

# Productivity Enhancement for SMEs Plastic Bottle Enterprise by Lean Technique Application

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Available online at: [www.isroset.org](http://www.isroset.org)

Received: 22/Oct/2020, Accepted: 05/Dec/2020, Online: 31/Dec/2020

**Abstract**— This research aimed to enhance productivity of plastic bottle production process focusing on High Density Polyethylene plastic bottles. There were 3 main stages of production process which divided to 13 steps operated by 8 workers. After analyzing the process, it found that cycle time was 5 seconds/pc with capacity 6,480 pieces/ 9 hours. At the 6th station; cutting bottle fins, it had the long cycle time leading to unmeet the target. In addition, at the 12th station of packing process, it is also the second-longest cycle time leading to delay work. On the contrary, low cycle time was found at the first main stage of mixing plastic beads. For improving productivity, lean technique focusing on 7 wastes was employed. Therefore, the 1st main stage station had been moved to operate at the end of working day for feeding on the next day process. For the 6th step, it was suggested to add the automatic machine for worker replacement. Furthermore, delay work occurred at the 12<sup>th</sup> step. It was improved by moving workers from the previous station to support work with the current workers at this station. It can be concluded that replacing automatic machine has reduced 3 workers. In addition, waiting time was also decreased. The cycle time was reduced from 5 seconds/ pc to 4 seconds/ pc which decreased by 20%. Production capacity can be enhanced from 6,480 pieces/ 9 hours to 8,100 pieces/ 9 hours which increased by 25%.

**Keywords**— High Density Polyethylene Plastic Bottle Plant, Productivity Improvement, Lean Manufacturing

## I. INTRODUCTION

Changing consumer's behaviour, at present, has continuously increasing. Food packaging is also more importance and highly recognition. In addition to highly demand, plastic packaging is used as one-way package. These effects lead to increase production of plastic packaging for responding consumers' demand. From the report of department industrial work, there are many SMEs industry producing plastic bottle in Thailand [1]. Various types of plastic resins are used to produce plastic packaging products, such as Polypropylene (PP), Polystyrene (PS), High Density Polypropylene (HDPE), etc. SMEs industry producing plastic bottles is a focused company for this study. Due to high density property and good chemical resistance, HDPE resin is widely used as materials for producing packaging [2]. It has been employed for substitution glass bottles and reduction production cost. Therefore, HDPE also used in the study company.

The focused company confronted with a problem of unachievable demand rate. Its production process consists of 3 main sections, which are raw material preparation, blowing plastic bottle, and screening & packaging section. Eight labours have operated work for a production process line. Operating time is 9 hours/ shift with the capacity 6,480 bottles. Increasing production over 8,000

bottles/shift for responding customers demand is required. Improvement techniques are studied and employed for solving this problem.

## II. RELATED WORK

Lean manufacturing is extensively applied for many industries. It focuses on flow of work, eliminating wastes, adding product values and continuously improving process. Seven wastes concept is one of method used for lean manufacturing [3]. From a literature review, there are many researchers applied lean manufacturing to the companies all over the world for improving their performances. New lean was applied by Dues, et al as catalyst to greening supply chain [4]. Karim and Arif-Uz-Zaman developed the simplified evaluation metric for measuring organizations' efficiency and effectiveness with lean manufacturing [5]. Pool, et al improved the planning process of semi-process with lean approach. It can improve process i.e. reducing stock, improving product quality, less planners, etc. [6]. Value stream mapping (VSM) was adopted for lean method, it was applied to OEM companies for automotive industry. The results showed that cycle time, level of workforce was reduced [7]. VSM also was applied to reduce lead time of product design process by 50% [8]. Sinha and Matharu reviewed for lean management, they found that lean had been adopted by developed countries and emerging economics with

noteworthy towards in Asian countries [9]. Many section companies were utilized lean in their organizations such as garment industry [10], in healthcare service by proposing patients queuing system [11], and also implement in healthcare process focusing on dedicate more time and efforts on patients [12]. Therefore, the present research has applied lean technique for improvement productivity of plastic bottle company. The method and its procedure will be described in the following section.

### III. METHODOLOGY

After studying the data of focused company, it was illustrated in table 1. There are 13 elements for production

process. For the first 3 steps, it is for preparation plastic resin which consist of transferring plastic resin to be mixed (1), then it is a mixing operation (2), and transferring mixed plastic resin to stock and waiting for blowing process (3). The second 4 steps consist of transferring mixed plastic from stock area to blowing machine (5), then blowing operation to produce HDPE bottle (5), deburring and removing plastic fins (6), and transferring plastic bottles to stocking (7). For the last 6 steps; transferring HDPE plastic bottles from stock area (8), feeding bottles into screening machine (9), screening process (10), waiting for drying bottles (11), packing and inspection products (12), and finally moving bottles to stock (13).

Table 1. Flow process chart of HDPE bottle production

Stage	Step	Description	Symbol				Cycle Time (sec)	Operator	
I (Preparation&mixing plastic resin)	1	Transferring plastic resins to mixing process		➔			0.09	A	
	2	Mixing plastic resin	○				0.4	A	
	3	Transferring mixed plastic resins to stocking		➔			0.02	A	
II (Bottle Blow Moulding)	4	Feeding mixed plastic resin into blow moulding machine		➔			0.03	B	
	5	Moulding HDPE plastic bottle	○				5	B	
	6	Deburring and removing plastic fins	○				5	C, D	
	7	Tranferring HDPE bottle to stocking		➔			0.01	B	
III (Screening on Bottle)	8	Tranferring HDPE bottle to screening machine		➔			0.02	E	
	9	Feeding bottle into screening machine	○				1	F	
	10	Screening process	○				1	E	
	11	Waiting for drying screened bottle			D		1	-	
	12	Packaging and inspection		□			1.39	G, H	
	13	Transferring finished products to stock		➔		▽	0.05	E	
<b>Summary</b>			<b>5</b>	<b>6</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>15.01</b>	<b>8</b>

Process' summary is shown at the bottom of table.1. No. of operations, transportation, inspection, delay, and storage are 5, 6, 1, 1, and 1, respectively. Meanwhile, summation of cycle time or flow time is 15.01 sec. Employed workforce is 8 operators. The production rate was 6,480 bottles with 9 working hours. Its cycle time is 5 sec/bottle, which operated at 5<sup>th</sup> and 6<sup>th</sup> step. However, demand rate of the company is 8,000 bottles/ 9 hours with takt time 4.05 sec/ bottle, as illustrated in figure 1.

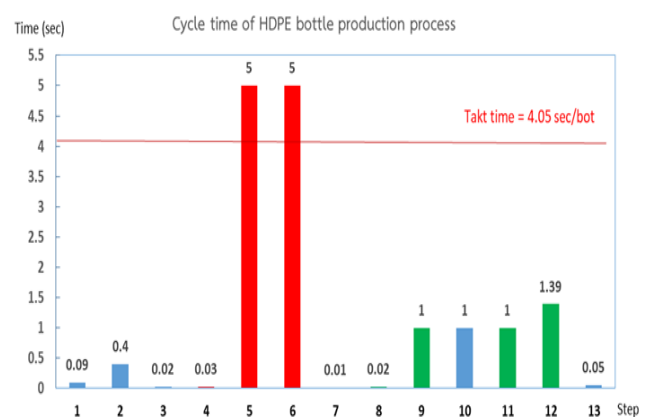


Figure 1. Cycle time and takt time of HDPE bottle production process

**IV. RESULTS AND DISCUSSION**

**Proposed concepts**

As analysing the production process in figure. 1, seven wastes of lean technique have been employed. It can be described as follows:

Idle times of worker was found at step 1-3. Due to low cycle time between 0.02 - 0.4 sec, these steps should be moved to be operated at the end of process and preparing for the next day processing.

Step 5 and 6 are bottle neck stations. Step 5 was operated by a machine. Although, speed of blow moulding bottle machine can be increased, but step 6 was still unable to speed up the production. Step 6 was performed by manual operation of 2 workers (operator C and D). It was proposed to install cutting machine instead of workers.

For step 12, its cycle time was the second-longest after step 5, 6. It led to high waiting time at step 11 and 13. This problem can be solved by increasing workers from 2 to 3 people. They were brought from the other steps.

**Process improvement**

As proposed method has mentioned above, implementation and modifying production line was executed. It can be summarized in table 2. Detailed of before and after improvement can be summarized in table 3. Due to

rearrange the work, the number of workers was decreased by 3, from 8 to 5. These 3 workers are assigned to do work at the affiliated plant. New machine for deburring and removing plastic fins was installed. New assigned work of remained operators was illustrated in table 3.

Effect of installation a deburring and removing plastic fins machine at step 6, it can reduce cycle time to 3 sec. Furthermore, speed of moulding machine at step 5 can be increased and reduce cycle time from 5 to 4 sec/bottle. In addition, adding operator at step 12 can reduce cycle time from 1.39 to 0.9 sec/bottle. Flow time of production can be reduced from 15.01 sec/bot to 11.01 sec/bot. These details are described in table 4. As a new cycle time (4 sec/bot), it can increase production from 6,480 to 8,100 bot/ 9 hrs.

Table 2. New tasks of 8 operators

Operator	Task
A	1. Performing step 1,2, and 3 at the ending of day for serving material of the next day process.
	2. Working at step 4 and 7 instead of operator B
	3. Working at step 8,13 instead of operator F.
B	1. Still working at step 5.
	2. Controlling a new machine at step 6, operator C and D were moved to operate the other steps
C	Working step 9 and 10 instead of operator E and F
D,E	Performing at step 12 instead of operator G and H
F, G, H	Rotated and moved to work in the affiliated plants

Table 3 Comparison of before and after improvement work

Stage	Step	Description	Operator	
			Before	After
I (Preparation & mixing plastic resin)	1	Transferring plastic resins to mixing process	A	1. Preparing materials at the ending of day for serving the next day process.
	2	Mixing plastic resin		
	3	Transferring mixed plastic resins to stocking		
II (Bottle Blow Moulding)	4	Feeding mixed plastic resin into blow moulding machine	B	A
	5	Moulding HDPE plastic bottle	B	B Machine
	6	Deburring and removing plastic fins	C, D	B Adding new machine
	7	Transferring HDPE bottle to stocking	B	A
III (Screening on Bottle)	8	Transferring HDPE bottle to screening machine	E	A
	9	Feeding bottle into screening machine	F	C
	10	Screening process	E	C
	11	Waiting for drying screened bottle	-	-
	12	Packaging and inspection	G, H	D, E
	13	Transferring finished products to stock	E	A
Summary			8	5

\*Operator F, G, and H were terminated and assigned to the affiliated plant.

**VI. CONCLUSION AND FUTURE SCOPE**

Improving productivity of HDPE bottle production process was performed by employing lean technique focusing on 7 wastes. The objectives of this research was attained. It can be summarized in table 5. Production rate is increased by 25%. Further, decreased 20% of cycle time. In addition, number of operators is reduced by 38%. However,

modifying process is also done by adding a new machine (deburring and removing plastic fins) which can be computed a pay back period as shown in table 6. Machine investment by 98,600 THB, it can replace work of 3 workers. Labor cost is 8,294 THB/worker/month. Therefore, 24,882 THB/month of labor cost can be saved.

Table 4: Comparison cycle time of before and after improvement

Stage	Step	Description	Cycle Time (sec)	
			Before	After
I (Preparation & mixing g plastic resin)	1	Transferring plastic resins to mixing process	0.09	Moved to be performed at the ending of the day
	2	Mixing plastic resin	0.4	
	3	Transferring mixed plastic resins to stocking	0.02	
II (Bottle Blow Moulding )	4	Feeding mixed plastic resin into blow moulding machine	0.03	0.03
	5	Moulding HDPE plastic bottle	5	4
	6	Deburring and removing plastic fins	5	3
	7	Tranferring HDPE bottle to stocking	0.01	0.01
III (Screening on Bottle)	8	Tranferring HDPE bottle to screening machine	0.02	0.02
	9	Feeding bottle into screening machine	1	1
	10	Screening process	1	1
	11	Waiting for drying screened bottle	1	1
	12	Packaging and inspection	1.39	0.9
	13	Transferring finished products to stock	0.05	0.05
Flow time			15.01	11.01

Table 5. Summary of process improvement

	Improvement			
	Before	After	% Changed	
Production (bot/9 hrs)	6,480	8,100	25%	Increased
Cycle time (sec/ bot)	5	4	-20%	Decreased
No.of Operators	8	5	-38%	Decreased

Table 6. Pay back period for investment of a new machine

Month	Investment (THB)	Labor cost saved (THB)	Pay Back Priod
0	96,000		
1		24,882	
2		24,882	
3		24,882	
4		24,882	(96,000/24,882) = 3 months 11 days

The results of this research can improve productivity of HDPE bottle production. It can support business of SMEs companies by employing lean technique for increasing production. Suggestion for further research, simulation modeling by computer program should be employed. Modifying and adjusting some factors in the production will be easily performed.

#### ACKNOWLEDGMENT

This research was funded by the Faculty of Engineering, King Mongkut's University of Technology North Bangkok (No. ENG 61-40), Thailand.

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