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APPLICATION OF SINGLE MINUTE EXCHANGE OF DIE ON MASS PRODUCTION COMPANY

S. A. Salah¹ and N. Sobhi²

ABSTRACT

Lean manufacturing philosophy is continually strive to eliminate the nun-value added activities, minimize the delivery cycle time and improve the quality of products. Most manufacturing companies adopt lean in order to meet customer expectations and become more competitive in the market. Implementation of Lean enterprise is an efficient and effective way to reduce the cost of the enterprise without incurring high capital expenditures. SMED is a popular lean tool used for dramatically reducing the set-up time for the machine, which is a set of techniques enabling for the replacement of tooling or set a production line in less time than 10 minutes. This paper focuses on implementing SMED methodology in a mass production company for food industries in order to reduce changeover time. The objectives of this paper are decreasing the setup times of the production line to enable the production flexibility and increase the maneuverability between different products according to customer needs. This paper monitoring carefully all production processes to identify all wasted time between processes and find ways to eliminate or decrease it. The achieved results indicate that implementation of SMED in the company has a significant impact on decreasing the setup times and increasing the total productivity and the net profit. The changeover time reduced by 25%, and the OEE increased from 48% to 70%, also, the sales opportunities increased by 465,600 EGP per year.

KEY WORDS

Lean production, Single Minute Exchange of Die (SMED), OEE, improve the productivity.

¹ Dr., Dept. of Industrial System Engineering, October University for Modern Science and Arts, Cairo, Egypt. Email: ssalaheldein@msa.eun.eg.

² Professor Dr., Dean of Faculty of Engineering, October University for Modern Science and Arts, Cairo, Egypt. Email: nahed.sobhi@gmail.com.

INTRODUCTION

Globalization world challenge the manufacturers to find ways to reduce the process time in order to improve operating performance and product quality. Most companies adopting lean production concepts to remain competitive in the market. The core idea of lean manufacturing is actually quite simple; relentlessly work on eliminating wastes from the manufacturing process. These wastes have a direct impact on costs; they are all non-value adding operations. The changeover is considered a main type of wastes; it affects the availability and utilization of the machine. In Industrial environments, SMED is a system for dramatically reducing the time it takes to complete equipment changeovers. The essence of the SMED system is to convert as many changeover steps as possible to “external” (performed while the equipment is running), and to simplify and streamline the remaining steps. SMED was developed by Shigeo Shingo, a Japanese industrial engineer who was extraordinarily successful in helping companies dramatically to reduce their changeover times. Shingo observed that a lot of time was being misused when switching from a product to another. In designing the SMED scheme, he set up improvements which provide a lot of benefits in the industry [1].

However, food manufacturing is a processing industry which means the application of lean will pose a greater challenge. This is due to the unique features of the food industry such as the inflexibility of the machines, long changeover times, and the complexity of the resources [2]. According to [3], the lean methodology can be applied in the food processing industry if it was adjusted according to its constraints to achieve faster throughputs, and reduce inventories. Lean manufacturing is defined as a system which utilizes less input to create the same output while delivering increased value to the customer [4]. The identification and elimination of wastes is the cornerstone of the lean philosophy. This paper applied the SMED methodology in a food industry company to reduce changeover time. This food industry company dealing with manufacturing a mass production of many kinds of biscuits and have many thousands of customers.

LEAN PRODUCTION PHILOSOPHY

Lean organizations are able to be more responsiveness to market trends and, provide products and services less expensively than their non-lean counterparts. The implementation of lean manufacturing in different types of industries was studied and concluded that lean is an effective tool to eliminate waste; inefficiency, reducing the production costs, improving quality and reliability, and speeding up cycle times [5]. The goal of lean is to improve the organization’s performance that make a competitive difference, by drawing employees into the hunt to eliminate unneeded activities and other forms of operational waste [6].

SMED Methodology

SMED is a popular lean tool for shortening the machine set-up time. Shingo defined SMED as a set of techniques for the replacement of tooling or set a production line in less time than 10 minutes. The basic premise of this method is a marked decrease the size of production batches in order to adjust production to the constantly changing according to customer’s demand. The needs to shorten the changeover

time are very critical to determine the batch size for the production [7]. SMED methodology is a set of techniques to perform the equipment's setup and changeover operations in less than ten minutes [8]. A setup or changeover represents the complete process necessary to change the production from a product to another, until it is achieved a certain production rate with accepted quality [9]. Small batch production results in a significant increase in the setup frequency and ensures adequate flexibility of the response to the customer demand [10]. The implementation of this methodology requires a previous analysis to clearly understand the changeover process, in order to know in detail each setup operation [11]. The setup operations are divided into two types: internal operations (performed while the machine is stopped) and external operations (performed while the machine is operating) [8]. Also any tasks performed during the changeover should be standardized and consequently the total time for changeover will be specific and known. This allows for the time and resources used during the hangover to be quantified and taken into account during the scheduling of the production process. The tasks performed during the changeover process can be split into two categories; internal tasks which performed when the machines are stopped and external tasks which performed while the machines are running [12]. SMED methodology is split into five stages according to Shingo [13]:

Classify activities: during this stage the activities are classified into internal, external, or unnecessary. They are performed while the machine is running or in full stop. In order to gathering information about these activities, the workers should be interviewed.

Separate activities: External activities should be moved to either the beginning or the end of the changeover process. The internal activities should be standardized to eliminate any wastes, and the activities deemed unnecessary removed completely. The operators must be trained on how to perform the tasks efficiently and according to standards; this can be achieved by using checklists to make sure the external activities are performed on time.

Convert internal activities into external activities: during this stage, an in depth analysis is conducted on the internal activities to detect any wrong assumptions and to discover ways to convert them into external activities.

Streamline and reduce internal activities: the time required to perform the internal activities should be reduced and optimized. This can be performed by applying parallel operations, and designing effective tools to help perform the activities.

Streamline and reduce external activities: all effort should be concentrated on the external activities, which done outside the changeover time and have no effect on it. Simplify the remaining internal tasks by using fixtures; locating pins or visual marks to speed up the required time to get the new parts. Perform the internal tasks in parallel. If two operators can perform tasks at the same time, the time can be reduced without increasing the number of workers required for the setup process [14] as shown in Fig. 1. Also, video recording provides a valuable view of what actually happens during the changeover. Point to point diagram (spaghetti chart) can highlight opportunities to reduce the time operators spend walking, by relocating tools, parts, and even control panels. There are different methods can be used during the implementation; 5S to

eliminate the inefficient time, group jobs in pairs and perform them in parallel, remove any adjustments, and increase number of workers.

Overall Equipment Effectiveness (OEE)

Mass production companies try to optimize the performance of their existing machines to maximize equipment reliability, minimize changeover times, and improve operator performance and consequently improve the profit. OEE is a simple tool that helps managers to measure the effectiveness of their equipment/processes. By using OEE concepts such as the six big losses (shown in table 1) the wastes can be exposed and the efficiencies of the equipment's will be improved [14]. These losses are quantified as availability, performance, and quality in order to estimate OEE as given in equation (1). OEE values of different production lines can be used for comparison, and thus highlight poor production line performance [16]. Figure 2 shows the time frame for the OEE.

$$\text{OEE} = \text{availability} * \text{performance} * \text{quality} \quad (1)$$

Availability relates to time lost during operating period due to breakdowns and waiting.

$$\text{Availability} = \text{operating time} / \text{planned production time} \quad (2)$$

Performance, the performance takes into account speed loss, which includes any factors that cause the process to operate at less than the maximum possible speed when running [16].

$$\text{Performance} = \text{Actual production} / \text{Planned production} \quad (3)$$

Quality, Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require reworking [16].

$$\text{Quality} = \text{Number. of good pieces} / \text{Number of total pieces} \quad (4)$$

APPLICATION OF SMED

There are five production lines in the factory. This paper focuses on the croissant production line which has the highest number of changeovers. There are three products produced on this line, the average number of changeover is eight times per month. The elapsed time in every changeover is four hours to change from one product to another. This line is developed to produce three types of croissants; (small, medium, and large) size molto.

Data Collection

A qualitative data was collected from a food industries company. The production line of this company works for three shifts per day. The production capacity is 19,800 pieces per shift. The production are passes through nine processes; dough making, lamination, fermentation, oven, aeration tower, injection, transportation machine, metal detection, and packaging. Figure 3 shows the flow chart for the croissant

production line. The collected data about the process time for every task during the changeover methodology are illustrated in Table 2. The changeover was observed by listing and timing all the actions done by the worker and drawing a spaghetti diagram. During the setup, there were some basic elements that need to be reviewed: planning, working method, and tooling.

Identify the Internal and External Tasks

Identify the internal and external tasks are the most important step in the implementation of SMED methodology. All activities have to be classified as external or internal based on whether they can be performed while the machine is working or not. All the tasks are done by 10 workers. The required motion time is included within each task's time. The classification of changeover tasks is represented in table 2. There are twenty-eight tasks done during the changeover process, and for simplicity, they are classified into six areas: preparation, injection, transportation m/c and metal detector, bypass, packaging, and finally trial run.

Convert Internal Tasks into External Tasks

In order to convert internal setup times to external setup times, the main focus was on the tasks related to material handling, information gathering, cleaning, adjustments, and control. In the current state, there are only nine tasks out of twenty-eight tasks can be done while the machine is working. These external tasks will be removed out of the changeover window. 70% of the tasks are internal tasks and due to safety requirements, it will be difficult to convert them into external tasks. However, the others are easy to be converted, such as the movement of the workers during performing these tasks and worker utilization.

Streamline the Internal Tasks and Standardize the Steps

Streamline the tasks means to remove unnecessary activities during the setup time, such as movement or lost time in searching for the tools. In the current state, when the worker needs more materials such as alcohol, water, and cleaning materials he goes by himself to the store and gets what he needs, which is considered as a waste of motion and time. They must assign a person to get the required tools and materials for the workers. The final steps are standardizing the setup procedures and ensure there are become like habits for the workers. To improve internal setup even further there are another three steps that should help setup to reach the wanted single digit timeframe:

Parallel operations, means the setup operations are assigned to more than one person working together to decrease the setup time.

Eliminate the adjustments for components by using numerical settings, centerlines, and reference planes.

Mechanize of activities to reduce the process time.

RESULTS AND DISCUSSION

SMED methodology is applied in the croissant line, in order to eliminate or reduce the changeover time. Applying SMED neither requires big investments nor a lot of work. It is relatively easy to do on a low level, but more standardization and improvements require naturally more recourses. The manufacturers now need to produce the product in fast time without affecting the product quality. Some of the improvement has been implemented such as setup time is recorded and statistical analysis is generated and the differences from data before improvements are presented in table 3. The detailed movements of workers during changeover tasks are presented in spaghetti diagram before and after improvement as shown in figure 4 and figure 5. The benefit is obvious, some long-distance movement is eliminated and the total number of movements is reduced from 250 to 100 m. The achieved results after implementation of SMED methodology in the production line show that; thee tasks are converted from internal to external tasks, and the total changeover time reduced from (240.35 to 179.76) minutes with total saving time 60.59 minutes. The total changeover time are calculated by areas before and after implementation of SMED methodology as shown in figure 6. The achieved results showed that the OEE in the croissant line increased from 48% to 70% after implementation of SMED methodology. That is means the availability increased by decreasing the changeover time. Then the OEE is affected by the changeover time as shown in figure 7. The total time saving per changeover is nearly one hour, which equal eight hours per month and 96 hours per year as shown in table 4.

CONCLUSION

This paper provides a broad perspective on studying the effect of implementing the SMED methodology in a food Industries Company. This methodology is applied in the croissant production line to propose an optimal standard procedure for changeover operations on defined machine. A Comparison of results and achievements before and after implementation were made to measure the effectiveness of SMED to reduce cycle time. The obtained results showed that the SMED methodology has great impact on reducing the changeover time and increasing the OEE. The changeover time is decreased by one hour; OEE is increased by 22% after implementation of that methodology. Also the sales size increased by 232,800 pieces per year. This achievement led to increasing the total price from sales by 465,600 EGP/Year.

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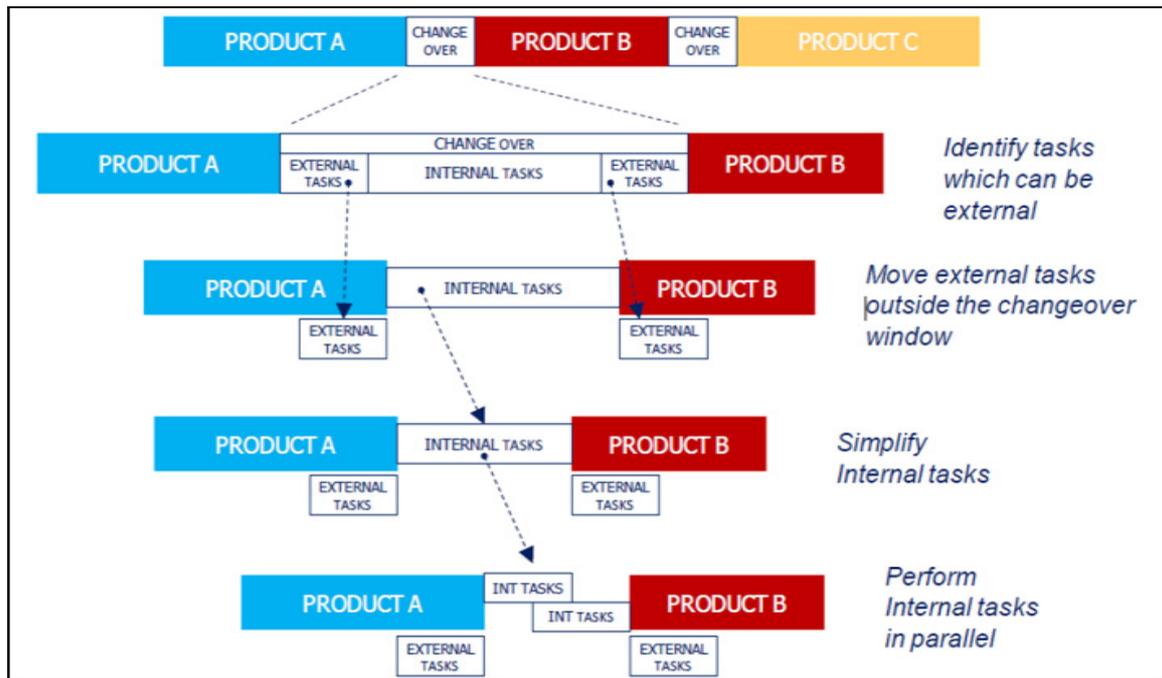


Fig. 1. Major SMED Improvement Steps [14].

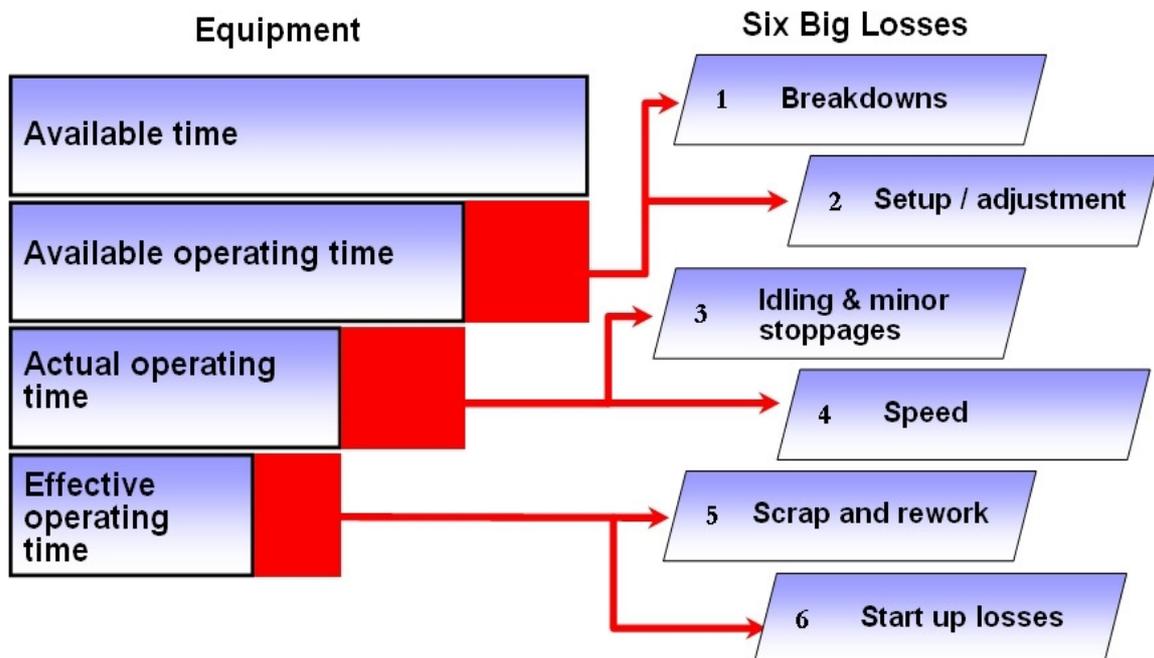


Fig. 2. OEE Time Frame [16].

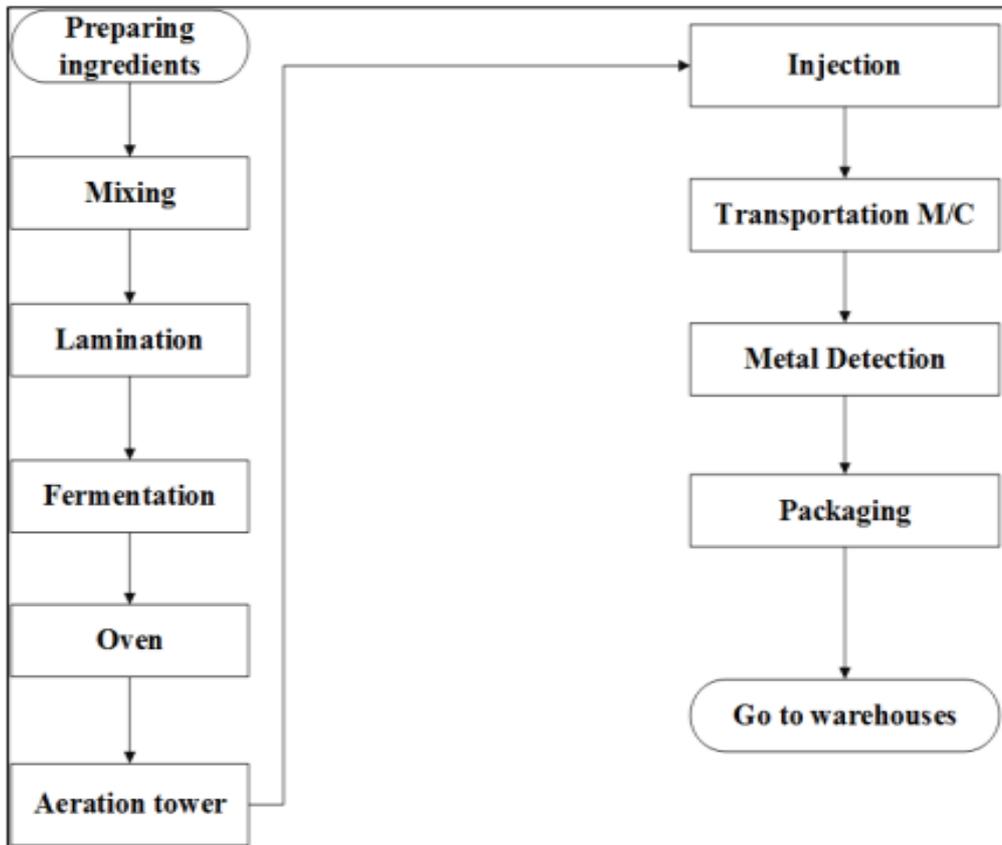


Fig. 3. Flow-chart for the croissant production line.

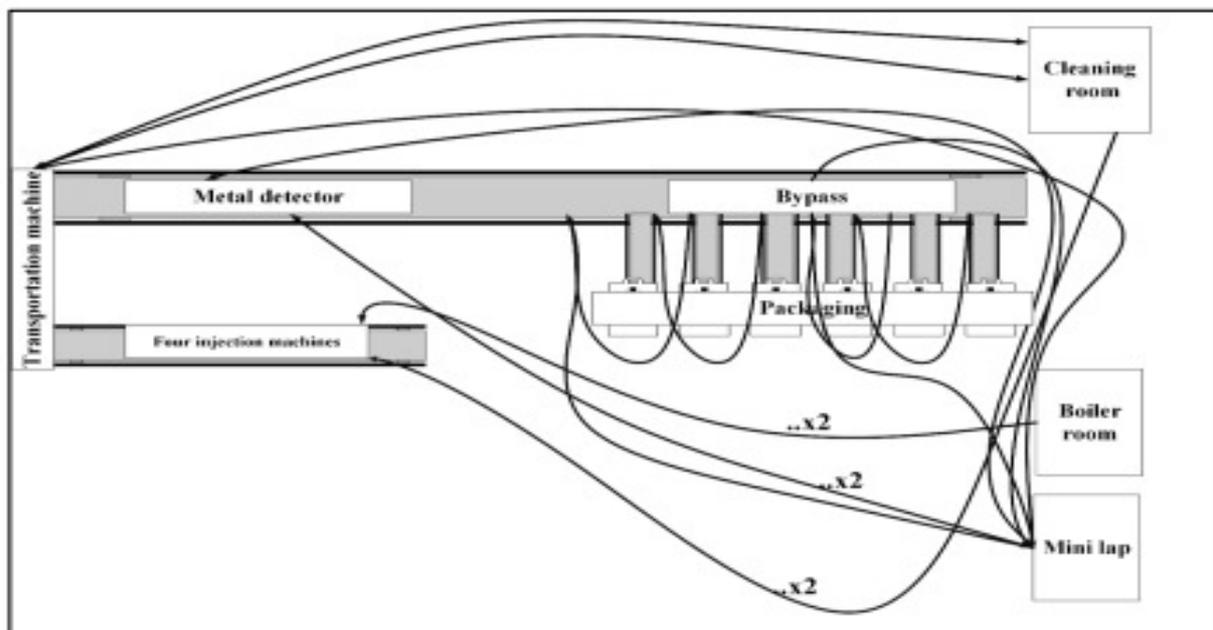


Fig. 4. Spaghetti diagram for the changeover areas before the improvements.

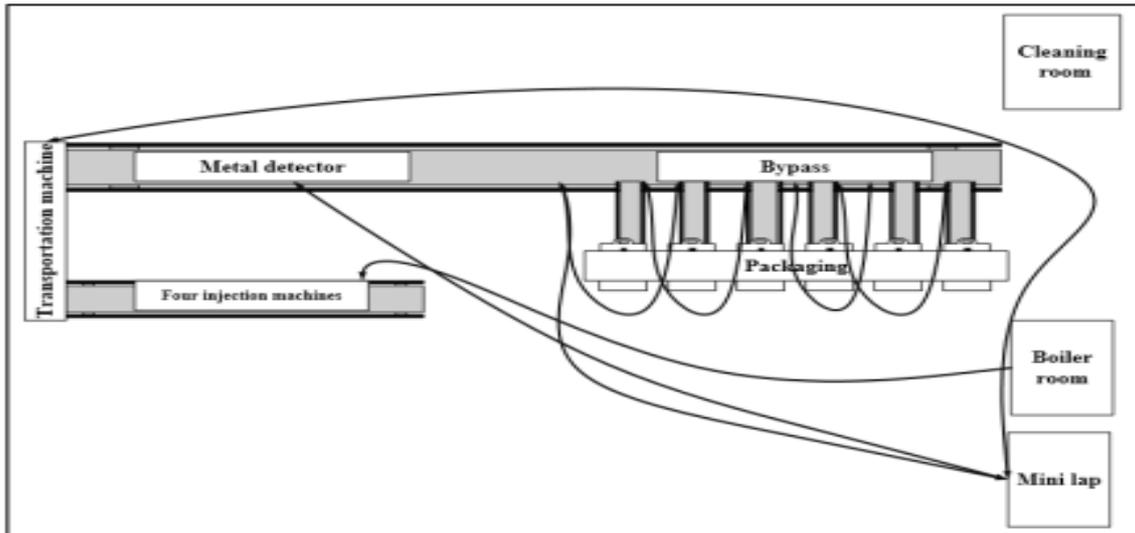


Fig. 5. Spaghetti diagram for the changeover areas after the improvements.

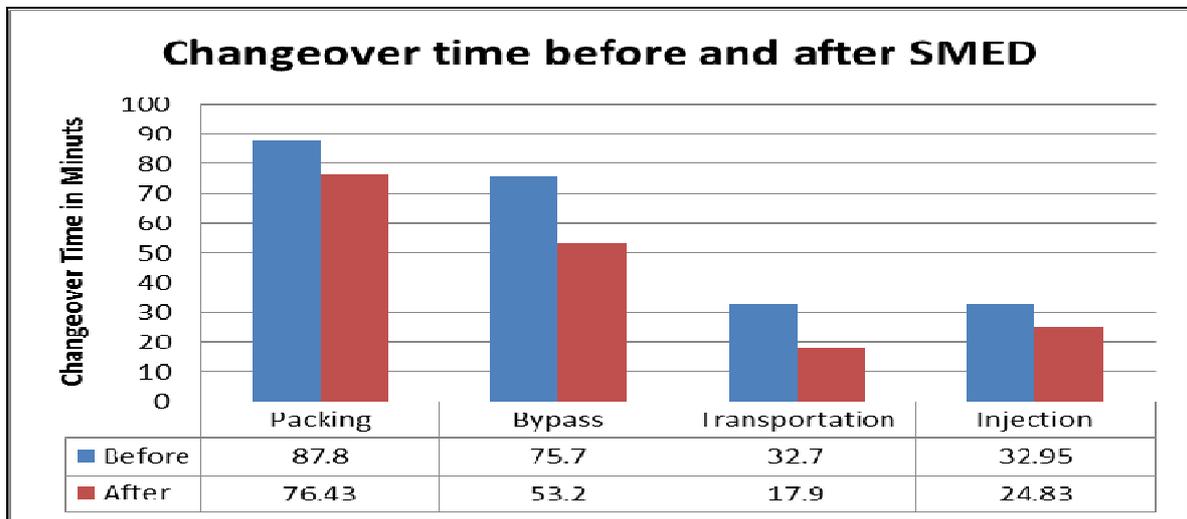


Fig. 6. Average Changeover Time by areas before and after the improvements.

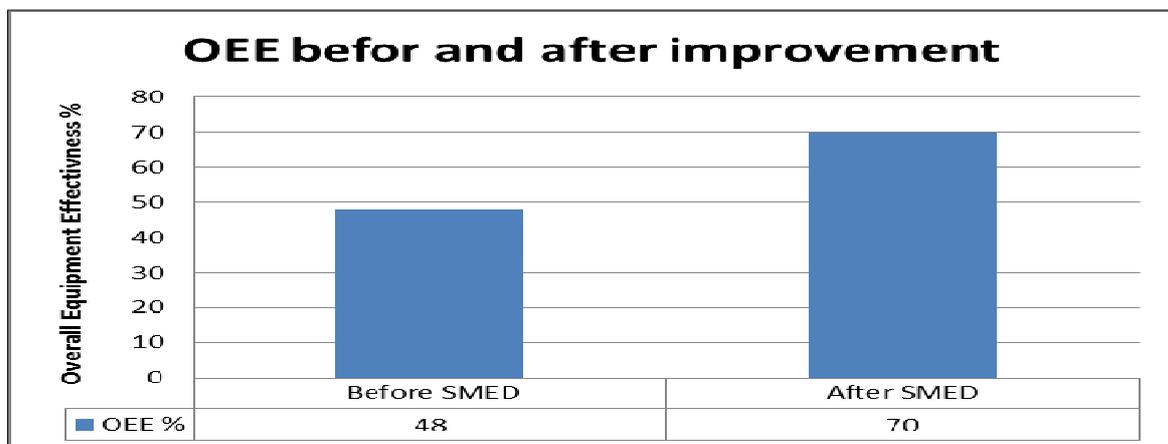


Fig. 7. OEE before and after the improvements.

Table 1. Six Big Losses [16].

Six big loss category	OEE loss category	OEE factors	Event Examples
Setup and adjustments	Down time loss	Availability	Setup/changeover Material. Material / Operator shortages. Major adjustments.
Breakdown	Down time loss	Availability	Tools failures. Unplanned maintenance. General breakdown. Equipment failures.
Minor stops	Speed loss	Performance	Obstructed product flow. Component jams. Sensor/delivery blocked. Cleaning/checking.
Reduced speed	Speed loss	Performance	Rough running. Under nameplate/design capacity. Equipment wear. Operator inefficient.
Startup rejects	Quality loss	Quality	Scrape/Rework. In process damage. Incorrect assembly.
Production rejects	Quality loss	Quality	Scrape/Rework. In process damage. Incorrect assembly.

Table 2. Classification of Changeover Tasks.

Area	Task Number	Task description	Time (min.)	Internal/ External
Preparation	1	Bring the required equipment and cleaning material from the store	4.2	Internal
Injection	2	Stop injector, remove flavor tank, prepare the required tools, and put the hot water tank.	2.3	Internal
	3	Release needles from all injectors	2.7	Internal
	4	Take the needles to the cleaning room and clean them by using hot water	20	Internal
	5	Clean injectors 1 & 2 by passing hot water through the pipes and the machine.	22	External
	6	Clean injectors 3 & 4 by the same method	24	External
	7	Sears some parts in the machine by using air pipes (time for 4 injectors).	4.7	Internal
	8	Install the needles and other parts for the four injectors.	3.25	Internal
Transportation M/C and Metal Detector	9	Release needle head, two heads, 4 bolts for each head.	1.3	Internal
	10	Clean the belts and the rollers under transportation machine	2	Internal
	11	Clean rollers under metal detector.	20	Internal
	12	Clean metal detector belts by using only water and cleaning materials	15.5	External
	13	Cleansing transportation machine belt by using alcohol.	1.2	Internal
	14	Sanitizing all belts in this area by using barfly	6.4	Internal
	15	Cleansing all belts in this area by using alcohol.	1.8	Internal
Bypass	16	Release doors of bypass machine and other related parts to allow the worker clean the rollers (15 doors).	20.7	Internal
	17	Cleaning the rollers and other related parts under the bypass belt by using water and cleaning materials	18	Internal
	18	Cleaning bypass belts by using water and cleaning material.	20.3	External
	19	Sanitizing all belts in this area by using belfry	18	Internal
	20	Sanitizing all belts in this area by using alcohol	32	External
	21	Put doors under bypass, put the containers under bypass, and ensure that all parts in the right position	19	Internal
Packaging	22	Remove packaging rollers from the six machines.	7	Internal
	23	Removing small belts of the bypass and some parts to clean	20	Internal
	24	Use air pipes to remove small pieces that are stacked between machines parts	15.3	Internal
	25	Use brush to clean packaging machine	6.3	Internal
	26	Put the bypass's small belts and parts that removed	8.2	Internal
	27	Put packaging rollers and other parts. Test and prepare the machines (one worker).	31	Internal
Trial run	28	Return all equipment to their places and prepare to restart the line	7	Internal

Table 3. Changeover time before and after SMED implementation.

Area	Task No.	Task description	Actual Time (min.)			
			Internal		External	
			Before	After	Before	After
Preparation	1	Bring the required equipment and cleaning material from the store	4.2	3.4		
Injection	2	Stop injector, remove flavor tank, prepare the required tools, and put the hot water tank.	2.3	1.3		
	3	Release needles from all injectors	2.7	1.5		
	4	Take the needles to the cleaning room and clean them by using hot water	20	15.7		
	5	Clean injectors 1 & 2 by passing hot water through the pipes and the machine.			22	22
	6	Clean injectors 3 & 4 by the same method			24	24
	7	Seals some parts in the machine by using air pipes (time for 4 injectors).	4.7	4		
	8	Install the needles and other parts for the four injectors.	3.25	2.33		
	Transportation M/C and Metal Detector	9	Release needle head, two heads, 4 bolts for each head.	1.3	1.3	
10		Clean the belts and the rollers under transportation machine	2	1.6		
11		Clean rollers under metal detector.	20	15		
12		Clean metal detector belts by using only water and cleaning materials			15.5	15.5
13		Cleansing transportation machine belt by using alcohol	1.2	-	-	1.2
14		Sanitizing all belts in this area by using Barfly	6.4	-	-	6.4
15		Cleansing all belts in this area by using alcohol.	1.8	-	-	1.8
Bypass	16	Release doors of bypass machine and other related parts to allow the worker clean the rollers (15 doors).	20.7	19.2		
	17	Cleaning the rollers and other related parts under the bypass belt by using water and cleaning materials	18	15		
	18	Cleaning bypass belts by using water and cleaning material.			20.3	15.3
	19	Sanitizing all belts in this area by using Barfly	18	-	-	18
	20	Sanitizing all belts in this area by using alcohol			32	32
	21	Put doors under bypass, put the containers under bypass, and ensure that all parts in the right position	19	19		
Packaging	22	Remove packaging rollers from the six machines.	7	5		
	23	Removing small belts of the bypass and some parts to clean	20	18		
	24	Use air pipes to remove small pieces that are stacked between machines parts	15.3	12.3		
	25	Use brush to clean packaging machine	6.3	4.4		
	26	Put the bypass's small belts and parts that removed	8.2	7.33		
	27	Put packaging rollers and other parts. Test and prepare the machines (one worker).	31	29.4		
Trial run	28	Return all equipment to their places and prepare to restart the line	7	4		

Table 4. The increase in sales size after improvement.

Items	Quantity
Time saved/changeover, [Hrs]	1
Time saved/Month, [Hrs]	8
Time saved/Year, [Hrs]	96
Production /Hour, [pieces]	2425
Increase sales/Year, [pieces]	232,800
Price / piece, [EGP]	2
Total increase in sales price /Year, [EGP]	465,600