

# **Streamlining the Flow of Production System through Elimination the Waste of the Overburden (*Muri*) for Manual Handling Process**

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## **Abstract**

In this paper the process improvement activity in a production system towards streamlining the production flow using the PDCA (Plan-Do-Check-Act) model for manufacturing industries was investigated by focusing on the waste of overburden (*muri*) for manual handling process. Currently the implementation of the continuous improvement in industries has numerous versions focusing on the elimination of the wastes (*muda*) but less consideration of work on overburden (*muri*). One of the issues in continuous improvement activity in manufacturing industries is to overlook other wastes as defined by Lean Manufacturing (LM) which are *Mura* and *Muri*. Targeting on the optimizing and streamlining the production flow, the detailed steps and processes of PDCA were used in this research based on experiences, knowledges and availability of the data collection. Thus, in this paper, detailed adaptation process for each phase in PDCA was investigated through published literature, current implementation of PDCA in case study industry and performance of the production system in the case study industry. Based on the investigation and implementation of the case study industry, the result shows an adaptation of PCDA in eliminating the waste of overburden (*muri*) with suitable tools for each phase complements well with the continuous improvement program. The production output as determined through the developed PCDA tools increased by 17.7% by the end of continuous improvement program.

## **Keywords**

Overburden (*muri*), PDCA, manual handling, production flow, continuous improvement program.

## **1. Introduction**

In the manufacturing industry, facility layout will be the main consideration in the control system to maintain and improve the production efficiency in production line. It is also known as factory layout or plant layout it depends on the organization of company consideration and focusing. Facility layout has been a significant contributor to manufacturing performance, has been studied many times over the past decades. A good placement of facilities will contribute to the overall efficiency of operation and can reduce until 50% of the total operating expenses (Drira et al., 2007). Rosenblatt (1986) also stated that better placement of facilities will reduce about 20% to 50% of the total operating expenses in term of reduced costs by 10% to 30% annually in material handling costs in manufacturing industry. The previous literature gives that a facility layout is an arrangement of everything needed for the performance of any job. It may be a machine tool, a work center, a manufacturing cell, a machine shop, a department, a warehouse, and any related departments.

An important consideration in plant layout design is the human comfort. This should be maximized while minimizing at the same time the distance between the facilities. The human factors which need attention in developing machining facilities include work environment with human body posture, stress and other physiological capacities of the work force. Successfully achieving such human factors enables good working conditions which are conducive for reduction in injuries, effective and highly production environment and reduced fatigue (Khan et al., 2013). It is found that these goals are fairly well achieved by using Systematic Layout Planning (SLP) that takes into consideration the human factors (Lan and Zhao, 2010). The SLP has been found to improve spatial distances between facilities (machines, between workstations and between departments) and also improve the flow improve the flow of material through the plant (De Carlo et al., 2013). Thus cost of material handling is reduced significantly. As a consequence, less material handling time is needed; workers move faster and the overall productivity increase (Ballard et al., 2003).

Commonly practiced by industrial practitioners, the production system normally designing based on two types on floor layout; process-based layout and product-based layout. Process-based layout is a design for the floor plan of a plant which aims to improve efficiency by arranging equipment according to its function (Patsiatzis and Papageorgiou, 2003). The production line should be ideally be designed to eliminate waste in material flows, inventory handling and management. In process layout, the work stations and machinery are not arranged according to a particular production sequence. Instead, there is an assembly of similar operations or similar machinery in each department (for example, a drill department, a paint department, etc.) The previous literature gives that a facility layout is an arrangement of everything needed for performance of any job (Neely et al., 2005). While, a product-based layout usually refers to a production floor designed by splitting work stations and equipment through with assembly lines based on several shapes such as straight line, U-shape, L-shape, S-shape and any other shapes (Ani et al., 2013). Usually, work units are moved along a production layout through interconnected work stations. In application the product-based layout, the total works to be performed must be dividable into small tasks that can be assigned to each of the workstations. Because the work stations each do small amounts of work, the stations utilize specific techniques, equipment tailored to the individual job they are assigned and most of the product-based layout consisted of semi-automation or manual assembly work or known as human depending.

So, the dilemmas of the product-based layout are worker convenience should also be taken into consideration while designing a layout. This is also very important since the worker is the one who is in the production floor and who has to do the operation. Therefore, it's the duty of the layout designer to take care of the ergonomic factors while designing a layout. Most of the shop floor operations are inherently tiring and require a great deal of physical work. So the layout should be designed in such a way that the worker's effort is being reduced and he or she does not have to undergo high amount of physical strain. Failure in considered an effective interaction between work stations and workers in designing production layout causing ineffective production system. Currently the implementation of the production layout by industries normally applied the concept of Lean Manufacturing (LM). LM also known as lean production has been one of the most popular paradigms in wastes elimination in the production system (Pampanelli et al., 2014). At the same time, LM similar knows as methodologies that have the systematic approach to process improvement in planning the process flow. This method was based on finding and reducing wastes coupled by applied continuous improvement in production system. The main objective of lean production is to satisfy customer needs on the highest possible level through the elimination waste. There are seven type of waste in lean production which includes; overproduction, waiting time, movement, transportation, inventory, over processing and defects (Liker and Morgan, 2006, Ohno, 1988). But, most of the continuous improvement program in production system adopted the LM is targeting the elimination of the wastes (*muda*) and less consideration of work overburden (*muri*).

Thus, in this article, the continuous improvement program will be developed and implemented by focusing elimination the waste of overburden (*muri*) in production system. The first objective is to evaluate the important of interaction between workers versus workstation, and then the weakness of interaction will be solved through development of the continuous improvement framework as a second objective. The primary objective is the elimination the waste of overburden (*muri*) in order to achieve the optimum smoothness of production system. The research presented in this article had been divided into five main sections. The first section overviews the concept of production system, then follows by second section which is overview the selected case study industry and discuss the problem facing by the case study. Completion of the second section, then data collection and improvement activity will be elaborated in the third section and section 4 will be discussed the impact of implementing the continuous improvement framework in the selected case study industry. The overall achievement of this research article will be concluded in the section 5.

## **2. The Case Study and The Problem Statement**

The case study company produces the refurbishment of petroleum gas and refurbishment services for a liquefied petroleum gas (LPG) cylinder. This company provides refurbishment services for LPG cylinder in accordance to the specification and requirement of the customer. Generally, in production layout the machines and equipment are arranged in a single line based on product-based production system, which depends on the sequence of process activity are connected and the material in the production floor typically flows from one workstation directly to the next workstation. The entire processes in production system are human depending and a lot of manual work such as transferring the production between workstations, lifting, labelling, checking and crating. Continuously monitoring and improvement of the quality system was applied in the working culture of the organization. With rapid increasing of demand in production, selected case study industry needs to increase their potential in production and effectiveness to compete against their competitors. At the same time, the production process needs to be equipped with the ability to have lower cost with higher effectiveness.

The production floor is divided into two main sections known as Front-of-Line (FOL) and End-of-Line (EOL), where the FOL performing the cleaning, weighing, welding and re-painting tasks. While, in EOL, the semi-finished product from FOL will be continued with finishing processes such as drying, labelling and weighing conformation prior transfer into transportation for delivery process. The information have been obtained related with this research article such as working hour per day, working shift, working procedure of each job, number of workers, production cycle time, daily production planning as summarize in Table 1.

Table 1: Summary of relevant information

<b>INFORMATION</b>	<b>DATA</b>
Working hours / shift	8.00 hours (45 minutes break time)
Number of shift per day	2 shifts per day
Available worker per shift	11 workers
Production cycle time	52.2 seconds
Daily production planning	1,500 per shift

Since, the entire processes of production system required manual handling and human depending, the company facing the issue of inconsistency of daily production output. Fluctuation number of daily production output from day to day causing increasing number of delinquency and extended the lead time. Furthermore, the company also facing the issue of high percentage of worker turn-over. Both of the issues affecting smoothness of the production system, where the issue of delinquency increases the production lead time, and losing talented and skilled worker due to high employee turn-over rate. Based on the information from management of selected company and observation results, both of the issues were caused by imbalanced manual work in production system due to each process is human depending.

The investigation on elimination the overburden (*muri*) issue in production floor is divided into four phases which are Plan-Do-Check-Act (PDCA). Plan phase is defining the current ineffective motion issue during performing operation tasks in production floor and the expected outcome after completion of the improvement activity is derived. Do phase is measuring the process cycle time in selected workstation to determine the time taken and identify the waste of motion. Then, improvement was implemented in this phase to solve the issue arising. Check phase consists process comparison in term of process cycle time between before and after the improvement, while Act phase is the phase of controlling the improvement process and ensure the response appropriate action if the issue will occur in future.

### 3. Application of Continuous Improvement Program for Elimination the Waste Of Overburden (*Muri*)

This section presents and discusses the application of the continuous improvement framework through a real world case study implementation. In order to derive upon reliable and detailed data collection and analysis, it is imperative to comprehensively determine the actual steps of the study itself. The application of the continuous improvement framework was implemented by using PDCA approach as summarized in Figure 1.

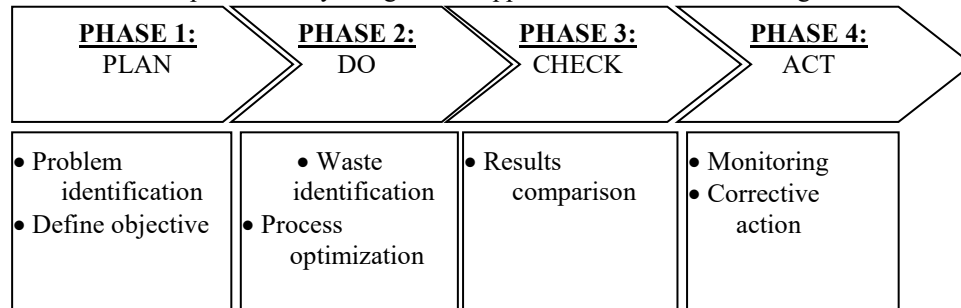


Figure 1. The Framework of Continuous Improvement Process in Elimination the Waste of Overburden (*muri*)

#### 3.1 Plan Phase

Plan phase consisted of two steps which are problem identification and define the objective of continuous improvement activity. This phase begins with identifying the issue facing by production system in term of ineffective motion during performing the operation process. The entire production processes in production system were observed based on manual handling process and highest time of manual handling will be selected as a case study and solve it using suitable tools and technique. Once the case study process has been selected, the next step is setting the objective once completing the continuous improvement activity to ensure the production system gaining the benefits and improve the current process. The objective was derived in this phase as a Key Performance Indicator (KPI) to measure the success of the continuous improvement activity. By the end of Plan phase, the problem statement and objective are expected clearly defined in ensuring the smoothness of production flow and free from interruption due to performing unnecessary motion elements.

##### 3.11 Problem Identification

Since the production system has divided into two sections which are FOL and EOL to complete the finished good product, the EOL section was selected for further analysis in this research because this section required fully manual process compared with FOL which is semi-manual process. The EOL consisted of five processes which are Re-valve, Air filling, Leak testing, Marking, and Weighing and Stamping process. Each process in this section was carefully observed in term of process cycle time to identify the bottleneck process. Based on the observed results, the bottleneck process is defined at Weighing and Stamping process because this process was identified as a highest

process cycle time as tabulated in Table 2. Once the case study process has been selected, the further analysis will be performed by observing the detailed motion elements in this process to identify the wastes.

Table 2: Summary of process cycle time

Process Sequence	Process	Cycle Time (seconds)
1	Re-valve	12.00 seconds
2	Air filling	13.50 seconds
3	Leak test	10.00 seconds
4	Marking	8.56 seconds
5	Weighing and Stamping	15.16 econds

### 3.12 Project Objective

Based on the observation of the process cycle time and bottleneck process identification, then the objective of this project was defined optimize the process cycle time in ensuring the smoothness of production system. As defined, weighing and Stamping process has been identified as bottleneck process with 15.16 seconds, the objective was derived from this situation by targeting to reduce the process cycle time from 15.16 seconds into 12.89 seconds which is equivalent to 20% improvement. The 15% improvement was identified based on average cycle time from overall processes of EOL, which is the total process time of EOL divided by number of available processes. By achieving this objective at the end of this project, the bottleneck process will be changed into Air filling process and the production output will be increased accordingly.






## 3.2 Do Phase

The Do phase consisted of observing the production flow for waste identification and process optimization to solve the issue related to the production system. Waste identification will be measured by segregating the selected process into motion elements and each element will be evaluated based on value added or non-value added process. Then, the cycle time will be captured for each motion element to measure the time taken in completing the process. Once the waste has been identified, the potential improvement activity will be analyzed by applying several techniques such as a waste hunting check sheet and lifting index analysis to improve or eliminate the waste of overburden (*muri*).

### 3.21 Waste identification

As normal practices, in conducting continuous improvement program in production system, when observing the production wastes normally often talking about *Muda*, or the seven wastes (Transportation, Inventory, Motion, Over production, Over processing, and Defects), but the other wastes defined within the Toyota Production System; *Mura* and *Muri* are normally overlooked. In this phase begins reviewing and understanding the motion elements in performing the operation processes by worker in production floor and the waste of overburden (*muri*) will be identified through waste hunting activity by using checksheet. In waste hunting check sheet, the motion elements divided into five categories known as operation, storage, delay, inspection and transportation. Every motion of worker will be drawn on the check sheet and the time taken for each motion element will be captured by using a stop watch to define the real time taken by worker to complete the operation processes. Then, based on the motion elements, the wastes activity and time taken will be identified as summarize in Table 3.

Table 3: The results of wastes hunting activity

No	Motion Elements	Transport 	Operation 	Delay 	Inspection 	Storage 	Cycle time
1	Pick-up the part from previous process	●					1.18 seconds
2	Place the part into work-in-progress (wip) area		●				2.01 seconds
3	Transfer the part into work station	●					2.00 seconds
4	Weighing the part				●		3.05 seconds
5	Transfer the part into floor	●					1.51 seconds
6	Stamping the part (sitting with awkward working posture)		●				4.10 seconds
7	Transfer the part into next process	●					1.31 seconds
		57%	29%	0%	14%	0%	15.16 seconds

The results of observations obtained as tabulated in Table 3, where the waste of transportation contributed the highest activity which is 57% based on four activities of transportation process decided with seven motion elements as identified. This identified waste considered as the potential motion element will be eliminated to improve the flow of production flow. Furthermore, motion element number 6 (Stamping the part) also considered potential elements to be improved because the worker was performing this task with awkward position and lifting index analysis was performed to identify the acceptance level of working posture. The results of lifting index analysis as shown in Table 4 and it was showing the index level is 1.965 which is considered as the awkward position because in ergonomic philosophy as mentioned by NIOSH lifting index must be below than 1.0 in ensuring comfortable working posture. Since the production process is repetitive works, the awkward working posture as shows in Figure 2 causing the low efficiency and effectiveness of production system.

Table 4: The results of lifting index analysis

Elements	Equation	Explanation	Results
Load Constant, LC	Constant value	23 kg	23.000
Horizontal Multiplier, HM	$25/H$	H = 40 cm	0.625
Vertical Multiplier, VM	$1-[0.003(V-75)]$	V= 60 cm	1.450
Distance Multiplier, DM	$0.82 + (4.5/D)$	D= 60 cm	0.895
Asymmetric Multiplier, AM	$1-(0.0032A)$	A= 0°	1.000
Frequency Multiplier, FM	From Table in Appendix 1	4 times / hour with working hours more than 2 hours per day	0.450
Coupling Multiplier, CM	From Table in Appendix 2	Good coupling	1.000

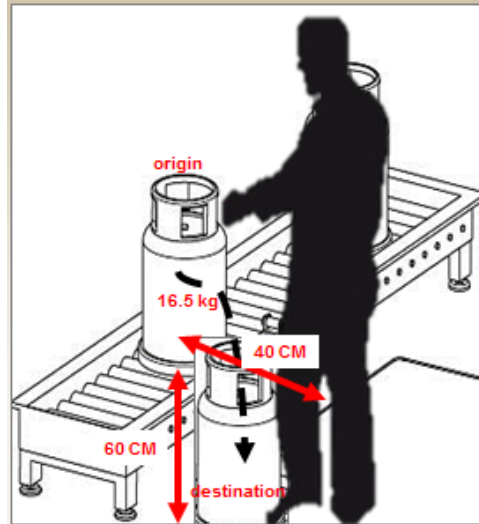


Figure 2. The Current Condition of Working Posture for Weighing and Stamping Process

Based on the results obtained as Table 4, then Recommended Weight Limit (RWL) was calculated by using Equation (1). Then, it was converted into Lifting Index (LI) by using Equation (2). Based on both equations, the results obtained in calculation RWL and LI are 8.395 and 1.965. The value of 1.965 for LI represented the working posture during lifting the part is not comfortable and this process should be re-designed to improve the working condition.

$$\text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM} \quad (1)$$

$$\text{LI} = \text{Load weight (weight of load in pounds or kilograms)} / \text{RWL} \quad (2)$$

### 3.22 Process Optimization

Since two wastes have been identified in previous section, then detailed investigation of the wastes in which the waste of transportation in performing the operation and process uncomfortability of lifting index causing overburden into worker. The Standard Operation (SOP) has been re-visited and revised by minimizing the waste of transportation during performing the weighing and stamping process to improve the efficiency and effectiveness of production system. As stated in Table 3, the motion element to place the part into work-in-progress (wip) area has been eliminated, where the part directly transferred into work station in avoiding delaying process. The revised SOP affected the sequence of processes where is the number of processes was reduced from seven processes into six processes. Indirectly the process cycle time was reduced from 15.16 seconds in 13.16 seconds. The procedure of lifting the part also revised by introducing the lifting trolley during transfer the part into the next process. The trolley has been designed based on suitable height as current process and five capacities in one time loading was introduced to ensure reduced the burden on workers. The lifting trolley was designed as illustrated in Figure 3 by using lightweight materials to help worker easier their tasks.

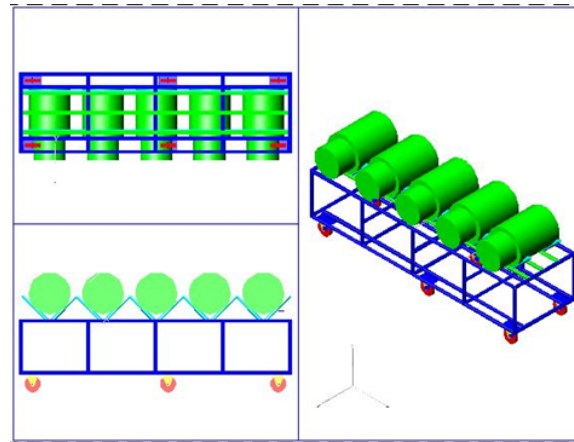


Figure 3. The Illustration of the Lifting Trolley for Transferring Process

Since the SOP has been revised and the technique of lifting the part also re-designed, the analysis of lifting index was re-calculated to ensure the designed process with lifting trolley will provide the comfortable working posture. The introduced lifting trolley was located next to the lifting process and the worker need twists the body to place the part into the trolley without lifting the part as illustrated in Figure 4. The process of transferring the part from horizontal position into vertical position will encourage the worker performing the stamping process without bending the body posture.

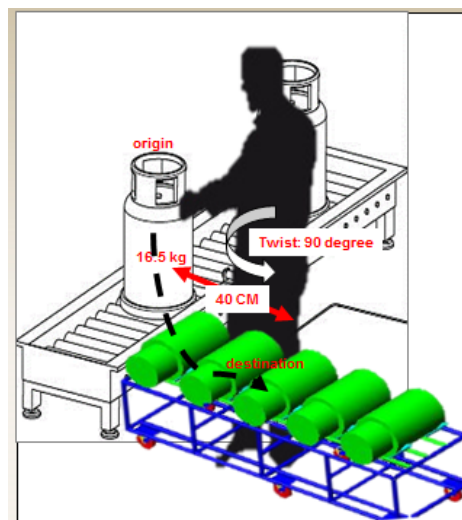


Figure 4. The Working Condition by Using Lifting Trolley

The results of re-calculating lifting index as shows in Table 5 and the RWL was calculated by using Equation (1) found the new result RWL is 18.815. Then, the LI also re-calculated based on the results of new RWL by using Equation (2), and the new LI was calculated at 0.88. The index of new LI represents the comfortable working condition because it's less than 1.0 as guided by lifting index philosophies. With the positive results from re-designed the weighing and stamping process, the efficiency of performing the operation process will be more easier and reducing the burden of lifting because the operation process required repetitive for the whole day production operation. Since, the process has been re-designed, the new cycle time of production process also re-captured to identify the process cycle time. The new results of process cycle time found the only required 3.81 seconds instead of 4.10 seconds in the previous design of operation process. At overall of process cycle time after improvement based on eliminating the transportation process and re-designed the assembly process, the time taken required for weighing and stamping process only 12.86 seconds compared 15.16 seconds as captured before the improvement activity. The improvement of weighing and stamping process contributed 15% improvement of process cycle time reduction and the weighing and stamping process considered not a bottleneck from the overall process of EOL.



Table 5: The results of lifting index analysis for re-designed process

Elements	Equation	Explanation	Answer
Load Constant, LC	Constant value	23 kg	23.000
Horizontal Multiplier, HM	$25/H$	H = 40 cm	0.625
Vertical Multiplier, VM	$1-[0.003(V-75)]$	V= 0	3.25
Distance Multiplier, DM	$0.82 + (4.5/D)$	D= 60 cm	0.895
Asymmetric Multiplier, AM	$1-(0.0032A)$	A= 90°	1.000
Frequency Multiplier, FM	From Table in Appendix 1	4 times / hour with working hours more than 2 hours per day	0.450
Coupling Multiplier, CM	From Table in Appendix 2	Good coupling	1.000

### 3.3 Check Phase

The third phase is Check, consisted of the comparison results of improvement in term of percentage of waste, lifting index, process cycle time and the production output rate as implemented in the previous phase. Since the improvement has been made in the second phase, the verification of the achievement results is required to ensure this improvement activity meeting the defined objective from first phase and to confirm the results through before-and-after data comparison. The third phase is Check, consisted of the comparison results In overall, the improvement successfully implemented in selected case study industry and the process improvement significantly impacted the production system based on improvement of transportation wastes, production cycle time, lifting index and production output.

The waste of transportation was improved through elimination one of the transportation motion elements where is the process sequence was reduced from seven processes into six processes. Through this elimination process, the percentage of transported waste was reduced from 57% in 50%. Secondly, the process cycle time to be improved from 15.16 seconds in 12.86 seconds enable to production system increased their output from 237 Units per Hour (UPH) into 279 UPH. The achievement of UPH because of elimination of overburden (*muri*) process during performing the operation tasks where the overburden (*muri*) was converted into LI and it was reduced from 1.965 into 0.88. The overall comparison data for before-and-after implementation as summarize in Table 6. Upon completion of the Check phase, the team members were conducted the Act phase which is will be discussed in the next section.

Table 6: The comparison between before-and-after improvement activity

Elements	Before improvement	After improvement	Remarks
% of transportation wastes	57%	50%	Reduction 7% of waste
Process cycle time	15.16 seconds	12.86 seconds	15% improvement
Lifting index	1.965	0.88	55% improvement
Production output	237 UPH	279 UPH	17.7% improvement

### 3.4 Act Phase

Once the project teams are satisfied with the process improvement, process through comparison before-and-after data, it's time to move on to Act phase, which is documented the results, inform others about process changes, and make recommendations for the problem to be addressed in the next PDCA cycle. Since the procedure of operating the process of weighing and stamping was re-designed, the new Standard Operation Procedure (SOP) was established to ensure the worker is understand the process and following the procedure of the operation. Once the project teams are satisfied with the process improvement, process through comparison before-and-after the production output was regularly observed through monitoring the daily production output to ensure sustainability of the improvement process. The Scatter plot was applied as the main tools to monitor the performance of the production process through to output monitoring based on UPH achievement as shows in Table 7. The scatter plot has been selected because the data collection based daily rate of production output and also under category of attribute data. Any arising issue impacting the production output will be immediately solved by a team member through the monitoring process. The Act phase is the stage to ensure the wastes will not appear in future based on PDCA phases.

Table 7: The output monitoring based on Unit per Hour (UPH)

MONTH:	May-18			
SECTION:				
TIME				
	1	2	3	4
08.00-09.00		151	149	142
09.00-10.00		148	163	180
10.00-11.00		163	151	146
11.00-12.00		158	150	178
12.00-13.00		143	161	150
14.00-15.00		156	148	138
15.00-16.00		139	148	180
16.00-17.00		148	151	200
OUTPUT SHIFT A		1,206	1,221	1,314
TARGET SHIFT A		1,500	1,500	1,500

## 4. Discussion

Wastes of production are a main enemy in production system where it affected the efficiency and effectiveness of production system and indirectly interruption the smoothness of production flow. Three terms often used together in the determination of production wastes (and called the Three Ms) known as *Muda* (waste), *Muri* (overburden) and *Mura* (unevenness) and that collectively describe wasteful practices to be eliminated. But, most of the industrial practitioner improved their production focusing the elimination of the *Muda* (wastes) and less consideration of work *Muri* (overburden). Actually in production process especially in human depending operation process involving a lot of manual handling and it contributed the overburden process. Companies strive to improve their production system rate during the manufacturing processes as much as possible but without systematic methodology and lack of focusing on the actual root causes blocking them to achieve the optimum solution. By checking and inspection of motion elements during performing the production operation by focusing all type of wastes the production efficiency and effectiveness will improve with some changes specifically at those focused area. PDCA model is one of the best emerging approaches for process improvement activity in production system. This paper discussed the implementation of PDCA methodology in improving the efficiency and effectiveness of production system focusing on waste of overburden (*muri*) in manufacturing industry. The PDCA approach has been used to achieve this result. This paper explains the step-by-step approach of PDCA implementation in this manufacturing process for optimizing the production output. Using the suggested PDCA methodology, the UPH was increased by 17.70% from UPH through improvement of elimination the waste of transportation and improving the overburden (*muri*) through analysis of

lifting index. With such encouraging result, the team decides to continue doing more improvement project for other products in the future.

## **5. Conclusion**

In this paper, PDCA methodology has successfully implemented focusing on elimination the waste of overburden (*muri*) in selected case study of manufacturing industry to streamline the production flow. The PDCA methodology is one of the method has been adopted in various types of industries because systematic approach to analyze the background of the continuous improvement activity step by step. The PDCA method is defined as project objectives and existing processes, measuring of the existing processes, analyze the data to determine the cause-and-effect relationships and improve the current process. PDCA methodology helps companies realize that it is a company-wide approach to eliminating production wastes. But, the PDCA methodology is only the platform of the continuous improvement activity with several versions of identification the application tools for every phase. Different type of industry will be using different tools for each phase depending on the type of data collection, data availability, the processes involved and experiences and knowledge of the team members. This paper presents the development of the process improvement focusing on the waste of overburden (*muri*) using PDCA model to streamline the production flow towards optimum efficiency and effectiveness of production system. Based on the investigation and implementation of the selected case study industry, the result shows an adaptation of PDCA with suitable tools for each phase complements with the process improvement program where the production output is was drastically increased by 17.7%.

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### Appendix 1: Frequency Multiplier Table (FM)

Frequency Lifts/min (F) ‡	Work Duration					
	≤ 1 Hour		>1 but ≤ 2 Hours		>2 but ≤ 8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

### Appendix 2: Table for Coupling Multiplier (CM)

Coupling Type	Coupling Multiplier	
	V < 30 inches ( 75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

### Biography

**Mohd Norzaimi Che Ani** is Lecturer of Manufacturing Section from Universiti Kuala Lumpur, Malaysian Spanish Institute. He earned B.Eng. in Mechanical Engineering and M.Sc. degree from Universiti Teknologi Malaysia. Research interests include the field related in industrial engineering and completed various research projects focusing continuous improvement programs.

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