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Implementation of Lean Strategies in a Furniture Manufacturing Factory

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Abstract:_This paper experiments application of different lean strategies to a real production problem at a furniture manufacturing company. The objective of the study is to improve the productivity of the factory floor. Initially, existing production process was analyzed to get a clear picture of the existing condition of the process. It was observed that there were some redundant tasks performed by the workers which resulted in longer waiting periods. Various lean strategies such as Single-Minute Exchange of Dies (SMED), Gemba (The real place), and Short Interval Control etc were proposed and implemented on the floor which resulted in significant improvement in both monetary terms and also in reduction of processing time of different lots. Multifactor productivity increased from 1.85 to 2.26; average distance travelled by the workers, OEE, wastage of materials and rejected quantity reduced significantly and an additional production equivalent to more than 1, 48705 taka per day was made possible._
Keywords:_Furniture factory, Lean strategies, Multifactor productivity_

I. Introduction

Globalization has forced the furniture companies to increase their production flexibility. The existing manufacturing scenario in furniture sector demands low quantity and high variety jobs. This type of production leads to more setup frequency which means a significant increase on total setup times (non-value adding activity). Due to highly competitive nature of the furniture manufacturing sector, the need to perform fast setup process and reduce non value adding activity as much as possible has become paramount. Lean manufacturing can provide a solution to this problem. Lean production aims to systematically identify and eliminate waste through continuous improvement, enabling increased flexibility and organizations' competitiveness[1]. Within the Lean Production system there is a huge range of tools and techniques (e.g. SMED, Gemba and Short interval control) that can be applied by manufacturing organizations to improve their performance.

Single-Minute Exchange of Die (SMED) refers to the theory and techniques used for the reduction of equipment setup times. SMED has as its objective to accomplish setup times in less than ten minutes, i.e. a number of minutes expressed by a single digit. Although not all setups can be literally reduced to this time, between one and nine minutes, this is the goal of the SMED methodology[2]. The need for SMED and quick changeover programs is more popular now than ever due to increased demand for product variability, reduced product life cycles and the need to significantly reduce inventories.Short Interval Control (SIC) can be defined as a structured process for identifying and acting on opportunities to improve the effectiveness and efficiency of production. It can be thought of a kaizen process as it encourages teams to work together to achieve improvements in the manufacturing process. Gemba is the process of making observations of the process in action. It emphasizes on taking the managers or the people in charge to the real place where the action is happening.

The effect of these three lean tools namely SMED, Gemba and Short interval control is observed and analyzed on a leading furniture manufacturing factory in Bangladesh. This factory produces a wide variety of products ranging from metal based furniture to various wood and board based furniture. It has 45 machines of various kinds on the home furniture factory floor. This company makes over 300 models of home furniture (bed, sofa, mini cabinet, dining table, showcase etc) alone and due to this huge variety this company was facing problems in fulfilling the demand of the market.So a project was undertaken to implement lean strategies on the home furniture factory floor to reduce non-value adding times as much as possible and increase the productivity of the factory.

II. Literature Review

SMED, also known as Quick change over of tools was developed by Shingo [2], who characterized it as a scientific approach for the reduction of setup times, and which can be applied to any industrial unit or machine. It reduces the non-productive time by streamlining and standardizing the operations for exchange tools, using simple techniques and easy applications[3]. Quick setup time 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 [4]. Gourbergen and Landeghem (2002) classify the different reasons for reducing setup times into three main groups namely flexibility, bottleneck capacity and costs minimization [5].Shingo (1985) showed that SMED consists of three conceptual stages namely separating internal and external setup, converting the internal setup to external setup and streamlining all aspects of the setup operation [2]. Cakmakci(2008) concluded that SMED is suitable not only for manufacturing improvement but also for equipment development[6]. Trovinger and Bohn(2005) applied the principles of SMED to pick and place chip shooter machines and they were able to reduce setup times by removing all activities that could be done online[7]. Michels(2007) applied the SMED methodology to the punch press changeover and the researcher concluded that SMED is an effective tool to provide improved changeover methods resulting in reduction in overall time and labor[8].Alves and Tenera(2009) concluded that SMED methodology can be combined with other classic tools, providing very positive results for companies [3].

Barraza et al (2012) used Gemba-Kaizen approach to develop a conceptual framework in a multinational food company [9]. However, to the best knowledge of the authors no research work has been found where SMED, Gemba and short interval control; these three lean strategies are used simultaneously to improve the condition of the factory floor.

III. Research Methodology

In order to achieve the original goal proposed in the first section, it was decided that a case study would be conducted based on a qualitative approach. This case study primarily consisted of eight steps which are shown in figure 1.

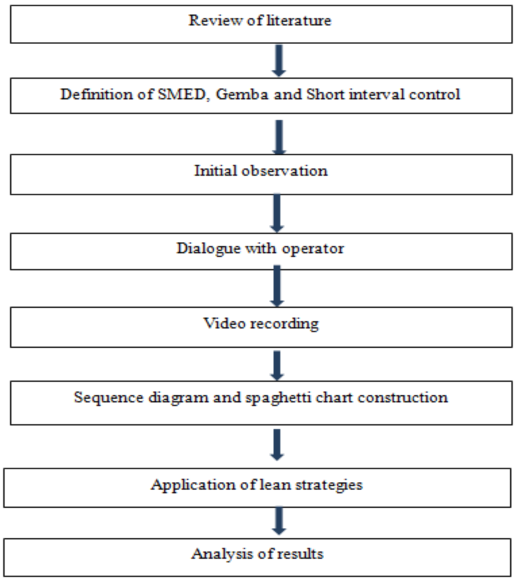


Figure 1: Steps of the research

3.1 Industrial application

The first step involved a review of the literature and the selection of the target furniture manufacturing firm. The second step involved the definition of the goals to be achieved at the firm through the implementation of lean strategies. After that, an initial observation was made which made it possible to identify various problems that affected the efficiency and productivity of the process. Thus the main problems registered were high setup times, high quantity of work in process inventory, unnecessary movements made by the workers, lack of supervision, lack of space in the factory floor and so forth. Operators of each machine were interviewed to get their view on the problems of the factory floor. Then the whole factory floor was video recorded for a period of one month to register all operations and movements of the workers. After that, sequence diagram and spaghetti chart was constructed to describe each and every setup operation, the distance travelled by the workers, the movements made by the workers(mainly machine operators) during the setup process and to identify areas which needed improvement. It should be noted that steps from one to six from figure 1can be considered as the preliminary stage of the project. However, it was decided to make this distinction to better illustrate the sequence of steps used in this project to implement lean strategies. After the preliminary stage, SMED was the first lean tool applied on the factory floor. At stage one of SMED implementation, a clear separation was made between external and internal activities. It was realized during this period that all setup related operations were executed as internal setup, since they were performed with the machine stopped. Table 1 shows the list of internal and external activities performed before SMED implementation.

Table 1: Internal and external activities during setup before SMED implementation

Internal activities	External activities
Setting different cutting tools on the machine	-
Removing different cutting tools from the machine.	-
Bringing cutting tools from the tool store	-
Returning cutting tools to the tool store	-
Cleaning the machine with pneumatic air hose	-
Lubricating the machine	-
Making adjustments on the machine based on cutting measurements	-

The techniques used for making this distinction was made by various techniques such as creation of a checklist which was used to indicate the information essential for the setup execution and the planning of the transportation of tools.In stage two of SMED implementation,some internal activities were converted into external activities. Table 2 shows this list after SMED implementation.

Table 2: Internal and external activities during setup after SMED implementation

Internal activities	External activities
Setting different cutting tools on the machine	Bringing cutting tools from the tool store
Removing different cutting tools from the machine.	Returning cutting tools to the tool store
Making adjustments on the machine based on cutting measurements	Cleaning the machine with pneumatic air hose
-	Lubricating the machine

Before, cleaning of the machine was done after a complete lot was processed. Now, the operators and helpers of the machines were given instruction to do the cleaning while the machine was running. The same was done for lubrication purpose. Another very time consuming task was bringing from and returning cutting tools to the cutter store for each lot. For bigger lots, workers had to go to cutter store multiple times for changing or sharpening the tools. Two additional helpers were assigned for every 15 machines and the workers no longer needed to make trips to the cutter store. Whenever the new tools were needed, it was made available beforehand. Standard setup procedures were also prepared and documented for each machine during this step.

For the improvement of supervision on the factory floor, a combined strategy of Gemba and short interval control was proposed. OEE (overall equipment effectiveness), Downtime minutes, total reject quantity and slower production rate by the workers were identified as the loss metrics. A supervision team was formed and trained to take necessary steps to eliminate this loss metrics. The guidelines provided for the supervision are:

1. Line supervisors have to document each lot on each machine being processed with part name, part quantity, starting time and finishing time on machine.
2. Shift in charges will collect report from line supervisors on every two hours and will make a call on whether each machine operator is performing efficiently or not and visit the machine.
3. Shift in charge will visit the floor on at least every 40 minutes on a rotational basis and visit as many machines as possible.
4. Each week there will be a periodic review of workers performances.

IV. Analysis And Discussion Of Results

4.1 SMED implementation

Table 3 shows the analysis of average setup time taken on each type of machine operating on the factory floor.

Table 3: Average time spent during setup on machines

Name of machine	Time to remove tool from machine(minutes)	Time to insert tool on the machine(minutes)	Time taken on tool adjustment(minutes)	Time taken to go and return from tool store(minutes)
Surface planer	5	7	3	5
Thickness planer	6	8	4	5
Mortising	3	3	8	5
Stand drill	2	2	6	5
Multi boring	3	8	8	5
Panel saw	4	4	6	5
DET	3	6	5	5
Stand router	2	5	3	5
Small router	2	5	2	5
Tenoner	5	6	10	5
Circular saw	3	5	7	5
Wide belt sander	5	8	6	5
Disc sander	4	9	2	5

Block sander	4	9	2	5
Moulder	3	3	4	5
Jig saw	3	4	8	5
Band saw	3	4	5	5
Radial arm saw	4	7	4	5

Among those machines, cutting tool of surface planer, thickness planer, panel saw, DET, wide belt sander, disc sander and block sander does not need changing for each successive lot. In case of these machines, every three to four lots needs tool change; otherwise only tool adjustment time was needed. After SMED methodology was applied in the machines, the results showed a significant improvement in time taken during setup which is showed in table 4.

Table 4: Average time spent during setup on machines (after SMED implementation)

Name of machine	Time to remove tool from machine(minutes)	Time to insert tool on the machine(minutes)	Time taken on tool adjustment(minutes)	Time taken to go and return from tool store(minutes)	Improvement (%)
Surface planer	2.5	5	3	0	48
Thickness planer	4	3.6	4	0	50
Mortising	2	2	8	0	37
Stand drill	1.2	2	6	0	39
Multi boring	2	6	8	0	33
Panel saw	3	3	6	0	37
DET	1.1	5.1	5	0	41
Stand router	2	3.3	3	0	45
Small router	1.3	4.2	2	0	46
Tenoner	3.9	4.2	10	0	30
Circular saw	2.1	3.2	7	0	39
Wide belt sander	2.9	5.5	6	0	40
Disc sander	2.2	4.9	2	0	55
Block sander	3.1	5.2	2	0	39
Moulder	2.8	2	4	0	41
Jig saw	2	2.4	6	0	48
Band saw	3	2.8	5	0	36
Radial arm saw	3	7	4	0	30

Another improvement attained was the reduction of operators' movement during the setup process. Table 5 represents the results obtained for the distance travelled by the operators.

Table 5: Improvements obtained in average distance travelled

Preliminary stage(m)	After SMED(m)	Improvement (%)
35.9	14.7	59

Figure 2 represents the spaghetti chart to demonstrate the difference between operators' movement before and after SMED implementation.

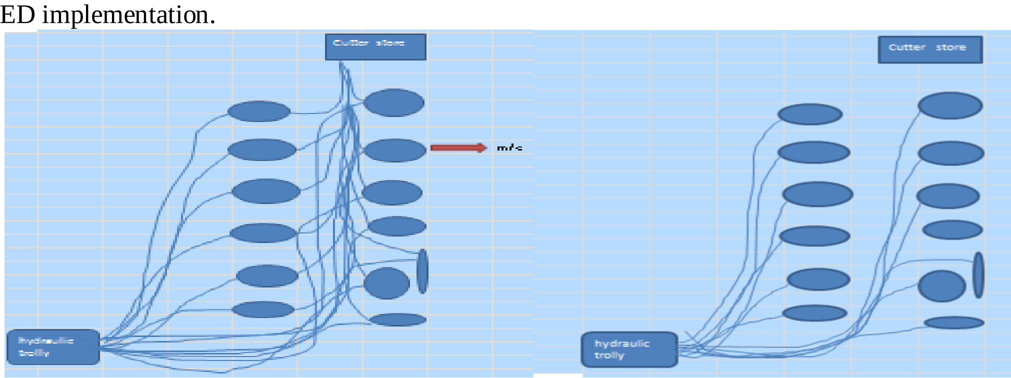


Figure 2: workers movement during the setup (before and after) for one line.

It is evident from the chart that non value adding activities such as getting cutting tool from the store, sharpening the tool etc are now performed during the external setup by additional helper.

It had been observed that for each lot processed in any machine, there was at least two setup times. On average each machine had five lots processed in 16 hour period. Before SMED implementation average machine setup time was 19.44 minute, and after SMED implementation this time reduced down to 11.47 minute. So a total of 7.97 minute was saved for processing each lot. If surface planer, thickness planer, panel saw, DET, wide belt sander, disc sander and block sander machines which needed fewer setups were excluded from the list, there were 31 machines in total. So for 31 machines total machine hour saved was 31*10*7.97 minutes or 41.18 hours. If 45 machines run for 16 hours and produce products equivalent to 26,00000 Taka per day, then extra machine hour of at least 41.18 hours would bring the firm additional 148705 Taka per day. From the calculation after SMED implementation, it was found that on average the daily production increased to almost 27, 59420 Taka per day.

1.2 Impact of GEMBA and Short interval control

Before the implementation of GEMBA and short interval control on the factory floor; OEE, total downtime minutes, reject quantity and wastage of materials were calculated and analyzed for a two month period. Mean time between failures(MTBF) was also calculated. Afterwards the supervision team started conducting short meetings (8-10 minutes) on every two and a half hours discussing the condition of above three loss metrics as well as solving them and following the general guidelines provided to them. This enabled them to have an instant grasp of the existing condition of the factory floor. After two months, this showed an impressive improvementwhich is showed in table 6.

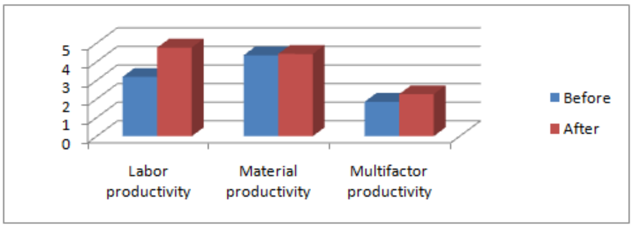
Table 6: Improvements in OEE, total downtime minutes, reject quantity and wastage of materials

Loss metrics	Before(avg. of two months)	After	Improvement (%)
OEE (%)	69.84	78.32	12
Total downtime minutes	9765	5891	40
Reject quantity(pcs)	244	211	14
Wastage of materials(% of raw materials)	4.83	3.29	32

1.3 Improvement in productivity

Before implementation of SMED, Gemba and short interval control methodologies on the factory floor, labor and material productivity was 3.19 and 4.35(calculated over a two month period). After implementing the above mentioned lean strategies, labor and material productivity increased to 4.76 and 4.42; resulting in a higher multifactor productivity of 2.26. Figure 3 depicts this improvement.

Figure 3: Labor, material and multifactor productivity



Labor productivity increased substantially due to increased supervision and reduction of setup times through the implementation of SMED technique. Slight increase in material productivity was also due to increased supervision which resulted in lower reject quantity and lower wastage of materials.

V. Conclusion

This study clearly shows that lean strategies such as SMED, Gemba and short interval control can be effectively applied to improve the condition of a furniture manufacturing company. The main results achieved were improvements in setup times of different machines on the factory floor, 59% improvement in the average distance travelled by the workers resulting in an additional 148705 Taka per day. 12%,40%,14%,32% improvement respectively was achieved in OEE, total downtime minutes, reject quantity and wastage of materials. Both labor and material productivity increased resulting in a higher multifactor productivity of 2.26. It was realized through this study that lean strategies can successfully be implemented in furniture manufacturing industry.

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