Productivity Improvement in Final Visual Inspection Process at Gunma Gohkin Philippines Corporation using Kaizen Technique

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Abstract

Lean manufacturing tools are used by various automotive industries in today's competitive world since the goal is to reduce waste in the whole process through incremental improvements to be more effective and more efficient. Hence, the purpose of this study is to identify and demonstrate, how non-value-added activities affect the productivity of the process. Furthermore, the study follows an applied research design since specific questions were answered with direct applications and an action, technique, or plan was deliberately presented and a result was seen. At the beginning of this study, lean tools, time study, and systematic questioning techniques were used to retrieve relevant data from the process and were analyzed. Consequently, from the observed results, it significantly showed that the cycle time was reduced from 247.30 seconds to 105.99 seconds and non-value-added activities were reduced by 34 percent. Furthermore, the output per day increased by 25 percent, process cycle efficiency increased by 12 percent, and the value-added time was reduced by 52 percent. Actual simulation was conducted to verify and validate the existing situation as well as to propose the results and the effectiveness of lean principles in a systematic manner with the help of a prototype.

Keywords: Lean manufacturing; waste; Kaizen; value stream mapping; productivity improvement; Gemba; cost-benefit analysis

I. INTRODUCTION

Productivity improvement is the significant factor for any firm to endure and to accomplish developments that are carried out with continuous improvement of any types of activities [1] [2]. Likewise, productivity improvement is the implication of managing and intervening during change of work processes.

Thus, to accomplish the persistent improvement in productivity, Kaizen can be utilized for this specific project to focus on explicit improvement with huge or slight changes in work processes. Kaizen is more of an idea that supports continuous, incremental changes that sustain high efficiency. Additionally, Kaizen is recognized as the best strategy for implementing improvement among all the methods as it includes less cost [3] [4] [5].

On the other hand, the automotive industry is one the most known sectors in the worldwide market that requires continuous development to discover an enormous ability to adapt to market demands. The intensity of competition in this sector has created a requirement for productivity, efficiency, and quality to satisfy customers' needs. Waste, however, is the one factors that causes low productivity, low efficiency, low quality, and higher cost that affect the overall processes of the automotive industry as well as their organizational goals and objectives. Eliminating waste in the process, however, cannot be done easily, but continuous improvement of the processes can help to lessen it.

Although, in numerous automotive industries, waste occurs because of untrained staff, inappropriate equipment, inadequate planning, and incompetent operators [6]. Thus, it us required to keep legitimate observations for limiting item rejection, producing products without defects, providing appropriate training for workers, and reducing the delays or unnecessary motions in the process. Since in today's market, the automotive industry is known as the most advanced and innovative industry, the overall number of cars and commercial vehicles produced worldwide in 2018 was greater than 90 million units, but this has decreased by 6.29 percent from the 2017 production [7].

The main purpose of this study is to identify and reduce non-value-added activities that cause long process time, fatigue, and low productivity among inspectors. Furthermore, to demonstrate how non-value-added activities affect productivity in the final visual inspection process.

Conceptual Framework

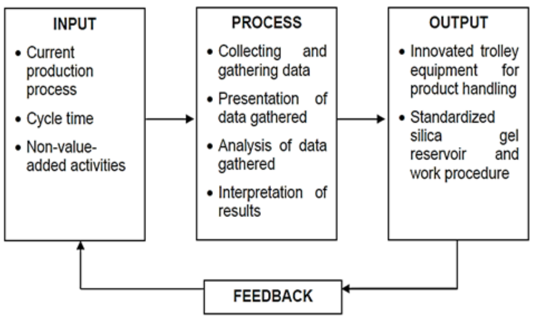


Figure 1. Conceptual Framework

Figure 1 shows the sequential process of how the researchers produced the study. The input was to determine current production process, cycle time, and non- value-added activities. The procedure incorporates collecting and gathering data by time study, common concern in the data was about non-value-added activities in current work procedure of inspectors. Through familiarization of the process and interviewing the team leader, however, researchers identified the type of non-value-added activities that occur in the process. Last, the output was to reduce non-value-added activities of inspectors through an innovated trolley equipment for product manual handling, standardized silica gel reservoir, and work procedure.

Objectives of the Study

The main purpose of this study was to identify and reduce non-value-added activities that cause long process time, fatigue, and low productivity of inspectors. Furthermore, to demonstrate how non-value-added activities affect the productivity in the final visual inspection process. Specifically, the study sought to determine the current production process and cycle time of each process; define the current work procedure of inspectors and illustrate the workplace layout in the final visual inspection process; identify the root cause of non-value-added activities of inspectors in the final visual inspection process; develop a prototype and reduce non-value-added activities of inspectors in the final visual inspection process; analyze data of before and after the improvement in the final visual inspection process; and assess the cost benefit analysis of the proposed prototype and task procedure.

II. METHODOLOGY

An applied research method was used in which an action, technique, or plan was deliberately presented, and results were as seen. Also, where a specific question was answered with direct applications. This research used different tools to identify the cause of the problem. These were used as conclusive information that helped in answering the objectives and problems of the study. Thus, to make it easy to understand, here are the following tools: (1) Value Stream Mapping, (2) Pareto Analysis, (3) Decision Tree Diagram, (4) Flow Process Chart, (5) Gemba.

However, to support the validity of the data gathered by every process, the researchers followed these steps: (1) select product family, (2) form a team, (3) analyze customer demand, (4) map the process, material, and information flow, (5) calculation of total productive time.

The gathered data by the researchers were analyzed through the formula and statistical method. These were used for the analysis and interpretation of the data. The following formula and statistical method used were: (1) Paired t-Test. A statistical method that is used to find out whether there is a significant difference between two variables for the same subject. (2) Normal Time. The amount of time that a worker produces a certain product at a normal pace. (3) Standard Time. The amount time that should be the average time a worker should produce one unit. (4) Takt Time. The process duration required to manage the pace of a customer request. (5) Productivity. The efficient use of resources, labor, capital, land, materials, energy, information, in the production of various goods and services. Higher productivity means accomplishing more with the same number of resources or achieving higher output in terms of volume and quality from the same input. (6) Process Cycle Efficiency. A metric commonly used by those following lean and/or Six Sigma principals and prioritizing improvement opportunities in a process by reducing non-value-added activities.

III. RESULTS AND DISCUSSIONS

Current Production Process using Gemba and Value Stream Map

The study started by walking and heading out to the floor, to able to assess how well Gunma Gohkin Philippines Corporation was doing. It was part of the continuous improvement cycle. Applying Gemba allows the researchers to see problems, clear them, find the root cause, and work into resolving them. Moreover, the current state of value stream map was constructed to determine the process that would serve as the focus of the study. To sum up, the purpose of Gemba and Value Stream Mapping was to understand the process flow, material flow, and information flow in the company and analyze to find a solution over the problems in them.

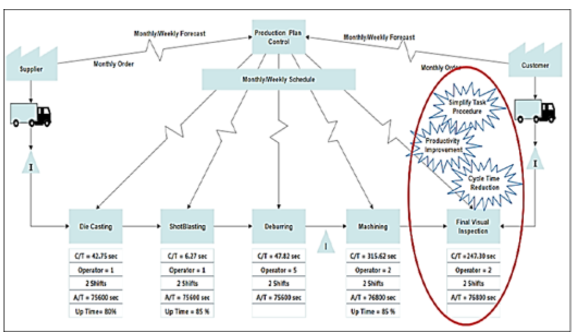
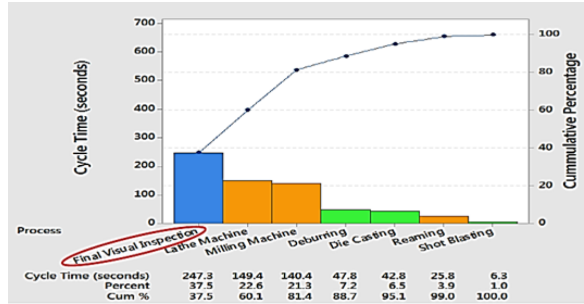


Figure 2. Current state of value stream map

Pareto analysis of the process constraint

The researchers not only made a value stream map to determine the process that would serve as the focus of the study, but also constructed a Pareto Analysis along with time to identify the other process that was possible to be included in the study.



Note: (a) Blue bar for Quality Control Assurance Department, (b) Orange bar for Production 2 Department, (c) Green bar for Production 1 Department

Figure 3. Pareto analysis of cycle time

Current Work Procedure of Inspectors

Flow Process Chart				
Location : Gunma Gohkin Philippines Corporation	Summary			
Activity : Final Visual Inspection Process	Event	Present	Proposed	Savings
Date :	Operation	13		
Operator : Analyst : Javier, Lorenzana, Macalalad, Magalong	Transport	2		
Method and Type:	Delay	1		
Method: Present Proposed	Inspection	3		
Type: Operator Material Machine	Storage	1		
Remarks:	Total Time (sec)	247.30		
	Distance (ft)			
	Cost			

Event Description	Symbol	Time (in seconds)	Distance (ft)	Remarks
Go to machining process		11.40		Innovate trolley to reduce this recurrently
Place the crates to trolley		14.80		This can be eliminate to avoid fatigue
Transfer the crates to final visual inspection process		13.54		Innovate trolley to reduce this recurently
Get box from the pallet, place plastic, and put partition		34.21		Provide box with plastic and partition to reduce time
Get product from crate, inspect and put in box		13.92		
Get silica gel		2.48		Provide arcylic container to reduce time and motion
Prepare second layer		12.34		
Get product from crate, inspect and put in box		16.84		
Get silica gel		2.14		Provide arcylic container to reduce time and motion
Prepare third layer		12.84		
Get product from crate, Inspect and put in box		16.70		
Get silica gel		2.50		Provide arcylic container to reduce time and motion
Tape the box		46.81		
Writing and put tag in box		21.90		
Place Finished Package to Pallet		6.10		Eliminate, no need to do this repeatedly
Wait to remove all finished package from pallet by handler operator		18.78		This can be eliminate to reduce delay

Figure 4. Flow process chart of current work procedure of inspectors

The researchers used the flow process chart since it contains considerably greater detail as shown in Figure 4. Also, it was valuable in recording non-value-added activities such as distances traveled, delays, and temporary storages. In addition, a flow process chart shows all the moves encountered by an item and inspector as it goes in the final visual inspection process. Thus, the researchers highlighted the non-value-added activities of inspectors in the current work procedure to reduce them by improving the process. Furthermore, it indicates that the current work procedure of inspectors consisted of 13 operations, two transportations, one delay, three inspections, and one storage. The total time of that current work procedure to complete was 247.30 seconds.

Current Workplace Layout and Flow Diagram in Final Visual Inspection

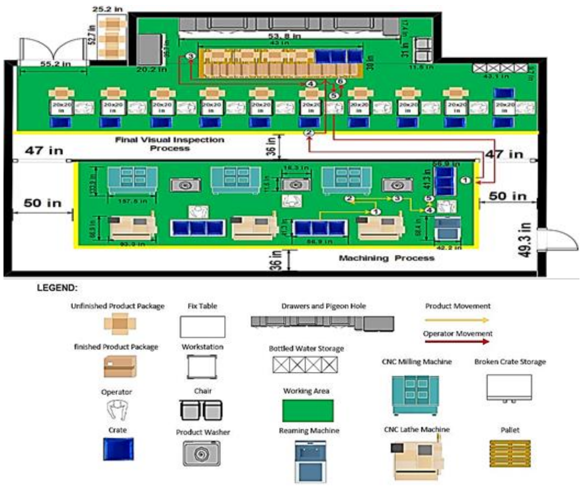


Figure 5. Flow diagram of the current layout of operation in the process

Figure 5 illustrates a workplace layout and flow diagram made in conjunction with a flow process chart to improve the problem related to the time consumed by non-value-added activities of inspectors. Since for every movement of an inspector there is a product involved, it represents either wastes of the process or operations with improvement potential. The workplace layout and flow diagram were very helpful supplements to the researchers since they indicate backtracking and possible traffic congestion in the process. Furthermore, the workplace was too cramped and not big enough for the kind of process. Thus, it facilitates development of an ideal workplace layout.

Value-added time and Takt time

The researchers calculated the takt time to measure the amount of time allowed for a unit to meet customer demand. Further, the main reasons for calculating takt time was to improve value-added activities and recognize hidden non-value-added activities across the process.

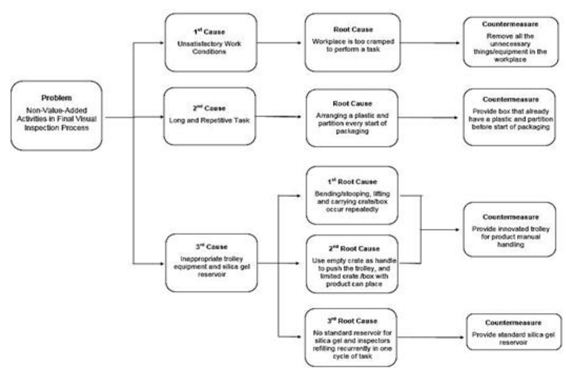
Table 1. Value-added time for final visual inspection process

Step No.	Value-Added	Time (sec)	Takt Time (sec)
1	Get box from the pallet, place plastic, and put partition	34.21	
2	Get product from crate, inspect, and put in box	13.92	
3	Get silica gel	2.48	
4	Prepare second layer	12.34	
5	Get product from crate, inspect, and put in box	16.84	
6	Get silica gel	2.14	
7	Prepare third layer	12.84	
8	Get product from crate, inspect, and put in box	16.70	
9	Get silica gel	2.50	
10	Tape the box	46.81	
11	Writing and putting tag in box	21.90	
Total time		182.68	70.72

Note: Arranging plastic and partition are hidden non-value-added activities or waste in the process

Root Cause Analysis of Non-Value-Added Activities

The researchers constructed a tree diagram to identify the different root cause of the problem in the final visual inspection process. With this tool, it can improve or resolve the moderately difficult problems across the process.



Note: Since the removal of unnecessary things/equipment cannot be done immediately by the company, it is included in the recommendation of the researchers for the company.

Figure 6. Decision tree diagram of root cause analysis

Development of a Prototype

Funding to support development of the concept into a prototype was secured by the researchers. This prototype was developed from the combined ideas of the researchers. Various crates and boxes from the final visual inspection process were staged to assess the optimum size and reach of the trolley; also, the working table of inspectors was assessed for the optimum size of acrylic container.

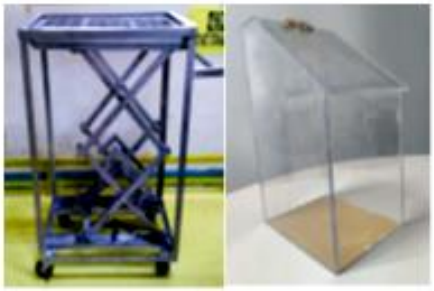


Figure 7. The Prototype

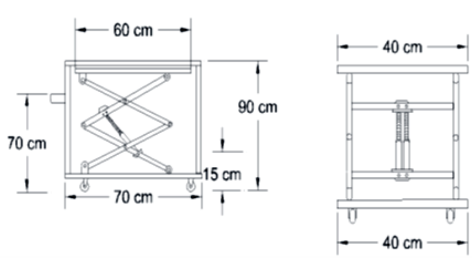


Figure 8. Design and dimensions of self-elevating trolley

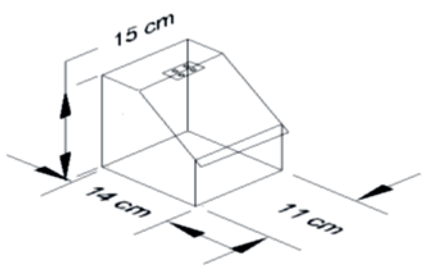
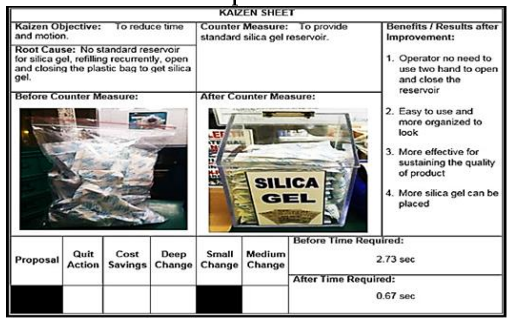


Figure 9. Design and dimensions of silica gel reservoir

Reduction of non-value-added activities using Kaizen technique

These Kaizen improvements were done to reduce fatigue and repetitive motion of inspectors. Thus, these improvements helped reduce the time for completing the task. Also, the non-value-added activities were reduced with the help of proper Kaizen improvements. Rebalancing was also done through the proper distribution of activities at various workstations. Furthermore, the time required for all workstations to complete activities was presented in the final visual inspection process. These are continuous improvements. The basic idea of improvement was taken from actual observation in the final visual inspection process. Also, the team leader and inspectors in the process provided some ideas for improvements.

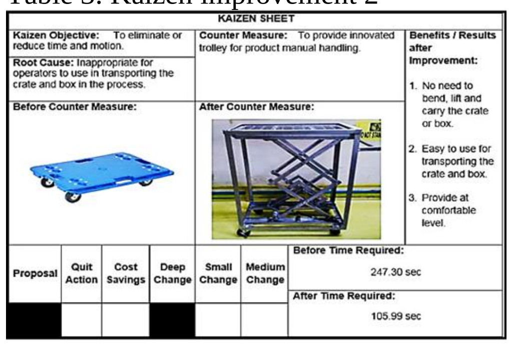
Table 2. Kaizen improvement 1



KAIZEN SHEET							
Kaizen Objective: To reduce time and motion. **Root Cause:** No standard reservoir for silica gel, refilling recurrently, open and closing the plastic bag to get silica gel.				**Counter Measure:** To provide standard silica gel reservoir.			**Benefits / Results after Improvement:** 1. Operator no need to use two hand to open and close the reservoir 2. Easy to use and more organized to look 3. More effective for sustaining the quality of product 4. More silica gel can be placed
Before Counter Measure:				**After Counter Measure:**			
Proposal	**Quit Action**	**Cost Savings**	**Deep Change**	**Small Change**	**Medium Change**	**Before Time Required:** 2.73 sec	
■				■		**After Time Required:** 0.67 sec	

As shown in Table 2, the zip lock bag for the silica gel was changed to acrylic container. This reduced the time and motion of the inspector to get silica gel. Also, refilling recurrently of inspector in 12 hours of work has been reduced since the acrylic container can house more silica gel—up to 150 pieces compared to only 20 pieces that caused delay in operation.

Table 3. Kaizen improvement 2



KAIZEN SHEET							
Kaizen Objective: To eliminate or reduce time and motion. **Root Cause:** Inappropriate for operators to use in transporting the crate and box in the process.				**Counter Measure:** To provide innovated trolley for product manual handling.			**Benefits / Results after Improvement:** 1. No need to bend, lift and carry the crate or box. 2. Easy to use for transporting the crate and box. 3. Provide at comfortable level.
Before Counter Measure:				**After Counter Measure:**			
Proposal	**Quit Action**	**Cost Savings**	**Deep Change**	**Small Change**	**Medium Change**	**Before Time Required:** 247.30 sec	
■			■			**After Time Required:** 105.99 sec	

In Table 3, the joinable platform trolley was changed to self-elevating trolley. Thus, it eliminates the time and motion of the inspector to take a crate or box. Also, it reduced the fatigue of the inspector in transporting the product from machining process to the final visual inspection process.

Table 4. Kaizen improvement 3

KAIZEN SHEET		
Kaizen Objective: To reduce time and motion.	**Counter Measure:** To provide innovated trolley with a comfortable height of handle and can placed more crate and box.	**Benefits / Results after Improvement:** 1. No need to use empty crate to make a handle 2. More crate or box can be placed 3. More comfortable to use in product handling
Root Cause: Empty crate is use to make a handle while transporting and only limited crate and box can be placed.		
Before Counter Measure: 	**After Counter Measure:** 	

Proposal	Quit Action	Cost Savings	Deep Change	Small Change	Medium Change	Before Time Required: 11.40 sec
■					■	After Time Required: 8.70 sec

In Table 4, the time has been reduced as well as the fatigue of the inspector in going back and forth from final visual inspection process to the machining process since the inspector can place a up to nine crates with product in the proposed prototype trolley.

Table 5. Kaizen improvement 4

KAIZEN SHEET		
Kaizen Objective: To reduce time and eliminate motion.	**Counter Measure:** To provide innovated trolley for the side of the operator at comfortable height.	**Benefits / Results after Improvement:** 1. No need to bend and easy to pick a product from the crate. 2. Crate place at comfortable height.
Root Cause: Bending occur while taking a product from the crate to inspect.		
Before Counter Measure: 	**After Counter Measure:** 	

Proposal	Quit Action	Cost Savings	Deep Change	Small Change	Medium Change	Before Time Required: 15.82 sec
■					■	After Time Required: 9.06 sec

In Table 5, it reduced the time and eliminated bending as well as strain at the back of the inspector to pick a product from the crate at a very low level of height. Furthermore, the result also leads to increase the morale of inspectors in terms of more enjoyable work and reduce overly complicated processes.

Table 6. Kaizen improvement 5

KAIZEN SHEET		
Kaizen Objective: To eliminate time and motion.	**Counter Measure:** To provide innovated trolley for product manual handling.	**Benefits / Results after Improvement:** 1. No need to bend, lift and carry the box to place in trolley from the pallet. 2. Product handler can easily get and transport the box.
Root Cause: Product handler bend to lift and carry the box from the pallet to place in existing trolley.		
Before Counter Measure: 	**After Counter Measure:** 	

Proposal	Quit Action	Cost Savings	Deep Change	Small Change	Medium Change	Before Time Required: 18.78 sec
■					■	After Time Required: eliminated

Table 6 shows that before, the product handler used the joinable platform trolley to transport the box from the final visual inspection process to the warehouse. Hence, the self-elevating trolley has been provided for the product handler; and as a result, it eliminated the time as well as motion/fatigue of the product handler since the box was already placed by inspectors in the self-elevating trolley. Moreover, it eliminated the waiting time of inspectors to the product handler to get the box in the final visual inspection process.

Analysis of Data for Before and After Kaizen Improvement

The results were analyzed by referring to the obtained data from before and after Kaizen improvement to measure the effectiveness of the Lean-Kaizen concept. Some tangible and intangible benefits of Kaizen were observed in the form of reduction of non-value-added activities and improvement in productivity.

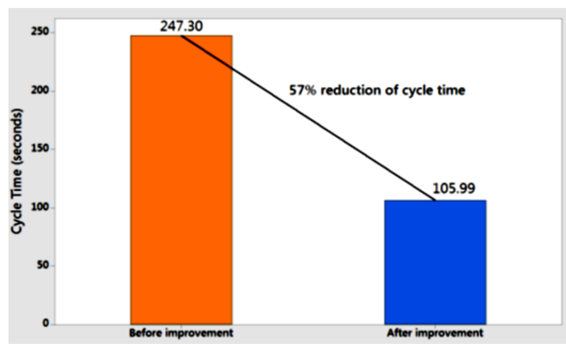
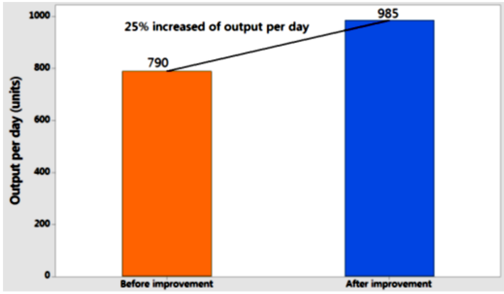


Figure 10. Analysis of time for one cycle

Figure 10 shows that the cycle time of the inspector is decreased from 247.30 seconds to 105.99 seconds. Percentage improvement observed is 57 percent reduction of cycle time. This shows that non-value-added activities in the process were reduced since the Kaizen technique was utilized.



Note: Data for output per day was retrieved from Quality Control Assurance Department

Figure 11. Analysis of output per day

As shown in Figure 11, the number of units before was 790 then it increased to 985 units after the Kaizen improvement. Percentage improvement observed was 25 percent increase. This shows that the Kaizen technique is very significant to resolve the problem, but also it validates that the reduction in cycle time has an impact in the increase of output per day and the productivity of inspectors in the final visual inspection process.

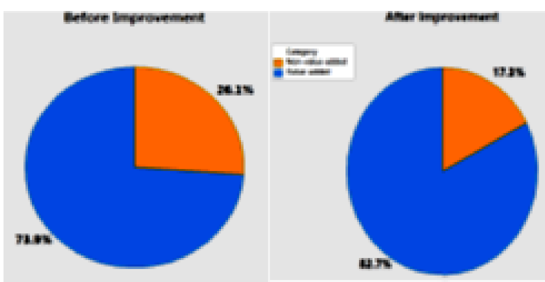


Figure 12. Analysis of non-value added and value-added activities

In Figure 12, the time was saved, and cost related to time was utilized properly by reducing non-value-added activities. Also, it indicates that streamlining the process through innovating existing trolley and developing a standardized procedure in the process improved value-added activities and reduced time of inspectors for completing the task. Thus, the number of non-value-added activities has significantly reduced in the final visual inspection process by 34 percent.

Cost Benefit Analysis

The researchers used cost-benefit analysis to analyze decisions, to compare the total costs of a study with its benefits, and to evaluate the overall impact of the study in quantifiable and monetized terms.

Table 7. Cost-benefit analysis of the intervention made to the equipment and work procedure

Cost – Benefit Analysis on Gunma Gohkin Philippines Corporation				
Current	**Component**	**Quantity**	**Price (Php)**	**Total (Php)**
Costs	Joinable Platform Trolley	22	12,173.47	267,816.34
	Plastic Bag	10	199.00	1,990.00
	Labor (procurement officer)	1	16,000.00	16,000.00
	Cost of Labor	5	8,000.00	40,000.00
	Days Delayed of Delivery	3	7,000.00	21,000.00
			TOTAL COSTS	**Php 346,806.34**
Benefits	Output per day	820	23,000.00	18,860,000.00
			TOTAL BENEFITS	**Php 18,860,000.00**
	Percentage Occurrence of Health Risk and Injuries of Inspector	16/30	53.33%	
Proposed	**Component**	**Quantity**	**Price (Php)**	**Total (Php)**
Costs	Self-Elevating Trolley	22	3,500.00	77,000.00
	Acrylic Container	10	800.00	8,000.00
	Labor (fabricator)	1	7,000.00	7,000.00
	Presenteeism of Labor	2	8,000.00	16,000.00
	Days Delayed of Delivery	1	7,000.00	7,000.00
			TOTAL COSTS	**Php 115,000.00**
Benefits	Output per day	985	23,000.00	22,655,000.00
			TOTAL BENEFITS	**Php 22,655,000.00**
	Percentage Occurrence of Health Risk and Injuries of Inspector	9/30	30.00%	
Savings in terms of Costs				
	Current – Proposed			**Php 231,806.34**
Increase in Productivity				
	Proposed – Current			**Php 3,795,000.00**
Percentage Reduction of Health Risk and Injuries of Inspector				
	(Current – Proposed) / Current			**43.75%**

Note: (a) The estimate was agreed as reasonable by top management of the company and was sufficiently favorable to convince the management team to implement the intervention strategy that was proposed, (b) After one year, the company can re-assess due to some changes in work situations in the process.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The observed results, it significantly showed that the cycle time was reduced from 247.30 seconds to 105.99 seconds and non-value-added activities were reduced by 34 percent. Furthermore, the output per day increased by 25 percent, process cycle efficiency increased by 12 percent, and the value-added time was reduced by 52 percent. Actual simulation was conducted to verify and validate the existing situation as well as to propose the results and the effectiveness of lean principles in a systematic manner with the help of a prototype.

Overall, the research shows that Kaizen and other lean tools/methods were found to be effective techniques that assist in handling waste or non-value-added activity removal in real-time working situations at the production process and motivating the individual to achieve the goals of the company.

Recommendations

Since the product handler transports the finished package product from the final visual inspection process to the warehouse, it is recommended to the final visual inspection process to change the opening direction of a door from inward to outward, to avoid any traffic congestion inside the process room and, for safety purpose of inspectors.

It is recommended for future researchers to resolve the second highest processing time that is part of the machining process, specifically, the lathe machine. It is also recommended for future researchers to use other Industrial Engineering techniques to resolve and improve the machining process of the company.

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