Perception of the Benefits of SMED Under the Point of View of Machining Services Providers

Percepção de los beneficios de SMED bajo el punto de vista de los proveedores de servicios de mecanizado

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Abstract: Since its proposal by Shingo in the middle of 50's, SMED has been largely used by companies around the world. However, not always it is used in a proper way, and the users do not get the benefits that arise from this methodology. This paper brings a research about the perception of these benefits and about the effective use of SMED. An exploratory survey was conducted with 40 machining services providers located in the State of São Paulo – Brazil, and showed that they declare to know the methodology but most of them do not use it properly and do not perceive the benefits the SMED can bring to companies that aim to implement Lean Manufacturing.

Keywords: SMED; Lean Manufacturing; Machining Services Providers; Benefits Perception.

Resumen: Desde que fue propuesto por Shingo a mediados de los años 50, el método SMED ha sido ampliamente utilizado por empresas de todo el mundo. Sin embargo, no siempre es utilizado de una manera adecuada, y los usuarios no obtienen los beneficios derivados de esta metodología. Este trabajo aporta una investigación sobre la percepción de estos beneficios y sobre el uso efectivo del SMED. Se llevó a cabo una encuesta exploratoria con 40 proveedores de servicios de mecanizado localizados en el Estado de São Paulo - Brasil, que demostraron conocer la metodología, pero la mayoría de ellos no la utilizan adecuadamente y no perciben los beneficios que el SMED puede traer a empresas que buscan implementar un modelo Lean Manufacturing.

Palabras clave: SMED; Lean Manufacturing; Proveedores de servicios de mecanizado; percepción de beneficios.

1. Introduction

To keep their competitiveness, companies are trying to suit their activities in order to optimize and improve the production systems. To do much, companies are adopting Advanced Manufacturing Technologies (AMTs) and Lean Manufacturing aiming Quality, Flexibility, Low Costs, Reliability of Deadlines and Velocity of Production (SLACK; CHAMBERS; JOHNSTON, 2009).

Lean Manufacturing is based on a set of techniques like: Kaizen; Set up times reduction /SMED; JIT; Pull Production; Poka Yoke; Heijunka; 5S and Housekeeping; Andon; TPM among others (PETERSEN, 2009). The author still brings a grouping of these techniques, emphasizing that all the main authors of Lean Manufacturing have cited some of them:

- Practices of JIT (including also Heijunka and Pull Production);

- Reduction of production resources (including production in small batch-es, waste elimination, reduction of setup time , reduction of lead time and reduction of Work In Process – WIP).

Set up reduction is one of the most important characteristics of Lean Manufacturing. Researches and reports show that companies that have adopted Toyota Production System (TPS) are the ones that most invested in tools to reduce setup time (AMOAKO-GYAMPAH; GARGEYA, 2001), and this technique can be very important not only for time reduction, but also for improvement of quality and to increase manufacturing efficiency (TROVINGER; BOHN, 2005). Moreover, Spence; Proteus (1987) showed that investment on new equipment (like machine tools) can be reduced with the effective use of setup reduction techniques - also called SMED, as proposed by Shingo (2000); and also, WIP reduction due to the downtime reduction, increase of machine availability and flexibility are other benefits that SMED can bring (REIS; ALVES, 2010).

According to Santos; Wysk; Torres (2009), time may be defined as the time elapsed between the production of the last part of a batch and the production of the first part of the next batch, and any setup process, regardless of the type of machinery or equipment may be divided into four steps:

- 1 - Prepare, adjust and check new materials and tools;
- 2 - Removal of the used tool and placement of the new tool in the machine;
- 3 - Measure, configure and calibrate the tool;
- 4 - Produce the first pieces and adjust the machine.

Companies want to reduce setup time for two main reasons: to increase productive capacity, that is, when production is the constraint; or to introduce / improve lean production (REIS; ALVES, 2010). However, in cases when the setup time is too long, many companies choose to produce larger batches, increasing the in-process stock, making unnecessary products and incurring losses in the production system, which is inconsistent with the lean production proposal. In such cases, the search for increasing the availability of machines reducing setups time is a way to avoid buying new equipment and to increase production capacity. In JIT production systems, reduction of production capacity problems is a direct result of the reduction of inventory in process.

Thus, according to Gaither; Frazier (2002), the time of preparation and the ex-change of tools shall be studied and improved with Kaizen practices and continuous improvement in order to make production more flexible. However, many companies do not explore all the possibilities that SMED, as proposed by Shingo (2000), brings. In the papers researched for this issue, none brought an assessment of the perception of machining providers about these possibilities and benefits arose from SMED. For this reason, the present paper targets to identify if the machining services providers located in the State of São Paulo - Brazil really know the SMED methodology and the benefits that can arise from its use. The choice for machining services providers is due to the constant change of batches with small sizes, and the consequent number of setups that are performed every day.

The methodology adopted was the exploratory survey.

2. Benefits of SMED

Among the benefits of SMED one can find: improvement of quality, increase of machine availability, increase of flexibility, increase of productive capacity and increase of productivity (SANTOS; WYSK; TORRES, 2009; ALMOMANI et al., 2013).

However, many other benefits can arise: downtime reduction; setup cost reduction; lead time reduction; optimization of machine utilization; reduction of production delays; WIP reduction; losses reduction; process variability reduction; layout improvement; safety improvement (JABER, 2006; Das et al, 2014; GAWRONSKI, 2012).

Downtime reduction and setup reduction have been seen as a major positive result from SMED adoption because it refers to less time waste with adjusts and preparations, allowing more velocity in production recovering of the workstations (GILMORE; SMITH, 1996; SAMADAR, 2001; SATOLO; CALARGE, 2008; GAWRONSKI, 2012). Freeland; Leschke; Weiss (1990) highlighted also the re-duction of setup costs as a remarkable benefit.

Reduction of lead time, cycle time and batch size were other benefits cited by diverse authors (HAHN; BRAGG; SHIN, 1988; WEMMERLÖV; VAKHARIA, 1993; NG; CHENG; KOVALYOV, 2004; HARIKRISHNAN; ISHII, 2005; FACCIO, 2013).

Benefits like increase of production capacity, of machine availability and of flexibility are resultant from the time that machines are available for production due to the reduction of downtime. A better utilization can be achieved in this situation and the need for investments in new machines can be reduced also (SPENCE; PORTEUS, 1987).

WIP and of losses reduction are result of a lower queueing time of batches in the production systems and of less variability of process (KANNENBERG; ANTUNES, 1995; SAMADAR, 2001).

Voros (1999) and Lovel (2003) highlighted that quality improvement due to a better processing in machines better adjusted is another remarkable result from the adoption of SMED.

Finally, Reis; Alves (2010) pointed that applying SMED on the production brings better and faster results than promoting changes on the project of the parts in order

to reduce lead times. It also improves the use of multifunctional workers, leading to a reduction of workers specialized in setup of machines.

Table 1 brings a summary of the authors and the benefits cited above.

The authors, in general, approach the issue SMED from a set of variables that can be grouped into:

- Setup time
- Number of setups performed per shift

- Number of different batches processed
- Size of batches
- Tooling
- Activities performed during setup
- Training of personnel to carry out the setup

A combination of benefits and approaches found in literature led to the following relationship (Table 2) that served as the basis for the questionnaire sent to the machining services providers.

TABLE 1 – BENEFITS OF SMED (ACCORDING TO THE LITERATURE)

	Reduction of setup time and of downtime	Reduction of setup cost	Reduction of lead time, of cycle time and batches size	Increase of capacity, availability and flexibility	Reduction of WIP and losses	Improvement of products quality and products design
Reis;Alves (2010)	x	x	x	x	x	x
Gilmore; Smith (1996)	x	x	x	x	x	
Satolo; Calarge (2008)	x		x	x		x
Kannenber; Antunes Jr. (1995)				x	x	
Freeland; Leschke;Weiss (1990)	x	x			x	
Gawronski (2012)	x		x	x		
Lovell (2003)		x			x	x
Wemmerlöv; Vakharia (1993)			x		x	x
Hahn; Bragg; Shin (1988)			x	x		
Voros (1999)		x				x

Faccio (2013)	x		x			
Spence; Porteus (1987)	x			x		
Samaddar (2001)	x				x	
Leschke (1997)	x	x				
Ng; Cheng; Kovalyov (2004)		x	x			
Godinho Filho; Uzsoy (2010)	x		x			
Harikrishnan; Ishii (2005)			x			
# citations	11	7	10	8	8	5

TABLE 2 – RELATIONSHIP AMONG BENEFITS AND APPROACHES OF SMED (BASED ON THE LITERATURE)

Benefits	Points to be asked
Reduction of setup time and of downtime	Previous preparation Training of workers Knowledge of workers about SMED Monitoring of setup times Reduction of setup time
Reduction of WIP and losses	Reduction of WIP and losses
Reduction of setup cost	Reduction of setup costs Reduction of unexpected downtime Reduction of adjusts after setup
Reduction of lead time, of cycle time and batches size	Reduction of lead time, batch sizes and cycle time
Improvement of products quality and products design	Improvement of product quality
Increase of capacity, availability and flexibility	Increase of capacity and of flexibility Use of multifunctional workers

3. Perception of the Benefits

To assess the perception of companies about the benefits that the use of SMED can arise, a questionnaire based on the Benefits and on the Points to be Asked listed on Table 2 was prepared according to the relationships shown on 3 Perception of the Benefits

To assess the perception of companies about the benefits that the use of SMED can arise, a questionnaire based on the Benefits and on the Points to be Asked listed on Table 2 was prepared according to the relationships shown on Table 3. A set of statements were established.

For each statement, there was the option of answers Agree, Disagree and Indifferent.

The order of benefits listed in the first line was established after a query on the importance of the items made to three specialists in the area of machining and setup.

The questionnaire was sent to the machining services providers listed by the magazine Máquinas & Metais, edition of November, 2014, by means of Survey Monkey (<http://www.surveymonkey.com>). The respondents were personnel directly linked to machining departments of the companies (machining managers or supervisors).

TABLE 3 – RELATIONSHIP AMONG BENEFITS, APPROACHES OF SMED AND QUESTIONS OF THE QUESTIONNAIRE

Benefits	Points to be asked	Statement
Reduction of setup time and of downtime	Previous preparation Training of workers Knowledge of workers about SMED Monitoring of setup times Reduction of setup time	Support devices and tools to be used are prepared in advance Setup team is periodically trained in order to reduce the setup time Setup team know and use the principles of SMED Setup time is periodically monitored and controlled Setup time was reduced
Reduction of WIP and losses	Reduction of WIP and losses	WIP and losses on the process were reduced
Reduction of setup cost	Reduction of setup costs Reduction of unexpected downtime Reduction of adjusts after setup	Setup costs were reduced There was a reduction of setup time and of downtime due to unexpected problems There was a reduction of the adjusting time during setup
Reduction of lead time, of cycle time and batches size	Reduction of lead time, batch sizes and cycle time	Lead time, cycle time and batches size were reduced
Improvement of products quality and products design	Improvement of product quality	Quality of machined parts and product development improved
Increase of capacity, availability and flexibility	Increase of capacity and of flexibility Use of multifunctional workers	Machine capacity, machine availability and machine flexibility increased Multifunctional workers are used on the production process

For the analysis of the results, the answers were put in an incidence matrix (I.M.) where lines represented the companies and columns represented the benefits of SMED. The answers were related to a value 1 (Agree), 0 (Indifferent) or -1 (Disagree) and were put in the cross of each company and benefit (Table 4).

TABLE 4 INCIDENCE MATRIX RELATING COMPANIES (LINES) AND SMED BENEFITS (COLUMNS) WITH THE SCALE VALUES.

Companies	# of Workers	Benefits												
		Previous preparation	Training of workers	Knowledge of workers about SMED	Monitoring of setup times	Reduction of WIP and losses	Reduction of setup time	Increase of capacity and of flexibility	Reduction of setup costs	Reduction of unexpected downtime	Reduction of adjusts after setup	Use of multifunctional workers	Reduction of lead time, batch sizes and cycle time	Improvement of product quality
1	250-500	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1 - 25	1	1	0	0	1	0	-1	0	1	1	0	1	0
3	50 - 75	1	1	1	1	1	1	1	1	0	1	1	1	1
4	100-250	0	0	1	1	-1	1	0	1	1	1	0	0	0
5	250-500	1	1	1	1	1	0	-1	1	1	1	1	1	0
6	100-250	1	0	1	1	-1	1	0	-1	1	-1	0	1	0
7	75- 100	0	1	1	1	1	1	1	1	1	1	1	1	1
8	50 - 75	1	1	1	0	1	1	1	-1	1	1	1	1	1
9	1 - 25	0	1	1	1	0	0	0	1	1	0	0	1	0
10	100 - 250	1	-1	1	0	1	1	-1	0	-1	-1	-1	-1	-1
11	100 - 250	0	-1	-1	-1	0	1	-1	1	1	-1	0	1	1
12	1 - 25	1	1	1	1	1	1	1	1	0	0	1	1	1
13	250 - 500	1	0	-1	0	-1	1	0	1	0	1	-1	1	1
14	250 - 500	1	1	1	1	1	1	1	1	1	1	1	1	1

An adaption of ROC method (proposed by King in 1980 according to Bashir; Karaa, 2008) was adopted. According to the ROC method, each line must be transformed into a binary number and then converted into a decimal number. From the numeric order of the decimal numbers, lines must be reordered. The same procedure must be applied to columns in the sequence. This must result in a new matrix with lines and columns reordered (Table 5). The adaption is related to the conversion of the binary number into decimal number. "Binary" values -1 were considered as being a negative value in decimal, subtracting values in the conversion process. For example, the "binary" 1111111011(-1)01 from line 38 would be converted into decimals on the following way:

TABLE 4 INCIDENCE MATRIX RELATING COMPANIES (LINES) AND SMED BENEFITS (COLUMNS) WITH THE SCALE VALUES (CONTINUED).

15	100 - 250	1	1	1	1	1	1	1	1	1	1	-1	0	1
16	25 - 50	1	1	1	1	1	1	1	1	1	1	1	1	1
17	75 - 100	0	1	1	0	1	0	1	1	1	1	1	1	0

18	100 - 250	-1	1	1	1	0	1	1	1	1	-1	0	1	1
19	500 <	1	1	0	1	1	1	1	1	1	1	1	1	1
20	50 - 75	1	1	1	1	1	1	1	1	1	1	1	1	1
21	25 - 50	1	1	1	1	1	1	0	1	1	1	1	1	1
22	100 - 250	1	0	1	1	1	1	1	1	1	1	1	1	1
23	50 - 75	0	0	1	1	-1	-1	1	1	1	-1	0	1	1
24	25 - 50	1	1	1	1	1	1	0	-1	0	-1	0	1	0
25	50 - 75	1	0	1	-1	1	1	1	0	1	1	-1	1	1
26	25 - 50	0	1	1	-1	1	1	1	1	0	1	1	0	1
27	75 - 100	0	1	1	-1	1	1	0	1	0	1	-1	1	1
28	25 - 50	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1 - 25	1	1	1	1	1	1	1	1	1	1	1	1	1
30	100 - 250	0	1	0	0	0	0	0	0	0	-1	-1	-1	1
31	25 - 50	1	1	1	0	1	0	1	0	-1	0	-1	1	1
32	1 - 25	1	1	1	-1	0	-1	0	1	0	1	-1	1	1
33	50 - 75	1	1	1	-1	1	1	1	0	-1	1	-1	0	1
34	25 - 50	1	1	1	-1	0	1	0	0	1	1	-1	-1	1
35	25 - 50	1	0	1	0	1	1	1	0	1	1	0	1	1
36	250 - 500	0	1	1	-1	-1	-1	-1	1	0	0	-1	-1	0
37	500 <	1	0	0	-1	-1	-1	-1	-1	-1	-1	0	0	1
38	50 - 75	1	1	1	1	1	1	1	0	1	1	-1	0	1
39	25 - 50	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
40	100 - 250	1	1	1	1	0	1	1	1	1	1	0	1	0

$-1 \times 2^0 + 0 \times 2^1 + (-1) \times 2^2 + 1 \times 2^3 + 1 \times 2^4 + 0 \times 2^5 + \dots + 1 \times 2^{12} = 8181 \rightarrow$ the term in bold $((-1) \times 2^2)$ will be considered equivalent to -4 in decimals.

4. Results

The result of the adaption of ROC Method described above allows joining companies according to the knowledge of SMED and of its benefits (Table 5), as

they have declared, and then it is possible to identify if companies know and apply SMED and if companies effectively perceive the benefits of SMED.

TABLE 5 - INCIDENCE MATRIX RELATING COMPANIES (LINES) AND SMED BENEFITS (COLUMNS) REORDERED ACCORDING TO THE ADAPTED METHOD.

Companies	# of Workers	Benefits												
		Previous preparation	Training of workers	Knowledge of workers about SMED	Monitoring of setup times	Reduction of WIP and losses	Reduction of setup time	Increase of capacity and of flexibility	Reduction of setup costs	Reduction of unexpected downtime	Reduction of adjustments after setup	Use of multifunctional workers	Reduction of lead time, batch sizes and cycle time	Improvement of product quality
14	250 - 500	1	1	1	1	1	1	1	1	1	1	1	1	1
16	25 - 50	1	1	1	1	1	1	1	1	1	1	1	1	1
20	50 - 75	1	1	1	1	1	1	1	1	1	1	1	1	1
1	250 - 500	1	1	1	1	1	1	1	1	1	1	1	1	1
28	25 - 50	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1 - 25	1	1	1	1	1	1	1	1	1	1	1	1	1
21	25 - 50	1	1	1	1	1	1	1	1	1	1	0	1	1
15	100 - 250	1	1	1	1	1	1	1	1	0	1	1	1	-1
38	50 - 75	1	1	1	1	1	1	1	1	0	1	1	0	-1
3	50 - 75	1	1	1	1	1	1	1	0	1	1	1	1	1
12	1 - 25	1	1	1	1	1	1	0	0	1	1	1	1	1
40	100 - 250	1	1	1	1	1	0	1	1	1	0	1	1	0
24	25 - 50	1	1	1	1	1	1	-1	0	1	0	0	-1	0
5	250 - 500	1	1	1	1	0	1	1	1	1	0	-1	1	1
8	50 - 75	1	1	1	0	1	1	1	1	1	1	1	-1	1
31	25 - 50	1	1	1	0	0	1	0	-1	1	1	1	0	-1
7	75 - 100	1	1	0	1	1	1	1	1	1	1	1	1	1
33	50 - 75	1	1	1	-1	1	1	1	-1	0	1	1	0	-1

The companies were arbitrarily divided in groups to express the effective application of SMED and the knowledge the benefits that this methodology brings to production systems. The groups were established according to the final decimal value of each line, regarding to the following interval:

TABLE 5 - INCIDENCE MATRIX RELATING COMPANIES (LINES) AND SMED BENEFITS (COLUMNS) REORDERED ACCORDING TO THE ADAPTED METHOD (CONTINUED).

34	25 – 50	1	1	1	-1	1	0	1	1	-1	1	0	0	-1
9	1 – 25	1	1	0	1	0	0	0	1	1	0	0	1	0
32	1 – 25	1	1	1	-1	-1	0	1	0	1	1	0	1	-1
17	75 - 100	1	1	0	0	0	1	1	1	1	0	1	1	1
22	100 - 250	1	0	1	1	1	1	1	1	1	1	1	1	1
27	75 - 100	1	1	0	-1	1	1	1	0	1	1	0	1	-1
26	25 - 50	1	1	0	-1	1	1	1	0	0	1	1	1	1
18	100 - 250	1	1	-1	1	1	0	-1	1	1	1	1	1	0
6	100 - 250	1	0	1	1	1	-1	-1	1	1	0	0	-1	0
35	25 - 50	1	0	1	0	1	1	1	1	1	1	1	0	0
36	250 - 500	1	1	0	-1	-1	-1	0	0	-1	0	-1	1	-1
25	50 - 75	1	0	1	-1	1	1	1	1	1	1	1	0	-1
4	100 - 250	1	0	0	1	1	-1	1	1	0	0	0	1	0
23	50 - 75	1	0	0	1	-1	-1	-1	1	1	1	1	1	0
19	500 <	0	1	1	1	1	1	1	1	1	1	1	1	1
2	1 – 25	0	1	1	0	0	1	1	1	1	0	-1	0	0
10	100 - 250	1	-1	1	0	1	-1	-1	-1	-1	-1	-1	0	-1
30	100 - 250	0	1	0	0	0	0	-1	0	-1	1	0	0	-1
37	500 <	0	0	1	-1	-1	-1	-1	-1	0	1	-1	-1	0
13	250 - 500	-1	0	1	0	1	-1	1	0	1	1	0	1	-1
11	100 - 250	-1	-1	0	-1	1	0	-1	1	1	1	-1	1	0
39	25 - 50	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

- Green group: companies that declared to know SMED and that effectively use this methodology (30% of the companies);
- Blue group: companies that declared to know SMED but use it partially (12,5% of the companies);
- Yellow group: companies that to know SMED but do not use it in a proven way (45% of the companies);
- 4 Red group: companies that declared they do not know much about SMED and, consequently, do not use it in their production (12,5% of the companies).

5. Conclusions

The analysis of the results shows that most of the companies, 57,5%, do not use SMED in a proven way, even though they declare to know this methodology and its benefits (yellow and red groups).

Even among companies that use SMED in a partial way, 12,5% (blue group), some of them declared do not know some of the benefits that arise with the use of this methodology.

Only a small parcel of the companies, 30%, effectively know and use SMED in their production systems (green group).

According to the perception of the respondents, almost all of the researched companies know the basic principles of SMED, but they do not really know the benefits that the use of this methodology brings, losing an opportunity that can help in increasing its competitiveness, something fundamental in the present days.

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