

Cost Based Overall Equipment Effectiveness Analysis via Application of Value Stream Mapping

Sadaf Zahoor and Walid Abdul-Kader

Department of Mechanical, Automotive, and Materials Engineering
University of Windsor
Windsor, N9B 3P4, Canada
sadaf@uwindsor.ca, kader@uwindsor.ca

Hamza Ijaz, Atif Qayyum Khan, Zeeshan Saeed and Shoaib Muzaffar

Department of Industrial and Manufacturing Engineering
University of Engineering and Technology
Lahore, Pakistan

Abstract

To enable sustainable continuous process improvements within organizational framework, Lean Manufacturing methodologies are considered as a competitive management approach. Therefore, in this study a Flexographic Printing Process is selected to demonstrate the systematic implementation of Value Stream Mapping (VSM): a Lean Manufacturing tool, integrated with small Kaizen activities to achieve methodically fostered process improvements. Overall Equipment Effectiveness and production cost are taken as performance metrics to evaluate the process improvements hence the significance of VSM.

Keywords

Lean Manufacturing, Value Stream Mapping, Flexographic Printing Process, Overall Equipment Effectiveness

1. Introduction

High quality in tandem with low cost products are the two key objectives of all competitive organizations in general and manufacturing organizations in particular. For the said purpose, several established approaches can be found from the literature such as Total Quality Management (TQM), Total Productive Maintenance (TPM) and Lean methodologies [1].

Lean manufacturing methodologies are proven as useful management concept for the process improvements hence productivity. A variety of lean tools including 5S, single minute exchange of dies, VSM and kaizen are available which can be used effectively to improve the productivity by eliminating non-value added activities and wastes within the process [2].

For the first time, Mike and Shook introduced VSM as an independent approach [3]. VSM is simple yet a competitive Lean Manufacturing tool to achieve a holistic overview of the current process. It consists of five basic steps: current state mapping of existing process, problem area identification, formation of future state map and implementation of final plan.

A significant literature can be found advocating the usefulness of VSM when combined with other Lean Manufacturing approaches in different manufacturing sectors. Kuhlmann et al. explained the process management's

framework to integrate VSM and short-cyclic improvements for systematic and continuous improvement [4]. While working on an assembly line of a manufacturing sector, Tabassum et al. presented a case study on effective implementation of VSM which consequently resulted into 62% improvement in productivity [5]. Similarly, Azizi et al. presented a case study regarding the application of VSM in a PCB assembly line to identify hidden losses; and Kaizen techniques were used for the improvement plan [6]. Applicability of VSM is equally noticeable in case of process sector as demonstrated by a case study in which Rohani et al. tried to improve the production line of color process industry via VSM. Value added and non-value added activities were identified using value stream mapping and eliminated by using basic Lean Manufacturing techniques [7]. The diversified use of VSM in different sectors can be illustrated through several examples like Kasava et al. considered an aircraft maintenance process to demonstrate the hybrid application of conceptual framework of Lean Manufacturing tool (VSM) and sustainable manufacturing concept. The process was categorized into value added and non-value added activities for the improvements [8]. Haefner et al. carried out a research on innovative approach of Value Stream Mapping, dealing with quality assurance issues, called Quality Value Stream Mapping (QVSM). This tool is very suitable for: 1) visualization, 2) Analysis, and 3) Quality Assurance Design. An implementation procedure model has been prepared for the sake of improvements [9]. Moreover, VSM offered process improvements from the perspectives of energy, materials and time. For example, Li et al. used an integrated tool for Aluminum recycling facility which was Energy VSM to evaluate and visualize the complex flow in manufacturing system [10].

To gauge the effectiveness of Lean Manufacturing methodologies (VSM in particular), combined set of different performance measures can be used [11]. OEE in combination with production cost are important industrially applied metrics to evaluate the performance of any improvement tool. OEE aims to focus on three major factors which are responsible for productivity improvement i.e., quality, availability and performance. OEE can be calculated as follows:

$$\text{OEE} = \text{Quality} \times \text{Availability} \times \text{Performance}$$

Ahire et al. used OEE as a metric for evaluation of process improvements after implementing failure mode and effect analysis as a Lean Manufacturing tool in a process organization [12]. Another study was found considering OEE as an evaluation instrument for process improvement in which implementation of Lean Manufacturing approach for flexographic printing process was discussed by Zahoor et al. [1]. In another study, OEE was taken as a key performance indicator by Ben Hassan et al. to evaluate the efforts of a lean tool i.e. 5S towards the successful implementation of TPM in heavy duty equipment industry for mining and quarries applications [13].

Similarly, production cost can be served as an important performance metric and technically known as “production part cost” as suggested by literature [11-14]. It is the cost which is required to run a process to produce a specific output. Production cost can be calculated using formula given below:

$$C_p = C_u / N_{dp}$$

Where;

C_p = Production cost

C_u = Utilization cost

N_{dp} = Sum of approved and reworked parts

The utilization cost is the sum of different costs including equipment and operator cost, material cost, tool cost, maintenance cost, scrap and rework cost, and other costs etc. All these costs have direct impact on the production cost, therefore, change in any of the cost can influence the overall production cost. In this way, the improvements achieved by any of lean approach can be linked to overall economy.

The reviewed literature provides clear evidence with regard to the significance of VSM in almost every manufacturing sector. Therefore, this paper tries to contribute to the literature by presenting a case study about widely applied concept of VSM integrated with Kaizen for the improvements of Flexographic Printing Process.

2. Methodology

A renowned packaging organization located in Pakistan was under consideration as a case study. Fast moving consumers' good manufacturers country wide are the main customers of the organization. The case study demonstrates

the cost based analysis of OEE via implementing VSM focusing on the reduction of breakdown time of the machine. Main problem areas causing breakdown time were identified after Pareto analysis and current state of process was mapped. After analyzing the data and situation, improvement routines and action plan were proposed, implemented and mapped on future state. Kaizen as a lean tool was used for real time improvements to increase the availability of the equipment. Based on improvements resulted by the collected data for one month, Overall Equipment Effectiveness (OEE) was calculated and later, cost analysis was carried out.

3. Value Stream Mapping

The 9 steps of flexographic printing process are shown in the Figure 1 below. The data based on the production year 2016-2017 was collected in consultation with the production department. The breakdown time of the process were recorded and on the basis of this breakdown time, OEE was calculated for the current process using equation as mentioned in section 1.

$$OEE = 98\% \times 59.20\% \times 85\% = 49.31\%$$

3.1 Current State Map

From Pareto analysis, four main areas were identified with maximum breakdown time which were responsible for overall process performance and availability. Based on the collected data, current state was mapped using “Smart Draw Software” and is shown in Figure 1.

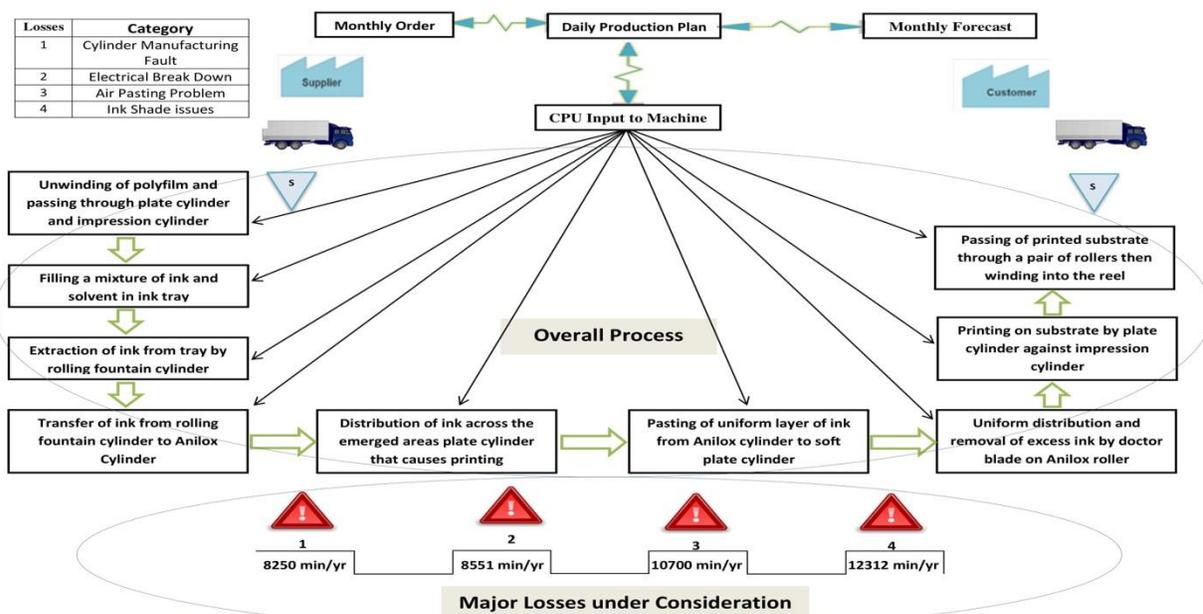


Figure 1. Current State Map

Table 1 shows the details of identified problem areas with recorded breakdown time.

Table 1. Details of problem areas

Serial No.	Problem area	Major effects on the process & consequence	2016-2017 Total breakdown time (minutes)
1	Cylinder Manufacturing Fault	Effect: Improper alignment of impression roller Consequence: duplication of printing	8250
2	Electrical Break Down	Effect: Short circuiting Consequence: Process breakdown	8551
3	Air Pasting Problem	Effect: Looseness in doctor blade Consequence: Grainy dots on impression patterns	10700
4	Ink Shade issues	Effect: Reducing ink sticky effects	12312

		Consequence: Fade printing	
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3.2 Proposed Improvements Routines for Target-Condition and Action Plan

Starting from current state map, improvement routines for target condition were proposed after the root-cause analysis (not mentioned in the paper). Target condition explains, “How” process performance should be in future which can be considered as a milestone leading towards the ideal state i.e., 100% added value. The ideal state serves as an aspiration for continuous process improvement.

A lean approach “Kaizen” was adopted to eliminate the bottlenecks, improve the problem areas hence reducing the breakdown times. The improvement routines along with action plan as suggested by Kaizen are given in the Table 2.

Table 2. Proposed improvement routines and action plan

Serial No.	Problem area	Improvement routines	Action plan suggested by Kaizen
1	Cylinder Manufacturing Fault	Polishing and proper waxing of impression roller before job setting	Inspection based on planned maintenance Training sessions for staff & workers
2	Electrical Break Down	Dedicated wire grouting	Daily Inspection as a part of preventive maintenance program
3	Air Pasting Problem	Inspection of air pressure as per preventive maintenance schedule	Awareness sessions for staff & workers
4	Ink Shade issues	Display of color composition and patterns charts for the proper mixing of ink shade	Training sessions for staff & workers

3.3 Future State Map

After incorporating the proposed improvement routines and implementing the action plan, future state map was developed as shown in Figure 2.

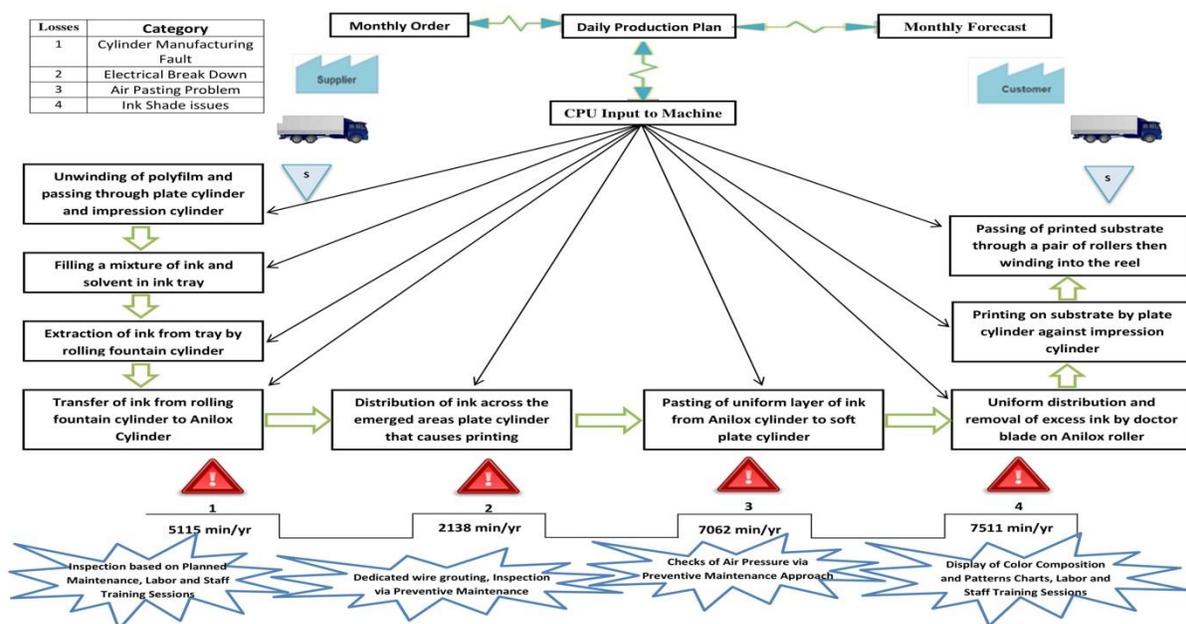


Figure 2. Future State Map

After the successful implementation of action plan, improved breakdown time was marked as given in the Table 3 below which resulted in 13.15% improvement in availability of the equipment followed by 13.25% improvement in OEE i.e., 56.78% as shown in Figure 3.

Table 3. Details of improvement in breakdown time

Serial No.	Problem area	Previous breakdown time (minutes)	New Breakdown time (minutes)	Time Saved (minutes)	Improvement in breakdown time
1	Cylinder Manufacturing Fault	8250	5115	3135	38%
2	Electrical Break Down	8551	2138	6413	75%
3	Air Pasting Problem	10700	7062	3638	34%
4	Ink Shade issues	12312	7511	4801	39%

Significant cost reduction based on improved OEE was calculated using the formula discussed in section 1 i.e., Rs. 80million (\$0.762million) to Rs. 69.5million (\$0.62million) for the next production year as shown in Figure 4 (1 USD = Rs. 105).

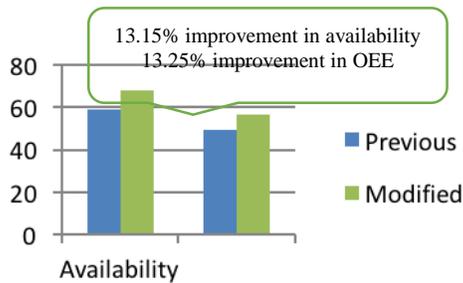


Figure 3. Improved availability & OEE

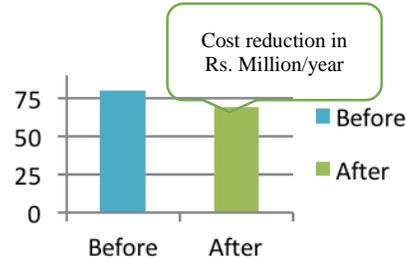


Figure 4. Cost estimation

4. Conclusion

This paper enlightens the usefulness of industrially applied approaches of Lean Manufacturing to improve overall equipment effectiveness of a flexographic printing process and also points out the significance of their integration. Value stream mapping combined with Kaizen proved as a competitive approach to not just establish the improvement routines for target-condition but also ensure the continuous process improvement through developing the action plans.

After the successful implementation of integrated lean approach, the availability of flexographic printing equipment was improved by 13.15% through reducing the breakdown times followed by the 13.25% improvement in OEE. The cost saving based on the improved OEE for the next production year was estimated from Rs. 80million (\$0.762million) to Rs. 69.5million (\$0.62million).

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Biographies

Sadaf Zahoor is an Assistant Professor in the Department of Industrial and Manufacturing Engineering Lahore Pakistan and a Post-Doctoral Fellow in the Department of Mechanical, Automotive, and Materials engineering, Faculty of Engineering University of Windsor, Windsor, Ontario, Canada. She earned B.S. in Industrial & Manufacturing Engineering from University of Engineering and Technology, Pakistan, Masters in Manufacturing Engineering from University of Engineering and Technology, Pakistan, PhD in Manufacturing Engineering from University of Engineering and Technology, Pakistan, she has published journal and conference papers. She has completed research projects with Packages Pvt. Ld. Pakistan, Millat Tractors Pakistan, Nestle Pakistan, Millat Equipment Ltd. Pakistan, PEL Orient Pakistan. Her research interests include sustainable manufacturing, reliability, scheduling, and lean. She is member of Pakistan Engineering Council.

Walid Abdul-Kader is a professor of Industrial Engineering in the Faculty of Engineering at the University of Windsor, Windsor, Canada. He holds a PhD degree in Mechanical Engineering from Université Laval, Québec City, Canada. He completed his bachelor's degree from Université du Québec à Trois-Rivières, Canada, and master's degree from École polytechnique de Montréal, Canada. His research interests relate to performance evaluation of reverse logistics and manufacturing/remanufacturing systems prone to accidental failure and repair. His publications have appeared in many leading national and international journals and conferences proceedings.