Implemantation of Lean Manufacturing Philosophy and Techniques in a Textile Business

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Abstract
The mass production system is devoid of flexibility, depends on a solid hierarchy and 'massiveness' involves waste. However, lean manufacturing is a system that consumes at least half of everything compared to mass production. That is, when compared to mass production, a lean factory requires half of the labor force, half of the producing space, half of the equipment investment and half of the engineering time spent to develop new products. For this reason, the present study is of particular importance in terms of knowing what lean manufacturing philosophy is and examining and knowing the companies that have adopted lean manufacturing in detail. This study, which includes a case analysis, presents the philosophy and techniques of lean manufacturing and the gains that companies will have when they implement these philosophy and techniques in their processes using real data. In this way, the study provides an option for having a competitive advantage to companies operating with limited resources in today's competitive conditions. This study primarily discusses lean manufacturing with an academic perspective using literature study as a method. In the implementation section of the study, a textile company which adapted lean manufacturing to its processes is presented through case analysis. Face-to-face interviews were conducted with the department manager, industrial engineer and lean manufacturing supervisors of the company and the lean manufacturing implementations performed by the company were closely observed. SMED and other techniques implemented at the factory of this textile business were viewed live during the implementation and the adaptation of the company to lean manufacturing was observed. All of the data obtained was collected into a case study.

Keywords: lean manufacturing, lean manufacturing techniques, case analysis.

Introduction
Lean Manufacturing System is a management philosophy and method that has proven its success around the world (Ohno, 2010). Together with the necessities of the changing times, there have also been changes in the desires and demands of consumers. Businesses have been obliged to try various methods in order to be able to comply with these changing consumer demands and the conditions of global competition that have become difficult day by day. Customer oriented businesses that can foresee the demands of their customers and

determine their starting point based on these demands are more successful compared to old style businesses that operate with the philosophy that a product can be sold anyway.

Textile and garment industry has a significant place in the progress of developing countries because of its labor intensive production structure, the employment opportunities it provides, the added value created in the production process and export opportunities. The industrialization of a country and the creation of an industrial society have generally been achieved through textile and garment industry.

It is considered that the lean production system, which first emerged in the automotive industry in the world, will find an application area in textile, which is also a capital-intensive sector. Owing to the automation and modernization practices implemented in textile businesses, yarn and fabric production processes are simplified, labor costs can be decreased and the quality defects caused by labor errors can be prevented. Improvements made in the business at the same time help to save space, shorten the process and enable the removal of processes that create no value for the customer by eliminating certain production steps, and thus can also decrease the cost of production.

Lean Manufacturing Philosophy

In the first part of our study entitled Lean Manufacturing Philosophy, the birth of the lean manufacturing system, its definition, principles and characteristics, wastes in lean manufacturing and the elements of lean manufacturing will be mentioned.

The Birth of the Lean Manufacturing System

In the light of the information gathered by Eiji Toyoda in 1950 during his visit to the US to know and examine Ford automotive business, it was decided that the mass production system that Ford had pioneered since the beginning of the century was not at all a suitable system for Japan and this decision paved the way for laying the foundations of a totally new understanding of production and management. That is, in light of the information mentioned above, the foundations of the management and production system which is today named as “lean manufacturing” was laid in the 1950s in Japan Toyota Company under the leadership of engineer Eiji Toyoda, a member of Toyoda family, and his colleague engineer Taiichi Ohno (Abdullah, 2003).

Definition of Lean Manufacturing

The essence of the production method, which was first adopted by Toyota and which has spread to every country and all lines of businesses, is simplicity. Lean Manufacturing, in its simplest form, is decreasing the time that passes from the production, distribution and delivery of the product to the customer and eliminating the waste from the value (Vincent and Alec, 2002).

According to Voss (1995), various names have been given to the approach of Japanese companies regarding production management. The current name used in Japan is “Toyota Production System”. The term “Just-in-time Manufacturing” is widely used in the west. At the same time, although it does not completely and correctly represent the Japanese approach, terms like “Continuous Flow Manufacturing” are also used. Famous Japanese consultant Shigeo Shingo uses the term “Stockless Production”. However, “Lean Manufacturing” has been the most commonly accepted one among these terms.

The terms we catch as lean philosophy, lean manufacturing or Toyota production system in fact represent the same concept. In the literature, terms like just-in-time manufacturing, Toyota production and stockless production are used as an equivalent of the Lean Manufacturing System. Lean manufacturing as a term was suggested in the 1980s by the International Motor Vehicle Program (IMVP) which had been conducting studies on the global automotive industry at the Massachusetts Institute of Technology (MIT) in the US. The term gained worldwide acceptance with the publication of the book “The Machine That Changed the World” by IMVP in 1990. Just-in-time Manufacturing is a term used by the founder of the system, Taiichi Ohno, to define the production system in question. The term Toyota Production System is generally preferred by Japanese experts and researchers. Stockless production is a term used by Shigeo Shingo, who worked as a consultant for numerous businesses including Toyota regarding the unique techniques of the system (Zeybek, 2013).

According to Womack (1990), compared to mass production, lean manufacturing is a system that consumes at least the half of everything. That is, when compared to mass production, half labor force, half production area and half equipment investment are required in a lean factory and half engineering time is needed in developing a new product. At the same time, half of the amount needed, less defective manufacturing and greater variety of production are advantages provided by the lean manufacturing system.

Principles and Characteristics of Lean Manufacturing

Lean Manufacturing targets to offer high performance, zero-error products to the customers by aiming to achieve high efficiency and quality in engineering and factory processes. It can be stated that the lean manufacturing system involves four fundamental characteristic principles (Rutherford et al., 2002):

(1) Product design based on continuous development and use of general purpose machinery,

(2) Prevention of buffer stocks and reorganization of the manufacturing process in order to develop production flow,

(3) Synchronous production for decreasing bottlenecks and establishing quality,

(4) Creation of a new working organization that will better utilize the knowledge of the labor force and improvement of team work.

According to Acar (2002), the characteristics of the lean manufacturing system are as follows:

- Leaders have a vision and a fighting spirit has been built in the minds of employees.
- At all times there are targets that are planned to be achieved.
- Targets are measurable and a reward system is in use.
- Long-term strategic plans are made.
- The human factor is in the forefront and is encouraged to participate through continuous development.
- It is important to see the whole.

- The system is customer and product oriented.
- Communication systems are as important as the production systems.
- Cross-functional groups are formed for product or production development.
- Employees bear responsibility.
- There is always a continuous search for innovation.
- Production is based on demand.
- Processes are established in a way to maintain continuous flow.
- Production lots are small and there is a flexible production system.
- The system focuses on prevention rather than correction.

Wastes in Lean Manufacturing

It is necessary to bear in mind the following two factors in order to completely eliminate all wastes and losses.

(1) Increasing efficiency is meaningful only when it decreases the cost. To achieve this result, it is necessary to produce only what we need and to use labor at the minimum level possible.

(2) We should observe the efficiency of each worker and each production line. Then, to increase efficiency in parts and as a whole, we should examine the workers in groups and evaluate the efficiency of the whole plant, that is, the whole factory (Ohno, 2010).

The factors that cause waste are as follows (Rother and Shook, 1999):

Inefficient operating methods, long lead times, inefficient processes, lack of training, insufficient maintenance, long distances, lack of leadership.

The explanations and details of the aforementioned wastes in production are as follows (Rother and Shook, 1999):

- Waiting times of the worker within the machine time are idle times when no work that adds value is done. This waste can be explained as the waiting of the machine or the waiting of the human.
- Unnecessary material transfers; are the movements of the material which do not add any value to the product and/or services.
- Unnecessary non-value-added operations; is to spend efforts for processes that add no value. Such processes include improvements that do not affect the customer.
- Semi-manufactured and finished product stocks; is the stocking of material, semi-manufactured and finished material beyond the amount needed for sale.
- Unnecessary worker movements; is the type of waste that occurs when workers are moved for a purpose that does not add value to the product and/or services.
- Scrap materials; repairing, fixing or remaking and repeating a product and/or service according to the requests of customers.

Nishuguchi (1989) points out the following based on Ohno’s practices. According to lean manufacturing approach, one of the biggest wastes or delays that might occur in the operation of a workstation/factory is the time wasted due to passive operations that add no value to the product such as moving the workers from one place to another, checking the operation of the machines, or waiting by the machine for the engine speed to halt.

These wastes result from transportation (carrying the materials/products from one place to another), stock (waiting of processed material/products), unnecessary movement (excessive movement under low ergonomic conditions), waiting (because of halts, deficiencies and confirmations), overproduction (producing more than required), over processing (adding more value than what the customer wants to pay), errors/reprocessing (correcting the errors).

Lean Manufacturing Technique SMED

Lean manufacturing uses certain application techniques in order to meet the principle of producing everything when needed and in the amount needed, in other words, not producing anything beforehand and in unneeded amounts, which is the main purpose of just-in-time production (Monden, 1983). In the third part of our study, within the scope of our research, Single Minute Exchange of Dies (SMED) lean manufacturing technique will be implemented and its effect on production efficiency will be examined.

Single Minute Exchange of Dies (SMED)

Shigeo Shingo, who worked as a consultant for numerous businesses in many countries around the world including Toyota, saw the "essential" primary requirement for stockless production in the 1950 as decreasing the "set-up" times of machines and managed to decrease these times in a very short time in hundreds of companies through the methods he developed. In this way, any machine had the ability to pass from one part to another in a few minutes, even in some cases in less than 1 minute. Thus, the machines gained an incredible flexibility and went beyond being "stock producers". This method is named as "single-minute exchange of dies: SMED", which was developed by Shingo to decrease set-up times (Okur, 1997).

Basic SMED principles are as follows:

1) The first step and the first principle is to detect the procedures that can only be completed while a machine is not operating (internal setup procedures) and the procedures that can be performed while a machine is still operating (external setup procedures) and converting all internal setup procedures to external setup procedures. In this way, it would be possible to save time at a ratio of 30-50%. For this, first it should be determined which procedures are performed when the machine is not operating and which ones are performed when the machine is still operating. If some of these procedures are being performed when the machine is stopped although they can easily be performed while it is operating without having an important change, this would be a big waste of time. Such procedures should definitely be performed when the machine is operating. These relatively simple changes should not be considered to be enough. It should be persistently maintained to perform more and more procedures when the machine is operating. For this, the possible adjustments that can be performed on the dies, tools and the equipment used needs to be investigated and solutions should be developed for practice.

2) In the change of dies, systems or carriers (conveyors) should be used which facilitate the removal of the previous die and the mounting of the next die. Such mechanization would shorten the time for shifting from one die to another.

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3) Eliminating the necessity of adjusting the machine when connecting a die would help save time. For this, it is necessary to have standardization in the dies and machine parts used in the connection process. For example, if the connection parts of the dies with the machines are standardized, that is, they are in the same size and shape, the same fasteners and tools can be used when connecting the dies. Thus, the standardized die changing process will take less time.

4) Designing the clamps and fasteners in a way that does not require screws and bolts also helps save time. In this way, workers can perform the fastening and unfastening procedures in a shorter time. For example, it is more proper to use the “pear shaped holes” method instead of screws in the fastening process.

5) Approximately 50% of the die changing time is allocated to the adjustment and trial procedures performed after the die is fastened. However, this waste of time can be automatically prevented if the die at first fits in its place as required. The methods that can be used here are one-touch setup “cassette” systems through which the die fits its place in a single touch, or a limit switch attached to the machine. In this way, there is no need for an adjustment process after the die is installed.

6) Storing the dies in places far from the machines causes waste of time through transportation. The solution to this problem is to keep the frequently used dies right beside the machines (Okur, 1997).

Methodology

The aim of the present study is to determine whether SMED, which is a lean manufacturing technique, increases production efficiency in the textile sector. This study is important with respect to how applicable the lean manufacturing philosophy is in the textile sector and to what extent it has an effect on the sector.

A method aiming at implementing a case analysis based on longitudinal data was used in the present study. Case study is a research method that investigates a contemporary phenomenon within its real-life context, over which the investigators have no control, when the boundaries between the phenomenon and the context are not clearly evident, and in which multiple sources of evidence are used (Yin, 2003). Longitudinal case analysis was used through approaching the innovation process that characterizes the enterprise business culture within the scope of marketing innovation. Longitudinal case analysis explains the changes at the organizational level, product differentiations, marketing innovations and process improvements by observing through months and years (Pettigrew, 1990; Van de Ven and Huber, 1990; Roberts and Amit, 2003; Damanpour, 2009). Besides, longitudinal data are important in that they measure the direction and degree of change and allow for causal explanations and interpretations (Menard, 1991). Longitudinal data provides the best results, approaches and estimates for having comprehensive and meaningful information especially about organizational processes and structures (Eisenhardt, 1989; Yin, 2003).

The universe of the study was the textile manufacturing businesses established in Turkey, and ISKO Textiles Inc. was selected for having the relevant qualities that represent the sample set. The most important reasons for selecting ISKO Textiles Inc. were that it was easy to access primary data, the company had become one of the biggest denim fabric manufacturers in the world in a short period, had serious and high R&D investments-which is a requirement of innovation studies in the textile sector-, and succeeded to become the most innovative brand in this field.

Composing the Literature and Proposal for Lean Manufacturing Techniques

The Master's thesis entitled "Lean manufacturing and a sample lean manufacturing implementation in Man Turkey Inc." has been summarized as follows: In today's complex world, the need for continuous improvement in products and processes is obviously known. Lean manufacturing, which has been increasingly implemented worldwide, is a sum of methods that aim to eliminate waste and inefficiency from manufacturing processes in order to maintain lower costs and greater competitiveness for manufacturers. In fact, lean manufacturing is one of the most important manufacturing development systems for manufacturers. In this study, the cooler pre-assembly area in MAN Turkey Inc., which is one of the leader bus manufacturers in Turkey, was analyzed based on the principles of lean manufacturing. In the implementation, all the processes in the cooler pre-assembly area were observed and work flows were determined. For these work flows, time measurements were performed by using the REFA time study method. Furthermore, current and suggested models were compared by using the Arena simulation program. Thus, the operations which do not create any added value were determined and eliminated in the improved state. In this way, an average of 42% was saved in pre-assembly times and 46 m^2 was saved in plant layout usage. The capacity plans were redesigned and as the result of lean manufacturing implementation, the number of workers at the work station was decreased from 3 to 2 (Arslan, 2008).

In a Master's thesis written in English entitled "The application of lean manufacturing principles to an aircraft maintenance, repair and overhaul company", the application of lean manufacturing concepts to a maintenance, repair and overhaul (MRO) company in a nonmanufacturing environment was examined. The aim of the study was to investigate how lean manufacturing tools can be adapted for an MRO work environment to identify and eliminate waste so that financial performance, productivity, quality, workplace safety and health are improved. The study endeavored to implement some of the lean techniques to an MRO company analogous to a manufacturing work environment. This idea was tested on Turkish Technic, the MRO Company of Turkish Airlines. As the first step, value stream mapping (VSM) was used to map the current state for the C-Check maintenance package process and the wastes within the process were determined. Then, the process was improved using lean principles and its future state was mapped using VSM. After that, 5S method was used in stands and ladders area, main tool shop and seat shop to organize these worksites and eliminate unnecessary movements, and non-value-adding search, determine the work method and improve safety and ergonomics issues in these work areas. Lastly, accelerated improvement workshop (AIW) was used to improve the assembly process of HPC Forward and HPT Shroud / LPT Nozzle modules of an engine. The results of the study showed that VSM displayed the wastes and bottlenecks in the C-Check package process. It also provided an implementation plan which reduced the time of the process from 12 days to 2½ days. Furthermore, 5S provided an efficient and organized workplace and eliminated safety and ergonomics problems related with the work area. Finally, a significant increase was maintained in efficiency for three module assembly processes. All these improvements showed that lean manufacturing methods can be applied to increase the productivity of a maintenance, repair and overhaul company (Açıkkollu, 2008).

From this point, the proposal below can be developed in order to implement SMED, which is a lean manufacturing technique in the general sense, in a textile business and to examine the relationship in terms of production efficiency.

Proposal: SMED Lean Manufacturing Technique has a positive effect on production efficiency.

The SMED study 'Complete change of back adjustments and frame heights for a bench which has undergone a type change' which was conducted by ISKO Textiles Inc. in order to decrease the revision times of the operation consists of 10 stages. These stages can be respectively listed as; setting up the team, waste and current state analysis, project plan, setting the targets, analysis and determining the countermeasures, implementation of the improvements, verifying the results, target/result analysis, gains, and standardization.

Within the scope of the research, the current state was analyzed and countermeasures were determined.

- Long-short weft yarn tunnels need to be on site, because otherwise the cleaning time gets longer.
- The existence of a single oil feeder causes extra walking and waiting times when operating synchronously. The number of oil feeders should be increased.
- The air holding process needs to be completed at a time by removing all the lids and then the wiping, fastening, lubricating procedures should be performed rather than doing these steps piece by piece, because the next blow might cause extra sublimate in the previous section.
- Contamination should be prevented by properly covering the machines that have completed the weaving process.
- Performing the change at the same time with cleaning the frequency gears may shorten the time.
- Unnecessary walks need to be avoided and the required material should be at the site before starting the work.
- It is necessary to be careful about not using the blowgun unnecessarily and a trial operation needs to be done to see whether the last general air blow would decrease the time.
- Steps should be taken to shorten the time by bringing the wiper to a capacity at which he can perform other tasks at idle times.

Variables

In the present study, the revision times observed on the production department between the 41st and 52nd weeks of 2013 were taken as variable in order to determine whether the implementation of SMED would have an effect on production efficiency.

Data Collection Procedure

In the study, first of all, the related literature was reviewed and the necessary information was obtained in order to form a theoretical basis. A form was developed for examining SMED Lean Manufacturing Technique through case analysis at ISKO Textiles Inc. in the October, November and December of 2013 in order to find an answer to the research problems and to achieve the aim of the study. The required information was gathered through face-to-face interviews with the business management.

Findings of the Study

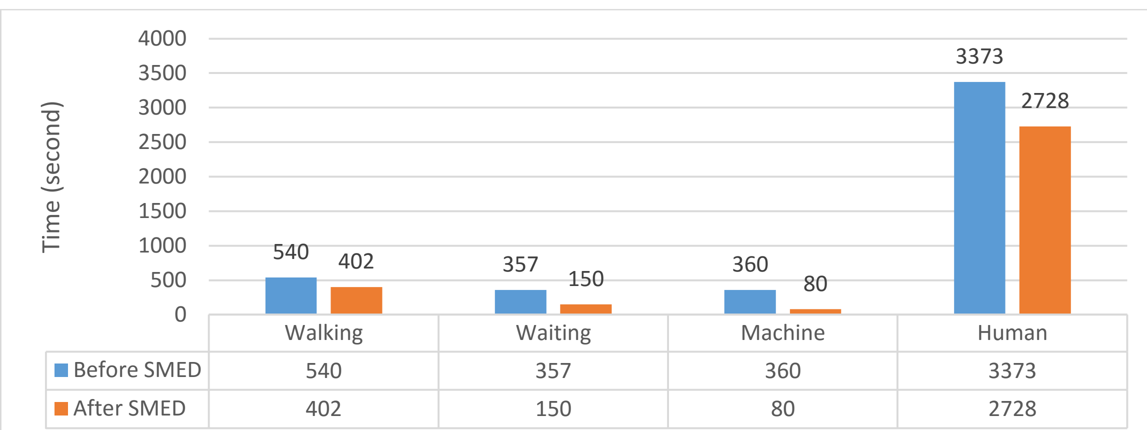
The following findings were obtained as the result of the measures taken: Before any step was performed, that is, before the SMED studies in October 2013, the process change-over time was 4500 seconds (75 minutes). Based on the SMED studies, the target predictions of the department was 3840 seconds (64 minutes) until the end of the year for December 2013. However, as the result of the study, this period was decreased more and was found as 3360 seconds (56 minutes). An improvement of approximately 25% was achieved as the result of the processes.

Table 1: Revision Master before SMED

	Walking	Waiting	Machine	Human
Seconds	540	357	260	3343
Minutes	9	5,95	4,33	55,71

Table 2: Revision Master after SMED

	Walking	Waiting	Machine	Human
Seconds	402	150	80	2728
Minutes	6.7	2.5	1.33	45.46



Graph 1: Revision master times before and after SMED

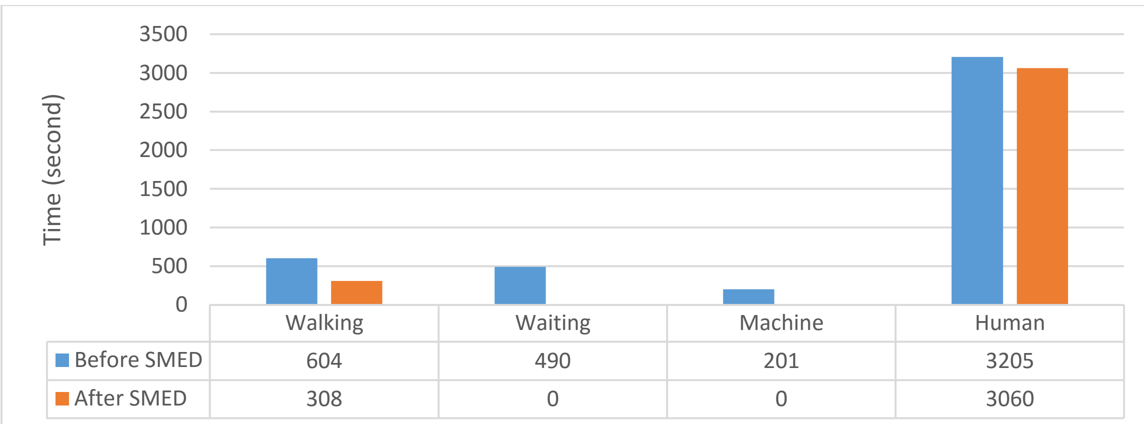
Based on the information given above, the revision master spent 4630 seconds (77.16 minutes) for the processes to be performed before SMED. The time spent after SMED was found as 3360 seconds (56 minutes). The total time saved by means of SMED was 21.16 minutes.

Table 3: Wiper before SMED

	Walking	Waiting	Machine	Human
Seconds	604	490	201	3205
Minutes	10,06	8,16	3,5	53,41

Table 4: Wiper after SMED

	Walking	Waiting	Machine	Human
Seconds	308	0	0	3060
Minutes	5.1	0	0	51



Graph 2. Wiper Times before and after SMED

Based on the information given above, the total time spent by the wiper before SMED was 4500 seconds (75 minutes). The total time spent after the implementation of SMED was found as 3368 seconds (56.13 minutes). A total of 18.47 minutes was saved by means of SMED.

The data obtained as the result of all SMED implementations performed in 2013 are as follows:

- In 2013, a total of 49425 minutes (823.75 hours) was spent for the 659 procedures performed at the department. After the improvement, this time decreased to 615 hours.
- The total time saved was 12521 minutes.
- The labor saved was 416 man hour/year.
- An SOT plan was created for the SMED implementation in 2013 and the operations were standardized by taking the necessary precautions.

Conclusion

In our day, businesses need to meet the consumer expectations that have been rising each passing day in order to be successful in an environment of global competition. Whether the customers are individuals or another producer or supplier, businesses have to supply the best quality product with the most economical price and in the optimal time in order to continue their existence. In Turkey today, every business faces the fact that they have numerous competitors and they serve to conscious consumers.

Lean manufacturing is a system of production which was first adopted by Toyota and which you can observe in all lines of business around the world. Businesses that have integrated lean manufacturing into their operations will have more flexibility and high revenues as the result of this flexibility. In fact, the lean manufacturing approach aims to reach a faster and more flexible production standard by eliminating the understanding of stock and unnecessary expenditure items.Textile industry comprises processes starting with fiber and proceeding with yarn, weaving, darning, die and press, whereas the garment industry involves the processes that turn these into end products for use. The process from fiber to yarn and fabric is known as textile. Textile is among the leading sectors that constitute an important building block of the industrialization process and have significant contributions to the progress of developing countries. In this sector with fierce global competition, the abolishment of quotas has made competition more important in terms of both supply and demand.

In the present study, the SMED practices that were integrated into production at the ISKO 11 department of ISKO Textiles Inc. are presented. This lean manufacturing technique which the department implemented provided numerous savings in terms of money, time, physical and mental conditions. Decreases were observed in the time spent for the production of goods and for various procedures that support the production process while increases were experienced in efficiency and effectiveness.

In the 'Complete change of back adjustments and frame heights for a bench which has undergone a type change' analysis conducted by the department to decrease revision times, a total of 49425 minutes (823.75 hours) were spent for 659 procedures. As the result of the improvement process, this number decreased to 615 hours and a total of 12521 minutes were saved. Besides, the total labor saved was 416 man hour/year. It was found out that the implementation of SMED Lean Manufacturing Technique in the textile sector had a positive effect on production efficiency.

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