Lean and Green Methodology in a Shoe Manufacturing Company

Jocelyn D. Abad, Franiel Germaine M. Tapang, Joe Ryan D. Romero, Mary Rose L. Anier, Timothy Ranil R. Domingo, Jhunnie Chris A. Bernabe, Yoshiki Kurata
Industrial Engineering Department
Technological Institute of the Philippines, Philippines
Tel: (+63) 02-911-0964

Abstract. Nowadays, companies are challenged to take part on sustainable development. Manufacturers around the world adopt the concept of lean manufacturing to decrease the raw material consumption, energy usage and environmental waste and pollution. These companies learn that eco-friendly practices can be profitable. This paper intends to propose a methodology that integrates Lean and Green practices. To determine the effectiveness of the integrated model, the proponent used an actual industrial case particularly of a shoe manufacturing to compare and evaluate existing and proposed results. The proponent also utilized simulation software to validate the procedure and methodology applicability. Results revealed an increase in efficiency of the company, reduction of the lead time and decrease in environmental waste and pollution.

Keywords: OEE, Lean and Green Methodology, Sustainable Manufacturing, Promodel Simulation, Non-Value Adding

1. INTRODUCTION

The concepts of sustainable development and preservation of the environment opt to put pressure for most manufacturing companies. Lean and Green is a practice that some companies aim to apply. The primary purpose is to reduce waste. This is essential for manufacturing companies since they are prone to produce different kinds of waste in the transformation processes.

As manufacturers around the world adopt lean manufacturing to minimize the raw material consumption, energy usage and environmental waste and pollution, they are learning that eco-friendly practices can be profitable. There are a lot of research studies that had proposed for several models, frameworks and methodologies to implement Lean and Green concepts. These models begin by assessing the current state of the value stream before evaluating possible tools and techniques to improve and develop the future state of the company's system. Some common tools that they use are Lean tools like 5S, Kaizen, Poka-Yoke, Root Cause Analysis, and Value Stream Map among others. All of these tools focus on the leanness of the company (Ruisheng Ng et al., 2015).

This study focuses on testing the validity of a Lean and Green methodology in a shoe manufacturing company. It aims to eliminate if not reduce the wastes in the said company by reducing the occurrence of prolonged transportation time, improving flow of production, and increase efficiency of workers by introducing green practices.

2. METHODOLOGY

2.1 Step 1 – Current State Assessment

The current state assessment involves outlining the product and customer requirements. This step also investigates the production management, working time, process information, inventory, and resource flows. The collected information is used to analyze the performance of the current state. The Overall Equipment Effectiveness (OEE), a widely adopted and proven metric, is used to monitor the efficiency of the manufacturing process.

The researchers also evaluated the Value Added (VA) Time, Non Value Added (NVA) Time and Essential Non Value Added (ENVA) Time. The VA Analysis is the time that the goods are produced. The NVA Analysis is the time that the workers do inspection, transportation and transferring processes. The ENVA Analysis is the time that cannot be taken away from the production because the process is important in the production.

2.2 Step 2 – Future State Analysis

This step indicates analyzing the areas for Lean and Green improvement. By analyzing the data for VA, NVA

To support improved VA and NVA Analysis, a proposed layouts using ProModel Simulation was made.

2.3 Step 3 – Kaizen Events

"Kaizen' is a Japanese term for continuous improvement (Imai, 1986). Having identified the specific issues and implementable initiatives, there will be areas where improvements are critical to achieve the vision of the future state of the company. An Ishikawa Diagram or fishbone diagram shall be used to identify the root cause of the problem and its effects to the whole company.

2.4 Step 4 – Action Plans

The Action Plan details the proposed recommendations that address the issues, the goals to be achieved, the timeline for implementation, the review date, and the people who are responsible for implementing the recommendations. It is a 'living' document, which means it

and ENVA time, the researchers determine which processes can be eliminated from the production. These eliminated processes should not affect the production operation of the company.

should be constantly reviewed and updated if necessary.

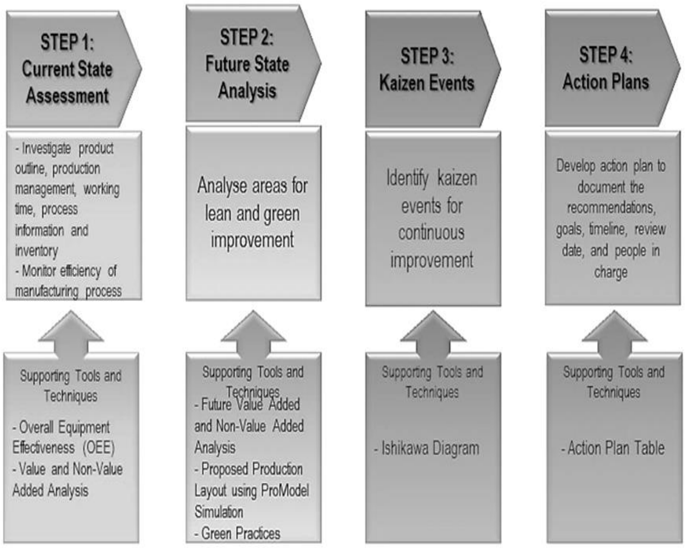

Figure 1: Integrated Lean and Green Methodology, (Ruisheng Ng et al., 2015)

3. RESULTS AND DISCUSSIONS

3.1 Step 1 – Current State Assessment

3.1.1 Product Description & Customer Requirement

The company's products are genuine leather school shoes for children. These children's shoes are distributed in seventeen (17) retails stores. The demand for children's shoes is ranging from 900 to 1,000 pairs per week. The average demand of the shoes is 984 pairs per week or 164 pairs of shoes per day.

3.1.2 Production Management

The production of the company is based on the sales of their retail stores. The company uses their own database system to monitor the weekly and monthly sales to help them decide on what specifically to produce. Almost 70% of the company's raw materials are imported.

3.1.3 Working Time and Process Overview

The company operates 6 days in a week. All employees are required to work for 8 hours from 8 AM to 5 PM.

The processes of making shoes are as follows: 1.) the worker should trace and cut the parts on the leather skin; 2.) then stitch the parts to form it in three dimensions; 3.) the shoelast must be pulled over to mold into its shape and stitch the inner sole of the shoes; 4.) the edge must undergo skiving to trim the thickness of the sides; 5.) the outer sole must be attached by stitching and applying adhesive glue; 6.) the shoelast must be pressed to firmly shape the shoes and 7.) then, remove it after acquiring the desired mold; 8.) the shoes are now ready to be heated in the oven so that it the adhesive glue will be dried up and lastly, 9.) after heating, the brand name is stamped and then it is ready for quality inspection.

The existing plant layout incurred waste of transportations. The arrangements of the workstation were not organized; hence distance travelled was high.

The proponents calculated the inefficiency rate by subtracting the number of expected output to the actual output and then divided by the number of expected output. The company should produce at least 164 pieces of shoes daily. However, the workers did not reach this expected output. Instead, the workers produce an average of 147 pieces of shoes per day. The computed inefficiency rate is 10.37%. Meanwhile, the defects range from 1 to 3 pieces per production.

Table 1: Value and Non-Value Added Analysis

CELL	PROCESS FLOW	ACTIVITY	Production Lead Time (min)	BEFORE IMPROVEMENT			ACTION PLAN
				VA	NVA	ENVA	
Transport	A1	Get the raw materials from Storage	1			1	
Production	A2	Trace the patterns on the leather skin	2.5	2.5			
Transport	A3	Transfer the leather skin to the Cutting Area	0.23		0.23		Eliminate
Production	A4	Cut the outlines from the leather skin	3.33	3.33			
Transport	A5	Transfer the cut outs to Skiving Area	0.25		0.25		Eliminate
Production	A6	Trim the thickness of the leather around the edges using Skiving Machine	1.67	1.67			
Production	A7	Stitch the parts that were cut to bring it on three dimensions	0.83	0.83			
Production	A8	Assembly - thread removing	5	5			
Production	A9	Attach the desired accessories	0.83	0.83			
Production	A11	Stitch the shoe into its inner sole	0.5	0.5			
Production	A12	Assembly - thread removing	5	5			
Inspection	A13	Quality Control Inspection	0.33			0.33	
Transport	A14	Transfer to Flatting Area	0.66		0.66		Eliminate
Production	A15	Press the shoelast for firmly molding the shape of theshoes	8.33	8.33			
Transport	A16	Transfer to Heating Area	0.16		0.16		Eliminate
Production	A17	Place the shoes inside the oven for drying	0.07	0.07			
Transport	A18	Transfer to Sole Attachment Area	0.33		0.33		Eliminate
Production	A19	Remove the unnecessary thread or dirt around the shoes	0.5	0.5			
Production	A20	Attach the outer sole by applying adhesive glue then stitch the outer part	3	3			
Transport	A21	Transfer to Finishing Area	0.16		0.16		Eliminate
Production	A22	Polish/clean the shoes and prepare for packaging	5	5			
Production	A23	Box Making	0.5	0.5			
Transport	A24	Transfer to Patch Attachment Area	0.16		0.16		Eliminate
Production to Inspection	A25	Attach the patch using the Stamping Machine and inspect for the last time	3			3	
Production	A26	Packaging	1	1			
		TOTAL	44.34	38.06	1.95	4.33	

Table 2: Overall Equipment Effectiveness

PROCESS	SKIVING	STITCHING	INNER STITCHING	PRESSING	HEATING	SOLE ATTACHMENT	STAMPING
Number of Operator	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shift Length (min)	480.00	480.00	480.00	480.00	480.00	480.00	480.00
Meals and Breaks (min)	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Changeover Time (C/O) (min)	3.00	5.00	6.00	9.00	2.00	5.00	4.00
Down Time (min)	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Run Time (min)	392.00	390.00	389.00	386.00	393.00	390.00	391.00
Total Time (min)	405.00	405.00	405.00	405.00	405.00	405.00	405.00
Cycle Time (C/T) (sec)	102.00	198.00	330.00	500.00	40.00	180.00	180.00
Target Counter (parts)	238.24	122.73	73.64	48.60	607.50	135.00	135.00
Inefficiency Rate (%)	10.37	10.37	10.37	10.37	10.37	10.37	10.37
Total Count (parts)	213.53	110.00	66.00	43.56	544.50	121.00	121.00
Defective Rate (%)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Good Count (parts)	209.26	107.80	64.68	42.69	533.61	118.58	118.58
Availability (%)	96.79	96.30	96.05	95.31	97.04	96.30	96.54
Performance (%)	89.63	89.63	89.63	89.63	89.63	89.63	89.63
Quality (%)	98.00	98.00	98.00	98.00	98.00	98.00	98.00
Overall Equipment Effectiveness	85.02	84.58	84.37	83.72	85.23	84.58	84.80

3.2 Step 2 – Future State Assessment

Table 3 shows the status of the VA and NVA Time of the company's production process. Eliminating the transport time reduces the total time of the production.

The three layouts were organized using the P-Shape, S-

Shape and U-Shape form. Table 4 shows the comparison of the layouts in terms of the percentage of the travel to use or the transportation. As a result, the S-shape Layout is the most efficient layout for the shoe manufacturing company as it decreased the time of the workers in the system and increased the total number of goods produced.

The industry contributes to volatile organic compound (VOC) emissions. However, Federal Environmental Agency- Environmental Standards in Textile and Shoe Sector (2011) suggests the use of dispersion adhesives in the gluing process of pre-coated materials which could reduce VOC emissions up to 40%. It also suggests the use of solvent-free adhesive system to reduce heat of 250 deg. C for 20 minutes. Replacing rubber cement or contact cement with hot melt adhesives or water-

Table 3: Summary of Simulation Result

Summary of Proposed Production Layout					
Production Layout	Total Exits	% Travel to Use	Ave. Time in System	% in Move Logic	% in Operation
Existing	172	3.06	270.59	3.93	14.99
P-Shape	194	1.14	267.82	3.8	13.15
S-Shape	200	1.06	260.92	3.41	13.5
U-Shape	195	1.04	268.75	3.78	13.11

Table 4: Energy Consumption Savings and Improvements

Types of Products	No. of Hours Used per Day	Cost per Hour	Quantity	Cost per Day	Cost per Week	Cost per Month	Cost per Year
Fluorescent Light Tube	9	0.579	12	62.53	437.71	1,625.78	**19.509.36**
LED Light Tube	9	0.24125	12	26.06	156.33	677.56	**8, 130.72**
Total Savings Per Year (in Pesos)							**Php 11,378.64**

Energy Efficiency & Energy Costs	Light Emitting Diodes (LEDs)	Compact Fluorescents (CFLs)
Life Span (average)	**50,000 hours**	**8,000 hours**
Watts of electricity used (equivalent to 60 watt bulb). LEDs use less power (watts) per unit of light generated (lumens). LEDs help reduce greenhouse gas emissions from power plants and lower electric bills	**6 - 8 watts**	**13-15 watts**
Kilo-watts of Electricity used (30 Incandescent Bulbs per year equivalent)	**329 KWh/yr.**	**767 KWh/yr.**

3.2.1 Green Practices

3.2.1.1 Energy Consumption (Light)

The table below compares the LED Tube Light and Fluorescent Light in terms of yearly energy consumption and costs. To promote green thinking, the researchers recommend the use of LED light not only because of the savings it can generate from the company but also because of its environmental benefits.

3.2.1.1 VOC Emissions

based adhesives or use of water-based finish (polishes, creams, waxes, dressings, varnishes) or finish with reduced VOC content decrease VOC emission and lower risk of chronic diseases of workers.

3.2.1.1 Ventilation/ Cooling System

The company has five (5) industrial fans installed in the company, and are turned on all throughout the production time. To maximize the cooling system and reduce energy costs, which also translate to carbon dioxide emission, coolers can be adjusted in a range to fit the outside temperature (for example 23 instead of 20 degrees

Celsius inside at an outside temperature of 30 degrees Celsius) rather than just run on maximum power, with a beneficial effect on energy consumption. Taking this aspect further, a good insulation of buildings helps to save energy used for heating and cooling. Furthermore, waste heat from the production process may be used for heating purposes of the building as well as natural ventilation or evaporation cooling effects for energy efficient cooling (PumaSafe, 2012).

Green practices help increase worker's efficiency. The strong odor of adhesive glue, improper ventilation and lack of personal protective equipment (PPE) slow down workers performing their tasks up to 40%.

3.3 Step 3- Kaizen Events

Using Ishikawa Diagram the main reason of having inefficiency loss is due to Lack of PPE/RPE. Incorporating the adhesive glue without RPE/PPE has an effect on the health of the workers. Unpleasant smell because of adhesive glue makes the worker to suffer headache and thus, makes them to become unproductive. Untidy workstation and unorganized workplace affects the inefficiency loss because of the delays during the production.

4. CONCLUSION AND RECOMMENDATION

The implementation of an integrated Lean and Green methodology in a shoe manufacturing company clearly shows that the benefit of increasing the efficiency and reducing environmental impact. Though the total elimination of wastes was not achieved, it reduced the company's wastes significantly.

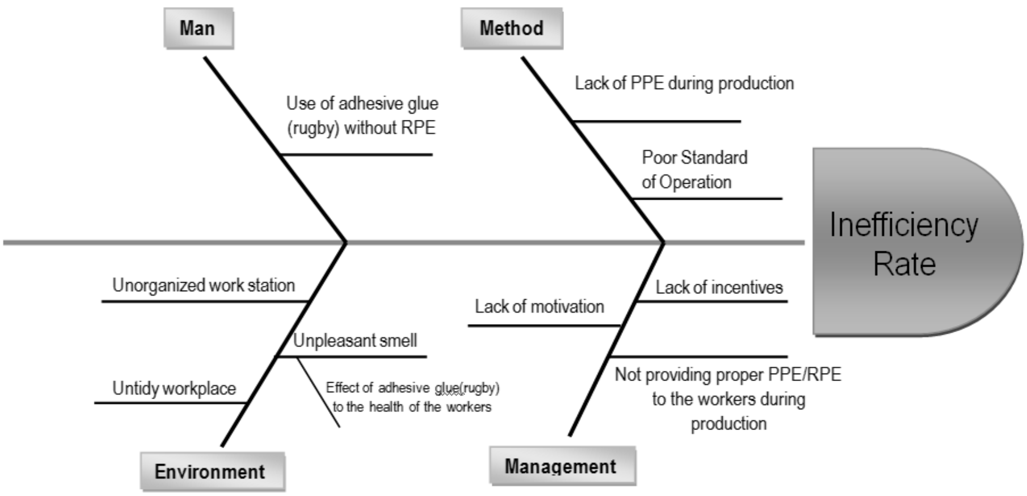

Figure 2: Kaizen Analysis

3.4 Step 4- Action Plans

Table 5: Action Plans

S/N	ISSUE	RECOMMENDATION	GOAL	TIMELINE	REVIEW DATE	RESPONSIBILITIES
1	High Efficiency Rate resulting in low Performance and OEE metrics	Provide Respiratory Propective Equipment(RPE); Documentation of SOP; Implement 5s	To decrease the Inefficiency Rate of the workers and to prevent health risk; To achieve the 90% and above OEE	60 days	Every 15 days	Management
2	Occurrence of Non-Value Added Time	Use Value Added and Non-Value Added Analysis	To eliminate Non-Value Added Time	15 days	5 days	Vice-President of Operation
3	Unorganized Production Layout	Rearrange the Production Layout	To achieve smooth flow of production	30 days	7 days	Management

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