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SMED (Single-Minute Exchange Of Die): A Noble Way To Reduce The Set Up Time.

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ABSTRACT

The competitiveness in the globalized environment highlights the importance of becoming more efficient in the execution of the company's operative and administrative processes in order to improve the level of customer service, delivery dates, quality of products, services and also to optimize the available resources. To survive in today's cut throat competition in this competitive world, all the industries need to reduce production time and costs in order to improve operating performance and operational flexibility. Single Minute Exchange of Dies (SMED) a Lean Manufacturing technique, mainly focuses on reducing the time taken to complete the equipment changeovers .Hence in this article i kept the objective to review the literature about this less studied topic: SMED. This paper covers the literature review of SMED and purpose of this literature review is to develop an overview of SMED as a Lean tool.

Keywords: Lean tools, Single Minute Exchange of Dies, Quick Changeover, Internal elements, External elements,

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I. INTRODUCTION

Flexibility and Responsiveness are the two main pillars of manufacturing, which is driven by the demand for the products variety and quality. The more varieties and fewer number of parts are the major requirements of the present production system throughout the world. Due to the smaller production batch size and more varieties of parts, the setup time will increases which leads to the reduction in productivity.In these days many industries are focusing their attention on how to reduce the setup time and to increse the productivity in order to remain in the competition. To face today's competitational environment, the manufacturers are trying to identify non value adding activities and eliminate them out of process. Thus many of the industries are going for the SMED method which is quite simple and results oriented.

II. HISTORY

Single-Minute Exchange of Die (SMED)was developed by the Shiego Shingo in 1985 in Japan. Due to the increasing demand for the smaller lot sizes and to meet the required flexibility of the customer, Shingo proposed this Single Minute Exchange of Die.Single Minute Exchange of Die is related to setup reduction and its main objective is to reduce this setup time to a single digit value. This will help the organization to minimize the setup time and helps in effectively bringing down the production cycle time and better utilization of the equipments. **Single-Minute Exchange of Die** (**SMED**) is one of the many Lean manufacturing methods for reducing waste in a manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product(Running from one product to another product). This rapid changeover is key to reducing production lot sizes and thereby improving flow .The phrase "**single minute**" does not mean that all changeovers and startups should take only *one* minute, but that they should take less than 10 minutes (in other words, "single-digit minute").

Shigeo Shingo was extraordinarily successful in helping the companies to drastically reduce their changeover times. His pioneering work led to documented reductions in changeover times averaging 94% across a wide range of companies.

Changeover times that improve by a factor of 20 may be hard to imagine, but considering this simple example of changing a tire we can understand the effectiveness of SMED.

- For many people, changing a single tire can easily take 15 minutes.
- For a NASCAR pit crew, changing four tires takes less than 15 seconds.

III.CONCEPT OF SMED

SMED is a system for reducing the time it takes to complete the equipment changeovers. The essence of the SMED system is to convert as many changeover steps as possible to "external elements or acticities" (can be performed while the machine is running).In SMED, changeovers are made up of steps that are termed "elements or activities". There are two types of elements or activities, namely,

- Internal Elements or Internal Activities (These are the activities which can be done after stopping the machine . Example, Removal of the Fixture or the tool etc.)
- External Elements or External Activities(These are the activities which can be done when machine is still on . Example, bringing the next Fixture or the Cutter when the machine is still on) and as mentioned earlier the SMED process focuses on making as many external elements as possible.

Now a days it is observed that the product life cycle of the products are reducing and demand for variable products are increasing drastically. Here comes the need of SMED.The analysis of the SMED has to begin with the details of the production process and the time study.

Also while seperating Internal and External activities we should consider the nature of activity as whether it is a Value adding(The time spent on activities that add value to an item from the customer's perspective. These are the activities that effectively change the form and function of a raw material into goods or service that the customer is willing to pay for)or a Non-Value adding(The time spent on activities that add cost but no value to an item from the customer's perspective. These are the activities that the customer is generally not willing to pay for) activity.

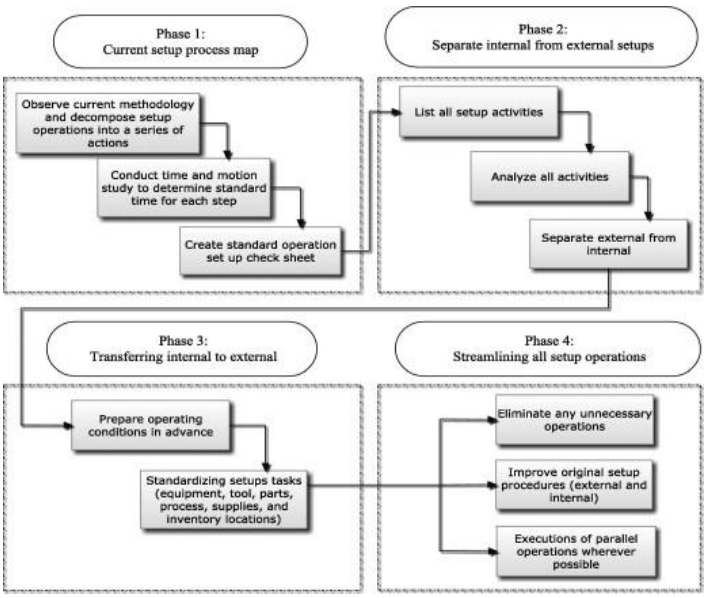
Here the major concern is to identify the non value adding activities which are being the part of the manufacturing process and then to separate them.If any internal activity cannot be eliminated or converted then it has to be combined or simplified or replace if possible.

Every manufacturing company that performs changeovers can benefit from SMED. The most of the companies are eager to understand where the productive time is being lost and how to plug it.For this SMED is a very excellant tool.

Many techniques used by NASCAR pit crews (performing as many steps as possible before the pit stop begins; using a coordinated team to perform multiple steps in parallel; creating a standardized and highly optimized process) are also used in SMED. In fact the journey from a 15 minute tire changeover to a 15 second tire changeover can be considered a SMED journey.

IV. CONVENTIONAL SMED APPROACH

The following diagram gives us an idea of ,how SMED is performed. In SMED the changeover process is split into a various steps called elements or activities. The essence of the SMED system is to convert as many changeover steps as possible to "external elements or acticities" (can be performed while the machine is running) and streamline the remaing activities.



V. PROCEDURE FOR IMPLEMENTATION OF SMED

In a broader sense the SMED can be conducted as per the following steps:

1. Form the setup reduction team.
2. Conduct training and education.
3. Study the setup process (e.g., use video tape).
4. Classify setup operations into waste, internal setups, and external setups .
    - Waste - Operation which do not add values to the setup.
    - Internal Setups - Operations that can only be performed while the machine is shut down.
    - External Setups - Operations that can be performed without shutting down the machine.
5. Eliminate the waste.
6. Convert as many internal setups as possilbe to external setups.
    - Use standard insert module.
7. Improve internal setups (include adjustment).
    - Use specially designed cart to organize

tools.

- Use quick-release fasteners instead of bolts and nuts.
- Use stoppers to quickly position the jigs.
- Use rolling bolsters instead of cranes.
- Use overhang mechanisms to handle heavy jigs.
- Use locating pins and holes (socket) to eliminate the adjustment.
- Use standardized die height.

8. Improve external setups.
    - Apply visual control principles.
    - Use checklist to avoid omission.
    - Use specially designed cart to help organize tools.
    - Organize workplace (5S) to reduce search.
9. Develop the standard operating procedure (SOP).
10. Evaluate the performance of setup reduction.
11. Prepare for the next setup reduction project.

Shigeo Shingo, who created SMED approach, claims that in his data from between 1975 and 1985 that average setup times he has dealt with have reduced to 2.5% of the time originally required; a 1/40 times of the original time.

Shigeo Shingo recognizes eight techniques that should be considered while implementing SMED.

1. Separate internal from external setup operations
2. Convert internal to external setup
3. Standardize function, not shape
4. Use functional clamps or eliminate fasteners altogether
5. Use intermediate jigs
6. Adopt parallel operations (see image below)
7. Eliminate adjustments
8. Mechanization

The detailed procedure of implementation of the setup reduction is as follows.

First establish a system for measuring manufacturing performance. Once a system for measuring manufacturing performance is in place, collect the data for at least two weeks to gain a clear picture of where productive time is being lost. Then follow the following detailed steps for the setup reduction.

a) –---Identify Pilot Area,

In this step, the target area for the pilot SMED program is selected. The ideal equipment will have the following characteristics:

Item	Description
Duration	The changeover is long enough to have significant room for improvement, but not too long as to be overwhelming in scope
Variation	There is large variation in changeover times (e.g. changeover times range from one to three hours).
Oportunities	There are multiple opportunities to perform the changeover each week .
Familiarity	Employees familiar with the equipment are engaged and motivated.

Once the target equipment has been selected, record a baseline time for the changeover. Changeover time should be measured as the time between production of the last good part (at full speed) and production of the first good part (at full speed).

b)–---Identify Elements,

In this step, the team works together to identify all of the elements of the changeover. The most effective way of doing this is to videotape the entire changeover and then work from the videotape to create an ordered list of elements, each of which includes:

- Description (what work is performed)
- Cost in Time (how long the element takes to complete)

c)–---Separate External Elements,

In this step, elements of the changeover process that can be performed with little or no change while the equipment is running are identified and moved “external” to the changeover . It is not unusual for changeover times to be cut nearly in half with this step alone.

For each element the team should ask the following question: Can this element, as currently performed or with minimal change, be completed while the equipment is running?

If the answer is yes, categorize the element as external and move it before or after the changeover, as appropriate.

The various elements for such consideration includes:

Item	Description
Retrieval	Retrieval of parts, tools, materials, and/or instructions.
Inspection	Inspection of parts, tools, and/or materials.
Cleaning	Cleaning tasks that can be performed while the process is running.
Quality	Quality checks for the last production run.

d)---Convert Internal Elements to External,

In this step, the current changeover process is carefully examined, with the goal of converting as many internal elements to external as possible. For each internal element, the team should ask the following questions: If there was a way to make this element external, what would it be? How could we do it?

This will result in a list of elements that are elements for further action.Once the list has been finalised then work can begin on making the necessary changes.

Examples of techniques that can be used to convert internal elements to external are:

Item	Description
Advance Preparation	Prepare parts in advance (e.g. preheat dies in advance of the changeover)
Jigs	Use duplicate jigs.
Modularize	Modularize equipment .
Modify	Modify equipment .

e)–-Streamline Remaining Elements,

In this step, the remaining elements are reviewed with an eye towards streamlining and simplifying so they can be completed in less time. First priority should be given to internal elements to support the primary goal of shortening the changeover time.

For each element, the team should ask the following questions: How can this element be completed in less time? How can we simplify this element?

As in the previous step a simple cost/benefit analysis should be used to prioritize action on elements.

Examples of techniques that can be used to streamline elements are:

Item	Description
Release	Eliminate bolts .
Adjustment	Eliminate adjustments.
Motion	Eliminate motion .
Waiting	Eliminate waiting (e.g. make first article inspection a high priority for QA)
Standardizing	Standardize hardware .
Operations	Create parallel operations (e.g. note that with multiple operators working on the same equipment close attention must be paid to potential safety issues)
Mechanize	Mechanize (normally this is considered a last resort)

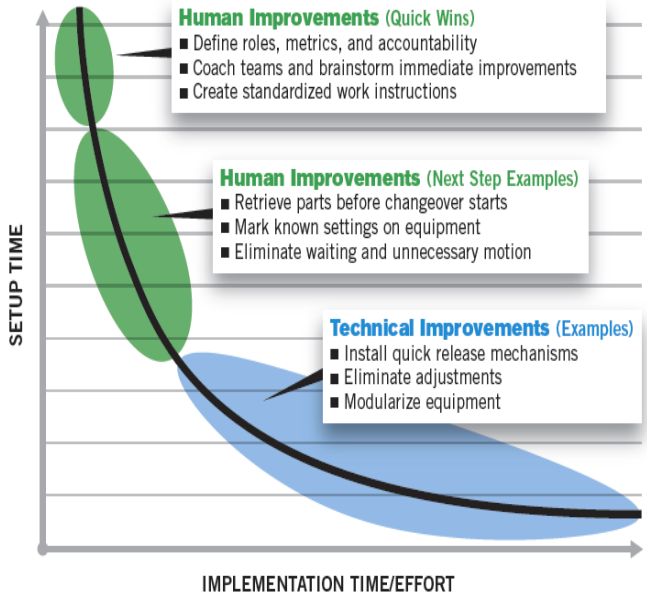
and Accelerate Progress,

When implementing SMED it is helpful to recognize that there are two broad categories of improvement:

- Human (achieved through preparation and organization)
- Technical (achieved through engineering)

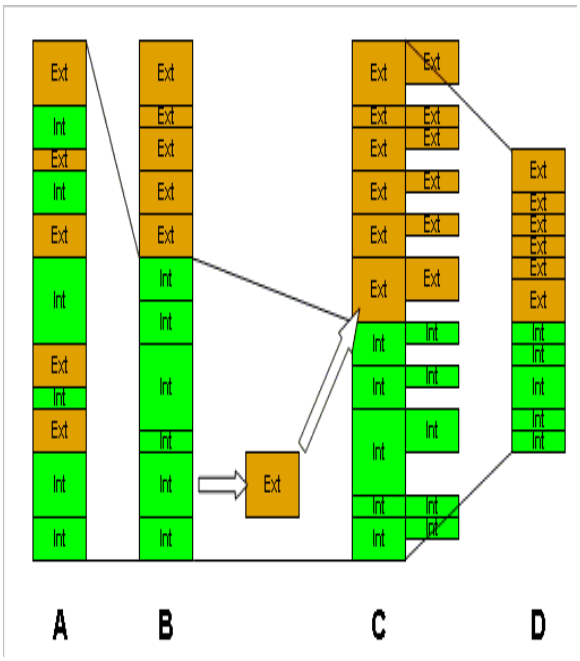
Experience has taught that the human elements are typically much faster and less expensive to improve than the technical elements. In other words, the quick wins are usually with the human elements. Avoid the temptation, especially with technically proficient teams, to over-focus on technical elements. Instead, focus first on the human elements.

The following chart illustrates this principle, showing example areas of opportunity for SMED projects.



VI. EFFECTS OF IMPLIMENTATION

Shigeo Shingo suggests that SMED improvement should pass through four conceptual stages: as shown in the figure.



A) ensure that external setup actions are performed while the machine is still running,

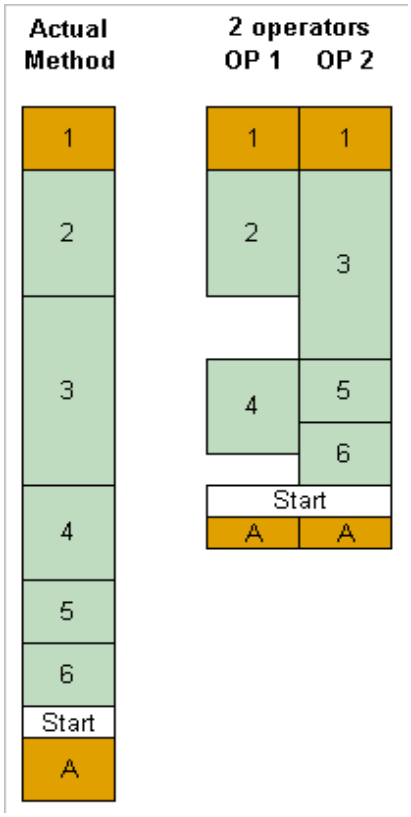
B) separate external and internal setup actions, ensure that the parts all function and implement efficient ways of transporting the die and other parts,

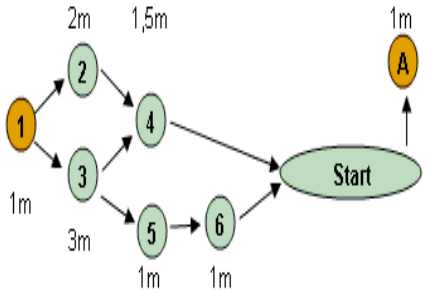
C) convert internal setup actions to external,

D) improve all setup actions.

Parallel operations using multiple operators By taking the 'actual' operations and making them into a network which contains the dependencies it is possible to optimise task attribution and further optimize setup time. Issues of effective communication between the operators must be

managed to ensure safety is assured where potentially noisy or visually obstructive conditions occur.





VII. TOOLKITS FOR SETUP REDUCTION

Many toolkits can be applied to help setup reductions. Following are some,

Visual Control.	Checklist.	Specially designed setup cart.	Workplace organization (5S).
Railed cart.	Standardized baseplate and socket.	Attachment plate.	Attachment plate.
Quick fasteners -- clamping cam, crank, clamping (lock) lever.	Standardized die height.	Locating pins.	Locating pins.

VIII. BENEFITS

After the successful implementation of SMED program, the organizations will have the following benefits:

- Lower manufacturing cost (faster changeovers mean less equipment down time)
- Smaller lot sizes (faster changeovers enable more frequent product changes)
- Improved responsiveness to customer demand (smaller lot sizes enable more flexible scheduling)
- Lower inventory levels (smaller lot sizes result in lower inventory levels)
- Smoother startups (standardized changeover processes improve consistency and quality)
- Reducion of the amount of cash tied up in stock.
- Reduction of the amount of handling and handling equipment required.
- Reduction in floor space required for stock.
- Reduction in lead times.
- Increase in Capacity.
- Improve in quality.
- Reduction in scrap levels.

IX. CASE STUDY

TPS – ThroughPut Solutions, USA are the Lean Manufacturing practitioners under taken lot of challenges all over the world. The following are some of their works in implementation of Lean Manufacturing especially with SMED and is summarized.

Industries	**Problems:**	**SMED (Lean) Solutions:**	**SMED (Lean) Results:**
1)FLEXOGRAPHIC LABEL PRINTING.	Long changeover and setup times between product runs were creating considerable downtime. Buying additional equipment was being considered to prepare for a forecasted increase in demand. Quality defects and raw material waste issues that were considered "inevitable in this business" were also of great concern.	Using SMED methods, we reinvented the entire operation and created a procedure that minimized downtime. Due to the nature of the equipment we also relied heavily on 5S and ergonomic tools to properly stage needed items and reduce risk of injury and operator fatigue. Quality defects were addressed by implementing a series of strategies for component maintenance and machine calibration. Raw material waste was also addressed through a "go, no go" procedure and a setup innovation.	1) Depending on the number of colors used on a job setups and or changeovers were consuming between 3 and 7 hours, (5 hours on average) of production downtime per machine. After implementing the new procedures all setups/changeoversdef.htm were completed in under 30 minutes. 2)This improvement negated any need to purchase equipment to meet forecasted demand. 3) Approximately 25% less raw material waste became standard, and quality defects were greatly reduced. The company gained shop floor production time of about 5 hours per machine per shift resulting in an additional 70 hours of capacity per day. These improvements resulted in more than a $3 million dollar annual windfall without adding a single piece of capital equipment or additional employees.
2)MILITARY HARDWARE.	This producer of military hardware was experiencing production problems. Costs were too high. Delivery performance was not at acceptable levels. They were experiencing severe scheduling difficulties.	The solution was to eliminate the constraints that kept them from producing at the same rate as the delivery requirements. An education overview of lean philosophy and techniques got the process started. Point of use stocking of components, and SMED techniques quickly allowed us to "build to rate." Once this was accomplished, kanban signals replaced subassembly work orders, significantly reducing complexity and cost. This dramatic reduction of work in process inventory reduced the amount of scrap and rework proportionally. Introduction of sequential inspection caught defects almost immediately and substantially improved the ability to define true root causes.	Within a few months: • lead times were cut by 80% • On-time delivery reached and remained at 100% • Shop floor space was cut in half • Yields doubled • The complex MRP based production scheduling was replaced by simple pull signal kanban controls • And overall productivity increased by more than 20%

3)PACKAGING INDUSTRY.	The CEO of this large integrated packaging company was a board member for one of our highly successful steel company clients. He asked us to help them achieve similar results. They had too much cash tied up in inventory. Their lead times were too long, costs were too high, and delivery performance was not world class. The company had a total of forty-five stand alone plants, all over the world.	The simple measurements (goal curves) included an inventory reduction target and on-time delivery objective. After a rapid, extremely successful pilot plant implementation, our role became that of train the trainers. The internal support teams that we had trained then took over the majority of plant support. Another team was targeted specifically onSMED. Many of the plants utilized similar equipment, so lessons learned were readily transferable. Our primary focus then shifted from "tools and techniques" to changing the corporate culture. Plants were provided the autonomy to set their objectives, and were expected to achieve them. Corporate and division roles were to support the plants in these endeavors. A process for achieving these goals was left in place.	Corporate wide inventory was reduced by $150,000,000, while lead times, quality, delivery, and profitability all substantially improved. Probably most important; a culture of continuous improvement was established and maintained.

X. CONCLUSION

SMED is an ideal tool which can be used to reduce the changeover time(set-up time) in many industries (including manufacturing, logistics, and service). It increases the flexibility of the company to produce the right number of products (hence less inventory, carrying costs, etc.) at the right time and minimizes(some times eliminates) bottlenecks to increase flow.

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