discover and evaluate causes of production bottlenecks. Five WHY evaluations affected output in several ways. Thus, productivity might be increased (Krishnan et al., 2017).