

Inspection Machine Productivity Improvement by Lean Manufacturing Technique: A Case Study of an Automotive Parts Company in Nakhon Ratchasima

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Abstract

The objective of this research was to increase the production capacity of the inspection machine's brush holder base components to meet the rise of customer demand from 100,000 to 110,000 pieces per month. The study began with examining the machine's operation, creating a Value Stream Map, and analyzing the waste occurred, primarily identifying waste from motion loss, process loss due to unsuitable sequence of working, and waiting loss. After applying the ECRS principles, particularly Elimination and Rearrangement to improve the workflow, the research found that the total number of steps in the inspection machine's operation could be reduced from 17 to 14 steps (a 17.65% reduction) and the total time for one cycle could be reduced from 20 seconds to 15.45 seconds (a 22.75% reduction). This resulted in an increase in production capacity from 95,040 pieces per month to 123,029 pieces per month (a 29.45% increase), successfully achieving the objectives towards the customer demands of 110,000 pieces per month.

Keywords

Productivity Improvement, Waste Reduction, ECRS Concept, Lean Manufacturing, Automotive Parts production.

1. Introduction

The demand for automotive spare parts remains constant for both new vehicle production and repairs. As of December 31, 2024, Thailand had over 44 million registered vehicles, with a rising trend every year, driving increased production in the automotive parts sector. The case study company produces Carbon brush holder for ABS Pump motors. The process involves injection molding, component assembly (Carbon brushes, wires, springs), and final testing using an inspection machine to verify electrical properties and physical completeness.

Currently, the company faces a challenge as customer orders have increased from 100,000 to 110,000 pieces per month (110% of original capacity). The existing inspection machine has been in operation for a long time without significant improvements. This research aims to apply Lean Manufacturing techniques to identify waste and improve the machine's efficiency to meet the increased demand and enhance the company's competitiveness.

1.1 Objectives

- To study the identification of waste in the workflow of the inspection machine of a company in Nakhon Ratchasima Province.
- To increase the number of workpieces that can be inspected to meet customer requirements.

2. Literature Review

2.1 Lean Manufacturing Principles

During the late 19th century, most production relied on manual labor. In 1776, James Watt successfully developed the steam engine, which marked the beginning of the Industrial Revolution, as steam engines were increasingly used to power various types of machinery, especially in the textile industry. Later, in 1908, Ford Motor introduced the Model-T automobile, marking the first instance of mass production. (Phenapa Chaengarun, 2020).

In 1950, Eiji Toyoda visited the Ford River Rouge Complex in Dearborn, Michigan, USA, where he observed inefficiencies in the production process. He then restructured Toyota Motor's production system by applying mass-production methods while improving and refining them. This led to the development of the Lean Production System, originating from Eiji Toyoda's ideas and eventually evolving into the Toyota Production System. Over time, Toyota continued to develop and expand these concepts into many branches, shaping the system as it is known today. (Kosal Deeseelatham., 2009).

2.2 ECRS Principle to Reduce Waste

The ECRS principle is employed:

- E (Eliminate): Removing unnecessary steps
- C (Combine): Merging steps to save time
- R (Rearrange): Reordering steps to reduce movement or waiting
- S (Simplify): Making the process easier and faster (Napawan Sukkhajai, 2012)

2.3 Value Added Analysis

- Value Added (VA): Adds direct value to the product.
- Necessary but Non-Value Added (NNVA): Essential for operations but adds no value (e.g., Inspection setup).
- Non-Value Added (NVA): Pure waste that should be eliminated. (Nenad Marcetic, 2568)

2.4 The 8 Types of Waste

Based on the concept introduced by Taiichi Ohno, regarded as the father of the Toyota Production System, the term Muda refers to unnecessary waste within processes. Today, the acronym TIMWOODS is commonly used to categorize these types of waste:

- T – Transportation Waste: Unnecessary movement or transportation of materials
- I – Inventory Waste: Excess inventory or storage beyond what is required
- M – Motion Waste: Unnecessary motion or movement of people or equipment
- W – Waiting Waste: Waiting for materials, information, or the next process step
- O – Over-Processing: Performing more work or using more processes than necessary
- O – Over-Production: Producing more than what is required
- D – Defect: Production of defective items, scrap, or the need for rework
- S – Skills: Not using people's skills to full potential
(<https://www.learnleansigma.com/template/8-wastes-timwoods-template>)

3. Methods

The research methodology follows these steps:

- Study current operation: Observe the machine's working cycle and record 1 cycle time.
- Create Current State VSM: Analyze the steps to categorize them into VA, NVA, and NNVA.
- Analyze waste: Identify specific wastes (Motion, Process, Waiting) using the 7 Wastes framework
- Apply ECRS: Propose solutions to eliminate or reduce identified wastes.
- Create Future State VSM: Design the improved workflow.
- Compare Results: Measure the difference in cycle time and production capacity between the current and improved states.
- Summarizing: The research findings by evaluating the implementation outcomes through the number of workpieces produced and the time taken by the inspection machine to perform its tasks, and by comparing the production capacity with customer demand.

4. Testing and Results

4.1 Current Machine Operation

The production line for Model A involves assembly and inspection processes, with workpieces passing through steps such as plastic injection molding, deburring, and cleaning. Key assembly stages include carbon brush assembly, wire assembly, spring assembly, wire soldering, and automated inspection. The inspection checks electrical properties, workpiece shape, and completeness of component assembly. Employees place the workpiece on the inspection jig, start the machine, and the inspected workpiece is then transferred down a chute to the next process (Table 1-Table 4).

4.2 Current State Analysis

Table 1. Current state process analysis

Step	Detail	Value Analysis	Time (second)
1	The actuator moves the workpiece to Position 1 to prepare for inspection.	NVA	1.25
2	The inspection camera checks whether the spring is present on the left side of the workpiece.	VA	0.5
3	The inspection camera checks whether the spring is present on the right side of the workpiece.	VA	0.5
4	The inspection camera checks whether the wire is present on the left side of the workpiece.	VA	0.45
5	The inspection camera checks whether the wire is present on the right side of the workpiece.	VA	0.45
6	The inspection camera checks whether the workpiece has both (two) carbon brushes.	VA	0.55
7	Pneumatic cylinder 1 moves downward to inspect the electrical characteristics of the workpiece.	NVA	1.2
8	Electrical characteristics are inspected.	VA	1.65
9	Pneumatic cylinder 2 moves upward to check the length of the workpiece.	VA	1.5
10	Pneumatic cylinder 2 moves downward back to its initial position.	NVA	1.5
11	Pneumatic cylinder 1 moves upward back to its initial position.	NVA	1.2
12	The machine actuator moves the workpiece to Position 2 to prepare for removal from the jig.	NVA	2
13	Pneumatic cylinder 3 moves upward to lift the workpiece from the receiving jig.	NVA	1.5
14	Pneumatic cylinder 4 moves to the right to push the workpiece down the transfer chute.	NVA	0.5
15	Pneumatic cylinder 4 moves to the left, returning to its initial position.	NVA	0.5
16	Pneumatic cylinder 3 moves downward, returning to its initial position.	NVA	1.5
17	The actuator moves back to its initial position	NVA	3.25

4.3 Waste Identification

After analyzing the following findings were observed:

- Step 1 contains waste caused by motion, as the actuator moves too slowly.
- Steps 2 through 6 contain waste due to an improperly sequenced production process, as the inspection alternates between left and right multiple times.
- Step 13 contains waste caused by motion, because Pneumatic Cylinder 2 has an excessively long stroke, resulting in long travel time for both forward and return movements.
- Steps 15 through 16 contain waste caused by waiting, as Pneumatic Cylinder 3 must wait for Pneumatic Cylinder 4 to return to its initial position before it can continue its movement.
- Step 17 contains waste caused by waiting, as the actuator must wait for Pneumatic Cylinder 3 to move down to its initial position before it can proceed. (Simplify): Making the process easier and faster

4.4 Using the ECRS Concept to Determine the Steps for Reducing Waste in the Process

4.5 Create a Value Stream Map of the Inspection Machine After Improvement

Table 2. After improvement state process analysis

Step	Detail	Value Analysis	Time (second)
1*	The actuator moves the workpiece to Position 1 to prepare for inspection.	NVA	1.15
2*	The inspection camera checks whether the left side of the workpiece has all components: spring, wire, and carbon brush.	VA	0.8
3*	The inspection camera checks whether the right side of the workpiece has all components: spring, wire, and carbon brush.	VA	0.8
4	The pneumatic cylinder 1 moves downward to inspect the electrical characteristics of the workpiece.	NVA	1.2
5	Electrical characteristics are inspected.	VA	1.65
6	The pneumatic cylinder 2 moves upward to check the length of the workpiece.	VA	1.5
7	The pneumatic cylinder 2 moves downward back to its initial position.	NVA	1.5
8	The pneumatic cylinder 1 moves upward back to its initial position.	NVA	1.2
9*	The machine actuator moves the workpiece to Position 2 to prepare for removal from the jig.	NVA	1.75
10*	Pneumatic cylinder 3 moves upward to lift the workpiece from the receiving jig.	NVA	1
11*	Once the sensor detects that the workpiece has been lifted from the receiving jig, the actuator moves back to its initial position.	NVA	2.9
12	Pneumatic cylinder 4 moves to the right to push the workpiece down the transfer chute.	NVA	0.5
13*	Once the sensor detects that the workpiece has been pushed into the transfer chute, pneumatic cylinder 3 immediately moves downward back to its initial position.	NVA	1
14	Pneumatic cylinder 4 moves back to the left, returning to its initial position.	NVA	0.5

* Means the steps that have been improved.

4.6 Comparison Current vs. After Improvement

Table 3. Summary of steps and time used before and after improvement

Item	Before	After	Percentage decrease
All process step	17 Step	14 Step	17.65 %
Value Added (VA)	7 Step	4 Step	42.86 %
Non-Value Added (NVA)	10 Step	10 Step	0 %
Total Time for all steps	20 seconds	17.45 seconds	12.75 %
Total Time per cycle (1 Cycle)	20 seconds	15.45 seconds	22.75 %

Table 4. Summary of the number of pieces produced before and after improvement

Item	Before	After
Production capacity 1 day (8 hours, 2 shifts working)	2,880 pieces	3,728 pieces
Production capacity 24 day (8 hours, 2 shifts working)	69,120 pieces	89,475 pieces
Production capacity 24 day (11 hours, 2 shifts working)	95,040 pieces	123,029 pieces

5. Conclusion

The research on the inspection machine at an automotive parts manufacturing company in Nakhon Ratchasima Province began with a study of the machine's operation. A value stream map was then created, followed by an analysis of waste, which identified waste due to motion, improper sequencing of production processes, and waiting time. The ECRS principles were applied to eliminate waste, using the *Eliminate* and *Rearrange* strategies. After improving the workflow, the number of inspection machine steps was reduced from 17 to 14, a reduction of 3 steps or 17.65%. The total time for all steps decreased from 20 seconds to 17.45 seconds, a reduction of 2.55 seconds or 12.75%. The total cycle time (1 cycle) decreased from 20 seconds to 15.45 seconds, a reduction of 4.55 seconds or 22.75%. Production capacity increased from 95,040 units per month to 123,029 units per month, an increase of 27,989 units or 29.45%. This was achieved using 11-hour workdays, 2 shifts per day, for 24 days, which is sufficient to meet the customer demand of 110,000 units per month.

6.Future Work

- Selecting pneumatic cylinders with a stroke length appropriate for the application, which may affect costs and spare parts storage.
- Some inspection steps can be relocated to earlier production processes before this stage. For example, workpiece length can be checked during the plastic injection molding process, which may further reduce the total cycle time.
- Machine design should involve collaboration among multiple departments to improve the design before manufacturing. In addition to production time, considerations should include worker safety, product quality, maintenance, and calibration.

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Biography

Mr. Thanapong Sa-ngiamsoongnoen. Currently in the position of Assistant Manager in the High-Frequency Heat Induction Department with experience in Maintenance, Process engineer and QA section. He holds a Bachelor of Engineering in Mechanical Engineering from Suranaree University of Technology and still improves engineer working skills.