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Research Article

Case Study on Overhaul Performance of Excavator CAT 320 Series by Lean Production Program

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Abstract: Present study developed and proposed improve steps of Overhaul process which conducted by lean production program. The research procedure includes four stages: analyze the current status, establish improve steps, implement improve step, and confirm improved status after implement improve step. The eight types of waste was confirmed and the improve steps was established after analyze the current status. After implement the improving steps, the Overhaul days was reduced from 88 to 49 days, reduced about 5% of costs, and increased about 18% of profit. The results were confirmed that the Overhaul performance of excavator can be improved by the improving steps which conducted by lean production program.
Keywords: Overhaul performance; Excavator; Lean production program

INTRODUCTION

Excavators (Fig. 1) are the indispensable equipment on earthmoving tasks and construction industrial. The Overhaul of the excavators is costly. Hence, the Overhaul income is one of the most importance revenue for the case company. For example, there are about NT 200 million of total revenue per year was come from Overhaul, and more than half was come from excavator Overhaul. However, the average Overhaul performance was loss about NT 3.5 million compare to the target at 2012. Therefore, the present study was aim to improve the Overhaul performance of the case company.

Fig-1: The illustration of excavators

LEAN PRODUCTION PROGRAM

There are four main constructors of lean production program: supplier, quantity, quality, and logistic. (1) Supplier: the host company must inseparable with supplier to guarantee quality and meet the highly frequency of delivery in pull system[1]. Highly frequency of delivery (small batch) not only reduce inventory and scrapped, but also easy to find defective products. Further, establish long term relationship also can reduce transaction cost and unit price. (2) Quantity: if the production system can reduce the lead time of the production procedures and costs, it can reduce delivery batch to meet customer's need[2]. (3) Quality: implement total quality management to achieve zero defect level. Therefore, from the initial manufactory process design to prevent defects. (4) Logistic: to delivery small batch parts on time and efficiency. Efficiency logistic can not only reduce inventory, cost, and production time, but also increase customer's satisfaction and better production flexibility[3].

RESEARCH PROCEDURE

The present was aim to improve the Overhaul performance of the case company. The research procedure was shown in Figure 2. The present study firstly investigated the goals of business and customers. Secondly, the present study employed lean production program to improve Overhaul performance. Finally, confirm the improve steps and results (efficiency and profit).

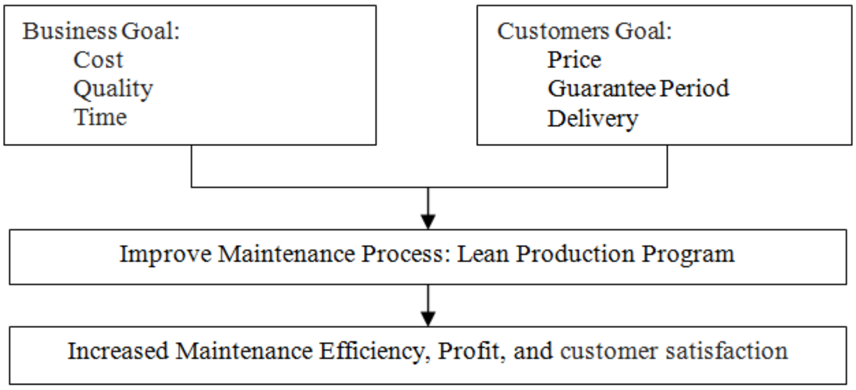


Fig-2: Research procedure

Table-1 shows the research stage and contents of improve Overhaul process, which includes four stages: analyze the current status, establish improve steps, implement improve step, and confirm the improved status after implement the improve step.

Table-1: Research stages and contents of the improve steps of Overhaul process

Research stage	Research contents
Analyze the current status	Analyze the current status of Overhaul performance of CAT 320 series.
Establish the improve steps	According to the current status analysis and conducted lean production program to establish the improve steps.
Implement the improve steps	Implement improve steps which established in above stage.
Confirm the improved status	Compared the different of Overhaul performance between current and after improved and confirmed the improve steps.

RESEARCH PROCEDURE

Analyze the current status

Excavator types

Fig-3 shows the CAT 320 series, which with type A to D. Today, the type D is the main type in Taiwan market. Therefore, the present study employed CAT 320D to illustrate the research. Figure 4 and Table 2 shows the structure details and names of excavator CAT 320D.

Fig-3: The excavators CAT 320 series in the world

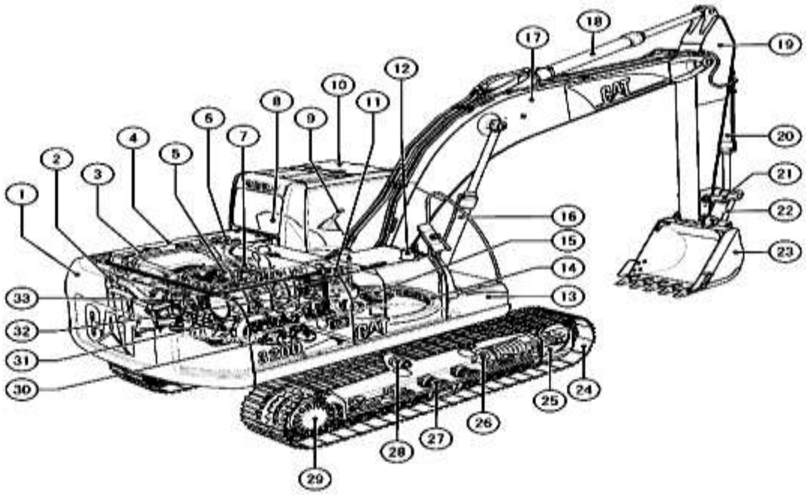


Fig-3: Structure details of excavator CAT 320D

Table-2: Structure names of excavator CAT 320D

(1) Counterweight	(12) Fuel tank	(23) Bucket
(2) After cooler	(13) Storage box	(24) Track
(3) Radiator & oil cooler	(14) Swing bearing	(25) Idler
(4) Engine cover	(15) Swivel	(26) Track adjuster
(5) Battery	(16) Boom cylinder	(27) Track roller
(6) Air cleaner	(17) Boom	(28 Carrier roller
(7) Control valve	(18) Stick cylinder	(29) Final drive
(8) Operator seat	(19) Stick	(30) Pump
(9) Control lever	(20) Bucket cylinder	(31) Swing drive
(10) Cab	(21) Link	(32) Return filter
(11) Hydraulic tank	(22) Rod	(33) Engine

Current Overhaul status

Firstly, the present study statistic the staffing, the layout, the facility, the average days, and the average costs of current Overhaul status. The Overhaul plant was included six areas: assembly bay, washing bay, parts warehouse, office/tool room, engine warehouse, and engine disassembly/cleaning bay. The Overhaul plant can repair and Overhaul three excavators simultaneously.

Current status of Overhaul plant

The present study also analysis the status before Overhaul of the Overhaul plant: Overhaul space before finishing, Overhaul preparation, and major Overhaul and installation work. (1) Overhaul space before finishing: there are three Overhaul areas to Overhaul three excavators, therefore, there are 3 level 1 Overhaul technicians (assist Overhaul), 2 level 2 Overhaul technicians (main Overhaul), and 1 level 3 Overhaul technician to Overhaul excavators (main Overhaul and leader). In average, there is need about 3 technicians and 8 hours to prepare Overhaul tasks. (2) Overhaul preparation: after the three excavators have been on location, the 6 technicians have to location in the same time. This will waste about 6 working hours. (3) Major Overhaul and installation work: includes the main structure demolition, components preliminary clean, components detail cleaning and oil, enclosure protection before installation of the components, etc.

Eight types of waste

Secondly, try to find the eight types of waste (I-U-WE-TO-DO) of the Overhaul plant. Table 3 shows the items and contents of eight types of waste which developed by case company.

Table-3: Waste items and waste contents of the eight types of waste

Waste items	Waste contents
Inventory	Excess raw material, work-in-process or finished goods.
Unused creativity/capability	Lost opportunities due to poor safety and an underutilized workforce.
Waiting	Lost time due to poor product and/or process flow-shortages, bottlenecks, down machines and errors.
Excess motion	Waste movement made while working.
Transportation	Excess and inefficient movement of work-in-process.
Over processing	Work that adds no value to the customer or business.
Defect	Production or rework of out-of-specification parts. Rework due to information errors or processes not adering standard work.
Over production	Excesssupply beyond the requirements of the next process.

Current status of the wastes

There are four major wastes in current status: (1) waiting: due to the weight of components usually geaterthan 40 kgs, therefore, must used hydraulic dray to transportation the location in order to obey the labor legislation. However, there are only 1 hydraulic dray and 1 stacker. The transportation task must wait the hydraulic dray and stacker to carry out. This resulted about 2 technicians and 12 working hours waiting for each excavator. (2) Excess motion: the sizes of the components were not the same, therefore, usually have to use 2 technicians to transport the components. This caused the excess motion waste about 2 technicians and 3 working hours for each excavator. (3) Transportation: due to the excess and inefficient movement of work-in-process. This resulted about 1 technicians and 1.5 working hours waste for each excavator. (4) Unused creativity/capability: lost opportunities due to waiting, excess motion, and transportation. This resulted about 1 technicians and 2 working hours waste for each excavator. Table 4 shows the PQVC analysis of the wastes and the objects of the Overhaul plant.

Table-4: PQVC analysis of the wastes and the objects of the Overhaul plant

Wastes	Objects
Unfamiliar with assembly procedures	People
Parts list is incorrect	Quality
Marked untrue	Velocity
Inefficiencies and excessive overtime hours	Cost

Established the improve steps

The present proposed several improve steps which conducted from lean production program.

Lead time

Generally, in time-based competition measure, usually focus on the lead time of manufacture, supply chain, information flow, and R&D [3]. The lead time also includes work-in-process between production batch, waiting time, processing time, and transfer time. Takahiro [4] also indicated that company must focus on the difference of manufacture system and information transfer in time-based competition measure.

Supply chain management

The supply chain management played a vital role in pull system. If the company can establish efficiency supply chain, it can improve their operation performance and competition ability[5]. Kerin & Sethuraman[6] indicated that long-term cooperation partnership can result better cooperation performance, reduce transaction costs, and increase customer value.

Modular

Standardization and in common of the parts are the main approach of mass customization. Employed modular design and manufacture can reduce costs and improve quality[7]. Sahin[8] indicated that the lean, agile, and mass customization all had connection and commonality, there are the common approach of improving production systems.

Smooth the production flow

This production flow gives the customer value, and covered the product, information, and services in the production system. The process of normalized production refers to the actual demand for the product according to the period, balanced flow and output in the production line, minimum waiting time of customers, minimize the shortage, and avoid insufficient capacity during the peak period. Equalization the staff working time, so that production workers will not sometimes faster or slower [9]. The concept of production flow includes smooth the production flow and pull production system.

Pull production system

This pull production system and smooth the production flow are the two main principles of just-in-time production system. The kanban is the most important tool and the information transfer tool in the pull production system among the processes[10].

Multi-skill workers

McDonald [11] indicated that multi-skill worker training allows field workers more flexibility when needs change. Multi-skill worker training also allows workers to better understand the function of the overall team [12], increasing work flexibility[9] and improving productivity[13].

Statistical process control

Statistical process control (SPC) has become an important tool of practitioners to solve manufacturing process and product standards, improve quality and continuous improvement.

Manufacturing operating performance

Lean production program has a significant contribution for the overall manufacturing performance, which is likely to enhance manufacturing capacity, improve product quality and rapid speed to market, and better ability to respond to customers [9]. The plant used lean production program, such as multi-skill workers or small batch production, not only can manufacture in a wide range of products, but also can retain the high quality and productivity[14]. Hunter[15] indicated that the four properties of lean production program: reduced unit costs, one hundred percent of the high quality, the shortest cycle time, and maximum the output flexibility. The advantages of lean production program includes: enhance productivity and product quality, shorten customer lead time, shorten the cycle time, and reduce costs[16].

Implement the improve steps

The present developed and proposed several improve steps based on lean production program. Table 5 shows the PQVC improving of the Overhaul plant. And, Table 6 shows the partial illustrations and statements of the improve steps of the Overhaul plant.

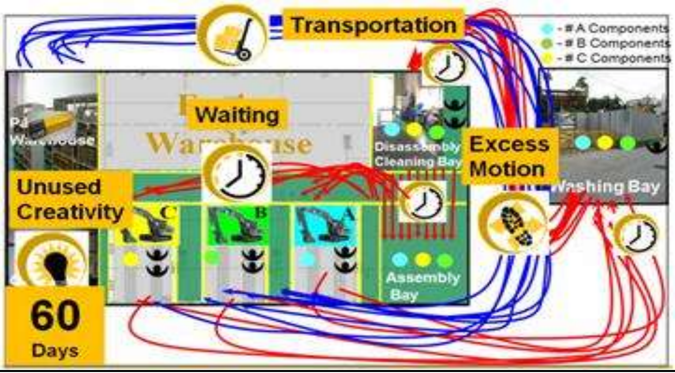
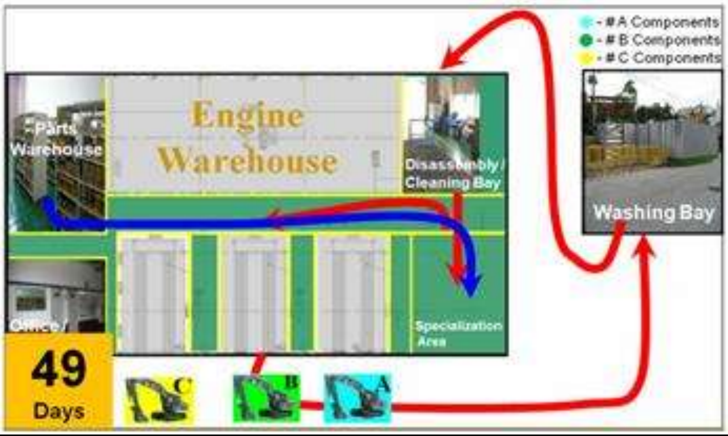
Confirm the improved status

After implement the improve steps, the Overhaul days not only lower than the customer's requirement (60 days), but also redused the cost and increased the profit. The Overhaul days was reduced from 88 to 49 days, reduced 5% of cost, and increase 18% of profit.

Table-5: PQVC improving of the Overhaul plant

	
People: improved the professional skills of the Overhaul staffs to increase the Overhaul performance and quality.	Quality: using test equipment to confirm the Overhaul quality.
	
Velocity: Overhaul velocity determines the overall profitability of Overhaul. Therefore, this study coding the materials and parts to reduce the Overhaul staff to check the time and reduces human error and the rework Overhaul of time.	Cost: cost is the main factor that usually affected the overall performance, through the Overhaul process improvement, not only effectively reduce Overhaul duration, but also reduce the rework time to reduce the cost.

Table-6: Partial illustrations and statements of the improve steps of the Overhaul plant

Illustration of the improve steps	Statements of the improve steps
	There are staffs waiting, materials over transportation, unused creativity, and staffs excess motion wastes at current status to cause the Overhaul periods more than 60 days (88 days in current status).
Step2-step7 are omission	Step2-step7 are omission
	After implement the improve steps, the Overhaul days was reduced from 60 to 49 days, reduced 5% of costs, and increase 18% of profit.

CONCLUSION

The purpose of present study is to develop Overhaul improving steps to reduce the total Overhaul cost, to reduce Overhaul day, and to increase the profit, and increase customer's satisfaction.

After implement the improve steps, the Overhaul periods was reduced from 88 to 49 days, reduced 5% of Overhaul costs, and increase 18% of profit. The results were confirmed that the Overhaul performance of excavator can be improved by applied lean production program. These improving steps also can implement to the others Overhaul plants of the case company.

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