ICMIEE18-260

Application of Lean and Six Sigma Tool to Waste Reduction and Productivity Improvement in Footwear Industry

Adhir Chandra Paul, Noor-E-Imam, Shakhawath Hossain*
Department of Leather Engineering,Khulna University of Engineering & Technology, Khulna-9203,BANGLADESH

ABSTRACT
Footwear sector in one of promising sector in our country as its raw material almost available. As a result we see many footwear industry has been set up in recent decades. This studyassesses the current operational and management practices. By applying Lean and six sigma tool, green manufacturing holds potential economic benefits including long term process efficiency benefits, cost saving, waste reduction. It also assists to attain the knowledge about different techniques of production improvement and environment related factors. This analysis focuses how environmental wastes are produced and analyses possible solutions in order to reduce cost. In this work, productivity has been improved from 13 pair/worker to 16 pair/worker through reducing standard time. In this competitiveness the present and future will belong to those whom can do both to achieve high productivity. The advantages of lean six sigma (LSS) are reduction in defects, cycle time, work in progress etc. as well as increase in product quality, reliability, customer satisfaction, productivity etc. leading ultimately to excellent business result.

Keywords: Lean, Six Sigma, LSS, Time study and Footwear industry.

1. Introduction:

Economic competition for high quality products has increased. Manufacturers always looking for systematic opportunity to eliminate energy and environmental wastes. Inter-linked and interrelationship among these factors are vital and should be balanced and variable relating to external and internal factors as well as environment related factors. This study also focus on waste producing across the manufacturing processes[1].

With the fast changingeconomic the competition for high quality products has increased. Product variety, high lead time, minimal waste, green manufacturing adds a major impact to manufacturing industries. Thus methods like Enterprise Resource Planning, Business Process Reengineering, and Just in Time (JIT) manufacturing and Lean Management have been developed[2]. Quality Management and Improvement can be defined as the fitness for use or purpose at the most cost-effective level.LSS is statistical measure of the performance of a process and measure the degree to which deviates from required value and then give efforts to improve the operations. [2]The traditional DMAIC Six Sigmaprocess, as it is usually practiced, which is focused on evolutionary and continuous improvement manufacturing or service process development, usually occurs after initial system or product design and development have been largely completed. It starts from an understanding of the customer expectations, needs and Critical to Quality issues (CTQs) before a design can be completed[3].

Applying Lean Six Sigma (LSS) methodology and waste management in the footwear industry leads to many of the improvements demonstrated in othersectors- reduction of raw material use, and increasing reuse and recycling on site respecting Bangladesh. Such improvements in environmental performance produce a directly beneficial effect on the profitability of business.

This work can be used to minimize work content as well as waste that also makes sense from a business perspective. In order to produce product like footwear resources in form of man, machine, materials, capital and others equipment are required. The more effective use of resources is ensured the more goods will be produced. By effective and effluent use of resources the economic system can attain self-sustain growth. Productivity improvement is not only just doing thinks better but also doing the right things better. The right things or more specially factors influencing productivity is the prime concern for the productivity manner.Here, it was shown the improvement of productivity by reducing standard time through time study.

2. Method:

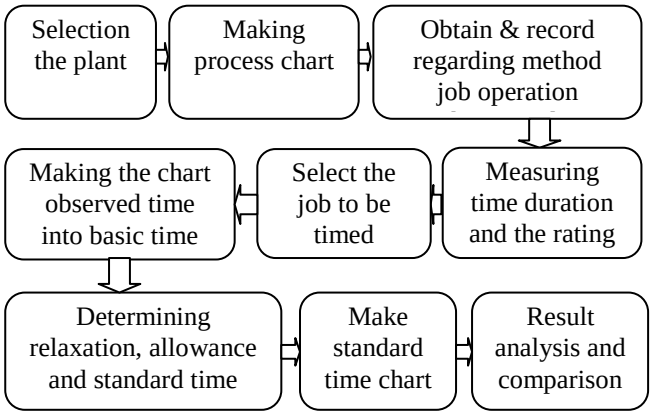

Fig.01: Overview of the study

2.1 Lean six sigma:

Lean Six Sigma is amethodology that relies on a collaborative team effort to improve performance by systematically removing waste; combining Lean

* Corresponding author. Tel.: +88-01723316621
E-mail addresses: adhirkuet@gmail.com

manufacturing and six sigma to eliminate the eight kinds of waste (muda): Time, Inventory, Motion, Waiting, Over production, Over processing, Defects, and Skills. Lean six sigma project comprise aspect of leans waste eliminations. Lean six sigma utilizes the DMAIC phase similar to that of six sigma.

2.2Work Study:

Work study can be defined as techniques that analysis the elements of a specific process carefully to eliminate unnecessary operations & to determine better method for these operation. Employees are trained to follow standard method. Equipment's & working conditions are also standardized.Work study can be divided into the following two compositions: [6]

- ✓ Method study (Method design stage)
- ✓ Work measurement (Standard time setting phase)

2.3 Method Study:

The purpose of is to analyses the element of a given work i.e. raw materials process, machinery, operating sequences & layout & to plan better working method & operating system. [6]

2.3.1 Operation analysis, Motion analysis & example of application:

Operation analysisemphasis improvement in various lands of working operations performed by individual or several operations. [6]

2.4Production Process Analysis:

Production process analysis primarily includes two types of analytical method:

- ✓ Process analysis
- ✓ Man process analysis

Production Process analysis is an analytical method applicable to various objectives & used to record & analysis specific process. This method includes five kinds of symbols denoting operation inspection transportation delay & storage to illustrate the various processes which appear during the course of production. It is used to investigate the structure of overall processing systems and used to determine improvement.

2.4.1 Production Process Chart:

Outline process chart (Simple Type)

- ✓ Simple type
- ✓ Assembly type
- ✓ Disassembly type

Flow Process Chart (Detail Type)

- ✓ Simple type
- ✓ Assembly type
- ✓ Disassembly type

The outline process chart is used to obtain a board understanding conditions. This is a short duration procedure performed through quick observation of workplaces in need of improvement. Only operation & inspection symbols are used at this stage. [6] [8]

2.5Work Measurement:

Work measurement is also known as "Time study". Work measurement is absolutely essential for both the planning and control of operations. Without this we cannot determine the capacity of facilities or it's possible to quote delivery dates or costs. Calculate proper working time for each optimum working thing system & to supervise output etc.The application of thistechniques designed to establish the time for a qualified worker to carry out a specific job at a defined level of performance. [6]

2.5.1 Time study:

Time study for recording thetimes and rates of working for the elements of specified job carried out under specified conditionsand for analysis the data so as to determine the time necessary for carrying out the job at the defined level of performance. [6] [11]

Steps in making time study- [6]

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operation, working conditions to affect the time study work.
3. Breakdown the operation into element.
4. Measuring the time by means of stop watch, taken by operator to perform each element of operation.
5. At the same time assess the worker effective speed of work called performance rating.
6. Adjust the observed time by rating factor to obtain normal time.
7. Add suitable allowance to compensate for fatigue, personal needs, contingencies etc.
8. Compute allowed time the entire job by standard time.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards where necessary.

Normal time = Observed time × Performance Rating (%) / 100

Basic Time = Cycle time (operation average time) × Performance rating

Standard time = Basic time + 15% relaxation allowance + 3% contingency allowance [6]

2.5.2 Step in time study:

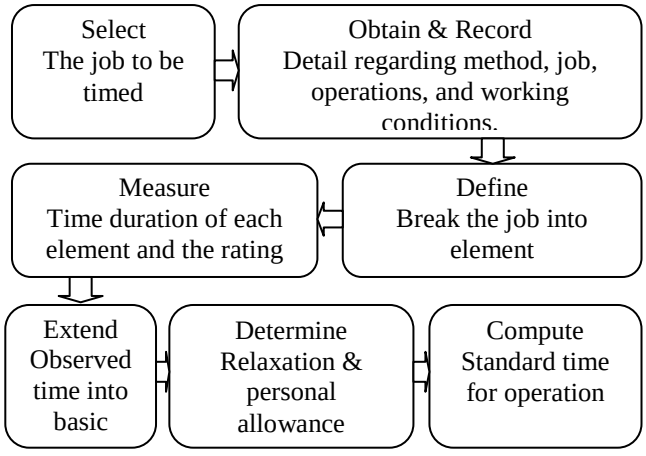

Fig. 02: Flow chart of time study

2.5.3 Observe time: The time taken to perform anelement or combination of elements obtain by means of direct measurement. [6]
2.5.4 Selected time:The time chosen as beingrepresentative of a group of times for an elements or group of elements by calculating means, median or mode. [6]
2.5.5 Rating:
Rating is the assessment of the worker's rate of working relative to the observer's concept of the corresponding to the pace. [6]

Rating Scale	Description
0	No activity
50	Very slow, clumsy, half sleep with no interest in job
75	Steady, deliberate, unhurried performance, looks slow but time is not being intentionally wasted while under observation.
100	Brisk, business like performance, as of an average qualified worker on piece work. It is standard rate.

2.5.6 Relaxation allowance:
Relaxation allowance is an addition to basic time intended to provide the worker with the opportunity to recover from physiological and psychological effects of caring out specified work under specified conditions.[6]
Generally relaxation allowance is about 15% of basic time.
2.5.7 Contingency Allowance:
Contingency allowance is a small allowance of time that may be included in a standard time to meet legitimate and expected items of work on delays, the precise measurement of which is uneconomicalbecause of their infrequent or irregular occurrence. Contingency allowance is 3% of basic time. [6]
2.6 Selection of operators to observe:
When the purpose of the study is to established standards, it is advisable to workers of medium or high skilled level in order to facilitate rating & file suspicious of other workers towards the standard time that is established. When improvement is the aim, it is best to select skilled workers with diligent personalities, in order to facilitate further improvement. [6]
2.6.1Efficiency:
Efficiency = Present output / Standard output

Efficiency = Minutes output / Minutes input

Increasing Efficiency = [(the efficiency of proposed line- present efficiency) / Present Efficiency] × 100

% of work content reduction per pair = [(present work content / pair - proposed work content/pair)/ Present work content / pair] × 100

Increasing Productivity (at 100% capacity) = [(Proposed standard output – Existing standard output) / Existing Standard output] × 100 [6]

3. Methodology:
3.1 Plant selection:
First, a suitable plant was selected for our thesis work. Thesis study was occurred at Bata Shoe Company (BD) Ltd. and its subsidiary Anonna footwear and FB Footwear Ltd. Dhaka, Bangladesh.
3.2 Time Study:
After selecting the lasting and finishing line for study, the cycle time into time study form named collected data from present production line was recorded.
3.3 Calculation:
The basic time and standard time of operations was calculated
Basic Time = Cycle time (operation average time) × Performance rating
Standard time = Basic time + Relaxation allowance + Contingency allowance
3.4 Modify the production line:
After calculating existing standard time and exploring, a modified production line was proposed through reducing standard time and man power.

4. Data collection and analysis:
After selecting the lasting and line for study, cycle time was measured by stop watch and recorded as collected data of existing production line as-below:
4.2 Calculations:
Average production of line =500
Total-Worker = 45
Working minutes per worker = 480 minutes

(8hours)

Work Minutes per pair = 2120/60 = 35.34

S. N	Name of operation	Observed Time (sec)			Average cycle time (sec)	Standard deviation	Ratin g(sec)	Basic Time (sec)	Std. Time (sec)	System	Man power
1	Last collection & insole attaching	45	44	46	45	±1	75	34	40	Manual	4
2	Apply adhesive to insole lasting	210	200	215	206	±1	75	155	183	Manual	4
3	Mulling	30	33	34	32	±1	75	24	28	Machine	1
4	Toe lasting	215	220	224	217	±1	75	163	193	Machine	2
5	Side lasting	70	74	72	71	±1	75	53	63	Machine	2
6	Heel seat lasting	205	210	200	203	±1	75	152	180	Machine	2

7	Conditioning	65	65	65	65	±1	75	49	58	Machine	2
8	Wrinkle chasing	320	315	318	314	±1	75	236	278	Machine	2
9	Roughing	325	332	330	326	±1	80	260	292	Machine	2
10	Upper cleaning & sole preparation	89	91	97	91	±1	65	63	75	Manual	2
11	Apply adhesive	52	55	57	54	±1	75	41	48	Manual	2
12	Drying	45	45	45	45	±1	70	31	37	Machine	2
13	Attaching sole	120	118	115	116	±1	75	87	103	Manual	2
14	Sole pressing	62	60	65	62	±1	75	46	54	Machine	1
15	Cooling	35	35	35	35	±1	75	26	31	Machine	2
16	Ironing	115	125	130	122	±1	75	92	108	Machine	1
17	Cleaning	120	140	125	127	±1	65	83	98	Manual	4
18	Brushing with wax	150	145	155	149	±1	75	112	132	Machine	2
19	Delasting	38	40	36	38	±1	85	32	38	Machine	2
20	Inspection	90	95	92	92	±1	75	69	81	Manual	4
Total									2120		45

Standard output at 100% efficiency = (480 × 45) / 35.34
= 611
Productivity = 611/45 = 13 Pair/worker
Efficiency = (500/611) × 100 = 82 %

4.1 Proposed modified line:
After analysed the collected data, a production line has been proposed as below-
4.1.1 Calculation:
According to collected data:
Average production =500
Total Worker = 38
Working minutes per worker = 480 minutes (8hours)
Work Minutes per pair = 1738/60 = 28.96
Standard Output at 100% efficiency = (480×38) / 28.96 = 630
Productivity = 630/38 = 16 Pair/ worker
Efficiency = (500 / 630) × 100 = 79%

5. Results and discussion:
Average production of line =500
Total Worker = 45
Working minutes per worker = 480 minutes (8hours)
Work Minutes per pair = 2120/60 = 35.34 Standard Output at 100% efficiency = (480*45) / 35.34 = 611
Productivity = 611/45 = 13 Pair/ worker
Efficiency = (500 / 611) * 100 = 82%
Here at below, the histogram shows the highest time consuming operation roughing and lowest time consuming operation mulling where X axis indicates operations and Y axis indicates standard time (second) according to present production line

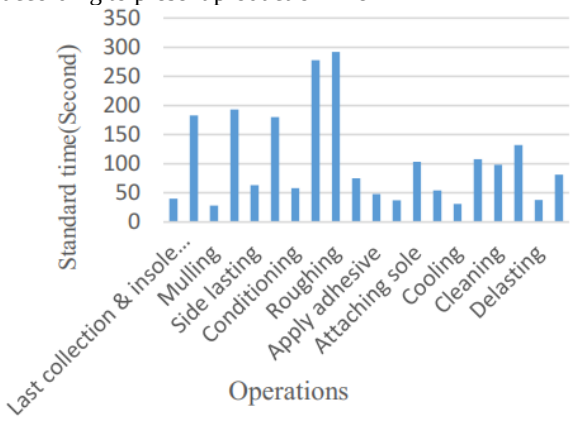

Fig. 03: Standard time in various operations of present line

According to modified line:
Average production =500
Total Worker = 38
5.1 Proposed modified line:

S.N	Name of Operation	Operation/ Cycle time (sec)	Rating	Basic Time (sec)	Std. Time (sec)	System	Manpower
1	Last collection & insole attaching	40	65	26	31	Manual	3
2	Apply adhesive to insole lasting	185	65	120	142	Manual	3
3	Mulling	24	65	16	19	Machine	1
4	Toe lasting	200	70	140	165	Machine	2
5	Side lasting	65	70	45	53	Machine	2
6	Heel seat lasting	180	75	135	160	Machine	2

7	Conditioning	60	65	39	46	Machine	1
8	Wrinkle chasing	280	70	196	231	Machine	2
9	Roughing	300	65	195	230	Machine	2
10	Upper cleaning & sole preparation	80	70	56	65	Manual	2
11	Apply adhesive	50	75	38	45	Manual	2
12	Drying	40	70	28	33	Machine	1
13	Attaching sole	110	75	82	86	Manual	2
14	Sole pressing	60	65	39	46	Machine	1
15	Cooling	35	75	24	28	Machine	2
16	Ironing	110	60	66	78	Machine	1
17	Cleaning	100	60	60	70	Manual	2
18	Brushing with wax	135	65	87	102	Machine	2
19	Delasting	40	70	28	33	Machine	2
20	Inspection	85	75	64	75	Manual	3
Total					1738		38

5.2 Analysis of operation:

Name of the operation	Existing line		Proposed line	
	Existing method	Std. time	Suggested method	Std. time
Last collecting & Insole attaching	It has been observed that theworkers waste their time by gossiping and their operation is done by 4 workers. Two of them attaching insole & others help them	40	If three workers involve in this operation and carefully done this work then productivity will increase	31
Apply adhesive on insole up to lasting margin	Four workers were doing this operation. Workers were talking adhesive very small amount by brush, so they repetitively take cement & apply to insole. As a result work content was increase	183	For applying cement, if three workers in this operation, take only one time they could able to save the time & productivity will increase	142
Drying	It has been observed that this operation was done by two workers were waste time by gossiping and wait for work during operation	37	If the operation is done by one worker, time and cost will save & Productivity will increase.	33
Cleaning	During upper marking they were using silver marker. To remove silver marking it was taking more time. Other two workers were waste time to wait for work during operation	98	If they will use proper pencil during marking then this problem solve easily. If two worker done this, then productivity will increase	70
Conditioning	It has been observed that this operation was done by two workers were waste time by gossiping and wait for work during operation	58	There is no need of two worker. If the operation is done by one worker, time and cost will save	46

			&Productivity will increase	
Inspection	Four workers were doing this operation. Workers waste their time by gossiping and remain idle waiting for next pair	81	If three workers involve in this operation and carefully done this work then productivity will increase and reduce cost	75

Figure 4.2: Operations analysis

Working minutes per worker = 480 minutes

(8hours)

Work Minutes per pair = 1738/60 = 28.96 Standard
Output at 100% efficiency = (480*38) / 28.96 = 630
Productivity = 630/38 = 16 Pair/ worker
Efficiency = (500 / 630) * 100 = 79%
Here at below, the histogram shows the highest time consuming operation wrinkle chasing and lowest time consuming operation cooling where X axis indicates operations and Y axis indicates standard time (second) according to proposed production line. This histogram also indicates the reduction of standard time of various operations.

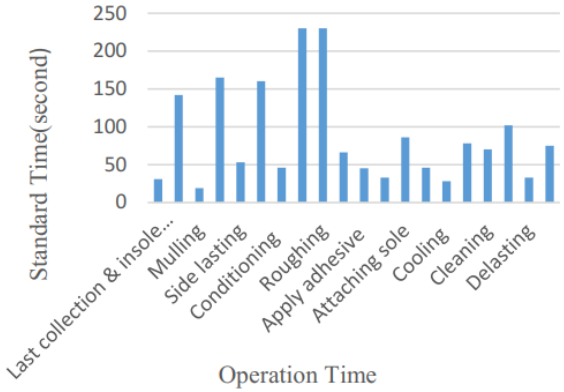

Fig. 04:Standard time in various operations in modified

Hence, Productivity improvement = (16-13) pair/worker = 3 pair/worker

Work content (Minutes) reduction = (82-79) = 3%

Here at fig: 5.2.1 histogram indicates improvement of productivity from 13 pair/worker to 16 pair/worker where Y axis indicates productivity.

At fig 5.2.2, this graph shows how standard time is reducing after modifying the production line where X axis indicates standard time and Y axis indicates operations

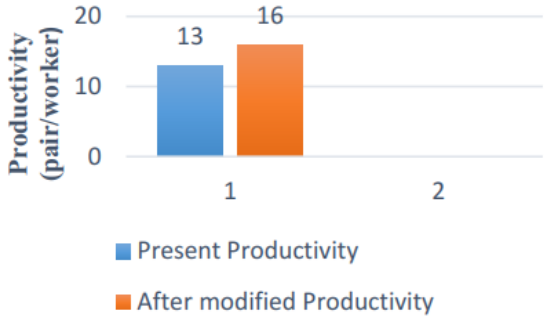

Fig. 05: Comparison of productivity between present and modified line

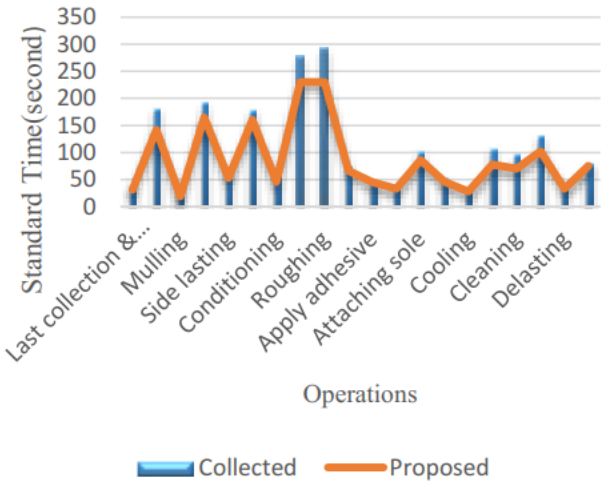

Fig. 06: Comparison of Productivity and standard time between Present and modified line

In proposed modified line Total work content reduction is 3% and worker could be reduced from 45 to 38. So the company can save 7 workers salary per month through proposed line and controlling labourWaste management is very difficult to provide a global image of the costs related to each practice; each country has its own costs and regulations. The environment is getting profit because the industry is generating wastes that can be more easily recycled. . The garbage maybe the raw material of anotherindustry. Sell it to another industry as by

product and get some profits. Avoiding the use of compressed air consume.The major common point is the costs regarding landfilling is the lowest everywhere and it is also environment friendly. In most cases, internal reduction solutions cannot reduce the quantities of waste very much and internal recycling solutions can only be applied in large scale.

6. Conclusion:

Productivity improvement is not only just doing thinks better but also doing the right things better. As a tool we use Lean six sigma to improve productivity and reducing waste.The methodology involves statistical analysis to quantify repeated common cause variations. Lean Six Sigma becomes a continuous process for quality improvement and cost reduction and developed the capability of reducing problems or issues effecting customer expectations on key business processes. This study also focus on waste producing across the manufacturing processes and act as an improvement and cost reduction process. Applying Lean Six Sigma (LSS) methodology and waste management in the footwear industry leads to many of the improvements demonstrated in other sectors. By going green manufacturers can realize savingsand increased profits beyond wildest imagination. To be productive enterprise must beable to produce efficiently and effectively. To require this

Organization must focus in skill upgrading and focus on Lean strategies that involves customers, distributors and manufacturer to reduce cost and quality. By applying Lean and six sigma tool, green manufacturing holds potential economic benefits including long term process efficiency benefits, cost saving, waste reduction. Here, we improve productivity from 13 pair/worker to 16 pair/worker through reducing standard time. In this competitiveness, the present and future will belong to those whom can do both to achieve high productivity. The advantages Of LSS are reduction in defects, cycle time, work in progress etc. as well as increase in product quality, reliability, customer satisfaction, productivity etc. leading ultimately to excellent business result.

7. Future approach:

After completing this thesis work it can be included for further modification of production line by applying Lean Sigma tool. In this thesis, Productivity has been improved from 13 pair/worker to 16 pair/worker by reducing standard time and man power through time study.Productivity can also be improved by studying analytical estimating and predetermined motion. By continuing the inspection, standard time can be reduced in minimum cycle time as well as increasing productivity

Further study can be done on-

- ✓ Reduction of material consumption
- ✓ Cost reduction measures on power consumption
- ✓ Rework cost calculation
- ✓ Line balancing of the other line

8. References:

[1]Syed HasibAkhterFaruqui. (2013), Application of Lean and Six sigma tool to waste reduction in industry, Journal of Cleaner Production, (1-6)

[2] https://en.wikipedia.org/wiki/Lean_Six_Sigma

[3] https://en.wikipedia.org/wiki/Six_Sigma

[4].https://en.wikipedia.org/wiki/Lean_manufacturing

[5] Andrea Chiarini, (2014), Sustainable manufacturing-greening processes using specific Lean Production tools: an empiric al observation from European motorcycle component manufacturers, Journal of Cleaner Production 85 (2014) 226-233

[6] MartandTelsang (2011) - "Industrial Engineering and Production Management", S. Chand, Ramnagar, New Delhi.

[7] https://en.wikipedia.org/wiki/Production theory

[8] https://en.wikipedia.org/wiki/Production

[9] http://www.gdrc.org/sustbiz/green/doc-prod_introduction.html

[10] Fourteenth Session of the Leather and Leaher Products Industry, Zlin, Czech Republic (13-15 December 2000)

[11] https://en.wikipedia.org/wiki/Time_and_motion_study#Time_study

[12] http://www.slideshare.net/AdvanceIgroup/defect-reduction-six-sigma-green- belt-project-in-footwear