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An Improvement of Raw Material Incoming Inspection Process by Implement Lean and IE Techniques

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Abstract. The objective of this paper is productivity improvement by means of Lean Manufacturing Principles in the automotive manufacturing industry. Lean Manufacturing is a popular tool to be implemented in automotive industry fields for the purpose of achieving successful production goals and it is a well-organized method used to eliminate waste or non-value-added activities. In this paper, the author is focused on IE Techniques which are work study and ECRS technique. This was obtained by decreasing the manufacturing cost by reducing the cycle time of raw material incoming inspection process and reducing workforce. An improvement in a case study of automotive manufacturing company was achieved by minimizing the cycle time. The suggestion for improvement by changing the measuring equipment and changing the sequence of raw material incoming inspection process can reduce inspection time from 3.64 hours per lot to 1.70 hours per lot, introduce new automatic collect data equipment (U-WAVE) can reduce re-inspection time by human error from 70.94 hours to be zero hours and set up the new standard of raw material incoming inspection level can reduce inspection time from 390.83 hours to 16.03 hours.

Keywords: productivity improvement, lean thinking, Waste(Muda), ECRS, Barnstorming.

1. Introduction

The company that was involved in this study is an automotive manufacturing company. The company faced the problem of customer orders fluctuating according to the economic situation. Sales in the year 2021 can achieve only 80% compared to the budget plan. Therefore, the Top management has temporarily suspended the employee recruitment plan and announced a policy to improve the working process and improve productivity in manufacturing. This project focuses on finding the solution for the incoming inspection process. Improvement activities start from work study and time study to understand the incoming inspection process and apply lean and IE techniques for improvement.

2. Literature review

A. Lean Tool

Kulkarni et al. 2014, Lean Manufacturing reduces the operation time of processes, increases maneuverability, and improves the corresponding attributes. It optimizes customer significance, minimizes waste, thereby achieving manufacturing excellence through the creation of more value with fewer or no capital investments. The various tools of Lean Manufacturing are given in figure 1.

Lean tools have not been derived or proposed in one single day. They have been derived from the research of people throughout the history. As they are why very complex & interdependent on each other and one can find similarities in one another [1]

Fig. 1. Lean tools (Kulkarni et al. 2014).

1) Type of wastes

The main goal of lean manufacturing is to eliminate waste by identifying seven types of waste. They are overproduction, waiting times, unnecessary transportation, unnecessary processing, unnecessary motion, waiting inventory and defected products.[2],[3]

2) 7 Wastes (Muda)

1. Transportation - The unnecessary movements of operator, products or components from one place to another result in this waste. Unnecessary transport more commonly occurs together with product damages, lost parts and systems, which are related with movements.
2. Inventory - Inventory is the quantity of materials in stores, which are required to manufacture a job. When they are not used, they take up valuable storage space, may become useless, which cannot be used for more important goods.
3. Motion - This waste comprises of all unnecessary movements occur when operator is moving around his work area and as a result of this; his time & efforts are wasted. All kinds of unnecessary motion may be caused by improper working standard practices, un-optimized process design or work space layout.
4. Waiting - If operators, machine, system or materials of the production process are delayed by any reason, production time is wasted, the productivity is decreased & the cost of production will be increased.
5. Over Processing - It can also mean manufacturing the products of a larger quality than required. This can also be result of not checking what the customers' real requirements are.
6. Over Production - It arises when the manufacturer is producing more products than the customer really asks for. This is the worst kind of waste, as it generally creates other kinds of wastes. It increases rework factor, material storage, processing, holding & waiting, as well as transportation & unnecessary motion.
7. Defects (Rework, Scrap) - Rework is required when products and components are defective or damaged. Defects are caused by bad manufacturing processes (caused by human or machine errors). In worst case scenario the items have to be discarded.

In these 7 wastes, 'Over Production' & 'Inventory' are observed to be very similar to one another & hence, in modern Lean Methodology, 'Inventory' is often replaced by 'Inspection'.

B. Work Study

In order to understand the work study methods, we need to understand the importance of method study and that of time study. 'Method study' (sometimes also called Work Method Design) is mostly used to improve the method of doing work When applied to existing products, method study aims to allocate better methods of manufacturing the jobs that are safe, effective, & economical, require mitigated human effort, and need smaller make-ready time. The better method involves the optimum use of best materials and appropriate manpower so that work is performed in well-organized manner leading to increased resource utilization, optimized quality and appeased costs.

Work study has been explained in brief in figure 2.

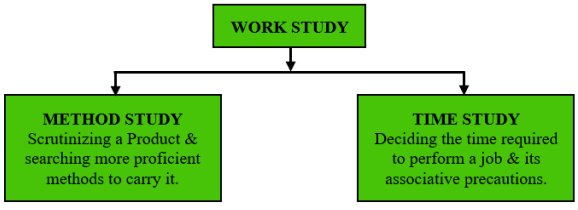


Fig. 2. Work Study Methods (Kulkarni et al. 2014).

It can therefore be stated that through 'Method study' one can have a systematic way of developing human resource ascendancy, providing elevated machine and equipment use and making economical use of

raw materials. ‘Time study’, however, provides the standard required time, that is the time needed by worker to complete a job by the standard method. By the application of method study and time study together with Lean Tools, any industry can thus achieve greater output at less cost and of better quality, and hence can easily achieve higher productivity [4].

1) Method study (work method design)

As seen earlier, Method study method of doing work, and for this reason method study is sometimes called Work Method Design. The following steps depict study.

1. Select (the work to be studied)
2. Record (all relevant information
3. Examine (the recorded information)
4. Develop (an improved way of doing things)
5. Install (the new method as standard practice)
6. Maintain (the new standard proactive)

2) Time study (work measurement)

Work measurement refers to the estimation of standard time for an activity that is the time specific for completing one job by using the predicted method. Standard time can be defined as the time utilized by an average experienced skillful operator for the job with provisions for delays beyond the operator’s control.

A work has to be measured for the following reasons:

- To identify and eliminate missing or ineffective time.
- To install standard times for performance & quality measurement.
- To measure performance against original expectations.
- o set manufacturing & operation objectives.

Time study can be simply defined as a technique to estimate the time to be allowed to a qualified and well -trained worker working at a normal pace to complete a specified task by using specified method.

C. ECRS

ECRS is an effective approach of the motion study technique used to improve production lines proposed by Mogensen (1932). ECRS represents the four core principles. First, eliminate waste (E) found in manufacturing such as waiting time, unnecessary movement and work step. Second, combine unnecessary work steps (C) to reduce the number of working steps and total processing time. Third, rearrange any process step (R) for reducing distance of moving or the number of movements. Finally, simplify (S) or propose easier method for working or introduce new equipment such as jigs, fixtures, support tools, or machine modification, to support operators. ECRS is a common technique in motion study; thus, when any process faces with inefficient working condition related to human works, ECRS is firstly considered and gives the effective results after implementation. When ECRS is introduced to improve any process, the results include reduction in processing time and proposing efficient working steps that can reduce unnecessary movement and waiting time. The improvement from ECRS leads to reduction in system cost and energy cost while the processing time is reduced. Furthermore, material cost and waste cost are reduced when the improvements are affected to reduce material loss from inappropriate working methods. [5],[6]

3. Methodology

The theory is applied to improve the raw material incoming inspection process by eliminating unnecessary workflows, reorganization of working steps and changing the tool to measure the component

part to make it easier for employees to work, increase productivity to meet the needs of customers. The steps and procedures have been planned in fig.3.

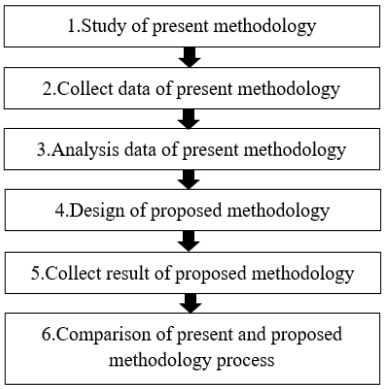


Fig. 3. Step follow for study incoming inspection process case study.

A. Incoming Inspection Process

Scope of work study is component part from a local supplier there are 8 steps of incoming inspection process.

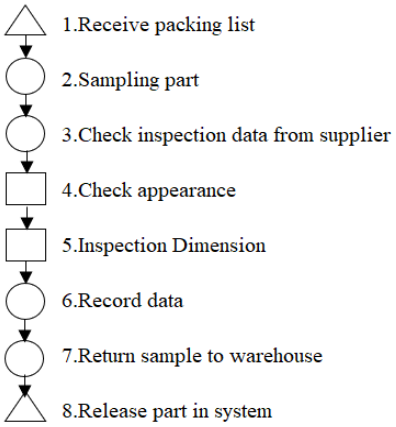


Fig. 4. Raw material incoming inspection process.

Sampling of parts for inspection will be randomly by lot number. The incoming inspection lot from January 2020 - April 2021, it was found that the average number of lot receiving was 243 lots per month, the maximum of receiving lot was 355 lots, and minimum of number lot receiving is 114 lots per month.

B. Selection Employee for Study Inspection Time and Collect Data

The current employee 3 persons who work for incoming inspection section was selected for work study and record inspection time. Study inspection time of each part number by using average inspection time for 3 lots.

C. Analysis Data

After studying the present incoming inspection process of case study company, the next step is to analyze the root cause of the problem and find a solution to the problem by using the theory of elimination of 7 wastes.

it was an analysis by applying the principle of 4M1E which would consist of Man factor, Machine factor, Method factor, Material factor and Environment factor.

D. Design of Proposed Methodology

To design the solution, this step applies ECRS technique. The solution of the problem was presented to Top management. All activities get approved before action in manufacturing.

1. Reduce inspection time and set the new standard.

2. Change the inspection sequence to reduce the total inspection time.

Apply easier method for working and introduce new equipment.

4. Result and Discussion

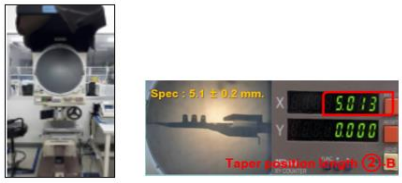
The work study is done of every work element and problem is identified below.

1. Time study use the stop watch. The result of time study data is given in Table I for incoming inspection process. There are 13 products and finding the highest of inspection time is part number 7 after brainstorming with the manager, supervisor and relevant employee the result found that the measuring equipment is not proper this part using profile projector to measure the dimension it's not use image measurement machine (IM) because some inspection point is unable to measure by image measurement machine (IM). And inspection step is not proper it should be rearranged inspection step to reduce movement distance.

   The inspection equipment has been shown in fig.5

TABLE I. INSPECTION TIME OF RAMATERIAL 13 PART NUMBER

No.	Process Element	Part number												
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Receive packing list	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	Sampling part	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
3	Check supplier data	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
4	Appearance check	10.0	5.0	15.0	2.0	10.0	10.0	15.0	15.0	15.0	10.0	15.0	15.0	15.0
5	Dimension check	9.0	3.0	27.3	1.5	8.0	8.0	218.5	186.6	154.0	78.2	46.2	27.9	13.4
6	Record data	25.0	25.0	30.0	30.0	25.0	28.0	60.0	110.0	110.0	110.0	25.0	28.0	35.0
7	Return sample to warehouse	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
8	Release part in system	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Total time(min)	**79.0**	**68.0**	**107.3**	**68.5**	**78.0**	**81.0**	**328.5**	**346.6**	**314.0**	**233.2**	**121.2**	**105.9**	**98.4**



Profile projector & Inspection

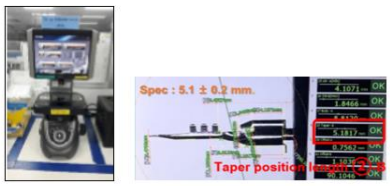


Image measurement machine & Inspection

Fig. 5. Inspection equipment.

2. Inspection report is rejected by the supervisor because the dimension record is a mistake. The result found human error because the employee manually records the inspection data mistake and typed the inspection result in the computer by keyboard mistake. The number of the rejected report have been shown in Table II. The reason of the human error is because one component part has many inspection items and employees hurry up to write down the result in the inspection report and fast type the data in the computer.

TABLE II. THE NUMBER OF REJECTED REPORT

Part number	Apr	May	Jun	Jul	Aug	Sep
1	5	4	8	6	3	1
2	8	8	2	6	7	7
3	33	47	32	50	58	55
4	7	2	0	5	6	0
5	2	4	11	14	12	0
6	13	11	6	10	11	15
7	12	5	8	12	10	9
8	1	0	2	0	1	0
9	1	0	1	1	0	0
10	15	12	35	32	28	37
11	38	36	22	33	27	45
12	9	23	22	27	16	19
13	4	5	3	2	3	3
Total received	148	157	152	198	182	191
Report mistake	6	8	4	4	7	5
% report mistake	4%	5%	3%	2%	4%	3%

To eliminate human error Top management approves to introduce of automatic collect data equipment (U-Wave) for the small tool. For the incoming inspection process use 2 types (1) Blade micrometer (2) Vernier caliper.

U-wave is the system of transferring measurement data from measuring instruments to user software such as Excel or Notepad via wireless data transmission saves time and reduces Error in recording data. It also reduces costs and improves efficiency. U-wave have been shown in fig.6.

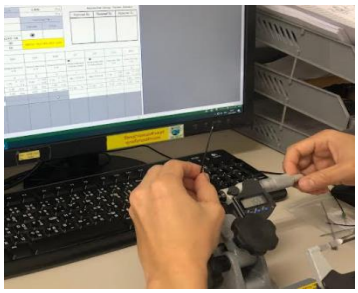


Fig. 6. Implementation U-wave for small tool.

3. From the study, there was no quality problem at the incoming inspection process when checking the data backward for 1 year, it was found that there was no component part rejection at all and the most supplier is more than 10 years of operations. The new inspection level by adjusting the frequency of lot inspection is considered to implement for high performance supplier. The result of inspection of the period April 2021-September 2021 have been shown in Table III.

TABLE III. THE RESULT OF INSPECTION APRIL-SEPTEMBER 2021

Part number	Month						Total inspection (lot)	Inpection result(Lot)	
	Apr	May	Jun	Jul	Aug	Sep		Pass	Fail
1	5	4	8	6	3	1	27	27	0
2	8	8	2	6	7	7	38	38	0
3	33	47	32	50	58	55	275	275	0
4	7	2	0	5	6	0	20	20	0
5	2	4	11	14	12	0	43	43	0
6	13	11	6	10	11	15	66	66	0
7	12	5	8	12	10	9	56	56	0
8	1	0	2	0	1	0	4	4	0
9	1	0	1	1	0	0	3	3	0
10	15	12	35	32	28	37	159	159	0
11	38	36	22	33	27	45	201	201	0
12	9	23	22	27	16	19	116	116	0
13	4	5	3	2	3	3	20	20	0

The current inspection standard separates the level of inspection as following;

- Appearance inspection follow AQL standard and control for 3 inspection level.
  - (1) Tightened Inspection
  - (2) Normal Inspection
  - (3) Loosed/Reduced Inspection

Type	Sampling size (n) Ac=0		
Lot (n)	Tight	Normal	Loose
2-50	100% inspection		
51-125			50
126-200		125	50
201-1250	200	125	50
1251-10000	200	125	50
10001-	800	125	50

The criteria to adjust the inspection level of appearance inspection show in the fig.7

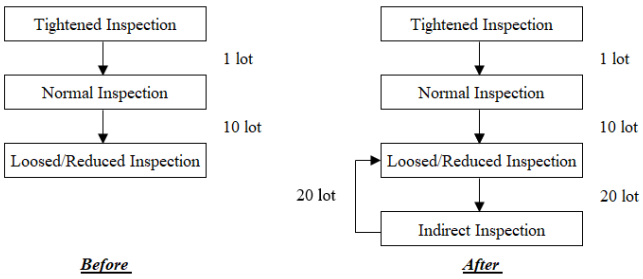


Fig. 7. The criteria of appearance inspection level adjustment.

- Dimension inspection standard have 2 levels (1) the first lot received will be inspected 30 pieces and then adjust to normal level by sampling check 5 pieces per lot.

The criteria to adjust the inspection level of dimension inspection show in the fig.8.

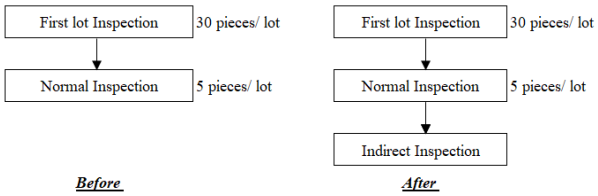


Fig. 8. The criteria of dimension inspection level adjustment.

The new standard of indirection inspection level means Inspection the supplier certificate or supplier inspection data until 20 lots then adjust back to the normal inspection 1lot.

5. Conclusions

The purpose of this study to improve incoming inspection process by applying the principles and methods of lean technique to eliminate waste and improve working methods by IE techniques. The related standardized work was modified and implemented effectively. After improvement, the comparison of the present and new methods are shown in Fig.9.

1. Changing the measuring equipment of the profile projector to an image measurement machine and rearrange the inspection step can reduce the inspection time of part no.7 from 3.64 hours per lot to 1.7 hours per lot. Time reduction per month is 18.11 hours.
2. Introduce automatic collect data equipment (U-Wave) for small tool 2 equipment (1) Blade micrometer (2) Vernier caliper. This improvement can reduce the loss time of re-inspection and record data by manual from 70.94 hours to zero.
3. Adjust inspection frequency of the good quality product. This new inspection standard will apply to the best performance supplier. Time reduction per month is 374.81hr.

Improvement	Before (hr)	After(hr)	Time reduce per month (hr)
Change measuring equipment	3.64	1.70	18.11
Introduce automatic collect data equipment	70.94	0	11.82
Adjust inspection frequency of good quality product	390.83	16.03	374.81
			404.74

Fig. 9. Comparison of before and after improvement.

From the above paper & Studies, it can be concluded that, Lean tools when effectively combined with Work Study Methods, if implemented in proper order, 100% positive results are assured.

6. Acknowledgements

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