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Integration of SMED with AHP: A Case Study in an Aerospace Company

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ABSTRACT

Setup time reduction in manufacturing organizations is widely recognized to provide significant benefits in industries. Minimum setup time is a vital element in every type of industry nowadays. Most of the setup reduction methods are based on Shingo's Single Minute Exchange of Dies (SMED). Despite a huge number of companies that succeeded in starting the original SMED, there are numbers of company that failed during the implementation stage due to poor decision making process throughout the whole SMED implementation. Therefore, this paper proposes a new hybrid method of integrating the original SMED with one of a Multiple Criteria Decision Making (MCDM) technique called the Analytic Hierarchy Process (AHP) in order to help Decision Maker (DM) to handle impreciseness of human's judgements in the pursuit of implementing the SMED method. For the sake of validation, a case study in an aerospace company is used to exemplify the new approach. Data analysis was presented to show the final results. The result validates the aptitudes of the proposed method in reducing the setup time.

Keywords: Analytic Hierarchy Process (AHP), Angle of Rotation (AROT), lean, Multiple Criteria Decision Making (MCDM), Single Minute Exchange of Dies (SMED), setup time reduction.

INTRODUCTION

LEAN is probably the most uttered word among engineers in industries at this moment. Nowadays, most companies are facing great competition in global industries hence, they must perform better than the others in order to survive and lean is the perfect solution to it. One of the lean's acclaimed tool is Single Minute Exchange of Dies (SMED) [1-2] .

SMED is recognized as one of the lean's tool for reducing wastes in a production process. There is a common misconception that SMED means changing the die in a minute. In a nutshell, SMED is a set of theory to make it feasible for the

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changeover procedure to be finished underneath 10 minutes (single digit minute), in this way gives the name of this methodology [3-5] .

The concept of SMED is taking out the squandered time in changeover procedure by identifying and simplifying the activities done before, during or after the changeover process and streamlining the remaining activities for smoothing the production flow [6-9]. Many successful SMED implementation had been reported in various type of industries including automobile [10-12], manufacturing [13–17], electronic [18] and packaging industry [19].

For decades, modifying the original SMED has received an extensive attention from many researchers. There are always different opinions about the expected improvement attained by improving activities within each phase of SMED to achieve implementation phase that yields the maximum improvement [20-21]. For example, SMED has been criticized for its sequential implementation approach [22]. Other than that, the decision making process in selecting the best improvement strategy also requires a sheer test of skills and knowledge of a lean manufacturing practitioner [23].

Therefore, this paper proposes a new method of incorporating one of a Multiple Criteria Decision Making (MCDM) technique called Analytic Hierarchy Process (AHP) into SMED methodology to help decision maker in choosing the best solution throughout the process of SMED implementation. By providing technique in identifying, weighing criteria and analysing the data collected, AHP can facilitates the decision-making process. AHP also can reduce bias in decision making by capturing both subjective and objective evaluation measures and thus offers a beneficial mechanism for proving the consistency of the evaluations [24-25].

RESEARCH METHODOLOGY

The methodology is divided into three separate sections namely; SMED-AHP framework, AHP hierarchy construction and pairwise comparison between criteria. The description for each section will be explained next. The case study is to choose the best improvement strategy for reducing the required time to calculate Angle of Rotation (AROT) in a setup process for 5-axis composite material's trimming machine. This case study is chosen due to the fact that according to the data from the company, the current method applied in calculating AROT is very time-consuming.

SMED-AHP Framework

The SMED-AHP framework is divided into three individual phases which are Phase 1: Initial Analysis, Phase 2: Improvement Stage and Phase 3: Implementation and Control as portrayed in Figure 1. The phases are constructed and improvised based on the original SMED framework by [1-26]. In Phase 1, the operations done are similar to the original SMED method including observing and mapping the current process followed by the identification and separation of internal and external activities. Phase 2 consists of the decision making process in order to reduce the setup activities to calculate AROT by implementing the best improvement strategy. Phase 3 refers to the step of implementing the chosen improvement strategy and streamlining the new setup process.

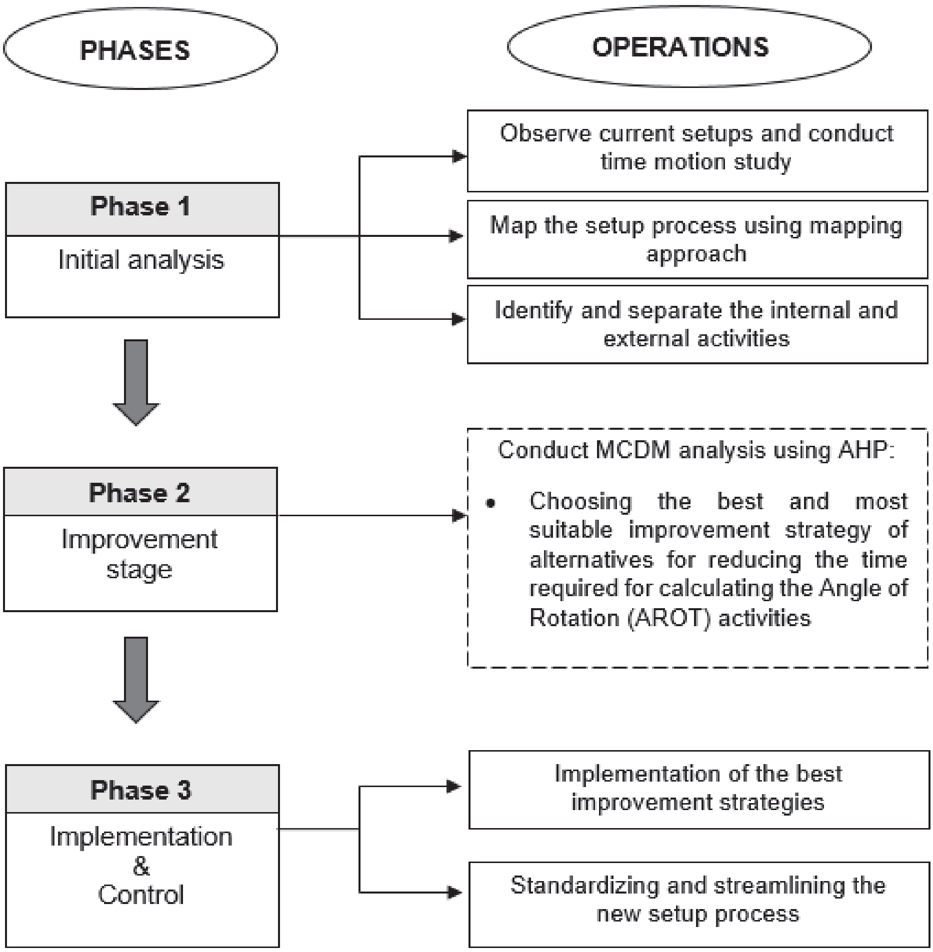

Figure 1: SMED-AHP framework

Table 1 provides setup activities with the corresponding time setup while Figure 2 visualized the sequenced activities required for AROT calculation with their duration in seconds. The number in the oval bullets represented the sequence number of the activities in the setup process.

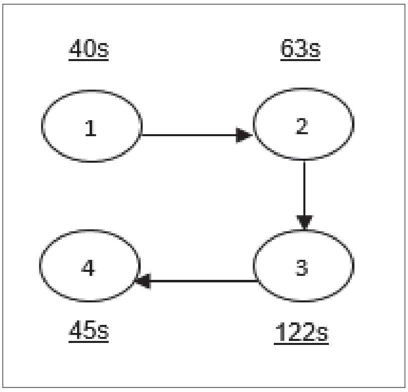

Figure 2: Map diagram of the setup activities for AROT calculation

Table 1: Activities required for calculating AROT

Setup activities		Time taken (second)
Taking pen and a piece of paper		40
Write and transfer machine coordinates to PC		63
Calculate AROT using Excel program in PC		122
Write AROT value on paper and transfer back Machine Controller		45
	TOTAL	**270**

AHP Hierarchy Construction

In this section, the decision making problem was decomposed into a hierarchy. Related criteria and the alternatives refer to the selection of three possible improvement strategies are defined according to the goal, which is to select the best improvement strategy for reducing time in AROT calculation. Hence, the criteria with their description as shown in Table 2 below are evaluated before being applied in the AHP hierarchy. Figure 3 shows the constructed hierarchy for the case study problem.

Table 2: Criteria description for AHP hierarchy

No	Criteria	Description
C1	Administrative constraints	Refers to the non-technical factors from the administration perspective including management commitments, worker’s teamwork and training

No	Criteria	Description
C2	Ease of implementation	Describes how easy of the improvement strategy to be implemented
C3	Cost effective	Refers to the cost required in implementing the selected improvement strategy
C4	Completion time	Describes the time required to implement the selected improvement strategy
C5	Risk of affecting other activities	Refers to the risk of the alternatives in affecting other setup activities
C6	Technological capabilities	Describes the availability of technological capabilities in the company such as skills and equipment
C7	Significant benefit	Refers to the how much of setup can be reduced after implementing the selected improvement strategy

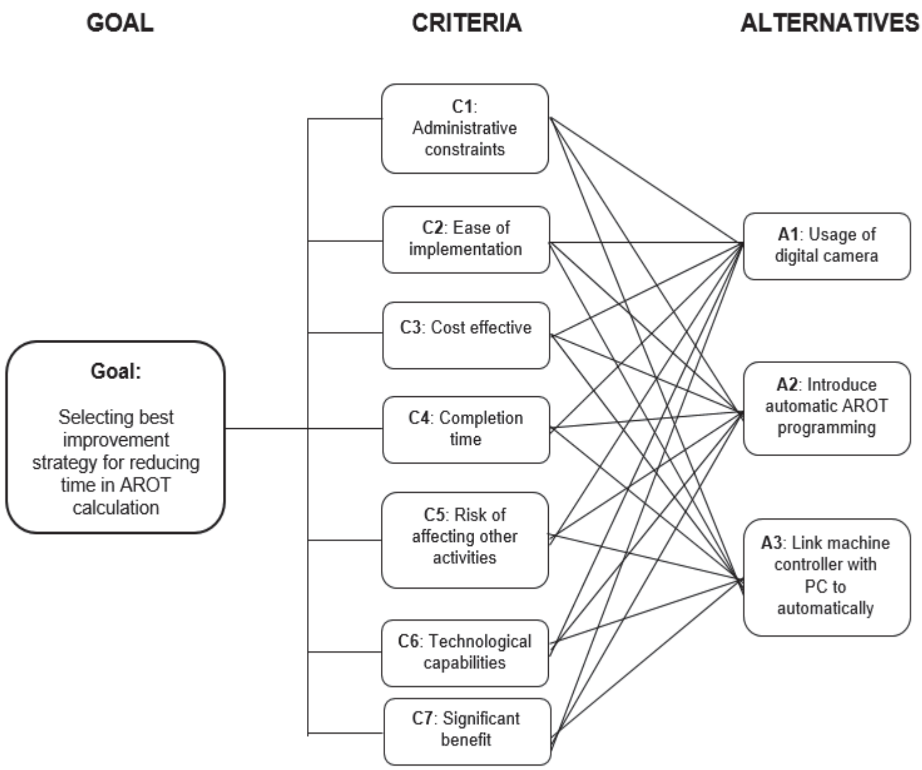

Figure 3: Hierarchy construction for selecting the best improvement strategy for reducing time required in AROT calculation

Pairwise Comparison

The pairwise comparison between all criteria were made by using a data from sets of questionnaire participated by three engineers who deals with the setup process. This comparison indicates the strength with one criterion dominates another using a method for scaling of weights. The weight values (1, 3, 5, 7, and 9) are used to determine the priorities of the criteria in the hierarchy reflecting the relative importance among other criteria as shown in Table 3.

Table 3: Pairwise comparison among the criteria involve in the hierarchy

Q#	9	7	5	3	CRITERIA	1	CRITERIA	3	5	7	9
1					C1		C2	■			
2					C1		C3	■			
3					C1		C4	■			
4					C1		C5		■		
5					C1	■	C6				
6					C1		C7		■		
7					C2		C3	■			
8					C2	■	C4				
9					C2		C5		■		
10				■	C2		C6				
11					C2		C7	■			
12				■	C3		C4				
13					C3		C5	■			
14				■	C3		C6				
15					C3		C7	■			
16					C4		C5	■			
17				■	C4		C6				
18					C4		C7		■		
19				■	C5		C6				
20					C5	■	C7				
21					C6		C7	■			

Comparison Matrices

The data of the comparison of each criterion towards each other were then synthesized into matrix form as in Table 4. On the contrary, the inverse comparisons were represented as 1/1, 1/3, 1/5, 1/7 and 1/9. Then, all the scores are averaged and totaled across the row in the matrix as in Table 5. Finally, the totaled scores are averaged to get the priority of all criteria involved. The priority of the criteria is then converted into ranking method. Ranking 1 for C7 refers to the top priority among all criteria.

Table 4: Comparison matrix for criteria

CRITERIA	C1	C2	C3	C4	C5	C6	C7
C1	1	1/3	1/3	1/3	1/5	1	1/5
C2	3	1	1/3	1	1/5	3	1/3
C3	3	3	1	3	1/3	3	1/3
C4	3	1	1/3	1	1/3	3	1/5
C5	5	5	1/3	1/3	1	3	1
C6	1	1/3	1/3	1/3	1/3	1	1/3
C7	5	3	3	5	1	3	1

Table 5: Averaged pairwise comparison matrix of criteria with priority ranking

CRITERIA	C1	C2	C3	C4	C5	C6	C7	Total	Average	Rank
C1	0.048	0.024	0.059	0.030	0.059	0.059	0.059	0.338	0.048	6
C2	0.143	0.073	0.059	0.091	0.059	0.176	0.098	0.699	0.100	4
C3	0.143	0.220	0.176	0.273	0.098	0.176	0.098	1.184	0.169	3
C4	0.143	0.073	0.059	0.091	0.098	0.176	0.059	0.699	0.100	4
C5	0.238	0.366	0.059	0.030	0.294	0.176	0.294	1.458	0.208	2
C6	0.048	0.024	0.059	0.030	0.098	0.059	0.098	0.416	0.059	5
C7	0.238	0.220	0.529	0.455	0.294	0.176	0.294	2.206	0.315	1

RESULTS AND DISCUSSION

AHP Analysis

All of the alternatives is then compared according to their relative importance with respect to each criterion. The pairwise comparison step was repeated as comparing the criteria to each other but this time the alternatives are compared to criteria. The result of the pairwise comparisons of alternatives towards each of the criteria is presented in Figure 4.

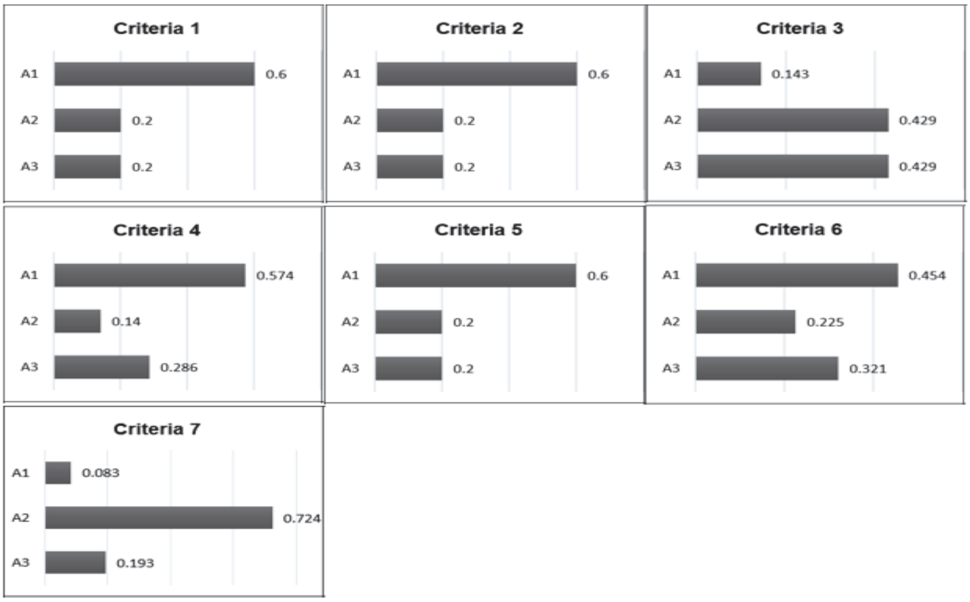

Figure 4: Result of pairwise comparison of alternatives towards criteria

Selecting the Best Improvement Strategy

After deriving the priorities for the criteria and alternatives through pairwise comparisons, the priorities of the criteria were synthesized to calculate overall priorities for the alternatives. Based on Figure 5, it is clearly shown that alternative 2 (A2) received the highest ranking with 39.9% indicating that the company should implement the automatic AROT programming towards the 5-axis trimming machine to reduce the time required for calculating AROT during the setup process.

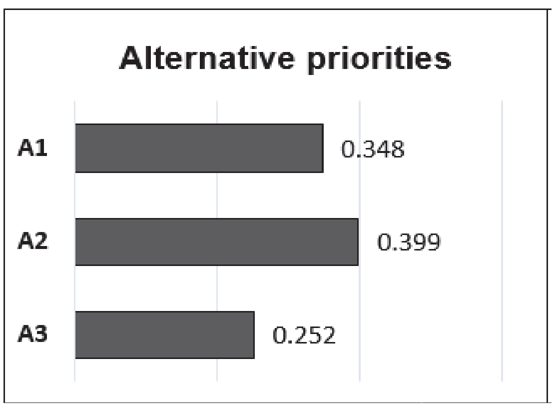

Figure 5: Ranking for alternatives (improvement strategies)

CONCLUSIONS

This paper provides a new framework of Single Minute Exchange of Dies (SMED) integrated with Analytic Hierarchy Process (AHP) in selecting the best improvement strategy in reducing the time required to perform AROT calculation during the setup process for 5-axis composite material's trimming machine in aerospace industry. Besides that, AHP takes into considerations several factors that affect the decision making process including administrative constraints, ease of implementation, cost, completion time, risk affecting other activities, technological capabilities and significant benefit in reducing setup time. The result shows that Alternative 2 received the highest ranking indicating that the company should implement the automatic AROT programming towards the 5-axis trimming machine. The SMED-AHP framework able to facilitate SMED practitioner in selecting the best improvement strategy by handling the impreciseness of human's judgements and capturing both subjective and objective evaluation measures.

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