

The Application of Lean Manufacturing to Reduce Setup Time of a Printing Process

Kasarin Chivatxaranukul
Aeronautic Engineering,
Vincent Mary School of Engineering,
Assumption University, Thailand
kasarinch@gmail.com

Abstract

In today's highly competitive world, industries are forced to find ways to survive by increasing efficiency and reducing costs. As one of several industries that are facing the challenges, the printing industry is threatened by competitions both among companies in the industry and technological threats like multimedia, e-books, etc., leading to the reduction in sales prices, higher competitions, and lower demands. This accentuates the need for companies to cut costs and improve productivity. The concept of Lean Manufacturing revolves around reducing wastes. Reduction of wastes can lead to significant increase in productivity and reduction in costs. Thus, Lean manufacturing is one of the techniques that can potentially be applied to provide means for companies in the industry to survive. This research studies the analysis of setup time reduction of a printing process using a lean concept called Single Minute Exchange of Die (SMED). Main strategy for SMED involves identifying setup activities, trying to convert the internal activities to external activities, and reducing activity times. The analyses of setup activities are conducted and a methodology to reduce standard setup time is presented. Although data used in this research pertain to the company used as a case study, the approach can be applied to a printing process in general.

Keywords

lean production, lean manufacturing, Single Minute Exchange of Die, setup time reduction

1 Introduction

Amidst the global decline of economy, companies are forced to find ways to survive by cutting costs, increasing efficiencies, and reducing losses among several other things. Among several strategies, Lean Production is one that has been implemented to a variety of industries in order to reduce costs or so called wastes and has allowed companies to increase their productivity and provide surviving leverages (Resende et al. 2014).

The concepts of lean emphasize elimination or removal of wastes, which have been traditionally categorized into seven types:- over production, transportation or unnecessary movements of materials, waiting time, processes (over processing or incorrect processing), inventory, motion, and defective goods (Elbert 2012). In the perspective of lean production, wastes involved in production activities are typically activities that do not add value to the product. The elimination of wastes leads to reduction of costs and subsequently results in more efficiency and higher profits for the organization.

1.1. Setup time reduction

Setup or changeover time is one element that can have a significant impact on overall production time or cycle time. It has been regarded by firms as one of the most expensive costs in manufacturing (Holweg 2006). Reducing setup time can lead to the reduction of cycle time as well as open up more capacity for production. This, in turn, leads to the

reduction of both tangible and intangible costs. An example of intangible costs is the opportunity cost from not being able to receive or produce for more orders when the machine or workforce is occupied. Examples of tangible costs include labor and overhead costs involved with longer production time.

In make to stock situations, manufacturers usually opt to produce large quantities or lot sizes in order to minimize setup costs. This, however, results in large inventories, which is considered as wastes. Thus, in view of lean manufacturing, reducing setup times is one key element for improvement. The reduction of setup times poses opportunities to reduce lot sizes and, consequently, inventory levels. In make to order production environments, where each lot produced is tailored to the customer's design, the impact of reduction of setup times will be even more significant as a setup is required for every change of jobs or orders.

1.2. SMED

Single Minute Exchange of Die (SMED) developed by Shingo, S. in 1985 (Shingo 1985) is a lean principle that focuses on reducing setup time. SMED was originally introduced in the automotive assembly industry and later has been extended to other industries. The process in implementing SMED involves the identification of setup activities and separating them into external and internal activities. Internal Activities are those that must be done on the machine or when the machine is stopping. External activities, on the other hand, are activities that can be done without stopping the machine. Converting as much of internal activity time to external activity time is a crucial step to improving the setup time.

1.3. Printing Process and Setup time

This research studies offset printing process, which is a process in book manufacturing and commercial printings. Printing can be considered as make-to-order production since each job has its own design and requirements. Producing one book requires printing several impressions. Typically, an impression of printing is a set of eight pages that requires one set of plates or dies. To produce one book, several setups is required with thicker books requiring more setup times. For example, a book with 96 pages comprises 12 impressions. Transitioning from one impression to another requires a change of plates as well as color matching process which is unique to every printing impression. The time required to setup one impression of print can be variable depending on the job and several conditions such as machine condition, the condition or paper, and materials.

On average, about 60-70 minutes is required for setup from the end of previous job to approval of printing of the next job. Depending on the lot size or printing quantity, the significant setup time can contribute to more than 50% of total printing time (including setup) for each impression, especially for the jobs with smaller lot sizes. The smaller the quantity, the higher impact setup time has on total printing time. If setup time can be reduced, even a matter of a few minutes, the accumulative results can be significant in the contribution to the reduction of costs and increase in productivity.

Although SMED theoretically attempts to reduce setup time to less than 10 minutes (Dave and Sohani 2012) which does not seem applicable to the setup of printing process initially, the concept of SMED can still be applied to improve setup time of printing impression even though it cannot be reduced to less than 10 minutes.

2 Literature Review

Considerable number of researches and papers have been dedicated to the study of lean production and its application. The works can be separated into literature reviews and analyses and applications of lean principles.

Gupta and Jain (2013) conducted a thorough literature review of lean manufacturing. They separated research works and studies in the field of lean manufacturing into the studies of lean philosophy, surveys, case studies, as well as research works that address the barriers to implementing lean and competitive benefits of lean manufacturing. Sundar, Balaji and SatheeshKumar (2014) provided a review on different implementation techniques of lean manufacturing.

The work was conducted by means of literature survey. Prajapati and Deshpande (2015) reviewed different lean principles and techniques for reducing cycle time.

Other works related to the implementation of lean manufacturing include Lodgaard et al. (2016), AlManei, Salonitis and Xu (2017), and Moeuf et al. (2016). Lodgaard et al. (2016) studied the barriers to successful implementation of lean strategies. Similarly, AlManei et al. (2017) identified obstacles and challenges in the successful implementation of lean and the frameworks required for success for Small and Medium Enterprises (SMEs). Moeuf et al. (2016) explored the difficulties experienced in the implementation of lean production.

This research work focuses on reduction of setup time, which is believed to be a significant contribution to the reduction of cycle time and, thus, reducing waste. A relevant lean manufacturing approach that focuses on setup time reduction is Single Minute Exchange of Die (SMED). Relevant previous research works pertinent to setup time reduction by the implementation of SMED include Esa, Rahman and Jamaludin (2015), Joshi and Naik (2012), Jagtap et al. (2015), Abraham, K.N. and Motwani (2012), Simoes and Tenera (2010), Resende et al. (2014), and Ferradas and Salonitis (2013). Joshi and Naik (2012) provided a literature review of SMED. Abraham et al. (2012) applied SMED to reduce setup time in a stamping line. Simoes and Tenera (2010) applied SMED to improve setup time in a press line. Azizi and Manoharan (2015) studied reducing lead time as opposed to only focusing on setup time using SMED and Value Stream Mapping (VSM).

3 Methodology

The process of SMED can be summarized as follows (Joshi and Naik 2012, Jagtap et al. 2015):

- Step 1: Analyze the setup operations
- Step 2: Separate internal and external setup activities.
- Step 3: Convert internal setup activities into external activities
- Step 4: Shorten internal setup and external setup activities

Considerable amount of work pertaining to the application of lean has been dedicated to the automotive industry. To the author's knowledge, no formal work has been published regarding the analysis of setup operations in the printing industry. This research discusses the analysis of activities involved in the setup of printing impressions, the separation of the activities into internal and external activities, and the conversion of internal setup into external setup activities.

The analysis of setup operations was performed through observation and gathering information from operators' time sheets over the course of three years as maintained by the company. Activities were then broken down into internal and external setup activities and standard time (the time required by an average skilled operator to perform a specified task under normal conditions using a prescribed method) for each activity was obtained by analyzing the time sheets and observations.

4 Settings and Assumptions

The printing process selected for this research is four color offset sheet-fed printing process performed on a semi-automated printing machine with no extra equipment for color reading. The printing machine selected has a computerized system to read and memorize the density of color dots on the mold in order to digitally preset the level of ink that each ink key will exert.

The setup time under study is defined as the transition time from the finish of one printing job to the finish of color setup for the next job. "Job" represents an impression which is printing using the same set of 4 molds for 4 process colors for printing 8 pages of standard A4 sized.

5 Applying SMED to Printing Process Setup

Step 1: Analyze the setup operations

Initially, the activities involved in the setup of a printing impression has not been formally broken down and analyzed. Without analyzing the activities involved in the setup process, it is impossible to improve the setup time.

It is essential to break down setup operations into small steps and identify time required for each setup activity or step. The analysis of setup operations was performed by observation and recording, which led to the breakdown of setup activities into small steps.

Activities required from finishing of the previous printing job to finishing color setting for the next job can be broken down into the following:

1. Washing of pervious set of printing blankets.
2. Filling ink in each of the four ink trays.
3. Preparing for plates (molds) of the next job.
4. Putting in four plates into four printing units (4 units for 4 process colors).
5. Setting paper size.
6. Putting paper stack in the feeding station.
7. Setting the machine ink keys to control the level of ink exerted from each zone.
8. Adjusting ink zones and machine settings to adjust colors.

This breakdown enables the analysis of which elements of the setup operations contribute to this considerable setup time that can possibly be improved. Standard time for each broken down activity has to be determined. The standard times are obtained by averaging recorded times of each activity under normal circumstances. Table 1 lists standard time used in each setup activity.

Step 2: Separate internal and external activities.

The analysis of activities discussed in step 1 results in the separation of internal and external activities as shown in Table 2.

Table 2 Separation of setup activities into internal and external activities

	Activities	Standard Time (min.)	Internal	External
1	Washing of pervious set of printing blankets.	8	√	
2	Filling ink in each of the four ink trays.	5	√	
3	Preparing for plates (molds) of the next job.	10		√
4	Putting in four plates into four printing units (4 units for 4 process colors).	20	√	
5	Setting paper size.	3	√	
6	Putting paper stack in the feeding station.	3	√	
7	Setting the machine ink keys to control the level of ink exerted from each zone.	15	√	

8	Adjusting ink zones and machine settings to adjust colors.	15	√	
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Activities 1 and 4 are require the machine to be performing the specified functions. Activities 5, 7, and 8 require the operator to enter commands onto the computer that controls the printing machine and the machine performs the setting accordingly. These are internal activities that cannot be performed unless the machine is not operating. Therefore, they are categorized as internal activities. Activity 3, preparation of plates is performed by an operator and does not require work to be done on the machine, thus, categorized as external. Activity 2 is performed manually by the operator but must be performed on the ink trays which are parts of the machine. Therefore, it is initially categorized as internal. Activity 6 can only be performed when the machine is not running and also categorized as internal.

As can be seen from Table 2, only 1 out of 8 activities (Activity 3: preparing for plates of the next job) is initially performed externally. This means that the setup process requires the machine to be stopped for 87.5% of the setup activities. Following the standard activity times in Table 2, these internal activities accumulate to 69 minutes of machine time.

Internal activities that can be transformed into external activities are analyzed and discussed in the next step.

Step 3: Convert internal setup activities into external activities

From Table 2, out of seven activities that are internal, three activities can be transformed into external activities without involving investments in machine replacement with higher technology. These activities that can be changed into external activities, resulting in the reduction of setup time are:

1. Activity 2: Filling ink in each of the four ink trays
2. Activity 5: Setting paper size
3. Activity 7: Setting machine ink keys to control the level of ink exerted from each zone.

Filling of ink into ink trays can be changed from internal to external by utilizing ink pipe feeding which allow for automatic pumping of ink to feed the trays. The process can also be done without having to invest in installing ink feeding system by simply changing the way operators perform work. Instead of waiting until the end of the job to feed ink for the new job during setup, operators can simultaneously fill the ink while the current job is still running.

Setting of paper size for the next job can also be done while the machine is working on the current or previous job by using a presetting function, which is already present in the printing machine but not currently utilized. Similarly, setting machine ink key levels can also be done prior to finishing the current job. However, these changes moving from internal to external activities present challenges as they require operators to work more effectively. This will involve a certain level of motivating, incentives, change of mindsets, and monitoring. Provided that these can be done, the breakdown of internal and external setup activities can transition from those presented in Table 2 to those in Table 3. Three more activities can be shifted to external activities.

Table 3 Separation of setup activities into internal and external activities after change

	Activities	Internal	External
1	Washing of pervious set of printing blankets.	√	
2	Filling ink in each of the four ink trays.		√
3	Preparing for plates (molds) of the next job.		√
4	Putting in four plates into four printing unit (4 units for 4 process colors).	√	
5	Setting paper size.		√

6	Putting paper stack in the feeding station.	√	
7	Setting the machine ink keys to control the level of ink exerted from each zone.		√
8	Adjusting ink zones and machine settings to adjust colors.	√	

Step 4: Shorten internal setup and external setups

In addition to transforming internal activities into external activities, SMED can also benefit from the improvement or shortening of each activity time. A further analysis yields a result that one activity, although cannot be changed from internal into external activity, can be managed such that the setup time reduces. This activity is Activity 6, which is the activity of putting a paper stack in the feeding station. Although putting a paper stack in the feeding station requires the machine to stop, setup time can be reduced by performing this activity in parallel with other setup activities like washing of previous set of printing blankets. Operating more than one activity simultaneously, however, requires adjustments which may involve increasing the number of operators as a different operator is required in putting the paper stack in the feeding station while other operators engage in other setup activities. This may be conducted without the need to increase the number of operators if current operators are motivated and utilized efficiently.

6 Results

The results of applying SMED to the setup of a printing process are shown in time as shown in Table 4. By converting identified internal activities to external activities, 23 minutes of standard setup time can be reduced. Another 3 minutes can be reduced by performing one internal activity in parallel with other internal activities simultaneously. The total reduction in setup time as shown in Table 4 amounts to 26 minutes, which contributes to 37.68% of the initial setup time.

Table 5 Results of SMED application to the printing process setup

	Activities	Before	After
1	Washing of pervious set of printing blankets.	8 min	8 min
2	Filling ink in each of the four ink trays.	5 min	5 min
3	Preparing for plates (molds) of the next job.	10 min	10 min
4	Putting in four plates into four printing units (4 units for 4 process colors).	20 min	20 min
5	Setting paper size.	3 min	3 min
6	Putting paper stack in the feeding station.	3 min	3 min
7	Setting the machine ink keys to control the level of ink exerted from each zone.	15 min	15 min

8	Adjusting ink zones and machine settings to adjust colors.	15 min	15 min
	sum of nonparallel internal activities	69	43
	External		
	Internal		
	Internal but Parallel		

Assuming that average lot size is 10,000 books and the machine speed is 10,000 sheets per hour, an approximation on time saving per day can be obtained as shown below.

Operating time per day: 8 hours or 480 minutes

Production time per one job: Setup + lot size ÷ speed

Initial production time per one job = 69 + 60 = 129 minutes

Production time per one job after improvement = 43 + 60 = 103 minutes

Initially, the total time required for producing one job with lot size of 10,000 is 129 minutes. For an eight operating-hour day, $480 \div 129 = 3.72$ jobs can be produced per day. After the improvement, $480 \div 103 = 4.66$ jobs can be produced by one machine daily. This contributes to 25.27% increase in production capacity, which can be significant.

7 Conclusion

This paper has analyzed the setup of a printing process for book production and applied SMED, a technique in lean manufacturing, to reduce or improve the setup time. The analysis of setup operations has led to the possibility of separating the activities into internal and external activities. Further analysis has been performed to provide ways to reduce the setup time by changing plausible activities from internal to external and by shortening some internal activity time by performing one activity simultaneously with other internal activities. This research provides solutions that can be implemented which results in an increase production capacity by 25.27% on average lot size provided in the assumption of the results section.

In practice, however, the success of the implementation depends on several other managerial issues and factors, such as motivation, operators' mind sets, and several other factors. This issue has been addressed by previous research works including Lodgaard et al. (2016), AlManei et al. (2017), and Moeuf et al. (2016) and is not the focus of this research. Further extension of this research may include a case study of real implementation, a more thorough study of the impact of setup time reduction on the financial performance, success factors involved in implementing the results, and further attempts to reduce time used in internal and external activities.

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Biography

Kasarin Chivatxaranukul is a lecturer in the department of Aeronautic Engineering at Vincent Mary School of Engineering, Assumption University, Thailand. She received her B.S. in industrial engineering from Sirindhorn International Institute of Technology, Thammasat University Thailand and her M.S. and Ph.D. from the school of Industrial and Systems Engineering, Georgia Institute of Technology, USA. Her research interests include production management, lean manufacturing, logistics system, supply chain management, production optimization, engineering management, engineering economics, and decision analysis.