Journal of Engineering
Research and Education
Vol. 9 (2017) 29-40

Setup Time Reduction for 5-Axis Composite Material's Trimming Machine by Using a New Framework of SMED Integrated with ECSC Concept

M. S. F. Soberi*, R. Ahmad, M. I. Hussain and N. Muhammad

School of Manufacturing Engineering, Universiti Malaysia Perlis (UniMAP), Alam Pauh Putra Campus, 02600 Arau, Perlis.

ABSTRACT

To survive in today's competitive world; industries and manufacturers need to find ways and alternatives to reduce the production time and costs in order to boost the operating performance, product quality and flexibility. One of the alternatives is to reduce the setup time. For many decades, extensive attention has been given to the action of reducing the setup and changeover time and most of them are practicing the "famous" Single Minute Exchange of Dies (SMED), developed by Shigeo Shingo in 1960s. Despite that, many companies are still having problems in implementing the SMED because of there is no specific guideline to apply the method. This paper proposed a new framework of SMED with detailed steps to facilitate lean practitioner in implementing it. The new SMED framework will helps decision maker in choosing the best options whether to eliminate, combine, simplify or convert the setup activities from internal to external activities by applying Eliminate, Combine, Simplify and Convert (ECSC) concept. A case study in composite aircraft manufacturing company is used to exemplify the approach. The data analysis was presented to show the final results. The result validates the aptitudes of the proposed method in reducing the setup time.

Keywords: Setup time reduction, changeover, Single Minute Exchange of Dies, SMED, lean manufacturing, ECSC concept.

INTRODUCTION

Over the years, there has been an explosive growth of interest in the research for setup time reduction. Setups are essential to follow the production process of various production types [1-3]. The setup process development is even more crucial when the product ranges in many manufacturing companies are growing and the production series size is reduced simultaneously [4-5]. Setup time refers to the time allocated for preparing the necessary resource to perform an operation [6-8]. Setup time also can be defined as the time elapsed between producing the last good product of the first lot and the first good product of the next lot [9-11].

* Corresponding author, Tel : +6019-5529584. E-mail address : *syazwanfaizmaat@yahoo.com* (M. S. F. Soberi)

One of the lean's tool that are regularly applied for reducing the setup time is Single Minute Exchange of Dies (SMED) [12-14]. The SMED which is introduced by Shigeo Shingo in 1960s refers to a set of theory that can be applied to reduce the equipment setup time. The primary objective of SMED is to accomplish the setup process in less than ten minutes, or single digit minutes which gives the name of this method [15-17]. The fundamental of SMED is eliminating the time wasted in changeover process by identifying and simplifying the activities done before, during or after the changeover process and finally streamlining the remaining activities for smoothening the production flow [18-21].

By using the SMED concept, all of the activities in the setup operation can be divided into two groups which is internal and external activities. All of the activities that can only be completed while the machine or equipment is shutting down are the elements of internal setup. They must be minimized, reduced and simplified because they are slowing down the production process flow. External activities can be done eventhough the machine is running. These activities can be performed before or after the machine is shutting down [22].

This paper concerned with the research study of reducing the setup time for the 5-axis composite material's trimming machine. The SMED philosophy along with the Eliminate, Combine, Simplify and Convert (ECSC) concept was adopted to achieve the optimum reduction in setup time. The implementation of the SMED integrated with ECSC concept is clearly explained. A real example of composite aircraft manufacturing company is used to validate the approach.

RESEARCH METHODOLOGY

The original SMED framework is compared and contrasted with the proposed SMED-ECSC framework. The framework explains the operations in each phase starting from Phase 1 until Phase 4. In the SMED-ECSC framework, there has been some improvement in Phase 3 of the original SMED framework. The proposed ECSC concept is applied in Phase 3. The overall setup process will be explained in the next section.

Case Study

This research study was conducted in the Trimming Department of Company X which is the manufacturer of structure composite bond assemblies and sub-assemblies for commercial aircraft industries. The setup time in this case study refers to the time required to setup the trimming machine and manage the Drilling Router Jig (DRJ) with composite panel. Table 1 shows the sequence of the setup activities.

Table 1: Current setup activities and their durations

No	Setup activities	Time taken(s)	No	Setup activities	Time taken(s)	No	Setup activities	Time taken (s)
#1	Drive forklift to the rack	34	**#2**	Lift a long DRJ	146	**#3**	Move the DRJ to another rack	25
#4	Lift a new long DRJ	73	**#5**	Move the new DRJ within rack	30	**#6**	Lift another long DRJ	102
#7	Adjust forklift to reverse	105	**#8**	Move the DRJ to another rack	19	**#9**	Drive forklift back to origin	23
#10	Checking LOB	68	**#11**	Drive forklift back to rack	75	**#12**	Take a new long DRJ	16
#13	Adjust forklift to reverse	33	**#14**	Move DRJ to another rack	276	**#15**	Reverse forklift	75
#16	Lift another DRJ	112	**#17**	Move DRJ to another rack	31	**#18**	Take the desired DRJ	59
#19	Adjust forklift to reverse	25	**#20**	Bring the desired DRJ to machine	117	**#21**	Adjust the overhead crane	14
#22	Attach hooks onto DRJ	172	**#23**	Lift the DRJ	7	**#24**	Place the DRJ onto the bed of the machine	12
#25	Release the hooks	101	**#26**	Move the overhead crane	50	**#27**	Clamp the DRJ	6
#28	Tighten the clamps for DRJ	19	**#29**	Adjust the tool bit using machine controller	93	**#30**	Touch offset the surface of the DRJ	102
#31	Set the machine program	9	**#32**	Adjust the tool for origin setting	73	**#33**	Origin setting one side of DRJ	38
#34	Origin setting other side of DRJ	111	**#35**	Check Line of Balance (LOB)	62	**#36**	Checking flatness point on PC	210
#37	Enter	12	**#38**	Adjust	186	**#39**	Origin setting	7

No	Setup activities	Time taken(s)	No	Setup activities	Time taken(s)	No	Setup activities	Time taken (s)
	flatness points into PC			flatness points			again for all points	
#40	Enter data into PC	88	**#41**	Origin setting for another part number	137	**#42**	Set program for part number	65
#43	Check origin point flatness	249	**#44**	Setting the tool bit	153	**#45**	Choose the composite panel	9
#46	Lift panel and place it onto the DRJ	28	**#47**	Attach vacuum hose	92	**#48**	Place another panel	123
#49	Close the machine door	6	**#50**	Find and choose program	533	**#51**	Start trimming process	4
Total time: 4215 seconds / 70.25 minutes								

SMED-ECSC Framework

In the new framework of SMED-ECSC as illustrated in Figure 1, Phase 1, Phase 2 and Phase 4 are similar to the conventional SMED. The improvement part is the eliminating process for unnecessary activities which is done in Phase 3 after the identification and separation of internal and external activities. Instead of starting to convert the internal to external activities in Phase 3, the possibilities of eliminating the unnecessary activities are taken into primary consideration because by eliminating the possible activities, the overall setup process can be reduced straight away. If the setup activities cannot be eliminated, the possibilities of the activities to be combined are taken into consideration.

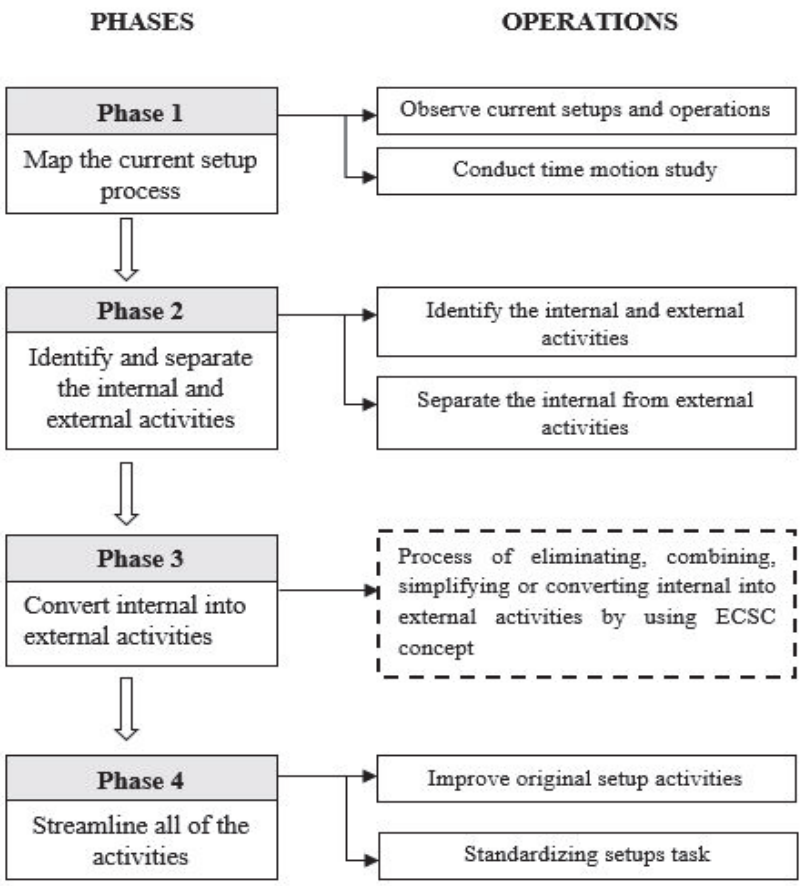

Figure 1: SMED-ECSC framework

Combination of activities refers to action of combining two or more activities into one improved activities such that they can be performed at the same time. If there is no possibility of the activities to be eliminated or combined, the next alternative is to simplify them. Simplification refers to the process of simplifying or reduces the time taken to perform the activities without eliminating or combining them. The next alternative is to convert the internal activities into external activities because by converting them to external activities, the activities can be performed without the stoppage of the trimming machine. The guideline for the decision making process is illustrated in Figure 2.

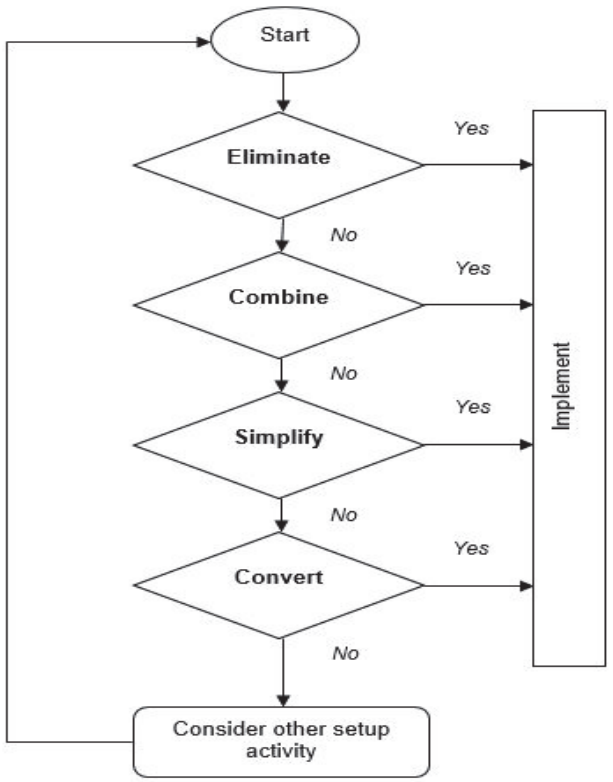

Figure 2: ECSC decision making process

RESULTS AND DISCUSSION

SMED Decision Making Process

By applying the ECSC decision making concept, the unnecessary activities such as driving the forklift back and forth to the DRJ rack and finding the desired DRJ are eliminated by preparing the desired DRJ while the previous panel undergoes automatic trimming process. This method saved a lot of times thus lead to setup time reduction.

Tagging system has been introduced to make sure that the worker put the used DRJ back to their rack correctly. This activity is performed to prevent the loss time due to finding the right DRJ. Next, the scanning system was introduced to simplify the operations of the setup process. Before this, worker needs to manually find the program in the machine control which consumes a lot of time. Other than that, another implemented improvement solution is by simplifying the activity to check the Line of Balance (LOB) by repositioning the machine controller, so that worker

can see the LOB clearly. Next, the location of the PC table is also relocated to a more suitable and nearer distance to the machine controller.

Setup Time Reduction

The setup time reduced from 4215 seconds to 3571 seconds with 15.3% of reduction after the implementation of SMED-ECSC concept as shown in Table 2. The ECSC concept helps in making decision whether to eliminate, combine, simplify or convert. In the context of this case study, only the elimination and simplification process are chosen. Figure 3 shows the bar chart representing the setup time reduction before and after the implementation of SMED-ECSC concept.

Table 2: Setup activities and their durations after SMED-ECSC implementation

No	Setup activities	Time taken (s)	No	Setup activities	Time taken (s)	No	Setup activities	Time taken (s)
#1	Drive forklift to DRJ rack	40	**#2**	Take the desired DRJ	15	**#3**	Adjust forklift to reverse	99
#4	Bring desired DRJ to the machine	70	**#5**	Clamping overhead crane hooks to the DRJ	123	**#6**	Lift the DRJ using overhead crane	22
#7	Move DRJ onto bed of machine using crane	32	**#8**	Adjust DRJ to fit into bushing	58	**#9**	Unhook all clamps	11
#10	Take the spanner	13	**#11**	Tighten the screws	77	**#12**	Take air gun	23
#13	Clean the DRJ using air gun	136	**#14**	Check offset of DRJ	159	**#15**	Touch surface of DRJ	34
#16	Find machine program	26	**#17**	Setting tool	43	**#18**	Probing	35
#19	Select program for panel	112	**#20**	Calculate AROT	55	**#21**	Select machine program	84
#22	Insert data into computer	87	**#23**	Find program number	48	**#24**	Start origin setting process	87
#25	Choose	103	**#26**	See	89	**#27**	Adjust	108

	program			flatness points in computer			clamps	
#28	Continue origin setting	95	**#29**	Select data to be use	135	**#30**	See flatness points in computer	89
#31	Automatic find the tool	213	**#32**	Choose tool bit	137	**#33**	Find program	241
#34	Search and replace coding data	128	**#35**	Choose tool bit again	213	**#36**	Choose and load composite mother panel on DRJ	89
#37	Attach vacuum hose	51	**#38**	Check pressure using vacuum gauge	108	**#39**	Check data in machine control	195
#40	Close door	31	**#41**	Start trimming process	57			
Total time: 3646 seconds / 60.77 minutes								

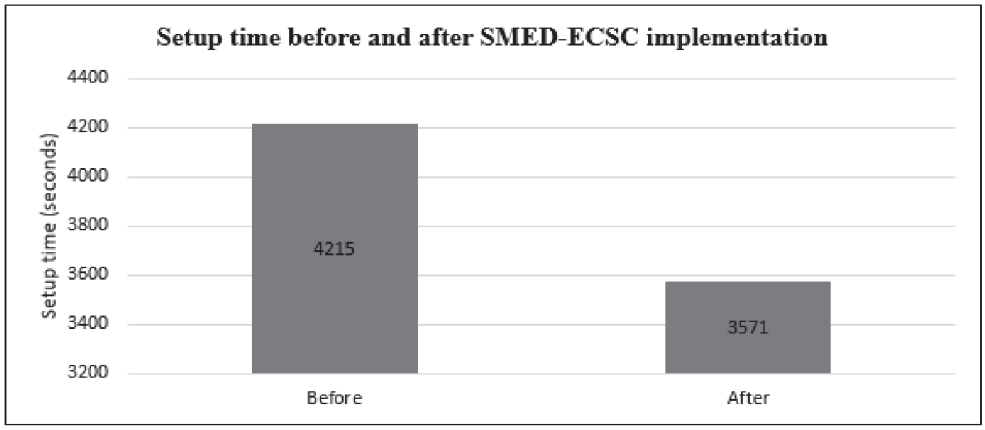

Figure 3: Setup time before and after SMED-ECSC implementation

CONCLUSIONS

Based on the recorded setup time before and after the implementation of SMED-ECSC concept, a comparison was made to measure the effectiveness of the new proposed framework. The proposed approach provides a systematic guideline in order to select the best decision for every activity in a setup process. There are 4 decisions that can be choose according to the possibilities of every activity whether to be eliminated, combined with other activities, simplified or converted from internal to external activities. The elimination process should be the primary alternative because by eliminating the possible activities away, the overall setup process can be reduced thus leads to setup time reduction. The second alternative is combining two or more activities at the same time, followed by simplifying and converting the internal into external activities. A setup time reduction of 15.3% setup time was achieved after the implementation of the SMED-ECSC concept. The result illustrates the benefits and the advantages of incorporating ECSC concept into the third phase of conventional SMED. This concept may facilitates the setup reduction initiatives in other industrial and manufacturing organizations.

ACKNOWLEDGEMENT

The authors wish to appreciate the professional collaboration that has been provided through the case study of the company for the completion of this research. Also, authors wish to acknowledge the support from University Malaysia Perlis via Research Acculturation Grant Scheme (RAGS), Grant No; 9018-00076. The authors are also thankful to the referees for their useful suggestions.

REFERENCES

[1] E. Costa, S. Bragança, R. Sousa, & A. Alves. (2013). Benefits from a SMED Application in a Punching Machine. *International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering*, 7(5):373–379.

[2] M. A. Almomani, M. Aladeemy, A. Abdelhadi & A. Mumani. (2013). A proposed approach for setup time reduction through integrating conventional SMED method with multiple criteria decision-making techniques. J*ournal Computers and Industrial Engineering*, 66(2), 461–469

[3] M. Cakmakci. (2009). Process improvement: performance analysis of the setup time reduction-SMED in the automobile industry. *International Journal of Advanced Manufacturing Technology,* 41(1-2), 168–179.

[4] B. J. Singh & D. Khanduja. (2011). Design for set-ups : a step towards quick changeovers in foundries. *International Journal of Sustainable Design*, 1(4):402–422.

[5] M. S. F. Soberi & R. Ahmad. (2016). Application of fuzzy AHP for setup reduction in manufacturing industry. *Journal of Engineering Research and Education*, 8, 73–84.

[6] A. Allahverdi & H. M. Soroush. (2008). The significance of reducing setup times/setup costs, *European Journal of Operational Research*, 187(3), 978–984.

[7] M. Faccio. (2013). Setup time reduction : SMED-balancing integrated model for manufacturing systems with automated transfer, *International Journal of Engineering Technology*, 5(5), 4075–4084.

[8] D. Stadnicka. (2015). Setup Analysis : Combining SMED With other Tools, *Journal Management and Production Review,* 6(1), 36–50

[9] C. Y. Liu & S. C. Chang. (2000). Scheduling flexible flow shops with sequence-dependent setup effects, IEEE Transaction of Robotics and Automations, 16(4), 408–419.

[10] T. Eren & E. Guner. (2006). A bicriteria flowshop scheduling problem with setup times, *Journal Applied Mathematics and Computations*, 183, 1292–1300.

[11] W. J. Chen. (2009). Scheduling with dependent setups and maintenance in a textile company, *Journal Computers and Industrial Engineering*, 57(3), 867–873.

[12] C. Karlsson & P. Åhlström. (1996). Assessing changes towards lean production, *International Journal of Operations and Production Management*, 16(2), 24–41

[13] R.Hurley. (2000). Economic justification of set-up time reduction - a mathematical model, *International Journal of Production Research*, 32(7), 73–83.

[14] D.Kim. (1997). Estimating the distribution and variance of time to produce a fixed lot size from given deterministic processing times and random down times, *International Journal of Industrial Engineering*, 21, 90–101.

[15] S. Shingo. (1985). *A revolution in manufacturing: The SMED system*. MA: Productivity Press.

[16] K. S. Kumaresan & M. Z. M. Saman. (2011). Integration of SMED and TRIZ in Improving Productivity, *Jurnal Mekanikal*, 33, 40–55.

[17] B. J. Singh & D. Khanduja. (2010). SMED: for quick changeovers in foundry SMEs, *International Journal of Productivity and Performance Management.* 59(1), 98–116

[18] M. A. Ibrahim, E. Mohamad, M. H. Arzmi, M. A. A. Rahman, A. Saptari, A. S. Shibghatullah, M. A. Sulaiman & M. A. M. Ali. (2015). Enhancing Efficiency of Die Exchange Process Through Single Minute Exchanging Die at a Textile Manufacturing Company in Malaysia, *Journal of Applied Science*, 15(3), 456–464.

[19] R. McIntosh, G. Owen, S. Culley, and T. Mileham. (2007). Changeover improvement: Reinterpreting Shingo's 'SMED' methodology, IEEE Transactions on Engineering Management, 54(1), 98–111.

[20] A. Sayem, M. A. Islam & M. M. A. Khan. (2014). Productivity enhancement through reduction of changeover time by implementing SMED technique in furniture industry, *International Journal of Industrial and System Engineering,* 7(1), 15–33.
[21] P. G. Ferradás & K. Salonitis. (2013). Improving changeover time: a tailored SMED approach for welding cells, *Procedia CIRP*, 7, 598–603.
[22] S. Shingo & A. P. Dillon. (1989). A study of the Toyota production system: From an Industrial Engineering Viewpoint*,* CRC Press.