Improving Forklift Efficiency by ECRS Techniques: a Case Study in a Logistics Company

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Improving Forklift Efficiency by ECRS Techniques: a Case Study in a Logistics Company

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Abstract: The logistics industry has a vital role in supply chain management, which is considered an important industrial sector. Warehouse performance is a very important element in business. The forklift has a materials handling support activity, which affects warehouse efficiency. Specifically, we focus on the importance of forklifts in materials handling and their impact on warehouse efficiency. The objective of this work is to investigate warehouse operations by improving and solving forklift efficiency problems using the ECRS (Eliminate, Combine, Rearrange, Simplify) approach. In this case study, the warehouse manager identified three processes to enhance forklift tasks, aiming to reduce waste and minimize the total number of forklifts in the warehouse. Before the implementation of the ECRS technique in 2021, the warehouse had 30 forklift units with an efficiency usage rate of 49%. After the implementation in 2022, the total number of forklifts was reduced to 27 units, a decrease of 3 units. Additionally, the forklift efficiency usage significantly increased to approximately 66%. The implementation of the ECRS technique not only resulted in improved forklift efficiency, but also had a substantial impact on logistics cost. The company in the case study was able to save 504,000 THB per year in forklift rental expenses due to the reduction in the number of forklifts and the enhanced efficiency of their usage.

Keywords: Supply chain management; materials handling equipment; efficiency; logistics cost

1. Introduction

Exporting automotive parts is the biggest sector of the economy of Thailand. A report of the total exports in year 2021 valued the parts at $23,359.02 million[1]. Currently orders by customer from overseas are increasing. Nowadays, the logistics business is highly competitive because of reduced costs, high quality, good service, elimination of waste and new technologies. Warehouses are one part of the logistics industry supply chain[2]. Warehouse operations involve activities such as unloading, receiving, picking, packing, vanning and the shipping process[3-4]. Materials handling equipment is a key for successful operational performance[5]. Forklifts are used in manufacturing, logistics and construction[6]. They are versatile and come in various sizes and configurations to suit different operations. Forklifts are an important piece of material handling equipment necessary for efficient transport and stacking of materials in the warehouse, like unloading parts from the milk run supplier, moving the parts to the receiving area, supply packages to the packing operation, moving the part FG to the part vanning area and for use in the vanning process. The logistics company in the case study has a total in-house area of 20,000 m^2 and an outside area of 6,000 m^2; the layout and forklift positions in the warehouse are shown in Fig. 1 and the total of 30 forklift units used in the warehouse. However, the resulting operation of the forklifts is considered efficient utilization. The total of the average from the report of operation efficiency of utilization in year 2021 is 49%, which is very low and has a direct impact on benefits and logistics costs (rental forklift). Lili et al.[5] proposed a simulation to solve the problem of effective utilization with prediction methods of power control of electric forklift with Markov chain, fuzzy neural networks and BP. Xiong et al.[6] studied the work efficiency and economic test in a real factory using 3.5 tonne forklifts comparing the proton exchange membrane fuel cell (PEMFCs) and lithium-ion batteries (LIB). The results show that the work efficiency of PEMFCs powered forklift is 40.6%, a higher work efficiency than from the lithium-ion battery-powered forklift. Mykhaylo et al.[7] present the result performance of a 3-tonne electric forklift using a fuel cell power module compared with metal hydride hydrogen storage. Abdulhameed et al.[8] studied the behavior of forklift drivers compared with energy consumption and productivity through statistical models and regression analysis methods. Improving the forklift efficiency involves reducing operational waste and forklift utilization activities. In general IE techniques are the classical approach aiming for continuous improvement in the manufacturing or industry such as 5W2H technique, a method used in problem solving analysis, and the ECRS technique that is a widely used in problem solving in manufacturing, Lean manufacturing aims to minimize waste while maximizing efficiency and value in manufacturing processes[31]; Toyota production system (TPS) is widely recognized as one of the most effective production systems for improving efficiency, while 7 QC tools are a set of essential tools used in quality management and problem solving to analyze and improve processes, and work study is a systematic approach used to analyze and improve work processes, increase productivity and optimize resource utilization[9-12]. ECRS is one technique to increase forklift efficiency utilization in the case study. The framework consists of eliminating all possible unnecessary work without decreasing value, combining term work movements or changing direction of operations to save time, rearranging sequences or balancing activities of operations and simplifying to improve the work or developing equipment for the necessary operations[13-16,24]. Kanoksirirujisaya[13] applied the ECRS technique to reduce waste in the QC inspection line of the frozen crab stick process. This technique can analyze the root causes of the problems and the results of a percentage of the amount of time spent before improvement is 65.93% and after improvement remaining is 14.56%, a reduction of the amount of time of 77.92 %. Bambang et al.[14] reviewed the furniture industry in Indonesia, applying ECRS and Value Stream Mapping (VSM) to reduce the waste time. The results can be a reduction of lead time for making a part of the furniture of around 4.79% and balancing the workload of the operators to increase the efficiency after improvement. Chompoonoot et al.[16] focused on manufacturing electronic parts in Thailand, applying the ECRS technique and material flow cost accounting (MFCA) to reduce material waste of frame scrap in the trigger coil and injection process. The results of ECRS and MFCA as solutions have proven a reduction in material waste in the process. Moreover, the tools used in the research shown the total positive product cost effectiveness to increase from 18,497.24 to 18,555.80 THB. There are articles that have focused on improvement about forklift efficiency such as improved electric forklift energy efficiency[5,29], studying the behavior of the forklift driver effect on energy consumption[8,30] and improvement of the technology maintenance applied to forklifts[17]. However, none of the studies have focused to improve the forklift efficiency utilization in a similar case study. The novelty of applying ECRS to improve forklift efficiency lies in its comprehensive approach, which combines process optimization, collaboration, continuous improvement and sustainability efforts. This multifaceted not only enhances the immediate efficiency of forklift operations but also contributes to the long term resilience and competitiveness of the entire supply chain. This paper focuses on applying ECRS in order to reduce waste and improve the forklift efficiency utilization base overall for forklift use in the warehouse, as organizations face considerable challenges to achieve several benefits.

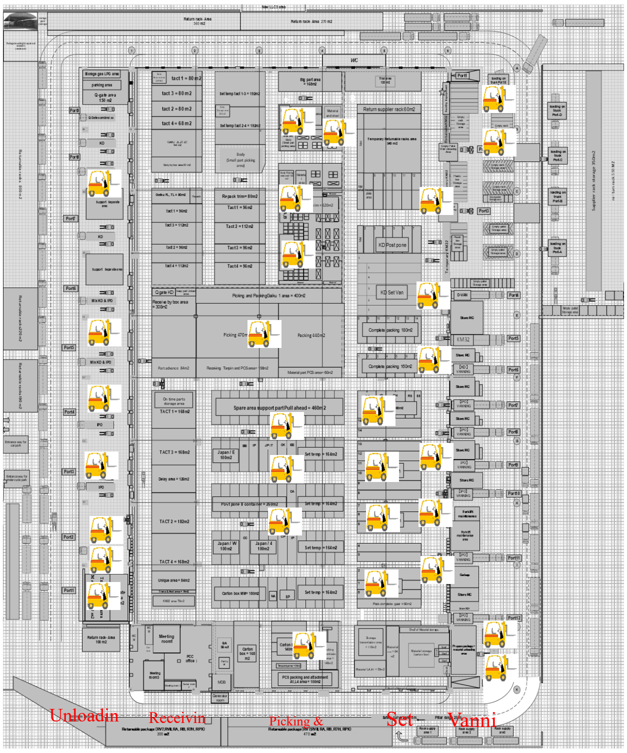


Fig. 1: Overall layout and forklift positions in the warehouse

2. Theoretical backgrounds

To understand and improve forklift efficiency, the management of an organizational set up to target and follow the main focus reduces waste and improves efficiency of forklifts relating to the current data report. To improve forklift efficiency and utilization in a warehouse, we must begin by understanding how forklifts are currently used and the types of tasks they perform. Given the above usage characteristics, the size and location of forklift operations are distributed in the warehouse as appropriate. The solution of the problem in the case study follows two decisions being:

1. How to use the methodology to increase the forklift efficiency utilization in the warehouse from current activities?

2. How much can we reduce the total amount of forklift usage less than 30 units?

The process improvement is important, so we introduce the ECRS technique to implement the process to reduce waste and eliminate non-value added, which can lead to reducing the logistics costs and improving overall forklift efficiency. The operations of the forklift are identified based on the processes in the warehouse which are activities or processes that need to be improved. An example of a forklift used in the warehouse is shown in Fig.2.

Fig. 2: Example of forklift

3. Research methodology

With the goal of business, companies must minimize costs and increase the potential competitive throughput[18,27,28]. This section describes the application of the ECRS technique in this study to improve the activity of forklift operation, due to the forklift usage in the warehouse in this case study involving many units and rental costs per month being expensive[19].The flowchart of ideas for the overall improvement activity of an experiment are presented in Fig.3. In the First step, the flowchart guides the brainstorming and the study of the problem in the warehouse area by the management team. In the second step, select the main problem in the case study for an improved forklift efficiency. In the third step, focus on developing ECRS tool ideas and creating a worksheet to record the daily working hours of a forklift driver during one shift from 08.00 AM. to 08.00 PM. After completing the worksheet, the supervisor will update and summarize the records. They will then calculate the percentage of forklift usage based on the monthly records, as shown in Table 1. In the fourth step, the management team will review the monthly results after implementing the trial ECRS tool ideas in the process. The fifth step is the step of improvement if the process trial passes after rearranging sequences and balancing the workload of some forklifts related to the results. Finally, in the sixth step, conclusions are drawn, and a new methodology for forklift operation in the warehouse is implemented.

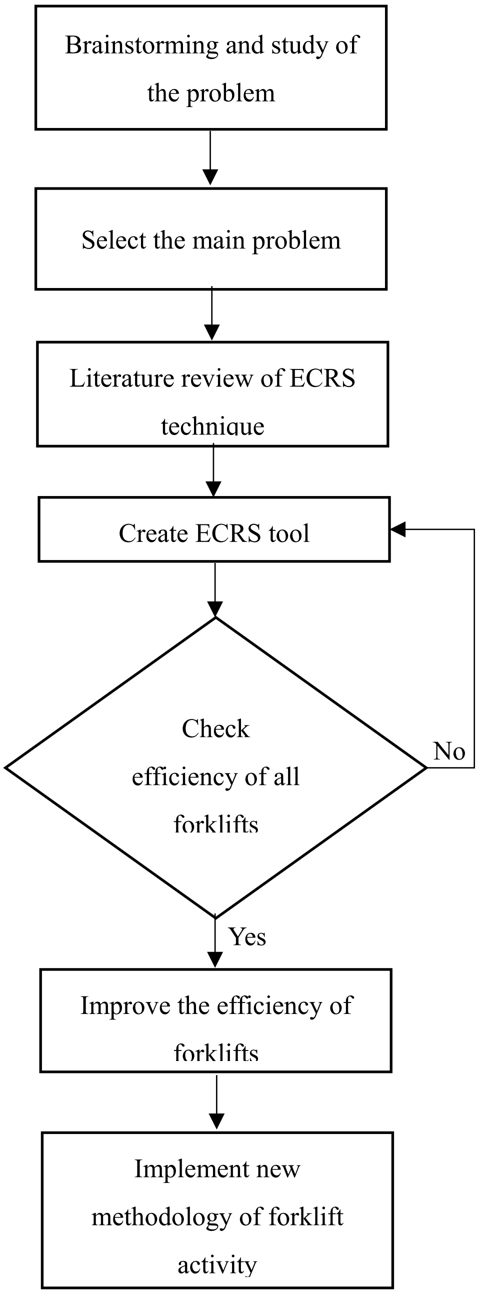


Fig. 3: The flowchart for improving the efficiency of forklift activity

Table 1. An example of the monthly worksheet record working hour usage of forklifts.

F/L No.	Size	Section	1-Jan	4-Jan	7-Jan	8-Jan	9-Jan	10-Jan	11-Jan	14-Jan	15-Jan	16-Jan	17-Jan	18-Jan	21-Jan	22-Jan	23-Jan	24-Jan	25-Jan	28-Jan	29-Jan	30-Jan	31-Jan
1	2.5 Ton	IPO - Set Temp	16%	9%	40%	72%	40%	46%	57%	40%	34%	19%	41%	50%	61%	55%	37%	69%	34%	25%	34%	34%	11%
3	2.5 Ton	KD - De-Van	71%	57%	36%	40%	45%	39%	42%	45%	22%	16%	2%	40%	55%	61%	60%	42%	23%	25%	55%	57%	54%
4	2.5 Ton	RCV - Unload	26%	21%	37%	63%	63%	55%	45%	7%	19%	10%	17%	24%	26%	47%	42%	30%	8%	15%	26%	21%	34%
5	2.5 Ton	IPO - Set Van	18%	2%	32%	50%	49%	42%	39%	32%	52%	34%	31%	45%	31%	32%	30%	23%	65%	19%	23%	30%	22%
8	2.5 Ton	RCV - Unload	42%	57%	58%	60%	52%	57%	46%	48%	45%	41%	48%	48%	52%	23%	16%	42%	44%	45%	42%	27%	45%
9	2.5 Ton	PKE / QA	7%	17%	3%	22%	16%	26%	15%	23%	13%	11%	5%	11%	3%	8%	1%	7%	5%	17%	8%	6%	9%
11	1.5 Ton	Return - Unload	30%	40%	52%	52%	49%	50%	45%	44%	42%	38%	46%	44%	40%	48%	23%	26%	42%	45%	32%	34%	48%
12	1.5 Ton	KD - Body Packing	46%	46%	46%	34%	46%	57%	34%	34%	34%	34%	23%	34%	46%	34%	34%	46%	46%	23%	34%	34%	23%
14	2.5 Ton	IPO - Supplier XX	36%	2%	77%	79%	81%	79%	60%	53%	54%	57%	31%	34%	69%	74%	48%	60%	21%	56%	62%	70%	52%
15	3.0 Ton	IPO - Set Van	23%	57%	57%	69%	69%	80%	69%	34%	57%	34%	34%	57%	46%	69%	69%	46%	57%	11%	23%	34%	46%
16	3.0 Ton	IPO - Van	34%	23%	23%	46%	46%	34%	46%	57%	34%	23%	23%	23%	23%	23%	46%	34%	46%	46%	34%	46%	23%
17	3.0 Ton	KD - Trim Packing	57%	69%	46%	69%	57%	57%	57%	57%	46%	46%	57%	46%	69%	57%	57%	46%	34%	34%	23%	23%	46%
18	3.0 Ton	KD - Vanning	46%	46%	73%	32%	33%	37%	17%	18%	18%	32%	14%	24%	36%	40%	34%	29%	17%	38%	48%	62%	50%
19	3.0 Ton	KD - Vanning	57%	73%	30%	73%	46%	55%	17%	62%	40%	33%	23%	27%	42%	31%	45%	30%	24%	30%	24%	57%	44%
21	2.5 Ton	KD - RCV - Body + Trim	46%	34%	34%	57%	34%	46%	34%	34%	34%	34%	23%	23%	46%	23%	34%	23%	34%	34%	23%	34%	34%
22	2.5 Ton	KD - Trim Packing	62%	56%	57%	58%	39%	42%	44%	45%	36%	48%	42%	36%	53%	50%	37%	37%	42%	42%	45%	38%	32%
23	1.5 Ton	KD - Body Packing	46%	34%	46%	57%	46%	46%	46%	23%	23%	34%	23%	23%	46%	34%	34%	46%	46%	23%	23%	24%	22%
27	1.5 Ton	IPO - Packing transmission	14%	5%	15%	18%	11%	21%	5%	8%	6%	15%	15%	27%	38%	31%	44%	31%	11%	27%	30%	30%	8%
29	3.0 Ton	IPO - Set Van	5%	25%	44%	57%	19%	73%	50%	26%	14%	42%	24%	28%	34%	23%	34%	34%	23%	23%	23%	23%	11%
30	3.0 Ton	IPO - Supply - Rack	21%	53%	60%	42%	34%	33%	27%	39%	34%	36%	33%	27%	39%	32%	40%	27%	26%	22%	38%	23%	23%
31	3.0 Ton	IPO - Supply - Rack	14%	29%	21%	16%	32%	38%	40%	44%	46%	45%	41%	40%	42%	38%	48%	42%	23%	23%	29%	37%	32%
33	2.5 Ton	IPO - Set Temp	11%	40%	47%	54%	49%	39%	39%	24%	27%	44%	24%	33%	21%	40%	11%	32%	13%	10%	37%	24%	28%
35	2.5 Ton	IPO Support Delay	13%	49%	25%	37%	42%	33%	47%	9%	16%	17%	18%	33%	24%	34%	36%	22%	52%	26%	33%	7%	15%
38	2.5 Ton	IPO - Packing	9%	34%	50%	55%	53%	41%	62%	58%	66%	53%	34%	40%	33%	45%	32%	56%	52%	38%	38%	47%	34%
41	2.5 Ton	RCV - Unload	30%	52%	50%	58%	53%	48%	39%	37%	37%	32%	42%	46%	48%	46%	48%	48%	44%	42%	36%	44%	41%
42	2.5 Ton	IPO - Set Van	40%	36%	37%	48%	46%	58%	61%	53%	45%	40%	34%	55%	50%	47%	30%	66%	61%	34%	34%	34%	11%
43	2.5 Ton	IPO - Set Temp	14%	11%	44%	39%	42%	32%	62%	29%	57%	29%	34%	44%	36%	31%	25%	49%	53%	30%	27%	30%	52%
44	3.0 Ton	IPO - Van	11%	11%	34%	46%	46%	46%	46%	34%	23%	46%	34%	34%	34%	34%	34%	34%	46%	23%	23%	23%	46%
45	3.0 Ton	IPO - Van	23%	23%	46%	46%	57%	46%	46%	46%	34%	23%	23%	34%	34%	34%	34%	23%	46%	23%	23%	11%	11%
46	3.0 Ton	KD - Return - WH + Long fork	34%	23%	34%	46%	34%	23%	34%	34%	34%	34%	34%	46%	34%	46%	34%	46%	23%	34%	34%	23%	34%

The percentage of forklift efficiency usage per day can be calculated as follows.

$$E = \frac{Workingtime\,/\,day}{Workinghour\,/\,day} x100 \quad (1)$$

The average percentage of forklift efficiency usage is generally given by the following equation[26]:

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (2)$$

Here, x_1, x_2,...x_n are the observations in a sample, and n represents the number of observations.

As indicated in the results of forklift efficiency operations in the year 2021, shown in Fig.4, this summary includes key data that helps to evaluate the efficiency of forklift operations. We observe that a group of forklift efficiency operations displays very low results, particularly in the packing engineer and quality assurance processes, as depicted in Fig.5, given that one unit of forklift uses common PKE/QA operations in the front port of the warehouse area. This operation supports the movement of parts and packages for both current and new models, aimed at optimizing packaging solutions as requested by the team[20]. The results of the IPO - packing transmission process indicate the use of one unit in the packing transmission area of the warehouse. This unit supports the packaging of engine parts from suppliers and exports them to customers based on orders, as shown in Fig.6, Additionally, the results of the IPO for the support part delay process reveal that one unit is on standby to support the unloading of parts from milk run trucks arriving at the warehouse, causing delays. This situation is illustrated in Fig.7.

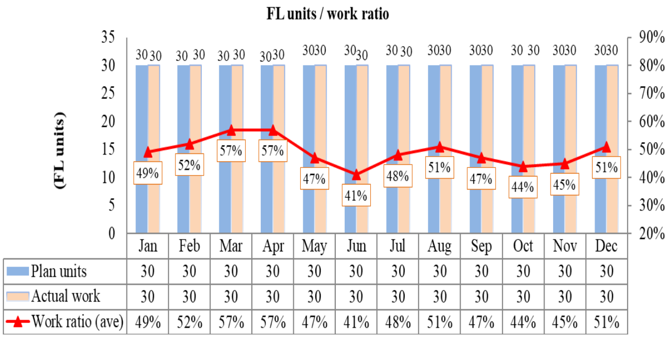


Fig. 4: Forklift efficiency operational results in year 2021

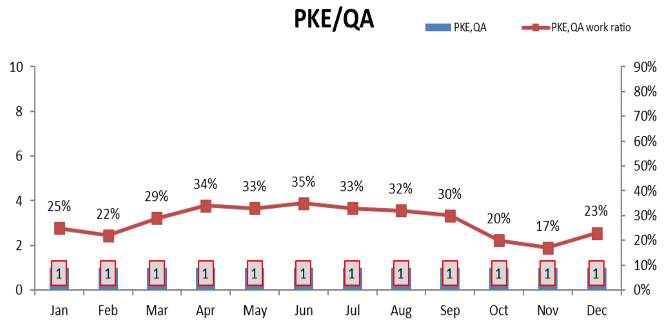


Fig. 5: Forklift efficiency packing engineer and quality assurance processes

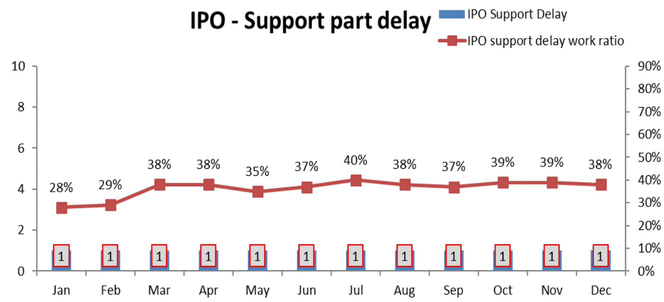


Fig. 6: Forklift efficiency IPO - packing transmission process

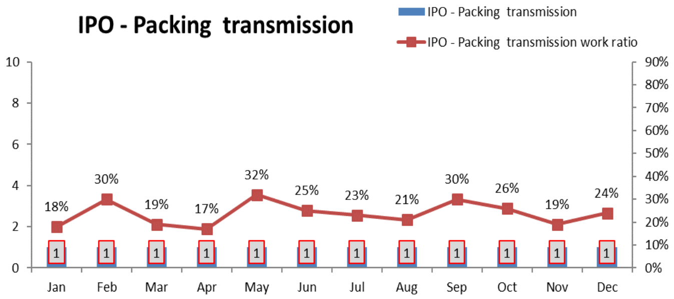


Fig. 7: Forklift efficiency IPO – support part delay process

4. Results

The management selected three processes in the warehouse for a case study for the simulation and improvement process, because their efficiency was less than other activity references for the volume by process[21,25]. The focus of the analysis was on the ECRS technique to reduce the number of forklifts in this process and improve forklift efficiency operation[22]. As the efficiency of forklift results before improvement from Fig.5-7 that can be separated by the process consisting of PKE/QA operation as average usage of 28%, for the IPO - packing transmission process the average usage is 24% and for the IPO - support part delay process the average usage is 36%. The results of the experimental approach developed in the process are as follows.

4.1 In the PKE/QA process, the first decision of the process was to the operate with different working hours based on the team's request. The idea of this application is to eliminate the forklift in process, balance workload and scheduling to optimize forklift to use common RCV-unload process so three units can be replaced. For the optimized unnecessary RCV-unload process, the result before improvement of average usage is 40% and after common usage two process average usage up to 58%. The resulting best solution from conditions is presented in Fig.8.

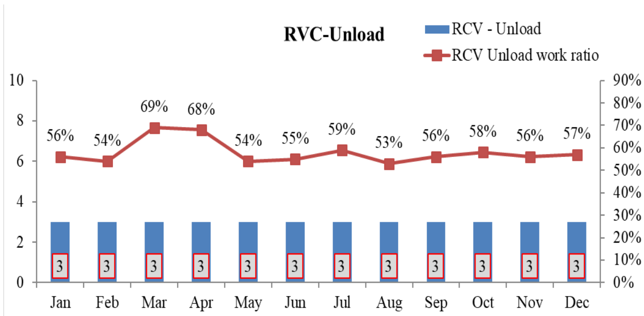


Fig. 8: Forklift efficiency RCV-unload process after improvement

4.2 IPO - packing transmission process; in this step a decision was made including IPO – set van four units replaced, the efficiency of the forklifts before eliminating and rearranging the process average usage is 39% and after the implementation common usage the percentage average increased to 56%; the management team was satisfied with the solution shown in Fig.9.

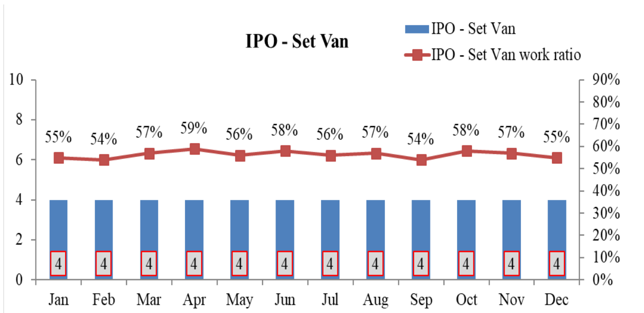


Fig. 9: Forklift efficiency IPO-set van process after improvement

4.3 IPO - support part delay process, for the adaptability of two past case solving problems, a decision can be an immediate action in this process with assignation allocated to IPO-set temp process three units support activity. Thus, the average efficiency of forklift before an improvement process is 36%; it can be observed after improvement the percentage of usage increases to 56%.

The results are shown in Fig.10.

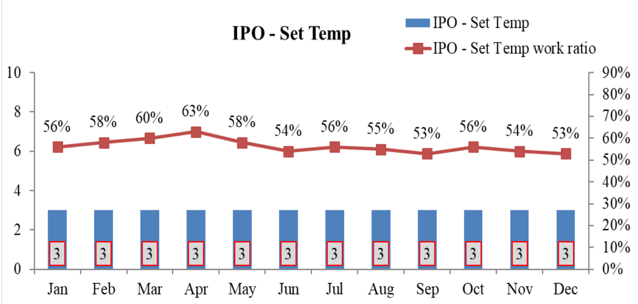
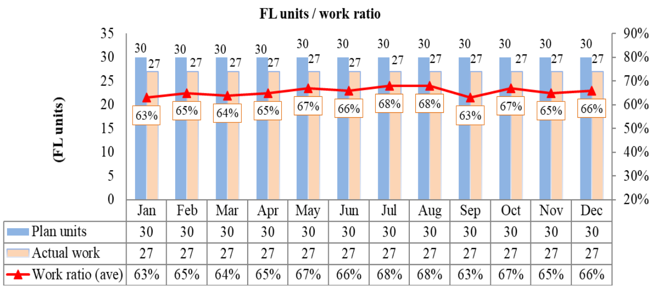


Fig. 10: Forklift efficiency IPO-set temp process after improvement

The main focus in this study is the application of the ECRS technique, which is used in solutions to improve efficiency of the forklift usage problem in a warehouse in order to reduce logistics costs. After implementation of the operation process by eliminating and combining tasks taking actions for some forklift locations, rearranging and simplifying the forklift process, the results cause a decrease of the number of forklifts from 30 units to 27 units. Forklifts reduced consist of PKE/QA process one unit, IPO - packing transmission process one unit and IPO - support part delay process one unit. The layout and position of forklifts in the warehouse after improved efficiency of the forklift usage are presented in Fig.11.

Fig. 11: Layout and forklift position in the warehouse after improvement

Finally, adjusting the forklift activity leads to a significant reduction of total usage in the warehouse. It was found that the total number of forklifts decreased and forklift efficiency increased from obtaining the solutions. Fig.12 shown a comparison of the results in changing the tasks of the forklifts. After finding the solution, we further compare and calculate logistics cost about rental forklift expenses in the year 2022 as presented in Fig.13, showing the company in the case study can save rental forklift costs from three units after improving activity would be 504,000 THB per year.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plan units	30	30	30	30	30	30	30	30	30	30	30	30
Actual work	27	27	27	27	27	27	27	27	27	27	27	27
Work ratio (ave)	63%	65%	64%	65%	67%	66%	68%	68%	63%	67%	65%	66%

Fig. 12: Forklift efficiency operation results after improvement in year 2022

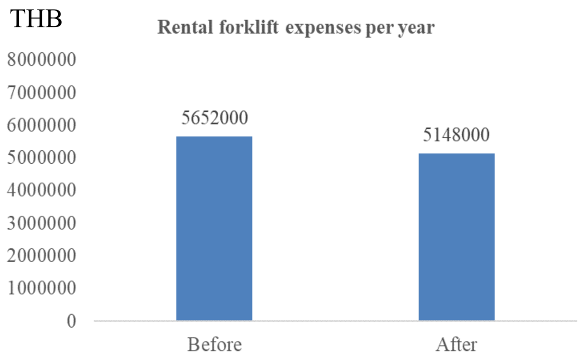


Fig. 13: Compare rental forklift expenses before and after improvement in year 2022

5. Conclusions

The efficiency of a forklift is a critical factor in the success of businesses or companies, impacting productivity and logistics costs. This research proposes methods to solve the forklift efficiency problem. We present using ECRS techniques to reduce waste and improve productivity in a case study with only three forklift processes. The forklift material handling is a crucial aspect of the warehouse operation use support activity[23]. From experimental analysis the forklift has low efficiency and significantly impacts performance and improvement by eliminating forklift percentage of usage by lowering, combining and rearranging the scheduling task operations of forklifts in the warehouse. The conclusions of this study are as follows:

1. The total of forklift usage after improved can reducing from 30 units remain 27 units per month.
2. The forklift efficiency usage increased from the year 2021 is 49% for the year 2022 is 66% increased approximately 17%.
3. The logistics cost resulting in lower rental forklift expenses and lower usage with a compared forklift plan

which reduced by three units and consumes less energy.
4. The highly efficient forklift operations can save costs significantly and can satisfy customers, being more likely to meet sustainability goals.

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