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Industrial benefits from a SMED methodology on high speed press in a punching machine: A review

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ABSTRACT

This paper describes the improvement of the setup process of a mechanical press machine in the metal-mechanic area of an elevators company. The work results from a master thesis project conducted during a period of five months. The Single-Minute Exchange of Die (SMED) methodologies were applied to reduce the setup times observed at the beginning of the project. With the developed solutions it was possible to reduce setup times, work-in-process (WIP) and distances travelled by operators. Additionally, the setup operations were standardized and consequently the process has become more fast and intuitive for the operators. These improvements allowed the reduction of energy and materials consumption and, consequently, a decrease on the Greenhouse Gases' emissions. In terms of future developments, and aligning with the continuous improvement approach, the authors propose the creation of one or more SMED teams. These teams would be responsible for the analysis and improvement of the company's setup processes. This paper covers the literature review of SMED tool and purpose of this literature review is to develop an overview of the conceptual framework of SMED tool. The various industrial applications and the existing articles indicate the relevance of the topic and methodology. Flexibility and responsiveness are main pillars of manufacturing, which is operated by demands of greater product variety and improved quality.

Key words: SMED, Eco-efficiency, Changeover, Die set, down time etc.

INTRODUCTION

Globalization has created the need for companies to increase their production flexibility, by producing in smaller batches. However, this type of production leads to a significant increase on the setup frequency. Thus, the ability to perform quick setup processes is widely acknowledged as an essential requisite to flexibility and small batch manufacturing (1). Lean Production aims to systematically identify and eliminate waste through continuous improvement, enabling increased flexibility and organizations' competitiveness. Within the Lean Production paradigm there is a huge range of tools and techniques (e.g. SMED, 5S and Standard Work) that can be applied by organizations to improve their performance, namely in terms of setup time. The SMED methodology consists of a set of techniques that enable the execution of setup processes in less than ten minutes (2). During the last years several authors and organizations have discussed the relationship between Lean Production and eco-efficiency. Eco-efficiency is associated to the sustainable development and intends to provide more value with less environmental impact, which meets the Lean expression "doing more with less". In this work it was analyzed the setup process of a mechanical press machine, in the metal-mechanic area of an elevators company. The objectives of this work were: (i) implementation of a methodology to reduce setup times, (ii) increase of the production flexibility and (iii) standardization of setup activities. As the press machine works with a great amount of products, it was necessary to develop an ABC analysis to choose an important product for the company – the results pointed out a product whose production requires three different setups. It was developed a methodology consisting of nine steps to analyze and implement the improvement solutions for each of the three setups through the use of several tools, including SMED methodology and other Lean tools. The eco-efficiency aspect was also considered (3).

The techniques used in the Lean philosophy are based on five fundamental principles: (i) create value for the customer, (ii) identify the value stream, (iii) create flow, (iv) produce only what is pulled by the customer, and (v) pursue the perfection by continuous identification and elimination of waste. Shingo (1989) considers seven types of waste: overproduction, inventory, waiting, defects, over-processing, motion and transportation. Lean Production provides a set of tools and techniques that can be applied to reduce those wastes, namely SMED, 5S, Visual Management, Standard Work and Value Stream Mapping. The Single-Minute Exchange of Die methodology is a theory and a set of techniques that make it possible to perform the equipment's setup and changeover operations in less than ten minutes (4). A setup or changeover represents the complete process necessary to change from the production of a product to the production of a different product, until it is achieved a certain production rate with quality. To accomplish JIT production and, consequently, a small-batch production it is necessary a quick setup process. This ensures that the flexibility of the response to the demand is adequate, as small batch production results in a significant increase in the setup frequency (5). Goubergen & Landeghem (2002) classify the different reasons for reducing setup times into three main groups: ·

Flexibility – due to the large amount and variety of products and due to the reduction of the quantities requested by customers, a company must be prepared to quickly react to customers' needs;

Bottlenecks capacity – especially in these cases, every minute lost is crucial. Setups should be minimized to maximize the available capacity for production;

Costs minimization – production costs are directly related to the equipment´s performance. With setup time reduction, machines stop during less time, thus reducing production costs. The SMED methodology is a Lean tool that supports organizations in the reduction of setup times and in the elimination of wastes identified in the changeover operations.

The implementation of SMED requires a previous analysis to clearly understand the changeover process, in order to know in detail each setup operation (6). The setup operations are divided into two types: internal operations (which can only be performed while the machine is stopped) and external operations (that can be performed while the machine is operating). The application of this methodology consists of following distinct stages:

Preliminary Stage - Internal and external setup not differentiated;
Stage 1 – Separate internal and external setup;
Stage 2 – Convert internal into external setup;
Stage 3 – Rationalize the internal and external setup.

The reduction of setup time usually provides many benefits to the companies, e.g., reductions in terms of stock, WIP, batch size and movements, and, improvements on quality and production flexibility. An important aspect that has been discussed throughout the last two decades is the relationship between Lean Production and eco-efficiency.
Eco-efficiency is "The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the Earth's estimated carrying capacity" (7).

Historical Background of SMED

Ohno at Toyota developed SMED in 1950. Ohno`s idea was to develop a system that could exchange dies in a more speedy way. By the late 1950`s Ohno was able to reduce the time that was required to change dies from a day to three minutes. The basic idea of SMED is to reduce the setup time on a machine. There are two types of setups: internal and external. Internal setup activities are those that can be carried out only while the machine is stopped, while external setup activities are those that can be done while the machine is running. The basic idea is to make as many activities as possible from internal to external and also concluded that setup reduction is a tool which is universally applicable. There has been lot of work done in detail for the SMED methodology in a textile processing industry and also suggest that the effective implementation of SMED necessitates a number of fundamental requirements, these are: team work, visual factory control, performance measurement, Kaizen and discussed about the role of manufacturing environment in implementation of SMED (8). The relationship between changeover and production leveling has also been studied and concluded that as the batch size decreases, the cost of each part will increase, since the changeover time will be spread over fewer parts. This leads to high manufacturing costs when changeover times are high and it also discussed the detail changeover analysis and concluded that in making a part, every degree of freedom of the machine must be specified and fixed. SMED is also used as a tool to improve flexibility and the greatest benefit from reduction in changeover time is the ability to produce parts in smaller batches. The relation between SMED and equipment design is also correlated and it indicated that SMED is suitable not only for manufacturing improvement but also for equipment development. New modified improvement framework for lean implementation has also been proposed and lean implementation has been divided it in to "waves" and put the SMED tool in second wave amongst overall four waves. Shingo states that "SMED can be applied in any factory to any machine". Work regarding the application of design changes to the changeover process and the balancing of production lines using the set up minimization.

Process of SMED:
1. Observe the current methodology: Current procedures generally recorded on video tape of all the changeover process. It covers the complete changeover from one model to another model.
2. Separate the Internal and External activities: Internal activities are those that can only be performed when the process is stopped, while External activities can be done while the last batch is being produced, or once the next batch has started.
3. Stream line the process of changeover: For each iteration of the above process, a substantial improvement in set-up times should be expected, so it may take several iterations to cross the ten minute line.
4. Continuous Training: After the successful first iteration of SMED application the prime requirement becomes the training of all the operator of the cell. Training has been given by cell champion (Master of Changeover).

SMED Terms: Adjustment Waste: Any activities that would cause the machine to cycle in a sample or trial mode which could create a part that must be inspected and then possible scrapped or reworded.

Batch: A quantity of items that are processed together.

Changeover: The process of switching from the production of one product or part number to another in a machine or a series of linked machines by changing parts, dies, molds or fixtures, also called a set-up. Changeover time is measured as the time elapsed between the last pieces in the run just completed until the first good piece from the process after the changeover (9).

Die Set: This is the tooling that is removed and replaced in a punch press during a changeover. A die set consists of a set of male punches and female dies which, when pressed together either creates a hole in the work piece or forms the work piece creating features desired by the customer.

Downtime: Production time lost due to planned and unplanned stoppages. Planned downtime includes scheduled stoppages for such activities as shift start up, production meetings, changeovers to produce other products and scheduled maintenance. Unplanned downtime includes stoppages for breakdowns, machine adjustments, material shortages and absenteeism.

External Setup: That part of the setup which can be done while the machine is still running, for example, preparing a die to be used for the next run (10).

Internal Setup: That part of the setup which must be done while the machine is shut down, for example, removing or attaching dies.

Lean Production: A system of production that makes and delivers just what is needed, just when it is needed and just in the amount needed. Lean manufacturing aims for the total elimination of all waste to achieve the best possible quality, lowest possible cost and use of resources, and the lowest possible production and delivery lead times (11).
Lot: A quantity of items that are processed together.

Non-Value Added Activities: The time spent on activities that add costs but no value to an item from the customer's perspective. These are activities that the customer is generally not willing to pay for (12).

Punch Press: A machine tool used to work materials (typically steel) by changing the shape of the raw material. Material shape is changed through application of direct pressure which forces the material to change shape. The function of the punch press is to hold the die set and apply the motion and pressure required to perform value added operations to raw materials.

Value Added Activities: The time spent on activities that add value to an item from the customer's perspective.

Value Stream Map: A diagram that defines each step of the material an information flow needed from initial order of a good or service through delivery (13).

CONCLUSION

On analyzing the whole review it is clear that lot of work already has been done on SMED and its implementation. SMED if implemented properly can help in reducing sources of waste in systematic way. This literature review provides attention to a lot of works that have done to implement the SMED tool and emphasizes that the possible expansion of the SMED. In the process of analyzing and study we come across the following conclusive points which are as follows: 1. Continuous training and awareness program from top management to bottom management is essential for availing true potential of SMED technique. 2. SMED can be applied to any industry. 3. As suggested in literature, the use of visual control and 5S can increased the power of SMED by many folds. 4. Implementing SMED resulted not only in mechanical improvements but also in procedural and organizational improvements. 5. Implementation of SMED also results in saving manpower which is one of the crucial most resources for the industry. 6. A comprehensive knowledge of possible improvement techniques has been found to be important if the `SMED' methodology is to be applied effectively.

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