Chapter 23
Single Minute Exchange of Die and Organizational Innovation in Seven Small and Medium-Sized Firms

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Abstract Innovation plays a very important role in businesses competitiveness. As Small and Medium-sized Enterprises (SMEs) stem for more than 95 % of the industrial fabric in the developed world, the improvement of the industrial production or the provision of a service are key to increase their productivity and competitiveness. The Single Minute Exchange of Die (SMED) is a Japanese process-based innovative methodology that involves the separation and conversion of internal setup operations into external ones. The SMED makes it possible for firms to reduce their lead times and to eliminate wastefulness during changeover activities. Although organizational innovation is a very important tool, it plays a silent role in productivity improvement, as it is less tangible than product or process innovation. Moreover, studies about SMED implementation and how teams have managed to achieve their results are still very limited among SMEs. The main objective of this chapter is to provide the results of seven projects involving business-university partnerships addressing this understudied topic: SMED implementation and organizational innovation in SMEs. The main finding of this study is that all firms managed to improve their setup times, although the results vary extensively. From the organizational innovation point of view, only one firm failed to intertwine the initiation and the implementation stages. Although all firms have initiation-implementation routines, there are clear differences among them. As a result, although it is possible to claim that all SMEs analyzed are ambidextrous organizations, their initiation-implementation routines, deserve deeper comprehension.

Keywords SMED methodology · Setup times · Organizational innovation · SMEs

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23.1 Introduction

Single-Minute Exchange of Die (SMED), also known as Quick Changeover of Tools, is a methodology that was developed to reduce the setup time during changeover (Shingo 1985). SMED has been used to respond to fluctuations in demand and leads to lead time reduction, the elimination of wastefulness and the reduction of lot sizes (Shingo 1985; Moreira and Pais 2011).

Organizational innovation has been extensively analyzed to understand how environmental contingencies influence firms. The ambidextrous theory focuses on the adoption of innovation and proposes two stages, the initiation and the implementation, in which firms perform differently.

Based on a set of seven projects from business-university partnerships, the main objectives of this chapter are: firstly, to cover the main results achieved from the implementation of the SMED methodology in the reduction of setup times in firms producing several types of products (dies; polyurethane and polyester foam; sanitary products; corrugated cardboards; rims for bicycles; and bolts and rivets); secondly, to provide examples of the SMED methodology outside the typical exchange of dies; thirdly, to address the importance of organizational innovation, namely the ambidextrous theory, in achieving continuous intangible improvements.

This chapter is divided in seven sections. The first section covers the introduction. The second section addresses the importance of innovation, namely organizational innovation. The third section addresses the literature review regarding the SMED methodology. The fourth section exposes SMED implementation. The research methodology is covered in the fifth section. The sixth section addresses the field work covered. In the seventh section the conclusions are drawn.

23.2 The Importance of Innovation

The increasing competitiveness in global markets unleashed a quest in the industrial business world for the improvement of productivity.

During the last decades the business world has witnessed a great deal of changes in the management and organization of production systems in such a way that industrial firms, whether large or small, need to keep up with their main competitors on a global scale. The technological revolution and the introduction of new organizational techniques played an important role in those changes. The former, led by the introduction of information systems, machinery, telecommunications, pervasive automation and robotics, created unprecedented productivity gains and improved operations planning and control. Most of the firms realized that despite their technological acumen, organizational innovations, based on human capital, sparked their productivity improvement, paving the way for better time to market efforts and improved flexibility (Womack et al. 1990; McIntosh et al. 2001; Holweg 2007).

Several studies have examined organizational innovation in an effort to answer to basic questions such as, "why some organizations are more innovative that others?" or "What organizational structures and management processes facilitate or inhibit innovations?". Most academic research have been on conceiving innovation as an outcome or as process and little attention has been given to organizational innovation.

Although, innovation is an important tool for competitiveness (Dantas and Moreira 2011), two types of innovation processes were distinguished: the firm as provider or user of innovation. As provider of innovation, the firm faces problems and makes decisions that involve the development of new products and processes (Moreira and Pais 2011). The company's success as an innovation provider stems from its exploration capacity and the possibility to profit from such innovation (Gopalakrishnan and Damanpour 1997). With this behavior, the firm follows an outward innovation process. The firm is not a passive entity "importing" concepts, products or processes: it plays the central role in generating change.

As user of innovation, the firm tries to incorporate novelties developed outside the firm. Zaltman et al. (1973) differentiated between two stages in this innovation process: initiation and implementation. The former includes activities that deal with the perception of the problem, the gathering of information and the development of an attitude that promotes and assesses innovation. The implementation stage is related to the decision making process regarding the adoption of innovation. In the initiation stage, competences possessed by individuals are essential. Group competences however, are crucial in the implementation stage as it is more systemic and involves the internalization of the innovation (Damanpour 1992). As user of innovation, the firm follows an inward innovation process.

The ambidextrous theory focuses on the process of adoption of innovation and proposes two stages in the process: the initiation stage and the implementation stage. The theory posits that high complexity (e.g. organic features) facilitate the initiation of innovations, while low complexity (e.g. mechanistic features) facilitates the implementation of innovations (Zaltman et al. 1973). Although very simplistic, this theory has not been assessed on a process perspective involving SMED projects.

Clearly, although process innovation is related to new elements, equipment or manufacturing methods that improve the production of a product and provide a better service (Damanpour 1991; Damanpour and Gopalakrishnan 2001; Dantas and Moreira 2011), firms play a different role as users or providers of innovation.

Process innovations are less tangible and more difficult to implement than product innovations (Ettlie and Reza 1992; Frost and Egri 1991). Ettlie and Reza (1992) and Damanpour (1996) state that product innovations are easier to imitate whereas process innovations are more organization specific, given that they cannot be copied without implementing changes in the organizational structure or management system.

The introduction of process innovations normally involves organizational innovation. For example, the introduction of lean technologies such as the Toyota Production System (TPS) and the Single Minute Exchange of Die (SMED) are examples of organization specific process innovation. The main objective of the TPS is to increase manufacturing productivity using techniques such as small-sized production lots and non-stock production with a strong focus on organizational change (Pisano and Hayes 1995; Godinho Filho and Fernandes 2004; Moreira and Pais 2011). Therefore, it is the firm's capability of deploying innovation that influences and triggers productivity. Organizational innovation has a distinctive characteristic: firms need to behave as providers of innovation by exploring new ways to improve their activities. However, they must also act as users of innovation since they have to internalize new solutions developed outside their boundaries.

The implementation of process innovation based techniques, which strongly rely on organizational changes, are very important among industrial competitiveness (Cusumano 1989; Womack et al. 1990; Womack and Jones 1994; Monden 1984; Liker 2004; Holweg 2007). Although, many of these techniques were introduced by Japanese firms (Lamming 1993; Nishiguchi 1994; Shingo 1985; Monden 1984), the implementation of Japanese process innovation-based techniques have had limited impact on the West (Nishiguchi 1994; Freire 1995; Pardi 2005).

The implementation of organizational and process innovation is in high demand for industrial firms for several reasons (Holweg 2007). Firstly, as competition is stiff, there has been a growing focus on product cost cuts. Secondly, as time-to-market is growing in importance, the reduction of setup times is a key component of competitiveness. Thirdly, as product demand is shrinking, there is a growing focus on the reduction of stocks and on the increase of flexibility. Accordingly, the better the efficiency of the firm in managing its production resources, the better ability the firm has to respond to the competitive challenges through improved operational performance. Consequently, the above mentioned initiation and implementation stages are key components of firms' competitiveness as they spark unique, difficult to match competitive advantages.

Individuals inside organizations can influence the processes of innovation with their personality, motivation, knowledge, work characteristics, and mood states (Anderson et al. 2004). In terms of groups, team structure, team climate, team processes, member characteristics, and leadership style are all considered determinants for organizational innovation (Anderson et al. 2004).

Damanpour (1991) settled thirteen organizational determinants of innovation: specialization; functional differentiation; professionalism; formalization; centralization; managerial attitude; managerial tenure; technical knowledge resources; administrative intensity; slack resources; external communications; internal communications; and vertical differentiation. The existence of two other determinants of innovation was also put forward: structural complexity, and organization size (Damanpour 1996). Pittaway et al. (2004) advanced five impediments of organizational innovation: inter-firm conflicts, lack of infrastructure, lack of scale, displacement, and external disruption. Klein and Knight (2005) focused on four different determinants affecting the implementation stage of organizational innovation, namely: positive climate; management support; learning orientation; and financial resources.

Clearly, organizational innovations are inherently complex. As SMED is based on a set of procedures that are used as a continuous improvement process, in this chapter the following definition of organizational innovation is going to be followed (Damanpour and Evans 1984): *organizational innovation is the use of new managerial and working concepts and practices*, which can be differentiated in structural and procedural changes.

23.3 Single-Minute Exchange of Die

Single-Minute Exchange of Die (SMED), also known as Quick Changeover of Tools, refers to the theory and techniques used to reduce setup times. It can be applied in any industrial unit and to any machine. It is defined as the minimum amount of time necessary to change the type of production activity and it takes into consideration the moment at which the last piece of a previous lot was produced *vis-à-vis* the first piece produced by the subsequent lot (Shingo 1985).

Traditionally, firms regarded setup times as one of the most expensive costs they had to face. Accordingly, many firms opted for minimizing the number of setups implemented. This resulted in very large production lots (Holweg 2007), contributing both to excessive inventory and low productivity (Liker 2004).

According to Shingo (1985), the development of the SMED methodology took place in Hiroshima, Japan during the 1950s. It was initially developed at the premises of Mazda Toyo Koyio and Mitsubishi Heavy Industries. Nevertheless, it was only in the 1970s, as part of the Toyota Production System, that the SMED methodology was widely acknowledged. Cusumano (1989), on the other hand, defends that the concept of Quick Changeover was already applied in the US during the fifties.

The SMED methodology was developed in order to reduce and simplify the setup time during changeover (Shingo 1985). SMED, which is a Japanese process-based innovation, makes it possible to respond to fluctuations in demand and results in lead time reductions. Furthermore, it eliminates wastefulness during changeover and diminishes lot sizes (Shingo 1985; Moreira and Pais 2011).

With the growing trend of product customization, mass production became obsolete. As a consequence, firms deploy strategies to compete, simultaneously, in terms of price, product quality, product differentiation, and delivery time. Accordingly, in order to improve production processes, it is necessary to analyze the value added by each activity and eliminate all those that do not add value to the product (Levinson 2002). Therefore, the SMED methodology becomes extraordinarily important.

When firms face demands with large diversity of products, it is imperative to be prepared to produce smaller lots without jeopardizing their global productivity (Blau 1994). Thus, firms must be capable of producing a large diversity of products in small quantities and, consequently, must have the competencies necessary for changeover activities. In order to compete, firms need to find ways to reduce setup times and eliminate wastefulness and non-added value activities. Furthermore, they must be able to convert idle setup time into regular production time. Therefore, a strong focus on process and organizational innovation is needed.

This type of problem can be successfully addressed following the SMED methodology (Shingo 1985). The main challenge is to implement a process-based innovation in which setup operations need to be standardized and properly documented. In this manner, production workers can follow all the procedures of a certain process, resulting in the reduction (optimization) of setup times.

Plenty of research on SMED have been widely described and presented with the exchange of Dies as the main focus (Monden 1984; Johansen and McGuire 1986; Sepheri 1987; Quinlan 1987; Noaker 1991; Gilmore and Smith 1996; McIntosh et al. 2000; Fogliatto and Fagundes 2003; Satolo and Calarge 2008). Van Goubergen and Van Landeghem (2002) analyzed how equipment design can improve existing setup times. In their study they analyzed more than 60 cases and concluded that up to 90 % of setup times could be improved. Neumann and Ribeiro (2004) analyzed how a supplier development program achieved a 50 % of improvement in the set up time of the firm. Sugai, McIntosh and Novaski (2007), addressing a single case study, concluded that the sequencing of production lots, the acceleration (during the setup) and deceleration (during post-setup) periods and the need to maintain rigorous set up times achieved are very important topics. Clearly, studies concerning SMED implementation and innovation process are in short supply.

As a consequence, and taking into account a set of seven projects from business-university partnerships in industrial firms, the main objectives of this chapter are: firstly, to cover the main results achieved from the implementation of the SMED methodology in the reduction of setup times in firms producing several types of products (dies; polyurethane and polyester foam; sanitary products; corrugated cardboards; rims for bicycles; and bolts and rivets); secondly, to provide examples of the SMED methodology outside the typical exchange of dies; thirdly, to address the importance of organizational innovation namely the ambidextrous theory, in achieving continuous intangible improvements.

23.4 The Operationalization of SMED

Traditionally, the minimization of the costs of idle machines during setup operations was to produce large lots, in order to obtain the lowest possible percentage of idle time per unit produced. As Toyota's inventory costs for their vehicles were extremely high, they decided to reduce setup times (Shingo 1985). Accordingly, if production changes could be done in less time, the ideal amount of production could be smaller decreasing the costs involved.

As the unitary costs are directly proportional to the setup time and to the production time, Shingo (1985) defends that firms need to have a clear strategy to reduce setup times, otherwise they can face the following disadvantages:

- The need for larger client orders, which is very negative and counter intuitive, as the SMED was developed to face the reduction of order sizes due to the growing customization;
- Longer lead times, which jeopardizes competitive responses to main competitors;
- Larger costs with inventory, pallets, forklifts, labor, among other things, which hinders business competitiveness;
- Larger quality problems, as we return to mass production techniques;
- Loss of money with inventory amortization, which hinders firm competitiveness;
- More labor linked to transport and inventory, which hinders firm competitiveness;
- More frequent refunds due to larger amounts of defects (probable).

According to Shingo (1985), one can extract direct and indirect benefits from the SMED application. The reduction of inventory, the increase of production flexibility and the rationalization of tools are among the indirect benefits. The direct benefits include the reduction of setup time, the reduction of time spent with fine tuning the machines, the reduction of errors during changeovers, the improvement of product quality and increased safety.

The principle behind the setup time reduction introduced by the SMED methodology is simple: the elimination of wastefulness related to the change of tools. To achieve this, Shingo (1985) applied a systematic approach in order to separate internal operations—namely, the Die exchange or the fitting of equipment, which must be performed with the machine in switched off mode—from external operations—namely, those performed with the machine in normal operation mode, as is the case of the preparation of tools. In their improvement process, firms normally go through the following four different phases (Shingo 1985):

- Phase A: the firm makes no distinction between internal and external setup operations and, consequently, machines remain idle for very long time periods. The main objective in implementing the SMED methodology is to study the shop floor conditions in great detail through a production analysis, interviews with workers and videotaping of setup operations.
- Phase B: the firm separates internal from external setup operations. Usually, this action saves 30 to 50 % of the time needed for the setup operation. Mastering this distinction is a key issue to achieving success in implementing SMED.
- Phase C: the firm converts the maximum internal setup operations to external ones. In this phase, it is important to re-examine all operations in order to assess if they were wrongly assumed as internal ones and, if needed, convert them to external ones.
- Phase D: Streamlining all aspects of the setup operation. This phase seeks the systematic improvement of each basic operation of internal and external setup, developing solutions to accomplish the different tasks in an easier, faster and safer way.

For firms to reach global success during the SMED implementation, Shingo (1985) describes, quite exhaustively, a set of procedures that must be followed:

- To analyze the actual procedure;
- To classify the several operations performed as internal or external ones;
- To convert internal operations into external ones;
- To develop brand new solutions in order to reduce both the time of internal operations and the time delays in external operations;
- Creating rigorous procedures in order to reduce flaws during the setup;
- Returning to the beginning of the process and repeating the whole procedure in order to continuously reduce the setup time.

This set of procedures requires a continuous analysis of the process in order to obtain good results. Whenever the method is applied, new and improved solutions must be obtained. Thus, a focus on process and organizational innovation is mandatory.

Several studies have implemented the SMED methodology. For example, Monden (1984) defends the simultaneous analysis of all internal and external operations and the standardization of all functions. On the other hand, Gilmore and Smith (1996) defend that Shingo's (1985) procedures can be applied even when not following his logical sequence. Moxan and Greatbanks (2001) analyzed the prerequisites for the implementation of the SMED methodology and found that the methodology might be very ineffective due to cultural, process-based management barriers. They defend the use of a preparatory/learning phase in order to reach a better implementation of SMED. Fogliatto and Fagundes (2003) identify four types of activities when implementing SMED: strategic, preparatory, operational and confirmatory activities. All these activities have different purposes and are part of a broader scope of teamwork, management involvement, training, visual management and internal communication of the results achieved. All these activities are necessary to fine-tune Japanese techniques to non-Japanese environments.

McIntosh et al. (1996) put forward an important contribution regarding changeover improvements. They experienced that even when firms conduct initiatives to improve setup time, and they successfully achieve them, the levels of performance of the initiatives kept sliding away to the same levels before the initiatives were taken. Although several difficulties were measured (motorization of the setup period, lack of production and quality measures, insufficient attention to setup time *vis-à-vis* to product quality on production rate, lack of improvement targets, lack of training and lack of goal orientation), the main problem is the lack of an organizational strategy in which a directive management style was used instead of a participative one.

Another important contribution is referred by McIntosh et al. (2001), who applied SMED to Total Productive Maintenance (TPM). They refer that the better the planning of the maintenance intervention, the lower the setup time of changeover activities. The achievements of their analysis are very clear. A good planning is essential to deploy organizational improvements, which will be reflected in the SMED results. Nevertheless, the message is very clear: without the proper training and human involvement it is difficult to achieve results.

Instead of focusing on SMED results, Gest et al. (1995) gathered information on the different specific techniques that might be used when implementing SMED. They conclude that although adjustments can be observed, the main contributory factor to setup problems firms face is the lack of clear instructions, namely due to the wide spectrum of machines they work with.

From a historical perspective Holweg's (2007) work is very important: SMED is just a part of a lean thinking philosophy, the Toyota Production Systems. Accordingly, mere transplants will certainly not achieve the results of an integrated perspective involving Kaizen, Six Sigma Value Stream Mapping and continuous improvement. This perspective is also supported by Hicks (2007) from a information management perspective and by Pardi (2005) from a socioeconomic perspective.

Satolo and Calarge (2008) analyzed the applicability of the SMED methodology and concluded that there are large differences among the firms that implemented it. More importantly, the differences were based on organizational barriers, resistance to change and difficulties in identifying opportunities for improvement. For Satolo and Calarge (2008), implementing the SMED methodology is doomed without proper staff preparation and training, and without the publication of results among those involved. Their contribution is very important in organizational terms, complementing Moxan and Greatbanks' (2001) and McIntosh et al.' (2001) studies about the difficulties in achieving results due lack of organizational strategy.

In order to circumvent the difficulties of the implementation of changeover activities, McIntosch et al. (2001) use a set of leveraging tools and a set of evolutionary steps for each of the four phases referred above:

- Phase A, which is the SMED project kick off: the analysis of the shop floor activities in order to differentiate internal from external operations.
- Phase B, which separates internal from external operations: the use of checklists; the definition of functions for each worker; and the improvement of transportations tools.
- Phase C, which converts internal to external operations: the previous preparation of setup operations; the automation of operations; and the utilization of different tools.
- Phase D involves the improvement of all aspects of the setup operation: the improvement of tool transportation and warehousing; the elimination of settings, calibrations and adjustments; and the the automation of operations.

Finally, an important issue that deserves some attention is that most classical studies have addressed the implementation of SMED methodologies in die casting activities for the automotive industry. However, newer experiences have implemented SMED projects in other types of industries (Moreira and Garcez 2013; Satolo and Calarge 2008). One important characteristic of these studies is that the results vary quite broadly. Thus, as mentioned above, the main objective of this chapter is to provide examples of the implementation of the SMED methodology in SMEs outside the traditional applications in the exchange of dies, taking into account organizational innovation.

23.5 Research Methodology

In order to achieve the goals proposed, it was decided to use a case study approach (Yin 1989). The methodology used is based on the SMED characteristics addressed in the last section. During the implementation of the SMED methodology, we followed the phases proposed above as well as the techniques presented by Shingo (1985). However, some of them could not be directly applied as the machines have different characteristics from those of Die casts.

For simplicity reasons, the firms will be presented first and the results afterwards. The seven cases reported herein involved Business-University partnerships. Due to confidentiality concerns, the name of firms cannot be disclosed.

Firm A involved the study of SMED implementation in a medium-sized moldmaker that uses a wide range of Dies: from 80 Tons to a maximum of 1100 Tons. Firm B produces foam in polyurethane polyether and polyester for several markets. The firm had a sales volume close to 27 million euros and employed approximately 140 people, in 2010. Firm B transforms 60-m-blocks of foam into 5-mm-wide foam rolls. This operation takes place in a Looper, which is the case study covered here.

Firm C is a medium-sized enterprise from Aveiro producing plastic sanitary products. Firm C embarked on a 3-year project involving 5Ss and SMED methodologies following a continuous improvement approach. The analysis of the implementation of SMED was based on setup time reduction in 47 different plastic molds injection machines.

Firm D involves a case study in a SME from the north of Portugal producing corrugated plates and corrugated carton packaging. The analysis involved SMED and Overall Equipment Efficiency (OEE) implementation on a pilot machine producing corrugated plates with several thicknesses. Firm E is a metal mechanic firm from the Aveiro region. It produces a wide range of products, from bowls and dishwasher in stainless steel to aluminum rims and wheels. The case reported herein involves the production of rims for bicycles and the analysis was based on SMED and 5Ss techniques implemented for two types of products.

Firm F is a SME with 100 employees producing metallic bolts and rivets. Their main clients are in the auto industry. Firm F witnessed a productivity improvement through a just-in time-project and decided to be involved in a setup time reduction project involving SMED methodologies. This case involved the analysis of 118 records of setup time improvement projects for a specific type of equipment. Finally, case G involves a SME producing corrugated cardboard. Two types of SMED projects were analyzed: corrugated cardboard and high quality printed corrugated cardboard packaging. The analysis reports two different types of results involving behavioral responses to the SMED projects.

The analysis of the seven case studies followed a similar pattern and the approach was very implementation-oriented. This analysis was divided in the following steps:

1. Describing and analyzing the setup operations on the shop floor, tracking setup times and measuring all operative movements;
2. Separating internal from external operations;
3. Converting internal to external operations;
4. Streamlining all aspects of the setup operation in order to accomplish the different tasks in an easier, faster and safer way;
5. Assessing the impact of the methodology implemented;
6. Preparing the diffusion of the new SMED methodology to the other firms of the economic group.

For operational reasons, it was only possible to record on tape the whole set up process for A, B, D and E.

23.6 Results

The initial analysis is very crucial for obtaining a correct diagnosis as it marks the beginning of a new production system. The results obtained in this phase are also important for a subsequent assessment of the impact of the adopted solutions. Accordingly, the main objective of this phase was to gather information regarding the setups, namely: the sequence of shop floor operations; the timings of different tasks and operations; the organization of workers during the setup and the machine work rates; and the identification of critical points that reduce the effectiveness of the production system, as well as their causes.

The analysis of the production system took place during the setups and involved the following aspects: the analysis of the standard procedures, if any; the communication among workers; the difficulties felt by workers during setup operations; the settings, calibrations and adjustments during the setup; and the coordination among the various departments involved in the setup operations.

During the participation in the several setups, it was possible to identify several common problems. The following are among the most important ones:

- Poor organization, since the people involved were inadequately prepared for the setup and the necessary material for performing the operations was not ready;
- Lack of knowledge of the procedures for carrying out the complete setup in time;
- Lack of an established check-list of activities for carrying out the setup;
- The carrying out of external operations as if they were internal ones;
- Incorrect assignment of tasks during setup;

- Lack of planned procedure to deploy setup operations;
- Strong separation between shop floor activities and other activities that affected the setup time;
- Lack of knowledge of the consequences of poor setup operations.

After this initial stage/step, through the analysis of the data gathered and the video recordings, when allowed, the internal and external operations were separated and the set time of each of them was analyzed. Afterwards, the analysis of the several operations that can be transformed in external ones took place, i.e., performing procedures with the machine in operation as opposed to performing them with the machine in standby. Departing from the data gathered in the previous stage, a thorough analysis of the setup operations was accomplished in order to identify which operations could change their status.

Subsequently, in order to improve all internal and external operations that compose the changeover, we analyzed the records of the operations previously accomplished and identified how we could reduce all operations. In this way a new, post-SMED operation mode for the setup series was prepared as a result of the work developed by the entire team involved in the reduction of the setup time project. This new SMED operation mode was defined as the new standard.

The results achieved in each case studied were different. For example, Firm A managed to achieve an average of 39.1 % of setup time improvement. Using only an incremental innovation approach with no investments performed on equipment, they not only managed to use and master innovation, but also enhanced the solution to other sister firms. Moreover, they developed brainstorming sessions to implement changes in the plant layout, the management of quality and maintenance activities and in the design of their equipment. They appointed an improvement team to be responsible for the continuous improvement of the setup times and regular training is provided to all staff involved in SMED activities. Clearly, Firm A managed to implement both the initiation and the implementation stages, proving to be an ambidextrous organization.

The average setup time improvement of the Loopers in Firm B was 65 %. They managed to decrease from a setup time of 114 to 40 min. As a consequence of the improvement, the firm regarded SMED as a moving target: all SMED team members need to include in their portfolio of activities the identification of internal and external setup operations, the conversion of internal setup operations to external ones and the reassessment of all conventional procedures. As occurred in Firm A, Firm B managed to implement organizational innovations in such a way that ambidextry is present through the initiation and implementation phases.

The results obtained by Firm C are, by no means, the best of all seven cases analyzed: the average setup time improvement was 80 % and the number of changeovers increased more than 3 times. This achievement is the outcome of a 3-year project involving 47 plastic mold injection machines. Indeed, Firm C has managed to internalize knowledge generated during the initiation phase (perception of the problem, gathering information and promote change) and has managed to deploy this knowledge through routines and procedures to the rest of the organization. They have managed to improve the working environment, to reduce product unitary cost as well as to reduce the lot size (although data was not released). Clearly, Firm C has managed to deploy both the initiation and implementation stages that characterize ambidextrous organizations.

During the SMED project implemented in Firm D, it was possible to conclude that 31.42 % of production time stoppages were due to changeover operations. With the project, the setup time reduction was reduced in 22.3 %, and several modes of failure were detected. After analyzing them it was possible to intertwine several setup operations with other modes of failure. In the end, the three main modes of failure were responsible for 43.6 % of un-programmed stoppages.

Firm G, that also produces corrugated cardboard, was involved in two different projects: one involving the packaging and the other one involving merely corrugated cardboard. Two different types of results were found. One project team managed to reduce the setup time in 43 %, increase efficiency in 32 % and reduce the un-programmed stoppages from 15 to 11.1 %. At the end of the project, working conditions and a growing motivation were achieved and improvements rapidly assimilated. With the second project team the results were astonishingly fuzzy: the setup time increased only 8 %, efficiency decreased 2 % and the time of un-programmed stoppages increased. This second team showed high resistance in internalizing new operational methods. The different outcomes clearly show that even with the same training and procedures, teams might perform differently. In order to sort this incongruence out, Firm G decided to swap several team members and to create a task force team to deploy best practices to subsequent projects, without disregarding the leadership style to make projects successful.

The implementation of the SMED project in Firm F, was very straightforward as they simply analyzed 118 records of a type of equipment, and following the SMED procedures, they managed to improve setup time in 33 % without being involved in further investment, i.e., they used only a continuous innovation approach. On the other hand, Firm E managed to embark on a SMED project and used the 5Ss approach in the production of rims for bicycles. The average setup time improvement was 56 % and the lot size was reduced in 49 %.

23.7 Conclusion

One of the main conclusions is that the results of setup time improvement among the seven cases presented vary extensively. Apparently, some firms manage to muddle through the intricacies of the SMED methodology more successfully than others.

The deployment of the SMED methodology, though not very complex, involves the training and the active involvement of all SMED team members as well as the other production employees. Once the improvements are being achieved, team members feel more comfortable with the implementation.

Although, all firms implemented the same type of project, all of them did follow different paths. For example, Firms A, B, E and G decided to deploy the SMED methodology as part of an incremental innovation process with no investments. In the end, firms A and B needed to invest in minor tools. On the other hand, firms C and E complemented the SMED methodology with 5Ss methods. While some of them implemented focused projects (Firms B, D, E and G) others followed a wide perspective (Firms A, C and F). With the exception of Firm G, workers could internalize the knowledge and the intricacies of this organizational-based methodology and improve the results with other process innovation investments.

Another important conclusion is that the deployment of the SMED methodology should always have in consideration the ideas of those directly involved in the process. Often, these ideas are simple, effective and involve low costs. In SMED, as in other organizational innovation tools, those directly involved in the process must be empowered to find the best solutions to solve the problems. As can be observed in Firms G, even when workers have the knowledge and procedural tools to make organizational innovation happen, it might not be enough for firms due to natural resistance to change and to the not-invented-here syndrome.

As in continuous improvement methodologies, the SMED should be regarded as a moving target. Once an objective is achieved, new and more challenging objectives should be defined. Therefore, SMED teams should include in their portfolio of activities the identification of internal and external setup operations, the conversion of internal setup operations to external ones and the reassessment of all conventional procedures. In this way, it is possible to generate the improvement of setup times and the deployment of brainstorming sessions. Such brainstorming sessions aid in the identification of aspects not yet included in the analysis of SMED activities such as plant layout, total quality management, total maintenance management and equipment design changes.

Ambidextrous organizations are those that perform well at both the initiation and implementation stage. Although plenty of studies relate the former with product and the later with process innovation, organizational innovations as SMED need to have both of them to be successfully implemented. For example, the problem perception, the gathering of information and attitude formation might take place even before the beginning of the SMED project and involves the modification of the internal operations in external ones. The definition of new procedures and the involvement of workers in enduring new achievements are typical examples of how important the implementation stage is. In this regard only firm G failed in intertwining the initiation and the implementation stages. Moreover although all firms have initiation-implementation routines, there are clear differences among them as can be analyzed by the difference in the setup time improvements.

The implementation of the SMED methodology involving equipment and processes different from those originally used is still controversial. Several methodologies described by Shingo (1985) are not readily applicable for all types of equipment. Due to the large diversity of equipment and industries in which the methodology could be implemented, a ready-to-use set of guidelines or procedures seems to be quite generic. Nevertheless, contrary to what has been claimed by Sugai et al. (2007), this methodology can be implemented and deployed in any equipment as long as it is adapted to the team, to the machine and to the firm.

An important aspect that was not explicitly addressed in this chapter was how knowledge management among teams underpins performance. Thus, future works need to highlight the flexibility of SMED teams, the need to use a knowledge-based approach to properly disseminate the SMED methodology within the company, the consequences of SMED in the design of new machinery and, the economic importance of inventory reduction to the firm.

One of the limitations of this study that deserves a closer analysis is that the SMED teams were not addressed. In fact, most of the studies address the results achieved but not how the teams are organized and what types of teams are best suitable in SMED projects. Thus, future studies should address the type of organizational structure of SMED teams within the production/industrial organization structure, the role of SMED teams in the implementation of brand new solutions, and the knowledge absorption capacity of the SMED team.

Another important future challenge would be to address SMED projects within a broader focus of continuous improvement, such as, involving lean manufacturing techniques of visual stream mapping, pull systems, manufacturing cells, total productive maintenance, and 5S systems, among others.

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