Implementing the Lean Six Sigma Framework in a Small Medium Enterprise (SME) – A Case Study in a Printing Company

Joshua Chan Ren Jie, Shahrul Kamaruddin and Ishak Abd Azid
School of Mechanical Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Nibong Tebal, Pulau Pinang, Malaysia

Abstract

Small Medium Enterprise (SME) is facing the pressure from its competitors; mainly large companies as they could provide products of greater value with lower cost as compared to SMEs. This paper is about implementing the newly integrated quality concept; Lean Six Sigma (LSS) in a SME company and the implementation of the LSS framework is shown in the case study. The LSS framework proposed in this paper is different from other LSS framework based on other initial studies in terms of the focus of LSS implementation in SMEs only. This paper contributes towards the research upon a structured implementation of LSS in SMEs where it addresses the issues faced by previous works regarding LSS implementation in SMEs.

Keywords
Lean Six Sigma, Small Medium Enterprise, Printing company, Productivity

1. Introduction
Customers have been putting pressure on the industry for the products they purchase to be of higher value. This has spark various industry to adopt various quality management tools and concepts in order to strive towards a better quality product, lower lead time and lower cost. This leads to adaptation of different quality management concept into the firm's production. Two of the most in-trend and proven successful practically quality management concepts in the industry (if applied properly) are the Lean Manufacturing concept and Six Sigma (Buesa 2009; Kaushik et al. 2012). Many researchers and industrial practitioners have been discussing about integrating Lean Manufacturing and Six Sigma to form Lean Six Sigma (LSS) as the latest quality management concept (Hoerl and Gardner 2010; Assarlind et al. 2012). The integration of both models will facilitate the achievement of zero defect manufacturing in organizations complemented by the elimination of non-value added activities which leads to greater results than either system can achieve alone (Snee 2010). However, the LSS concept has largely been on a theoretical level; whilst discussion is important, the practicality of the newly integrated quality concept is equally important as well (Assarlind et al. 2012). Little research has been carried out on the practical side of the LSS concept, but early results shown by some researchers in implementing LSS framework to guide larger firms to adopt this concept has so far been successful (Thomas et al. 2009; Laureani and Antony 2010; Ray and John 2011). This further increases the pressure on SMEs to stay in the industry as larger firms could compete with a greater value product with less cost. This paper aims to provide a structured LSS framework which can be adopted in the SME label printing company in order to reduce waste and variation in their production; aiming to increase its productivity while reducing the cost of production.

The arrangement of this paper is as followed: Section 2 will discuss about the view of LSS, Section 3 will provide a LSS framework together with the case study on the implementation of LSS in a SME Label Printing company. Section 4 will be the discussion of the LSS implementation in the case study and the conclusion will be in Section 5.

2. Lean Six Sigma
Lean Six Sigma (LSS) concept is the integration of two (2) quality management concepts which are Lean Manufacturing and Six Sigma whereby it attempts to increase the scope and size of improvements achieved by either concept alone. However, different individual and companies view LSS in different ways. Some would perceive LSS as a fully integrated system between Lean Manufacturing and Six Sigma while others would perceive LSS as two different concepts which is adapted in parallel (Assarlind et al. 2012). Moreover, the integration between the two quality management concepts varies between each integration as Assarlind et. al. (2012) points out that each integration may involve transferring of different tools, ideas and philosophies. This leads to many theories on how Lean and Six Sigma could be integrated. Some authors recommended that Six Sigma should lead the initiatives, with

Lean tools added during the analysis phase of the initiatives while other authors recommend that Lean should be the backbone of the framework and Six Sigma is used to reduce and then eliminate the variation found.

Lean Manufacturing focuses on waste reduction and non value-added activities in production (Womack et al. 1990) while Six Sigma focuses on process variation reduction with both concepts aiming to reduce waste. The integration would take into account the strength, weaknesses and effective aspects of each concept to form a better concept (Kumar et al. 2006; Snee 2010). There is a need towards this integration in quality management as a solution provided via Lean Manufacturing concept would be of no use if the execution of the solution has high variation. The Six Sigma concept on the other hand would give too much focus in reduction of variation only leading to high risk of providing poor service due to long lead times even if the company are operating at Six Sigma level. Even though most would agree that there is a need for the integration of Lean and Six Sigma, most companies would prefer to implement both concepts in isolation (Smith 2003) or in parallel but this would lead to increase of projects and resources while causing conflicts of interest between the two quality management concepts (Bendell 2006). Implementation of both concepts in isolation too will not enable each concept to be adopted effectively as it is constraint by one another’s needs in the organization. In fact, Lean and Six Sigma can be compatible whereby both are of quality management (Shah et al. 2008), both are methods that brings changes and improvement to organization; particularly as a cost reducing mechanism (Achanga et al. 2006), both has the same final objectives which is to provide quality throughout the organization and both stresses the needs towards continuous improvement at all level in the organization (Pepper and Spedding 2010). Both concepts complement each other, where lean can adopt the scientific, standard and data driven approach from the Six Sigma DMAIC (*Define, Measure, Analyze, Implement, Control*) methodology to reduce waste while Six Sigma can change their focus from projects work based on identified variation to a customer requirement focus (Bendell 2005). Through the implementation of lean, a company would be able to recognize key areas of improvement while Six Sigma would then be implemented in those key areas to reduce variation.

The LSS framework proposed in this paper is focused towards SME, particularly in the label printing industry. The development of the framework depends on the environment (management culture, size of the industry, technology) of the particular company. The observed environment for the implementation of LSS in the case study company is not particularly supportive towards quality management. The company puts its focus only on production; aiming to meet customer datelines and to cope with demand. However, its focus in production does not help in coping with quality of products, hence turning their attention to quality management; particularly in LSS. Implementation of LSS is particularly tough in an SME as it lacks expert personals and experience in the LSS field to lead the project, the framework seems to be complicated and might require high cost of implementation. Due to lack of knowledge in LSS, it is irrelevant to provide a general framework for SME where it has high flexibility of using different lean tools within the methodology. A general framework without a step-by-step guide is particularly of no use if there is no expert leading the LSS project. Hence, the developed framework gives a detail guide in each phase and is simple enough for people with lack of expertise and experience in this field to use. As pointed by Kumar et al (2006), there is a need for clear guidance within the LSS framework and also a clear understanding of tool usage within the framework. A detailed adoption of the LSS framework is given in the following sections.

3. Case study

The developed LSS framework is verified in an SME label printing company. The label printing section produces various types of labels such as computer labels, offset & silkscreen stickers and bar code labels. The management wants to implement LSS because the label printing production has low productivity and produces high wastage; where it increases the lead time of the production and the cost of the product.

3.1 Lean Six Sigma Framework

The LSS framework has five (5) phases as shown in Figure 1 with each phase providing an easy and structural guide towards root-cause identification of a problem, hence proposing and implementing feasible solution to eliminate the root cause through continuous improvement. It should be noted that there is by no means this framework is the only technique that can be used in LSS adoption. Thomas et al (2009) also mentioned the same towards their LSS framework development. As mentioned earlier, the developed framework is based on the suitability of the environment which LSS is being implemented.

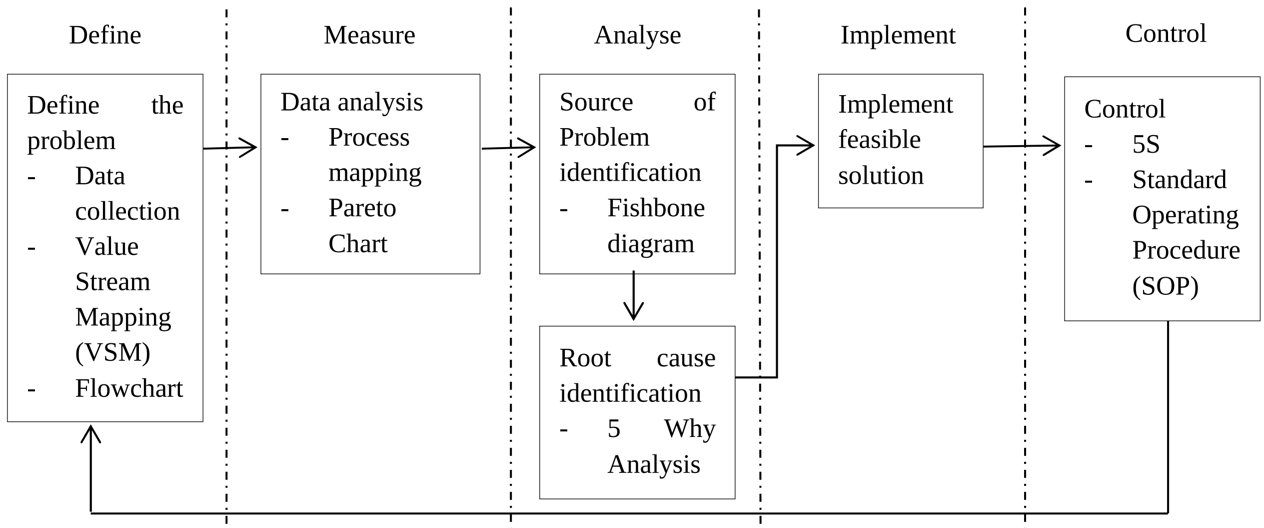

Figure 1: Lean Six Sigma implementation framework in SME label printing industry

The LSS framework as shown is actually a simplification of the Six Sigma's DMAIC methodology with guided steps on utilizing certain lean tools in each phase. The framework utilises data driven and guided standard approach of the Six Sigma DMAIC methodology while utilising lean tools in each phase to determine improvement opportunities and further analyse the problem(s).

3.1.1 Phase 1: Define the problem - Data Collection

The label printing industry is competitive, where each company will strive to provide their products with lower cost and lower lead time. In order to compete at such level, a company should be operating with as minimal waste as possible. In order words, the production of the company should strive towards operating at six sigma level and aiming towards lean. The company in this case study is unable to cope with demands, leading to unsatisfied customer with late delivery of products. The company too is unable to receive orders which are urgent; reducing the number of customers in the company. While it is obvious that the problem is the inability to cope with demands, the root cause towards the problem is yet to be identified. Solving the root cause of the problem will reduce the probability of the same problem to occur again. To determine the root cause of the problem, data regarding the label printing production has to be collected and analyse in the next phase. Collection of data includes data regarding products, capacities and capabilities of the label printing production and process flow. Collection of data is carried out based on observation in the production line, discussion with the manager, supervisor and operator of the label printing section and time study. There is a lack of written data regarding the production in SME because their focus is to keep on producing to cope with demand, while lacking personnel to lead quality management initiative in the production. These data are crucial to gain insights of the current production of label printing. It has to be understood as well that label printing only requires one printing machine for one job order; and each job order varies according to the types of ink, labels and printed words. Each type of machine has its own capabilities and job orders are scheduled for each machine according to the machine's capabilities and the job order requirements. Table 1 shows the summary of capabilities of all five (5) printing machines in the label printing section.

Table 1: Capabilities of the label printing section

Attributes	Machine A1	Machine A2	Machine A3	Machine B	Machine C
Production capabilities (impression/week)	235,000	235,000	235,000	128,000	230,000
Current production output (impression/week)	123,937	117,074	118,676	51,256	105,800

Based on Table 1, the current production output for each machine is approximately 50% lower than its capabilities for machine type A; 40% and 45% lower respectively for machine type B and C. The data on the current production output is based on the average monthly production output for the year 2011.

3.1.2 Phase 2: Data Analysis and problem source identification

Based on the data collected, it can be deduced that low productivity is the reason why this company cannot cope with customer demand. Customer demands for labels with printing ink are much higher than UV ink; hence, the focus of the LSS implementation will start off with analysis on machine type A. The current Value Stream Mapping (VSM) for the process flow for machine A1 is constructed as shown in Figure 2 with areas of improvement being identified.

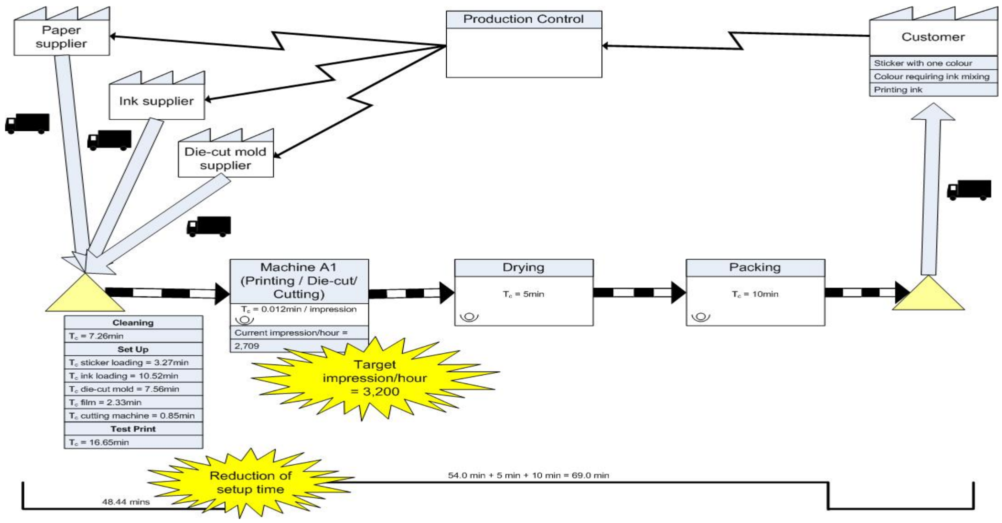

Figure 2: Current Value Stream Mapping of machine A1 for one job order on average

Referring to Figure 2, the production time for one job order is 117.44 minutes which is approximately 2 hours per job order on average. Out of these 117.44 minutes of production time, 41.2% of the time is used for setup. The production processes such as printing, die-cut, cutting, drying and packing process have a very low significant amount of defects. Based on the discussion from the manager and supervisor, the company aims to reduce the setup time of each job order thus an analysis relating to the setup is further carried out. Time study is carried out to determine the time required for each setup and a Pareto chart as shown in Figure 3 is developed based on the time used for each setup process.

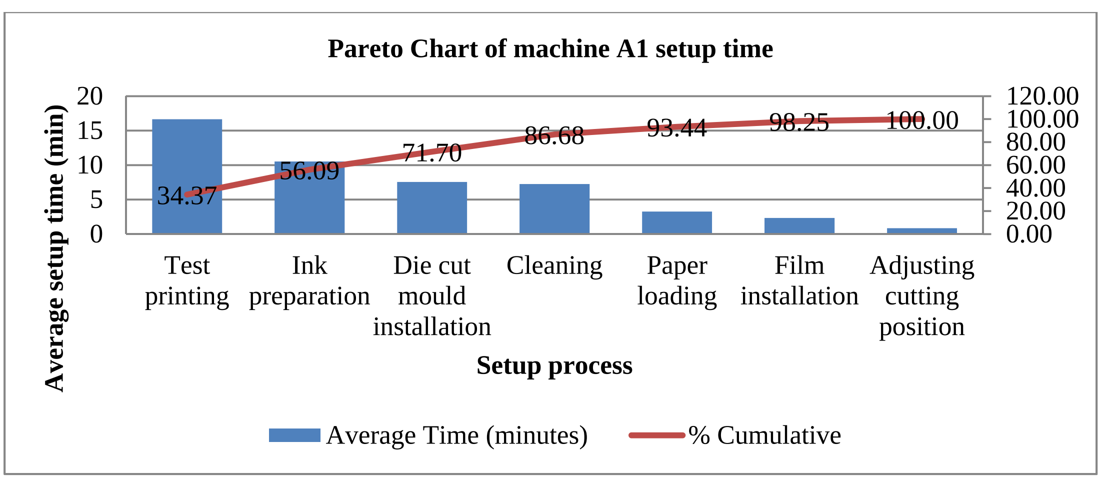

Figure 3: Pareto chart of the time used for each setup process

The Pareto principles states that 80% of the problem comes from 20% of the causes. In this case as depicted in Figure 3, the main causes of high setup time are due to test printing, ink preparation and die-cut mould installation. Hence through VSM, time study and Pareto chart, the sources of problem that causes low productivity are identified.

The three (3) setup process that are test printing, ink preparation and die cut mould installation will then be analysed further to determine the root causes of its high setup time in the next phase.

3.1.3 Phase 3: Root Cause Identification

Based on the observation in the production line of each setup and discussion with manager, test printing time is directly proportional to how well each setup is being made. This is also depicted in Figure 4 where test printing time is repetitive if the previous setup is not carried out correctly at the first time.

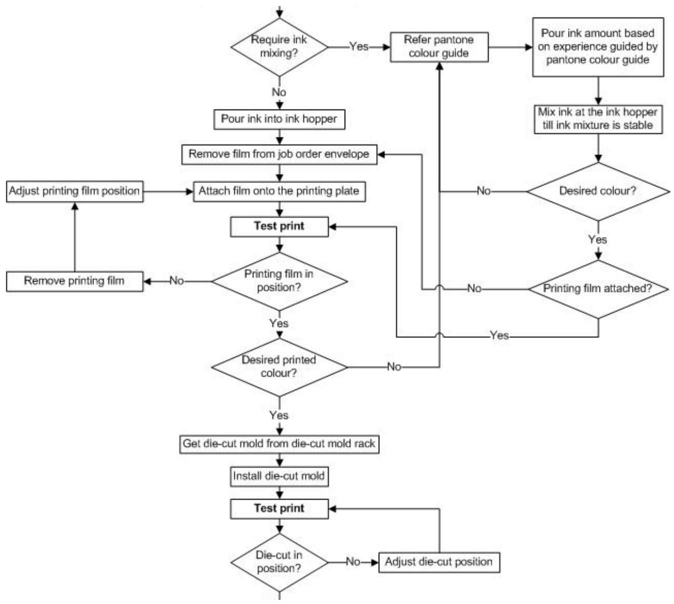

Figure 4: Part of the setup which includes test printing for machine A1

If each setup is carried out correctly, then test printing time will eventually be low. Hence, the focus of root-cause analysis will be carried out for setup of ink preparation and die cut mould installation. Fish bone diagram is developed based on each setup to assist the findings of the cause of this problem. It is developed through brain storming and discussion with the manager, supervisor and operator of the label printing section. The diagrams are shown in Figure 5 and 6 respectively for each setup process.

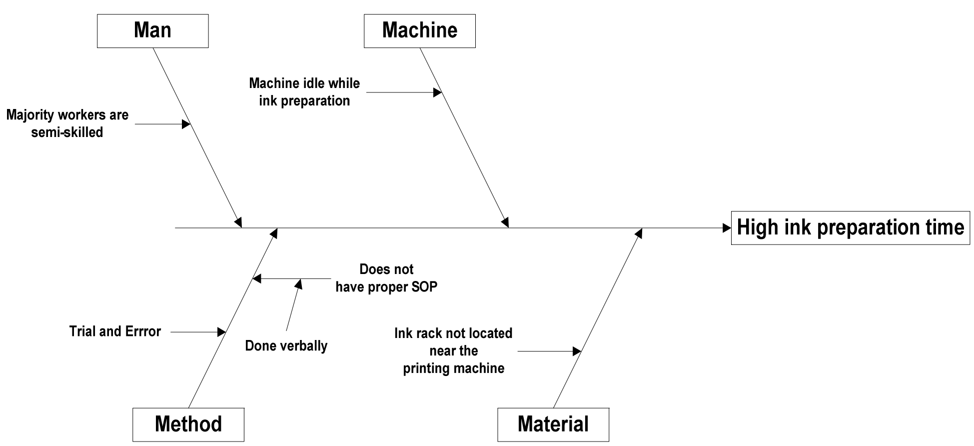

Figure 5: Fish bone Analysis on the high ink preparation time

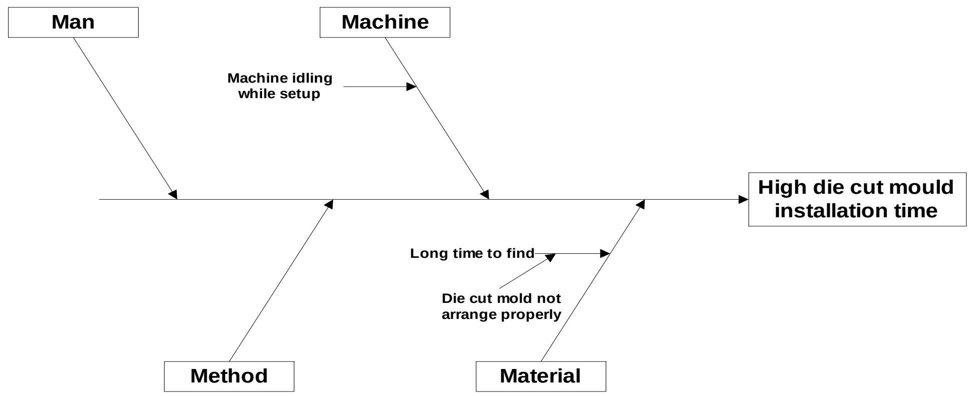

Figure 6: Fish bone Analysis on the high die cut mould installation time

Based on Figure 5 and 6 of the fish bone diagram, the main causes that leads to high setup time for both types of setup is tabulated in Table 2.

Table 2: Main causes of high setup time

Setup	Main causes
Ink Preparation	Trial and error ink mixing procedure Machine idling while setup
Die Cut Mold Installation	Hard to find die cut mould

The main causes of each setup are deduced from discussion with the manager and supervisor of the label printing section based on all the causes from the fishbone diagram. Die cut mould installation has caused the long setup time due to the inability to locate the materials needed for both setups while Ink preparation setup is high due to the trial and error method used for ink mixing and was carried out while machine is idling. The company uses trial and error method for ink mixing because ink mixing is rather unique in the way that it requires skilled and experienced worker to be able to get the desired colour in a short time. Although there is a pantone colour guide for the operator to determine the ratio of base colour to be mixed in order to get the desired colour, the operator still needs to add ink mixing accordingly because the guide doesn't give 100% accuracy of the colour mixed. Furthermore, there are still other variables that have to be taken into consideration such as type of label used and the amount of ink allowed to be fed to the ink roller which could also produce different results of ink colour mixed. Hence, the other main causes that have been identified will then be further analysed to determine the root cause of high setup time for each setup using the 5Why analysis as shown in Figure 7 and 8.

Main cause	• Hard to find die-cut mold
Why 1	• Die-cut mould is not arranged properly in a drawer
Why 2	• Hard to arrange and not suitable for certain amount
Why 3	• The arrangement system is not sustainable
Why 4	• The existing method is not convenient to find and keep the die-cut mold
Why 5 / Root cause	• **There is no proper slot to keep the die-cut mold**

Figure 7: 5Why analysis on the root cause for a hard way to find the materials.

Main cause	• Machine is not fully utilize
Why 1	• Available time to utilize the machine is limited/short
Why 2	• Setup causes the machine to be idling
Why 3	• Setup can only be done when machine is not running
Why 4	• Machine is part of setup
Why 5 / Root cause	• **Setup is internal of production**

Figure 8: 5Why analysis on the root cause for underutilization of machine.

3.1.4 Phase 4: Implement feasible solution(s)

Based on the root causes that have been determined in Phase 3 via Fishbone diagram and 5Why tool, feasible solution is being discussed and brainstormed in order to reduce or eliminate the root causes. In order to reduce the time to find the die cut mould and ink, a proper storage has to be designed. The design of the storage has to be sustainable where it is easy to keep and find the material. By reducing the time to locate these materials, the total setup time will be reduced. The storage is designed with a pigeon hole concept, whereby the die-cut mould is place into the slot according to the customer code. In order to allow the die-cut mould to be arranged into the slot easily, a cardboard is attached to the die-cut mould to allow the mould to stand without leaning onto each other. Each die-cut mould will be labelled, and each label will be coloured according to the customer code. The probability of misplacing the die-cut mould will be reduced by having different coloured labels for different customer code. Another feasible solution to propose is to implement SMED on the label printing process by shifting the setup process out from the real production process called external setup (OED, or outside exchange of die). By removing the setup from the production, machine will not be part of setup; hence, production can run continuously. Since setup is now the external part of the production, setup can be done in parallel with the production. The ink preparation is proposed to be setup externally where by a dedicated cell with one skilled and experienced worker is required to prepare ink for the A1 machine. Hence, the setup time of ink preparation will be reduced drastically since the operator operating machine A1 is not required to prepare ink.

3.1.5 Phase 5: Control

This phase is very important in the Lean Six Sigma implementation as LSS does not only aim to reduce waste but also to be able to sustain the improvement that has been made. 5S and Standard Operating Procedure (SOP) are used as a control tool in the LSS framework because 5S provides a guideline to sustain the arrangement of the die cut mould while SOP provides a step by step guide in implementing the new setup process since some of the setup process is shifted externally. 5S is a name representing the five (5) steps that needs to be taken in order to maintain efficiency and effectiveness of a work place. The five (5) steps mentioned are seiri, seiton, seiso, seiketsu and shitsuke which means sort, arrange, clean, standardize and sustain. This method is essentially important to control the process of searching die cut mould as this helps sustain the arrangement of die cut mould in the new storage system. SOP is a guided procedure for operator to do a certain job. Since ink preparation setup is made external, a guided SOP is designed to guide operator in their change of work activities such as the process flow for setup on machine A1 and the process flow of externally mixing ink.

4. Discussion

The LSS framework is a relatively simple guided methodology used in problem identification providing suitable solutions to solve problem(s) and controlling the improvement made. This method emphasize on problems derived from data, and solution deriving from the root cause of the problem. The strength of using this method is that problem identification can be relatively easy when there is data supporting it and the solution towards the problem is to solve the root cause of it. By solving the root cause, the potential for the same problem to arise will be low once the improvement is made. In phase 1, data collection will be on the product and capabilities of the production, the capabilities of the equipment and the process flow of the production. Phase 2 emphasizes on analysing the data which is collected in Phase 1 and identify the problem based on the data collected. Then, the root cause of the problem is identified in Phase 3 using necessary tools such as Fishbone diagram and 5Why. Then in phase 4, the solution to solve the root cause is implemented and then controlled in phase 5. The results of the implementation of LSS framework in the SME label printing section has yielded an increase in productivity as depicted in Table 3.

Table 3: Summary of the process improvement in a SME label printing section

Attributes	Current (Year 2011)	After improvement
Production Capabilities (impression/hour)	5,142	5,142
Current Production Output (impression/hour)	2,709	3,303
Average setup time (minutes/job order)	48.44	30.07

The productivity of the label printing section shows an increase by 584impression/hour, approximately 896,000impression/year which is an increase of 21.93% of the current production output. With such increase of the productivity of machine A1, the label printing section is able to have an extra capacity of almost two (2) months which would allow them to cope with customer demands and have more flexibility when dealing with urgent orders from customers.

4.1 Challenges faced when implementing LSS framework

There are a few challenges faced in the course of LSS adoption in the SME label printing section. The challenges can be divided into two (2) perspectives, the management of the SME label printing section and the LSS framework.

There is a minimal management support towards the LSS adoption in the initial stage as the management is not able to project the benefit of such adoption. The management would prefer to focus on production rather than spending time and money to improve the quality aspect of it. The management is not flexible for changes in culture and work activities in the label printing production. The management is worried that these cultural changes in the production would bring negative impact towards the production. Hence, in order to implement these solutions, it has to be done in stages, where changes are not too drastic in order to visualize the improvement made in a practical way to the management. The management lacks skills and knowledge in managing such frameworks and applying it in the production. The SME label printing section does not have technical expertise in Lean Six Sigma but they want to strive in order to compete in the industry. Hence, the LSS framework developed for the SME label printing section has to be in a guided form; explaining the function of each phase and tools used.

The LSS framework is data-driven; where problems and solutions to the problems are initiated by data. However, the label printing section does not have a data collection system as their focus is primarily and mainly on the production. Hence, all data regarding the product, the capacities and the capabilities of the production and the flow chart has to be collected from scratch. There is also a lack of written and formal standard operating procedure (SOP) in their process flow which prolongs the time spend on data collection alone. This leads to poor support from the management as well since the initiation phase of the framework requires longer period, especially in the data collection phase. However, this initiation of LSS in the label printing section provides a pool of written and documented information regarding the label printing section which has to be updated along time so as to ease continuous improvement in the future.

5. Conclusion

The adoption of the LSS framework has provided a systematic and guided approach to identify a problem and to provide a feasible solution and sustain the improvement made. Each step taken in this approach has been shown in details in every phase of the study. Machine A1 has an extra 896,000 impression/hour of capacity in order to help the company cope with customer demands. This extra of capacity is worth 2 months of the current capacity in the label printing production. A significant improvement has been observed in machine A1, where it yields the productivity from 2,709 impression/hour to 3,303 impression/hour giving 21.93% of improvement.

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Biography

Joshua Chan Ren Jie received BEng (Hons) degree in Manufacturing Engineering with Management from Universiti Sains Malaysia in 2012. Currently, he is an MSc (Research) candidate in School of Mechanical Engineering at Universiti Sains Malaysia. His research interest is on development of a lean six sigma framework for SME industries.

Shahrul Kamaruddin received the BEng (Hons) degree from University of Strathclyde, Glasgow, Scotland in 1996, the M.Sc. degree from University of Birmingham, U.K., in 1998, and the PhD from University of Birmingham, in 2003. Currently, an Associate Professor with the School Mechanical Engineering (under the manufacturing engineering with management programme), Universiti Sains Malaysia. He has various past experiences with manufacturing industries from heavy to electronics industries especially in the field of industrial engineering, manufacturing processes and product design. He has more than 100 publications in reputed international and national journals/conferences. His current research interests include simulation and modelling of manufacturing systems, production planning and control, maintenance management and manufacturing processes.

Ishak Abdul Azid received the B.Sc. degree in Mechanical Engineering from Clarkson University, Potsdam, NY, in 1992, the M.Sc. degree from University of Wales, Swansea, UK, in 1995, and the Ph.D. degree from University of Wales, Cardiff, UK, in 1999. He is currently a Professor at the School of Mechanical Engineering, Universiti Sains Malaysia, Penang, Malaysia. He has published more than 100 papers in journals and conferences. He has various experiences in manufacturing industries especially in the field of optimization in industrial engineering. His research interests include application of artificial intelligence in industrial engineering, micro electromechanical systems (MEMS) and thermal management in electronic packaging.