

Spare Part Management of Supply Chain Pile Driver Crane Business: A Case study in Nakhon Si Thammarat, Thailand

Thitima Phiromrot¹ and Somnuk Aujirapongpan^{2*}

¹ MBA Student, School of Accountancy and Finance, Walailak University, Thailand

² Assoc. Prof., School of Accountancy and Finance, Walailak University, Thailand

*Corresponding author: asomnuk@wu.ac.th

Abstract

The objective of this research is to 1) identify the causes of management problems that lead to losses in the supply chain of the precast concrete Pile Driver Crane Business, and 2) study the management of spare parts and propose solutions to address the problem in the supply chain of the precast concrete Pile Driver Crane Business in Nakhon Si Thammarat province, taking into account the four factors that contribute to the problem in the business, namely methods, spare parts, people, and machinery. The fishbone diagram was used to synthesize the research. The research method was a mixed-methods approach, using quantitative research and qualitative research with structured questionnaires and semi-structured interviews. Data were collected using the Delphi technique from a sample group of 15 participants, categorized into three groups according to the size of their businesses: small, medium, and large. Descriptive statistics, such as means and percentages, were used to explain and analyze data according to the research objectives. The study also looked at the standard deviation to measure the dispersion of data from the questionnaires.

The study found that the main cause of problems in the supply chain of pile driving and pole drilling businesses in Nakhon Si Thammarat province was due to methodological factors, with an average score of 6.55 and a standard deviation of 1.39. The problem was considered highly significant, and the main issue causing the problem was inefficient parts management, with a highest importance score of 0.358 or 36%. The accuracy index (CI) was -0.026, and the data's confidence level (CR) was -0.029, indicating that the pairwise comparison was acceptable since the confidence level was less than 0.1 (the consistency index (RI) was 0.9).

The results, divided according to the size of the businesses of the studied manufacturers of concrete pole and pile, into three groups. The research found that the main cause for all groups of entrepreneurs was the method cause. However, the similar and different problems were as follows: 1) Small entrepreneurs, the problem was the inefficient management of spare parts, with the highest value of 0.539. 2) Medium-sized entrepreneurs, the problem was the inefficient management of spare parts, with the highest value of 0.342. 3) Large entrepreneurs, the problem was the lack of planning in their work, with the highest value of 0.481. Therefore, the problem with the highest average value was the inefficient management of spare parts, caused by the method cause in all groups of entrepreneurs.

The researcher proposed a method to increase efficiency by planning management processes using the PDCA cycle. They suggested a method of condition-based maintenance for parts, using technology to prevent and diagnose problems (such as IoT) or using artificial intelligence (AI) to process abnormal machine data and perform deep analysis and reporting to pinpoint issues, thus reducing maintenance costs and improving machine efficiency. This management approach is simple and effective in problem-solving. Additionally, the study found that machinery is an asset in business, and management methods are the core of the business to achieve lasting success for entrepreneurs.

Keywords: supply chain, Pile Driver Crane Business, entrepreneurs, parts management, problems.

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I. Introduction

The construction industry in Thailand has a significant impact on the country's economy, with approximately 100,000 registered businesses (Department of Business Development, 2020). However, only 691 of these are large businesses, representing just 0.7% of all registered businesses. Despite this, large businesses account for 82% of total revenue, with medium-sized businesses contributing 14% and small businesses just 4%. Although there have been ongoing impacts from the COVID-19 crisis and the escalating conflict between Russia and Ukraine, the overall construction industry has continued to grow, expanding by 4.1% YoY to a value of THB

1,364.8 billion in 2019 (Ministry of Transport, National Economic and Social Development Council, and REIC, 2019). EIC analysts predict that the construction industry in Thailand, along with the overall economy of Asia, will continue to grow in the coming years and that there will be an increasing demand for construction projects related to health and manufacturing. The real estate market has also shown signs of recovery, with an 8.5% increase in transfers in the first 8 months of 2023 compared to the same period in 2021, and the opening of nearly 9,000 new projects per month, almost back to pre-COVID levels of 9,300 projects per month in early 2022.

In the past 10 years, from 2012 to 2021, construction investment in Thailand accounted for an average of 8.1% of the country's Gross Domestic Product (GDP). This can be divided into two categories: public and private investment, with a ratio of 59:41 in 2021. In 2021, the majority of public construction projects were infrastructure investments, accounting for 82% of all public construction projects. The remaining 16% were construction projects for government buildings and 2% were residential buildings for government officials. Private construction projects were primarily focused on residential buildings, accounting for 52% of all private construction projects. The remaining 20% were industrial and commercial buildings, while the rest, 28%, were other buildings such as hotels and hospitals (Office of the National Economic and Social Development Council, 2020).

Construction work on bridges, small-sized building projects, medium-sized building projects, large-sized building projects, single houses, townhouses, commercial buildings, factories, hotels, and hospitals are all important projects where the foundation is a crucial part that serves to support the weight of the entire structure. This includes the part of the foundation known as the pile, and even though construction technology in Thailand has made some progress from the past to the present, pile driving machines are still used in the process of driving piles. Therefore, the pile driver crane business is an important industry in the construction sector. Its objective is to provide strength to the foundation of important buildings and structures, using large machinery called "pile driver cranes." Pile driving is a widely used method in large-scale projects that require a strong foundation for buildings or structures, to prevent movement under the surface and to ensure that the structure remains durable and long-lasting.

From the study of the Pile Driver Crane Business, it is a growing business alongside construction projects that are expanding after the economy slumped in the early stages of the COVID-19 pandemic. In order to ensure smooth business operations in the future, entrepreneurs need to manage resources appropriately to efficiently respond to service demands. Researchers have studied the supply chain of the Pile Driver Crane Business and found that the most important and valuable service resource in the business is the pile driving machine. It requires systematic maintenance to maximize efficiency and minimize breakdown losses. This depends on the entrepreneur's readiness to manage various repair and maintenance processes. Researchers conducted field observations and studies from one entrepreneur in Nakhon Si Thammarat province, who is responsible for procuring various spare parts for maintenance. The machine operator is responsible for maintenance and monitoring of the machine's condition, and a mechanic is available to inspect the machine's condition and suggest purchasing spare parts. There is a procurement process to purchase spare parts when breakdowns or malfunctions occur, which can cause delays in procurement, ordering, and transportation. This is an unstructured management process that still lacks efficiency in repairing machines during breakdowns, as waiting for spare parts to arrive can lead to long delays and operational losses.

The researcher therefore aims to study the root causes of the management impact problem that arises in businesses when machinery breaks down and needs to stop working. The study also surveys the management practices of businesses involved in the production of pile-driving and pole-setting equipment in Nakhon Si Thammarat province, regarding how they handle the problem that occurs in the supply chain of the business when machinery breaks down, in order to identify effective management strategies for preventing and resolving the underlying causes of the problem. The objective of the study is twofold: 1) to identify the causes of the management problem that leads to losses in the supply chain of pile-driving and pole-setting equipment businesses when machinery stops working, and 2) to study spare parts management and provide recommendations for effective management strategies to prevent and resolve the problem in the supply chain of businesses involved in the production of pile-driving and pole-setting equipment in Nakhon Si Thammarat province.

II. Literature review

1. The concept of Supply Chain Management (SCM) is the process of managing the interconnected businesses that make up the entire supply chain, from all sources of raw materials, transportation of raw materials to the manufacturer, the production process, delivery of products to consumers, and ultimately the use of products by customers. All these processes are based on the foundation of creating value-added (Value Chain) throughout the entire process.

2. The concept of Spare Part Management is the management of components of a machine that are used for replacement when the original components become damaged, worn out, or deteriorated. The replacement of spare parts is considered an activity of maintaining and servicing the machine, and the spare parts used for maintenance and servicing are called "repair materials" such as lubricants, anti-freeze, and coolant. Since spare parts are

components of a machine, there are many spare parts for each type of machine, and the way they are used may vary. Some spare parts may be used only once, while others may require maintenance and good management.

3. Inventory Management Theory

Inventory is a circulating product that businesses must have to support production activities. However, according to the lean concept, inventory storage is a form of waste. It refers to raw materials, equipment, parts, and components used in the production process, as well as sub-assemblies and sub-components such as meters, switches, nuts, and bolts. Maintenance parts and components, such as fuel and lubricants, are also included in the inventory.

4. Maintenance Parts Support System

The Analytic Hierarchy Process (AHP) is a process used to analyze the prioritization of problem-solving options when there are multiple criteria for consideration. AHP is the best decision-making aid for complex and difficult decision-making. The AHP was developed by Thomas L. Saaty in 1970 and is a theory that mimics human thought processes. It is widely used for decision-making purposes.

III. Research Methodology

Population and Sample.

Population refers to business owners or individuals who are involved in the manufacturing of concrete piles in Nakhon Si Thammarat province, with a total of 15 individuals.

Sample groups refer to business owners or individuals who are involved in the manufacturing of concrete piles in Nakhon Si Thammarat province, with a total of 15 individuals divided into 3 groups based on the size of the business, including the number of tools or machinery, capital, and labor. There are 3 groups: small-sized business owners, medium-sized business owners, and large-sized business owners, with 5 individuals in each group, as shown in Table 1.

Table 1 Shows the criteria for grouping the sizes of the mold and steel rod manufacturing businesses in Nakhon Si Thammarat province.

Symbol	Entrepreneur	No. of Machines (Sets)	Registered Capital (million baht)	Labor (people)
S	Small	1 -3	Less than 1 but less than 3	Less than 10
M	Medium	3 - 5	3-5	10 – 30
L	Large	More than 5	More than 5	More than 30

Source: Researchers.

Research Tools

The research tools used in this study were structured questionnaires and semi-structured in-depth interviews for data collection to achieve the research objectives. The questionnaire was divided into two parts, with a total of 2 sections and 8 questions in section 1, which aimed to screen respondents and obtain important information relevant to the research objectives. The questions were related to general work information and utilized a checklist response format.

Section 2 of the questionnaire aimed to identify the causes of losses in the supply chain management of the prestressed concrete pile and pole business by using the 4M management principles. These principles include four dimensions of management related to this business, which were analyzed to formulate the research questions. The questions were divided into four topic areas.

- 1) The cause that arises from the method.
- 2) The cause that arises from the material.
- 3) The cause that arises from the people.
- 4) The cause that arises from the machine.

The questionnaire is structured into 2 parts with the following topics:

Part 1: The objective is to study the management approach for the problem of material management in the concrete pile and prestressed concrete pole business, and to obtain information on how business owners solve the problem. The questions will be open-ended.

Part 2: The objective is to obtain information that is different from what has been studied and suggested. The questions will be open-ended.

Data Collection:

Primary Data is collected from questionnaires obtained from a sample group. The data is then verified for completeness and analyzed and interpreted mathematically using descriptive statistics to describe, narrate, and summarize the characteristics of the data group by measuring data dispersion.

Secondary Data is collected by reviewing literature, ideas, theories, and research related to the study of spare parts management theory, inventory theory, and supply chain theory, which are used to supplement the results of this study.

The research process has been summarized in the flowchart presented in Figure 1.

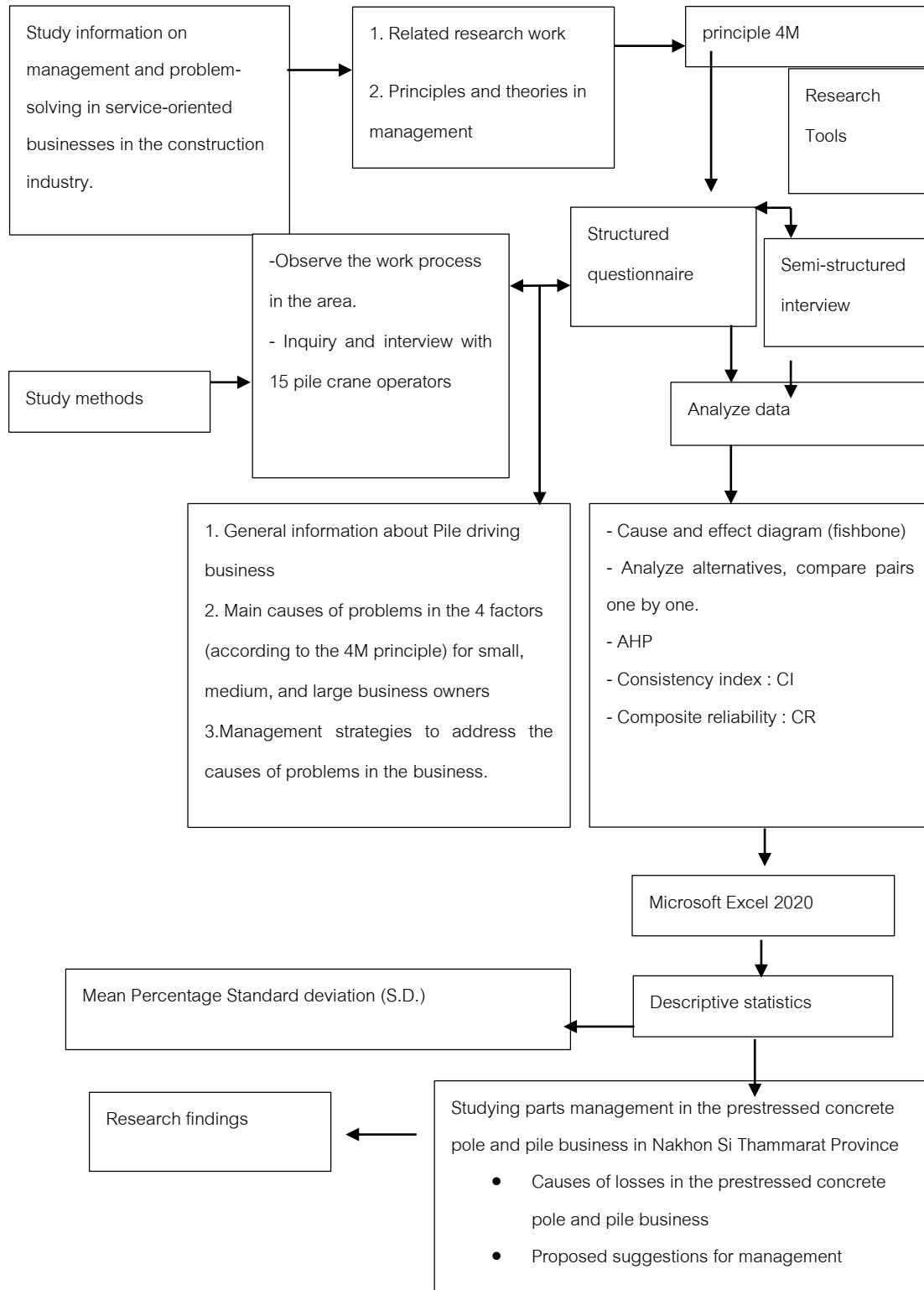


Figure 1. Research Process

IV. Research Results

1. The causes of management problems that lead to losses in the supply chain of the pile and pole manufacturing business in Nakhon Si Thammarat province were studied. The study identified 3 groups of entrepreneurs based on the size of their businesses.

group 1, consisting of small business owners, the main cause of the problem was found to be inefficient parts management, which resulted in losses in the supply chain when machinery stopped working. The importance ranking of this factor was the highest at 0.539.

group 2, consisting of medium-sized business owners, the main cause of the problem was also found to be inefficient parts management, which resulted in losses in the supply chain when machinery stopped working. The importance ranking of this factor was the highest at 0.342.

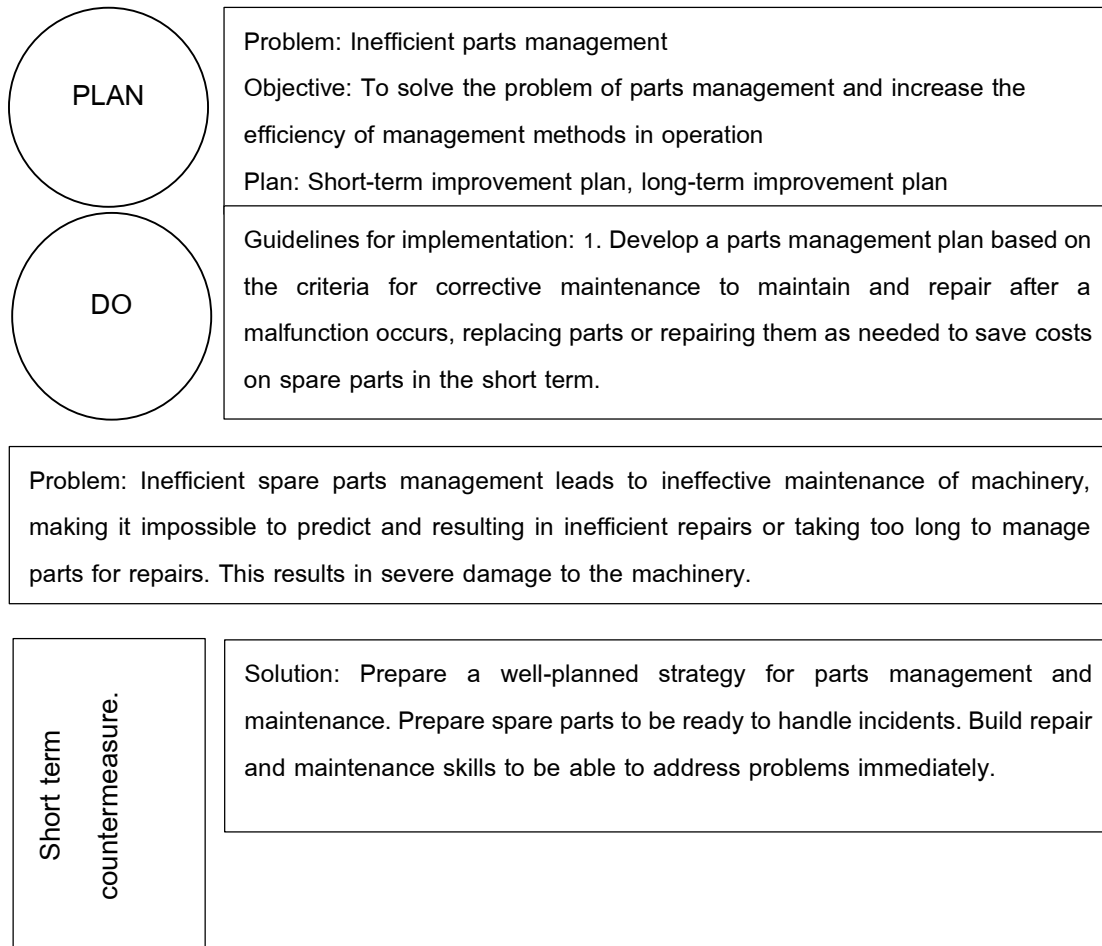
Group 3, large business owners found that working without a plan was the main cause of supply chain losses when machinery stopped working. It had the highest importance ranking at 0.481.

Overall, from the opinions of all business owners, it was found that inefficient spare parts management was the main cause of supply chain losses when machinery stopped working. It had the highest importance ranking at 0.358.

Management of spare parts and problem-solving strategies in the supply chain of the pile driving and pole drilling industry of entrepreneurs in Nakhon Si Thammarat province.

Based on the study of spare parts management and problem-solving strategies in the supply chain of the pile driving and pole drilling industry, through analysis of interviews, it was found that the spare parts management practices of entrepreneurs in Nakhon Si Thammarat province, overall, still lack systematic planning and are managed according to the personal ideas of the entrepreneurs, without referring to problem-solving management strategies. Therefore, the spare parts management practices of entrepreneurs, divided into three groups according to the size of the business, were studied and presented in a flowchart as shown in Figure 2.

PDCA TO GUIDE THE OPERATION AND SOLVE PROBLEMS EFFECTIVELY.



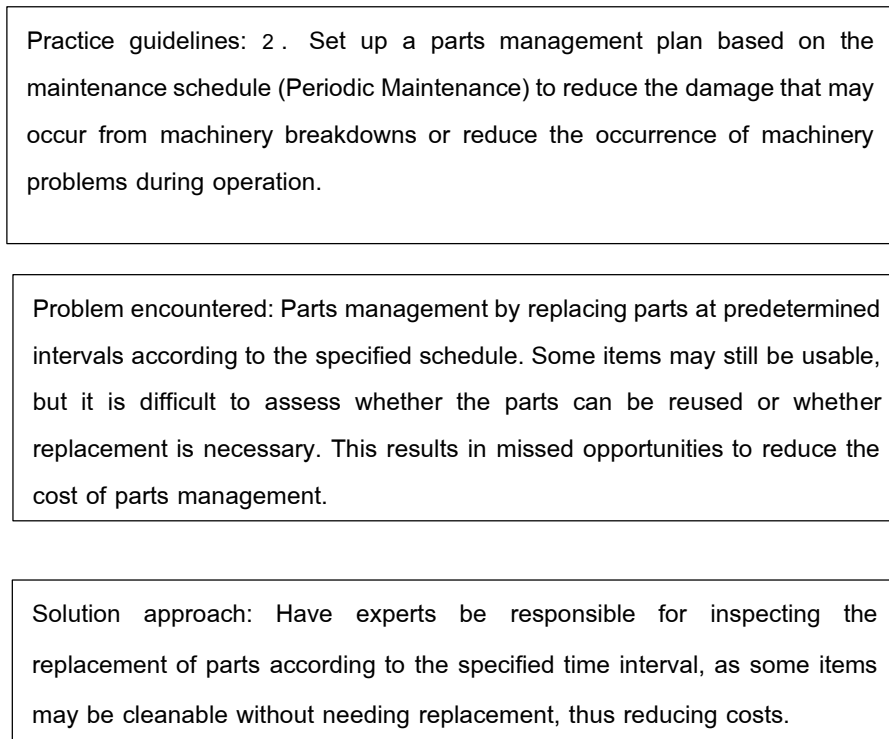


Figure 2. Deming circuit to solve inefficient parts management issues in the Pile Driver Crane Business.

V. Conclusions

1. The causes of management problems leading to losses in the supply chain of the pile driving and pole drilling business among entrepreneurs in Nakhon Si Thammarat province. From the study, it was found that inefficient spare parts management was the main cause of problems leading to losses in the supply chain of the pile driving and pole drilling business. When the machinery stops working at the highest level, if divided by size of the entrepreneur, small and medium-sized entrepreneurs believed that inefficient spare parts management was the main cause of problems leading to losses in the supply chain when the machinery stops working at the highest level, as well as Vorayu Boonsang (2015) found that the problem of missing spare parts occurred from inefficient inventory management. As for large entrepreneurs, they believed that the main cause of problems leading to losses in the supply chain when the machinery stops working at the highest level was the lack of planning, similar to what Panit Pasuk (2017) found that the work process in the business was the cause of the problem that caused the machinery to stop working.

2. Management of parts and problem-solving in the supply chain of concrete pole manufacturers in Nakhon Si Thammarat province:

The study found that overall, the management of parts by entrepreneurs still lacks a systematic approach. The management of parts is done according to the entrepreneurs' own ideas, feelings, and financial conditions, without referring to problem-solving management methods. The following can be summarized: small-scale entrepreneurs manage parts through corrective maintenance, while medium-scale entrepreneurs manage parts through corrective maintenance and periodic maintenance. Large-scale entrepreneurs reserve and store parts in stock and record the replacement of parts according to a specified time frame. The management of parts is done through periodic maintenance. From the management approach of entrepreneurs and researchers, they see the alignment of Condition-Based Maintenance in managing parts maintenance according to their condition, helping to reduce part costs by being able to replace parts at the most cost-effective time, using technology to prevent, detect problems (IoT) or using artificial intelligence (AI) to process abnormal machine conditions, such as imbalance, improper installation, and wear and tear of various parts. Deep analysis and visualization can pinpoint and resolve issues, reducing maintenance costs and ensuring machinery operates at full efficiency. This is a convenient, fast, and efficient approach that researchers analyze using a Deming cycle, consistent with the research of Panit Pasuk (2017). The plan for maintenance of machinery has been developed according to the PDCA cycle, and a manual for operation and maintenance of the machinery has been prepared. As a result, the machinery's readiness level has increased. In addition, Wannawisa Thaworn (2017) developed a plan to improve building efficiency through the use of a CMMS system using the Idel program. This is similar to the approach proposed in this research, which

is the Condition-Based Maintenance approach. By using technology to analyze the machinery's readiness level, parts can be maintained in a timely manner, problems can be corrected and prevented before they occur, and the downtime of the machinery can be reduced, thereby increasing working time.

VI. Recommendations

From the study, it was found that small and large business owners have the opinion that the factors resulting from parts are "delivery exceeding 24 hours" and "inappropriate quality of parts" which are ranked as the least important factor (ranked 4th). However, medium-sized business owners have the opinion that the factor resulting from parts "delivery exceeding 24 hours" is ranked as the 2nd most important factor, different from other business owners. Therefore, the study of factors resulting from parts may be consistent with the cause of the method, which is "parts management". Therefore, business owners should consider factors related to parts because all studied factors are interrelated in the supply chain of all businesses. If one factor causes a delay, it may also cause another factor that works in conjunction to stop. This is to reduce machine breakdown, which is a problem that leads to losses in business operations and affects the credibility of business operations. Moreover, it also affects business opportunities in receiving new jobs.

Recommendations for further education:

- 1) From the study, it was found that, overall and in each size of business, the factor of insufficient data in purchasing was ranked as the third most important problem, accounting for 13% of the total. In small businesses, 21% of respondents identified the lack of job skills as the top problem, while in medium-sized businesses, 17% cited improper inventory management of spare parts. In large businesses, the average factor was 22% for lack of job skills. Analyzing the factors that arise from individuals is interesting, and it is also a matter that is close to home that can study many other interesting sub-factors. Some factors are not mentioned in this research for certain reasons, as they are problems that need to be further investigated, such as people and safety. In addition, it is also an important factor in the successful business operations, as demonstrated by the importance ranking of opinions from business analysis factors in this research.
- 2) From the study, the researchers chose to investigate the management factors that are the causes of problems in the pile-driving business. However, there are still factors that the research did not study but are topics that are relevant in practice, such as problems caused by the terrain in the pile-driving area, problems caused by sitting at the pile-driving shop, problems with job control, safety issues, and problems with working near hazardous areas.

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