Wastes of Production Process Management for Eastern Industry

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Abstract

This research focused on developing the management of production process wastes for the Eastern industry There were three main objectives: (1) to analyze production process wastes, (2) to analyze production process waste management in terms of waiting and defects, and (3) to propose guidelines for developing production process waste management in terms of waiting and defects. Documentary research and in-depth interviews are examples of research tools. The research findings revealed that (1) the production process wastes for eastern industry were different depending on the production process management, based on an analysis of seven wastes, namely overproduction, inventory, transportation, motion, excess processing, waiting, and defects, (2) the management of production process wastes in terms of waiting and defects differed depending on the continuous and intermittent production systems, and (3) the development of the management of production process wastes in terms of waiting and defects centered on continuous improvement for both continuous and intermittent production systems through the use of quality control tools.

Keywords: 1) Management 2) Wastes 3) Production Process 4) Eastern Industry

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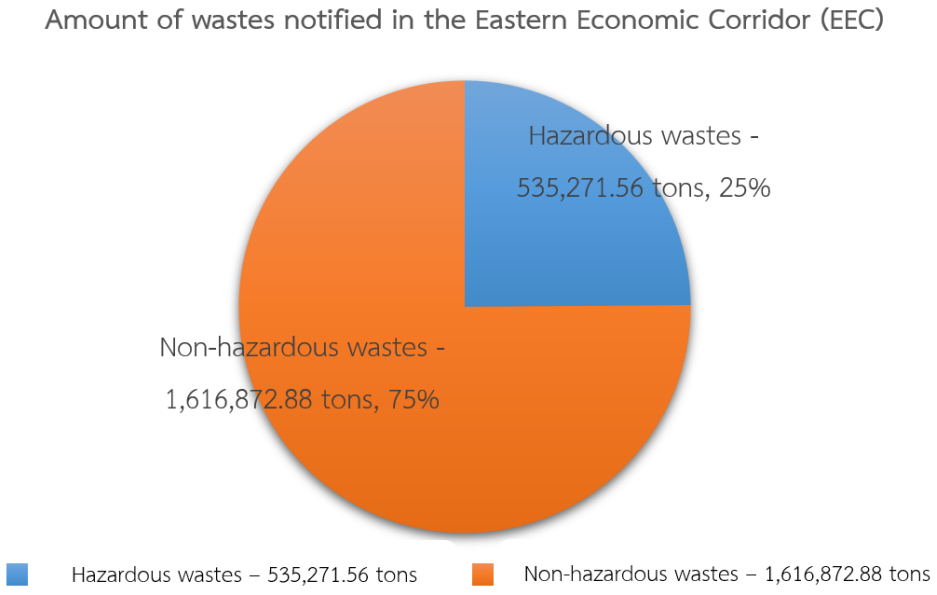
Introduction

According to the Twelfth National Economic and Social Development Plan (2017-2021), eleven target industries for the country's development have been identified: (1) Six industries that make up the country's income base, including electronics, electrical appliances, automotive, biodiesel/ethanol, petrochemicals/plastics, and rubber products, and (2) Five future industries, including creation, aerospace, biochemical/bioplastics/biomaterials, clean energy, and health products (Kumpirarusk and Rohitratana, 2018, pp. 53-58). Although the government has supported the industrial sector to spread to various areas throughout Thailand, there are still a lot of Thai industries in Bangkok and the eastern region because it requires industrial integration and connection as well as factors that are conducive to investment (Kiatruangkrai, Thepkham, and Chinwornwathana, 1977, p. 3).

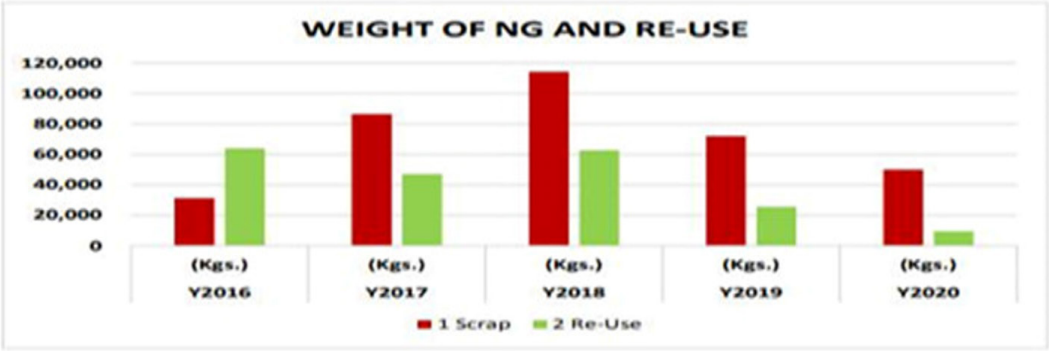
Investors in the government-supported Eastern areas mostly operate in industrial estates, with the majority of them producing products or providing services that require multiple steps in their processes. Critical components are involved in these processes, particularly "wastes" caused by overproduction, inventory, transportation, motion, excess processing, waiting, and defects. As a result, all waste incurs unnecessary costs. If they can be eliminated, operating costs will be reduced while profits will increase.

The research team concentrated on wastes caused by waiting and defects, which, if eliminated, could directly reduce product production costs per unit. According to the statistical data of the Department of Industrial Works (2020), the amount of wastes reported in 2019 can be divided into two categories: hazardous and non-hazardous wastes, as shown in Picture No. 1.



Picture No. 1 Amount of wastes notified in 2019

Picture No. 1 depicts an overview of the amount of wastes in 2019 of the manufacturing industry in the Eastern Economic Corridor (EEC) totaling 2,152,144.44 tons. They included wastes or unused materials generated from factory operations starting from the process of receiving raw materials, production, quality control, pollution treatment, surrounding demolition, and sludges or residues from them, whether in solid, liquid, semi-solid, semi-liquid, or gas states. Hazardous wastes, 535,271.56 tons or approximately 24.87%, included flammable, corrosive, and reactive substances, etc., Non-hazardous wastes, 1,616,872.88 tons or approximately 75.13%, included metal scraps and wastes generated from production that was not standardized and could not be corrected to meet the specified standards, etc., This was consistent with the information collected from factories that produce automotive parts in Rayong, which is in the Eastern Economic Corridor (EEC). It was found that when a product was incorrectly produced and became a waste, it would be reused/reworked or disposed of as a waste or scrap. This resulted in a loss due to the production of wastes, including a useless loss of costs of raw materials, machinery, labor, storage space, and rework time (Sixth key informant, Automotive spare parts manufacturer and distributor, 2020), as shown in Picture No. 2.



NO.	Detail	Y2016 (Kgs.)	Y2017 (Kgs.)	Y2018 (Kgs.)	Y2019 (Kgs.)	Y2020 (Kgs.)
1	Scrap	31,312	86,411	114,230	72,054	50,060
2	Re-Use	63,938	47,085	62,651	25,660	9,570

Picture No. 2 Reuse/Rework

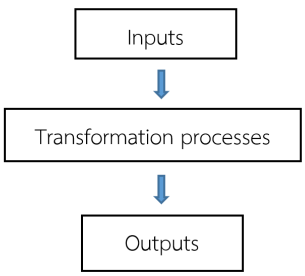
In addition to excessive defects generated in the production processes affecting the wastes and increasing the operating costs, waiting is another factor that causes wastes because machinery or employees have to stop working due to necessities for production, such as waiting for raw materials and machinery breakdown. The lack of good maintenance causes a production delay, affects the delivery of the products to customers, and creates an opportunity cost. From the aforementioned problems, Thailand has to build an industrial production base capable of efficiently responding to the needs of customers in order to create an industrial trade market and connect relationships with the world industry through

its role as part of the supply chain management. Various technologies of Thai industries have been developed to promote innovations in the production processes in efficiently producing quality products that meet the needs with low costs. Therefore, the research team was interested in investigating the management of production process wastes for eastern industry that is related to production, production costs, logistics, innovations, and services.

Literature Review

Production and Quality Control Tools

A production system is the process of creating something from the use of available resources or inputs. It follows the sequence of actions; i.e. available raw materials are transformed into a product in a desired shape. For the production to achieve such objective, it is therefore necessary to manage it in the form of a production system, which consists of three important parts: inputs, conversion processes, and outputs that may be product and services.



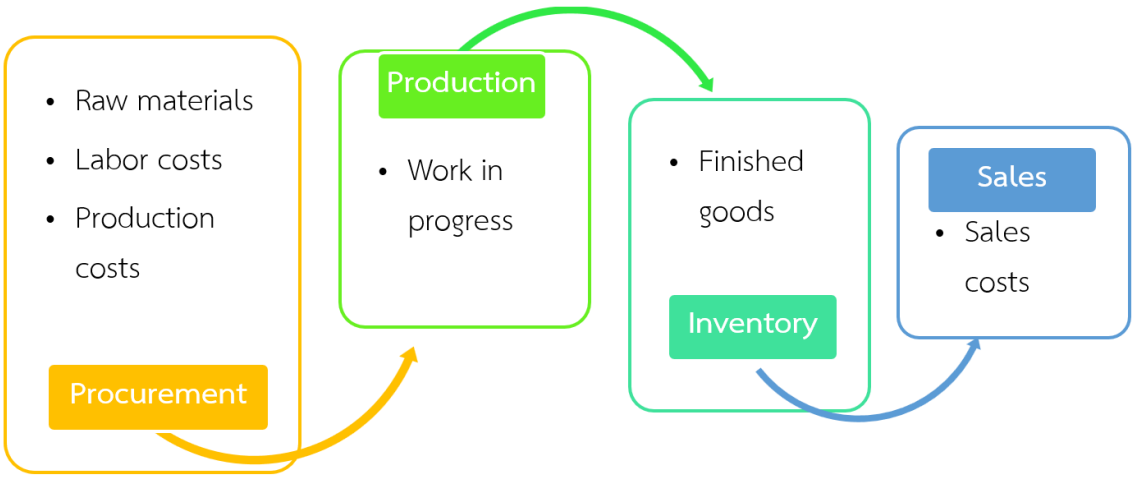
An industrial production system is divided into two major systems: intermittent production system, or order manufacturing, with no continuous flow of raw materials along the production line and continuous production system with a continuous flow of raw materials along the production line (Lalitaporn, 2010, pp. 18-19). From past to present, production processes have generated several wastes, causing unnecessarily high production costs. Currently, as entrepreneurs have paid much attention to production cost control, a lean production system focusing on production processes has been adopted by emphasizing and continually eliminating the wastes generated from these processes step by step. There are seven wastes generated, including overproduction, processing, defects, delay, motion, transportation, and inventory (Phongthanapanich, 2014, p. 1).

Production planning and control aim to maintain consistency in the smooth flow of raw materials through the production processes. This allows the production to proceed with the least damage, the least time required, and the highest quality and standard outputs (Feigenbaum, 1991, p. 10). A lean production system can be applied in both intermittent and continuous production systems as a technique to increase productivity by reducing losses in factories. Business operators must be aware and focus on reducing the losses incurred in their production processes. Thus, the ECRS waste reduction and productivity technique (Akarapathomphong, 2020) consist of “Eliminating” seven wastes found in production processes, “Combining” unnecessary work, “Rearranging” production steps to reduce unnecessary motions or waiting, and “Simplifying” work practices to be easier and more convenient. This is a simple principle that can be used to effectively start reducing wastes, or MUDA (Thamchaisopit, 2016, p. 13). For quality control, it involves monitoring and solving problems as well as checking or testing

to control the products to meet the specified requirements so that there are no wastes during the production processes. This is similar to Kaoru Ishikawa's quality management concept of 7 Quality Control Tools (7QC Tools), which have been developed to help ensure that there are no or very few errors in the production processes, including graphs, check sheets, scatter diagrams, Pareto analysis, cause and effect diagrams, histograms, and control charts (Kittiyakajon, 2018, p. 74).

Production and Logistics Costs

Production and logistics costs are another important factor of increasing the productivity of the industry because they are both financial and non-financial costs, especially the costs related to the supply chain. A logistics system of the manufacturing industry consists of (1) Procurement activity, (2) Production activity, (3) Inventory activity, and (4) Sales activity, as shown in Picture No. 3.



Picture No. 3 Production and logistics costs

Picture No. 3 depicts the supply chain relationship of the factors related to the logistics costs of the manufacturing industry as well as the overall production activities, which can be included in the analysis and determination of production costs in each activity. These logistics costs consist of (1) Costs of procurement activities associated with procurement of raw materials, labor costs, and production costs, (2) Costs of production activities associated with production processes, (3) Costs of inventory activities associated with finished goods inventory management, and (4) Cost of sales activities associated with sales costs.

In the production processes and activities, there are losses during production, which are considered part of the waste costs. The major losses are: (1) Waiting costs (Department of Industrial Promotion, 2020) are incurred from waiting in the production processes that do not cause products and values possibly due to Insufficient raw materials for production, broken machinery, unbalanced production processes, or accidents during production, and (2) Defect costs (Department of Industrial Promotion, 2020; Apisithpinyo and Apisithpinyo, 2016) are incurred from defects and reworks in the production processes, which result in

increased costs of raw materials, labor costs, and production costs. These defect costs may be caused by unskilled or negligent employees or workers, inappropriate work practices, poor raw materials, less efficient machinery, or too rushed production. They can be divided as follows: (2.1) Normal defect costs are caused by defective wastes and items and lost scraps that occur in the production processes inevitably and are included in the production costs and (2.2) Abnormal defect costs are also caused by defective wastes and items and lost scraps that exceed the standard and must be controlled or avoided. These costs are regarded as expenses during the production cycle. In addition, the resulting defects can be reused or reworked to make them a better product. Products that do not meet the standard or quality required by customers cause an incremental cost from production rework. If they cannot be reused or reworked, they are called a scrap, which is a defect from the production processes, but they can be utilized in other industries by collecting them in large quantities and then selling them out.

Innovation Management

The management of innovations related to the production system is an important factor that makes management and control possible in an orderly fashion. Companies are required to develop more innovations than ever before in order to achieve solutions and gain access to a competitive advantage in the situations the businesses are facing (Drejer, 2002, pp. 4-17). The generation of innovations may or may not be related to technology at all. According to the study, innovation is something new generated from using knowledge and creativity that are beneficial to the economy and society (Aujirapongpan, et al., 2010, pp. 52-54). What generated from the use of knowledge, creativity, skills, and experience must be in order to develop and drive a product or a new production process to meet the goals of the organization (Organization for Economic Co-operation and Development, 2018, p. 20). Innovation is defined as "A new or improved product or process (or may be generated by integration) that is significantly different from those that have been used before and is ready to be used". However, the minimum requirement for innovation is to be something new (or significantly developed or improved) to the organization. It can be divided into 4 types of innovation (Organization for Economic Co-operation and Development, 2018, pp. 21-29), consisting of: (3.1) Product innovation is to develop new products or services or to improve existing ones to be more quality, including improvements of techniques, components, production software, and usage or other characteristics, (3.2) Process innovation is to change into new approaches or methods for developing and improving techniques, tools, equipment, and software, (3.3) Marketing innovation is to change into new marketing methods, including product, service, and packaging designs to promote marketing, and (3.4) Organizational innovation is to change into new operation guidelines, business practices, workplace organization, and external relations.

Methods

This research was qualitative research with the following details of the methodology:

1. Key Informants

Key informants in this research were managing directors, general managers, factory managers, and production managers, a total of six people, representing the organizations in Nikhom Phatthana District, Klaeng District, and Pluak Daeng District in Rayong Province and Sriracha District in Chonburi Province. The researcher team collected qualitative data through in-depth interviews by focusing on three key informants who are the management of factories with continuous production process and three key informants who are the management of factories with intermittent production process.

2. Research Tools

Research tools used collect data in this research were as follows:

2.1 Documentary Research:

2.1.1 Government documents of both Rayong Province and Chonburi Province, including related agencies; and

2.1.2 Research and academic papers, research and academic articles, books, online documents, and other related documents; and

2.2 In-depth interviews: Key informants, including managing directors, general managers, factory managers, and production managers, were able to provide their comments and information freely and as much as possible. The research team used a semi-structured in-depth interview method using open-ended questions about organization management, production processes and quality control tools, waste management, production and logistics costs, innovations, service quality, and knowledge application for the development in order to obtain information according to the research team's interview guidelines under the concept of the management of production process wastes for eastern industry.

3. Data Collection

In this research, the data were collected as follows: In the first phase, a working network was created for key informants to know this research project. Therefore, the project was introduced to key informants who were managing directors, general managers, factory managers, and production managers.

In the second phase, the data collection was conducted. The research team contacted key informants by phone to schedule a date and time for performing an in-depth interview using the interview form.

Table No. 1 Details of key informants

Continuous Production System	Intermittent Production System
The 1st key informant is a manufacturer of plastic packaging with Thai management, located in Nikhom Phatthana District, Rayong Province	The 4th key informant is a manufacturer of automotive safety accessories and parts with Japanese management, located in Sriracha District Chonburi Province
The 2nd key informant is a manufacturer of ready-to-eat foods from aquatic animals with Thai management, located in Klaeng District, Rayong Province	The 5th key informant is a manufacturer of ready-to-eat foods from aquatic animals with Thai management, located in Klaeng District, Rayong Province
The 3rd key informant is a manufacturer of yarn spinning and coating products for weaving automotive brake hoses and tires with Japanese management, located in Sriracha District Chonburi	The 6th key informant is a manufacturer and distributor of automotive spare parts and other accessories with American management, located in Pluak Daeng District, Rayong Province

4. Data Verification

Data verification used a triangular data approach. The research team used the data obtained from important sources, consisting of: (1) Time source by comparing data from interviews with observations and in-depth interview to verify accuracy of discussions on the same topics in each chronological order, (2) Location source by comparing data from in-depth interviews with various archives, including in-depth interviews in different locations of key informants with different statuses, in order to verify accuracy of data in different locations, and (3) People source by performing in-depth interviews to obtain information from different key informants in order to verify accuracy of data received from trusted key informants.

5. Data Analysis

The research team analyzed the data on management of production process wastes for eastern industry as follows:

5.1 Documentary Analysis

The research team studied and examined the concepts and theories from academic documents of government agencies and major organizations, including research and academic articles, and other documents related to the issues studied.

5.2 Content Analysis

A content analysis was conducted based on the conceptual framework of in-depth interviews. It was related to the contents obtained from the in-depth interviews through descriptions or explanations.

Results

The results of the study on production process wastes for the types of production processes as shown in Table No. 2 can be classified into two important issues as follows:

1. Production Process

1.1 Production processes are classified into two types by the nature of the production processes: continuous production processes and intermittent production processes; and

1.2 Production processes are classified into three types by the nature of the management: Thai management, Japanese management, and American management.

Table No. 2 Types of production processes

Classified by nature of production processes	Classified by nature of management
1. Continuous production system	1. Thai management
2. Intermittent production system	2. Japanese management
	3. American management)

2. Characteristics of Wastes

There are seven wastes in the production processes as follows: (1) Overproduction is defined as an order to produce more products than the customer requires, resulting in waste of work and time, as well as product deterioration. (2) Inventory refers to a large order of materials at one time, resulting in excess inventory, which causes product deterioration or obsolescence. (3) Transportation is the result of poor transportation planning, which results in wastes that affect transportation costs, such as labor and fuel expenses. (4) Motion at work involves inappropriate physical arrangements and positions, resulting in accidents, lost time, and delayed work. (5) Processing denotes the placement of some unnecessary production processes, resulting in an excessive number of production steps, waste of unnecessary costs, and overwork, (6) Waiting refers to the absence or delay of some activities, such as employees on leave, absenteeism, and waiting for raw materials and machinery used in production, which results in wastes of lost time, additional costs, and discrete production processes, resulting in poor quality products, and (7) Defects involve an improper design and manufacturing process, which results in production wastes, lost time, the need for reuse/rework, poor quality products, and Although they can be sold, they are not the primary source of income.

This research found two main problems: waiting and defects, which can be described below.

2.1 Waiting

A. Characteristics of wastes found

1. Waiting for raw materials is caused by delays in the procurement process. As a result, raw materials cannot be delivered on time and it is needed to wait, which creates wastes, making it impossible to do that job and thus resulting in occurrence of wastes and ineffectiveness.

2. Waiting for machinery involves waiting for installation of new machinery that have just been introduced in the organizations, installation of machinery before starting the production processes, and broken machinery waiting for the repair, making it impossible to do that job and resulting lost time, additional costs, discrete production processes, and

occurrence of wastes and ineffectiveness.

3. Other waiting problems include employees on leave and absenteeism, causing insufficient employees for production, which creates wastes, making it impossible to do that job and resulting lost time, additional costs, discrete production processes, and occurrence of wastes and ineffectiveness.

B. Waste management

1. Waiting for raw materials can be managed through planning of production systems and optimization of procurement to have sufficient raw materials and timely production.

2. Waiting for machinery can be managed by increasing knowledge and skills in machine installation and regularly checking the conditions of machinery before, during, and after use.

3. Other waiting problems, such as employee issues, can be managed by allocating the workforce properly on a balanced manner and developing skills for employees to work with multiple working skills.

C. Development of waste management

1. Development of waste management in terms of “Waiting” with continuous production processes

1.1 For production processes and quality control tools, there are guidelines for the development of waste management in terms of "Waiting" by: (1) Developing a procurement system, both domestically and internationally, by optimizing planning, (2) Developing a machine management system, both installation and maintenance, by providing training to increase knowledge and skills in installing machinery more efficiently and increasing the efficiency of machine maintenance by checking the conditions of the machinery before, during, and after use regularly, and (3) Developing a human resource management system by allocating the number of employees to be balanced for the operations with no unnecessary absenteeism and providing skills training for employees so that they can work with multiple skills.

1.2 For production and logistics costs, there are guidelines for the development of waste management in terms of "Waiting" through the development of an appropriate production cost management system, comprising direct raw material costs, direct labor costs, and production overheads, including indirect raw material costs, indirect labor costs, and other expenses related to production at the factory. It is also related to logistics costs that must be managed to be at an appropriate and low level, including costs associated with the movements in the raw material purchase process, production processes, work in process, and inventory management.

1.3 For innovations, there are guidelines for the development of waste management in terms of "Waiting" through the development of innovations, technologies, and supporting equipment for convenience, speed, accuracy, and standards in the ordering, production, and inventory management processes. In addition, more information systems have been developed, including ordering, production, accounting and finance, and inventory systems.

1.4 For services, there are guidelines for the development of waste management in terms of "Waiting" by improving the

quality of services, both within and outside the organizations, at every step of the various activities, including service accuracy, appropriate time and opportunities, and consistent services.

2. Development of waste management in terms of “Waiting” with intermittent production processes

2.1 For production processes and quality control tools, there are guidelines for the development of waste management in terms of "Waiting" by: (1) Developing a procurement system, both domestically and internationally, by optimizing planning, (2) Developing a machine management system, both installation and maintenance, by providing training to increase knowledge and skills in installing machinery more efficiently and increasing the efficiency of machine maintenance by checking the conditions of the machinery before, during, and after use regularly, and (3) Developing a human resource management system by allocating the number of employees to be balanced for the operations with no unnecessary absenteeism and providing skills training for employees so that they can work with multiple skills.

2.2 For production and logistics costs, there are guidelines for the development of waste management in terms of "Waiting" through the development of an appropriate production cost management system, comprising direct raw material costs, direct labor costs, and production overheads, including indirect raw material costs, indirect labor costs, and other expenses related to production at the factory. It is also related to logistics costs that must be managed to be at an appropriate and low level, including costs associated with the movements in the raw material purchase process, production processes, work in process, and inventory management.

2.3 For innovations, there are guidelines for the development of waste management in terms of "Waiting" through the development of innovations, technologies, and supporting equipment for convenience, speed, accuracy, and standards in the ordering, production, and inventory management processes. In addition, more information systems have been developed, including ordering, production, accounting and finance, and inventory systems.

2.4 For services, there are guidelines for the development of waste management in terms of "Waiting" by improving the quality of services, both within and outside the organizations, at every step of the various activities, including service accuracy, appropriate time and opportunities, and consistent services.

2.2 Wastes caused by scraps

A. Characteristics of wastes found

1. Rework wastes are caused by an improper design and manufacturing process, which causes production wastes, lost time, need of reuse/rework, poor quality products, and additional costs.

2. Scrap wastes are caused by an improper design and manufacturing process, which causes production wastes, loss of storage space for scraps that must be unnecessarily removed. Although they can be sold, it is just a general income, not the main income.

B. Waste management

1. Rework wastes can be managed by creating correct and appropriate work and raw material standards and providing training to employees to be knowledgeable and competent.

2. Scrap wastes can be managed by encouraging employees to have awareness of production quality, developing efficient work processes, simplifying production processes, and regularly checking machinery before, during, and after use.

C.Development of waste management

1. Development of waste management in terms of “Defects” with continuous production processes

1.1 For production processes and quality control tools, there are guidelines for the development of waste management in terms of "Defects", both rework and scrap wastes, by increasing the efficiency of employees to have work skills, building safety awareness against negligence, reviewing and providing training on appropriate work practices, optimizing procurement system for quality raw materials, increasing efficiency of the machine work, both installation and maintenance, and establishing action plans with no rushed production.

1.2 For production and logistics costs, there are guidelines for the development of waste management in terms of "Defects" through the development of an appropriate production cost management system, comprising direct raw material costs, direct labor costs, and production overheads, including indirect raw material costs, indirect labor costs, and other expenses related to production at the factory. It is also related to logistics costs that must be managed to be at an appropriate and low level, including costs associated with the movements in the raw material purchase process, production processes, work in process, and inventory management.

1.3 For innovations, there are guidelines for the development of waste management in terms of "Defects" through the development of innovations, technologies, and supporting equipment for convenience, speed, accuracy, and standards in the ordering, production, and inventory management processes. In addition, more information systems have been developed, including ordering, production, accounting and finance, and inventory systems.

1.4 For services, there are guidelines for the development of waste management in terms of "Defects" by improving the quality of services, both within and outside the organizations, at every step of the various activities, including service accuracy, appropriate time and opportunities, and consistent services.

2. Development of waste management in terms of “Defects” with intermittent production processes

2.1 For production processes and quality control tools, there are guidelines for the development of waste management in terms of "Defects", both rework and scrap wastes, by increasing the efficiency of employees to have work skills, building safety awareness against negligence, reviewing and

providing training on appropriate work practices, optimizing procurement system for quality raw materials, increasing efficiency of the machine work, both installation and maintenance, and establishing action plans with no rushed production.

2.2 For production and logistics costs, there are guidelines for the development of waste management in terms of "Defects" through the development of an appropriate production cost management system, comprising direct raw material costs, direct labor costs, and production overheads, including indirect raw material costs, indirect labor costs, and other expenses related to production at the factory. It is also related to logistics costs that must be managed to be at an appropriate and low level, including costs associated with the movements in the raw material purchase process, production processes, work in process, and inventory management.

2.3 For innovations, there are guidelines for the development of waste management in terms of "Defects" through the development of innovations, technologies, and supporting equipment for convenience, speed, accuracy, and standards in the ordering, production, and inventory management processes. In addition, more information systems have been developed, including ordering, production, accounting and finance, and inventory systems.

2.4 For services, there are guidelines for the development of waste management in terms of "Defects" by improving the quality of services, both within and outside the organizations, at every step of the various activities, including service accuracy, appropriate time and opportunities, and consistent services.

Conclusion and Discussion

Conclusion

The management of production process wastes for the Eastern industry focuses on the wastes of waiting and defects because there are large quantities of wastes, both rework and scraps, for the industry in the East, resulting in the waiting for rework as well as for raw materials, employees on leave, and machinery repairs. The results indicated that (1) production process wastes, especially waiting and defects, which are essential parts of seven wastes: overproduction, inventory, transportation, motion, excess processing, waiting, and defects, were different depending on the production process management. (2) The management of production process wastes in terms of waiting and defects are different, depending on the continuous and intermittent production systems concerning production processes and quality control tools, production and logistics costs, innovations, and services. And (3) the development of the management of production process wastes in terms of waiting and defects mainly focused on continuous improvement for both continuous and intermittent production systems concerning production processes and quality control tools, production and logistics costs, innovations, and services.

Discussions

The results of this research are discussed as follows:

1. According to the first objective, the

production process wastes, especially waiting and defects, which are the essential parts of seven wastes: overproduction, inventory, motion, transportation, excess processing, waiting, and defects, were different depending on the production process management which was consistent with the Department of Industrial Promotion (2020) on production costs and how to reduce production costs. The results of this research indicated that there are guidelines for these seven wastes management.

2. According to the second objective, the management of production process wastes in terms of waiting and defects were different depending on the continuous and intermittent production systems about production processes and quality control tools, production and logistics costs, innovations, and services, were consistent with an online article of the Department of Industrial Promotion (2020) on production costs and how to reduce production costs describing that waiting is a process that does not produce products and values due to insufficient raw materials, broken machinery, unbalanced production processes, or accidents. There are guidelines to reduce costs caused by waiting by reviewing and improving safety minimum order quantity, establishing a machine maintenance plan, analyzing processes, setting standard times, and providing machinery and personal protective equipment.

In addition, the management of production process wastes in terms of defects, both rework and scraps are different depending on the continuous and intermittent production systems about production processes and quality control tools, production and logistics costs, innovations, and services. It was also consistent with Apisithpinyo and Apisithpinyo's (2016) findings on the costs of wastes, rework, and scraps in the made-to-order cost accounting system, which stated that spoilage is generated during production processes and sold at a lower price than the good yields. If it is severely damaged, it will be disposed of. These wastes are classified as normal spoilage, which must occur in acceptable proportions in the manufacturing process, and abnormal spoilage, which occurs in the manufacturing process but exceeds the general standard. They can be modified to be good products or services, but there must be an incremental cost from corrections or improvements. Moreover, they may include scraps of raw materials, materials, or parts obtained from the production processes, which can be utilized in other industries or sold as an income.

3. According to the third objective, the development of the management of production process wastes in terms of waiting and defects mainly focused on continuous improvement for both continuing and intermittent production systems concerning production processes and quality control tools, production and logistics costs, innovations, and services. It was consistent with Phongthanapanich's (2014) insights into Toyota production system stress and elimination of seven wastes of production processes. Toyota production system consists of six concepts: one-piece flow system, pull system, customer focus, self-control, waste elimination, and continuous improvement, which was also consistent with

Kittiyakajon (2018) on the application of an analytical and hierarchical process in selecting quality improvement projects to reduce waste: a case study of air cylinder manufacturing process. It involves quality control activities using 7 QC Tools: graphs, check sheets, scatter diagrams, Pareto analysis, cause and effect diagrams, histograms, and control charts, including the analytic hierarchy process (AHP). In addition, this was consistent with Kiatruangkrai, Thepkham, and Chinwornwathana (2020) on 10 years of Thai industry "How far have we come?", describing the Thai industrial sector during a decade that: (1) The same industries, such as foods, automobiles, and electronics, are still an crucial driving force of the Thai industrial sector, (2) The Thai industrial sector has increased its investment in capital factors mainly on machinery and equipment while investment in intangible assets, such as software, copyrights, and patents, is still very low, (3) Large Thai enterprises are the primary group that drives the added value of the industrial sector, but their production capacity is still lower than that of multinational enterprises, (4) Small Thai enterprises grow slower with a better disparity with large enterprises than other countries, and (5) Production contracting enterprises play a declining role, and even the big ones have played more roles, they are still likely to face risks from more intense external competition and low labor productivity.

Research Suggestions

1.Government-established waste management policies for the manufacturing process should be reviewed, updated, and improved on a regular basis.

2. Private waste management should prioritize waste management costs.

3.Additional research should be conducted to investigate other issues of waste management in the production processes of various industries in the eastern region as they evolve into the industry 4.0 era.

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