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Optimization of Lean Methodologies in the Textile Industry Using Design of Experiments

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Abstract**—**Industries in general have a lot of waste. Wool textile company, Baniwalid, Libya has many complex problems that led to enormous waste generated due to the lack of lean strategies, expertise, technical support and commitment. To successfully address waste at wool textile company, this study will attempt to develop a methodical approach that integrates lean manufacturing tools to optimize performance characteristics such as lead time and delivery. This methodology will utilize Value Stream Mapping (VSM) techniques to identify the process variables that affect production. Once these variables are identified, Design of Experiments (DOE) Methodology will be used to determine the significantly influential process variables, these variables are then controlled and set at their optimal to achieve optimal levels of productivity, quality, agility, efficiency and delivery to analyze the outputs of the simulation model for different lean configurations. The goal of this research is to investigate how the tools of lean manufacturing can be adapted from the discrete to the continuous manufacturing environment and to evaluate their benefits at a specific industrial.

Keywords**—**Lean manufacturing, DOE, value stream mapping, textiles.

I. Introduction

THERE has been a small portion of research over the past years in unindustrialized textile industries. Hokoma [1] published research focused on areas of modeling and simulation of manufacturing operations, whereas strategies and implementation within textile industries were less studied. Over several decades, profitability and competition from the textile companies, has resulted in fewer low cost foreign manufactures in the marketplace.

Rudrajeet et al. [2] and his team concluded that many companies have utilized lean manufacturing techniques because they help their organization with shorter delivery times, improvement in quality, and reduced cost. However, even though this helps with upstream customers, it has been noticed that it may not be so helpful to downstream customers and competitors who operate with lean principles.

The goal of lean manufacturing is to help companies aspiring to enter the competitive market to find ways to recover their operations and be more competitive to accomplish this, companies can implement use of diverse lean manufacturing tools and techniques to eliminate waste and non-value- added activities at every production or service process in order to improve product quality, enhance productivity and reduce costs. Womack and Jones [3] describe the word “lean” as a system that adapts to operating with a smaller amount, in conditions of all inputs, to produce indistinguishable outputs indistinguishable from to those produced by a usual mass production system, all while increasing quality for the end buyer. The use of a lean system means to manufacture what the customer wants in a product, when it is required and in the quantities arranged.

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II. Expected Research Contribution

This research will provide a methodology for textile industries, using lean manufacturing tools. The research includes new structured and statistically significant items such as DOE analysis of a simulation model as a manufacturing inspection tool. This research is to fill this study need reduction/ elimination of waste. In addition, to validating the waste, this research intended to provide the study of the need for reduction/elimination of waste. This paper will focus on the work involved in enabling companies to use objective lean manufacturing tools in companies. However, the study will focus specifically on identifying the current waste in textile company, as well as identifying ways to develop and enhance textile company’s’ manufacturing process design methods in order to determine which lean principles are appropriate for implementation in the textile industries. A feature simulation model will be used to evaluate the outputs of the simulation model for different lean configurations. The dissertation will present development of a road map for companies and ways to implement(s) this strategy to eliminate waste in plants, enhance quality, productivity, reduce manufacturing costs, and utilize just in time (JIT) philosophy.

Identifying and controlling wastes significantly influence quality, productivity, delivery and cost. JTP in Libya has many complex problems that led to enormous waste generated due to the lack of lean strategies, expertise, technical support and commitment.

Twenty million dollars are wasted annually on non-value added activities at the Janzour textile plant in Tripoli, Libya. Eighty percent of the plant shipments were delivered late to customers during the period from November 2010 through February 2011. This creates customer dissatisfaction and has resulted in cancellation of orders. More than forty percent of Janzour textile respondents in 2013 mid-year survey stated that they were very or somewhat dissatisfied with communication within the departments.

The objective of this study is to develop a lean manufacturing strategy with a clear road map for Janzour Textile Plant (JTP) using VSM to detect process variation and effectively control the operating variables and always be able to set these variables at their optimal levels to improve product quality, productivity, delivery and reduce operating cost.

This research will study the textile industry, its current manufacturing processes, layout design, utilization of resources, inventory level, efficiency, and the concepts of lean manufacturing and how it could be utilized in the textile industry, along with recommendations for future improvements by using **DOE** for both states the current state and the future state.

The aim of the simulation study is to assist the layout planning activity by estimating the quantity of WIP work-in-progress inventory within the proposed facility. The goal is to assist the textile industry to keep active in new competitive market places. Companies have been working on approving new business initiatives to stay competitive; one of these initiatives is lean manufacturing with the objective of cost reduction by eliminating any non-value added activities. Staffing competition and low labor costs are an issue confronting the textile industry in order to stay competitive. Improvement in the manufacturing processes is a must in order to be prepared to compete with foreign manufactures. To reduce the impact of cheap imports, the implementation of cost saving lean manufacturing techniques can be put into action and development of evaluations for outputs for different lean configurations to be developed in order to provide a comparison between these operating policies before implementation in the plant. The objective of this research is to reduce waste to at least twenty percent leading to cost savings of four million dollars.

III. The Increasing Importance of Lean Tools in Industries

The traditional methods of operating textile companies simply don't work anymore. The days of holding massive amounts of inventory and taking months to deliver a product a consumer wants in days are long gone. With our better understanding of the need for change. Let's learn more about what Lean is and how it can help each and every one of us. First of all, "Lean is an operational excellence strategy that enables you to change for the better." This brings us to the present day. We need to definitely begin to eliminate waste and increase profits in manufacturing environments around the world. Lean has also spread to many other areas; in fact, you will find lean begin commonly utilized in office environments for simple things such as reducing the time it takes to process customer order is very common. Another area lean taken offer in our hospitals where thing like reducing errors in the time it takes to find critical supplies has a tremendous value. The military is also using variations of with both lean and six sigma. Even part of the US Postal Service has begun the journey to see if it will benefit from using tools like VSM and error proofing.

IV. Complete Design of VSM

Once the initial strategy requirements are recognized, we may create to calculate how well VSM can be expected to be implemented. A rigorous design waste modes and effects analysis will be completed to identify the most significant waste in the current VSM. The VSM will be led through enablement by a group of engineers from both the equipment supplier and the assembly plant. Beginning with the defined waste, future VSM value steam mapping will be constructed based on the information provided by current VSM. Each waste will be expressed in terms of equipment waste. The result will be an ordered list of waste for concept design. We will determine a strategy for addressing the significant waste. Once the design is determined to be acceptable using the VSM tool, a formal **DOE** will be used to fully define the sensitivity of waste on our future VSM and to locate factors expected in a production system. In essence, the DOE validates the results of VSM.

Abdullah [4] did his Ph.D. on Lean and he described VSM as an assortment of all actions added, including non-value added that are essential to transport a product or group of products that make use of the same resources through the main flows, from raw materials straight to the customers. The nucleus of profitable lean operation are the information and operation flows in the overall supply chain. The use of VSM is an improvement method to assist in the visualization of the complete production process, on the behalf of material and information flows.

Adaptation of sensor and actuator methodology to textile structures has been realized by [5], an innovative approach based on integration of electronics onto textiles. Their result shows that the working principle of the system is based on two main functions: sensing the surrounding environment as well as detection of obstacles via sonar sensors and guiding the user by actuators by using a novel control algorithm based on a neuro-fuzzy controller implemented to a processing unit.

Ngai et al. [6] and his team, based on the classification systems considered distributed the textile and apparel supply chain into sectors of textile production, apparel manufacture, and distribution/sales and analyzed the business practices of each sector in terms of operational processes and management/ control processes

It is important when using the value stream technique to try to identify any types of waste in the stream and develop steps for finding a way to eliminate the waste. Using the value stream tool to improve the whole flow and not just optimization means to look at the whole picture of the process and not just individual processes. A more thorough decision making process is improved in the value stream due to the common language in the production process. There has been widespread use of numerous tools developed by researchers and practitioners to help in the research of individual firms and supply chains. Several of these tools are less helpful aiding with the facilitating development of links between the visualization of the nature of the material and information flow of a company entity. A great way to start off as a lean company, would be the use of VSM a good concept to start with. The following list demonstrates the benefits of VSM: Helps observer to envision more than the single process level in production, allowing the user to see the entire flow. Helps in seeing waste and its source in the value streaming. Uses the common language of manufacturing processes. Combines lean concepts and techniques. Forms a basis for an implementation plan. Becomes a blueprint for lean implementation

VSM is created by hand with paper and pencil. There are several benefits in using this tool. Manual mapping allows what is actually happening in the shop floor value stream to be seen, rather than controlled by a computer. Another benefit is that this process acts as a plan-do-check-act cycle that expands our understanding of the overall flow of value, or lack thereof. See icons used in VSM shows in Fig.1.

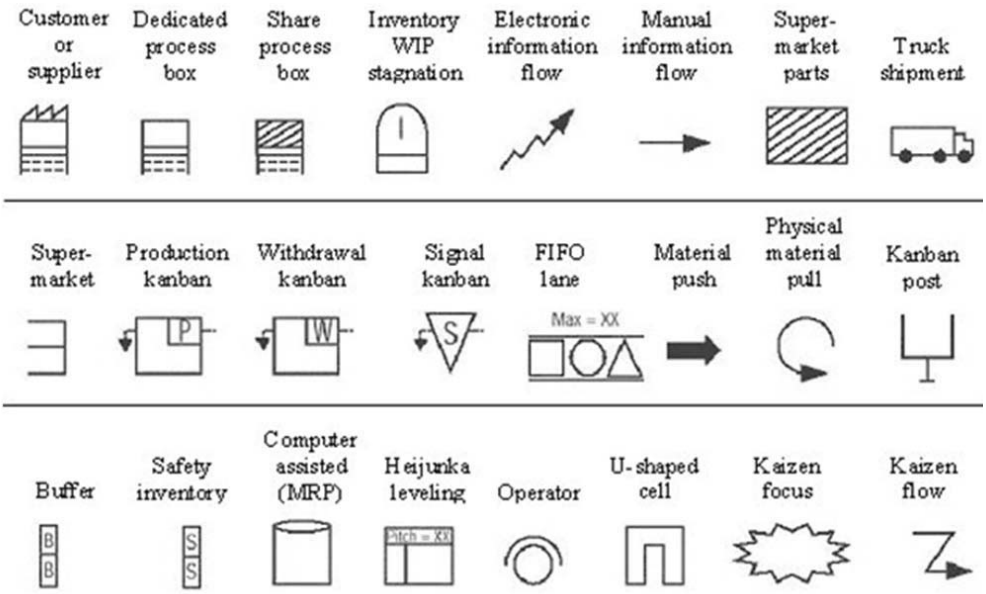

Fig. 1 Icon Used in VSM

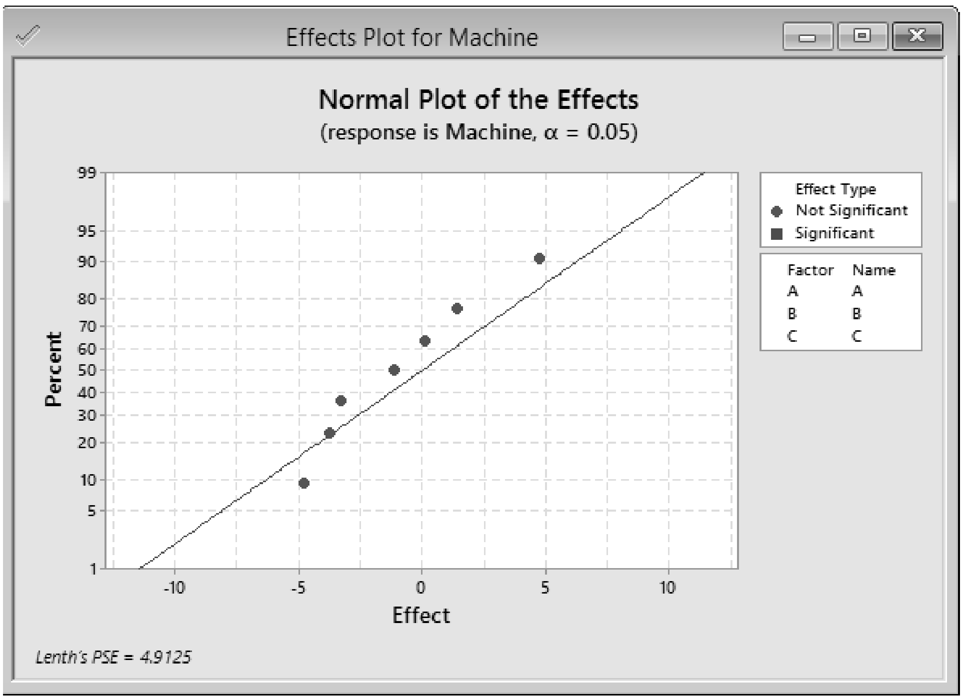

Fig. 2 Effect Plot for Machine

The first step in VSM is to pick a product family as the target for enhancement. Since it is impractical to map everything that passes through the shop floor, customers only focus on their products. It is too difficult to draw all of the product flow in one company. Use of either product or process matrix to categorize similar process steps for different products or selecting products that use the highest volume will help in identifying a product family.

After choosing a product family the next step is to draw a current state map to take a snapshot of how things are being done now. This is done while walking along the actual pathways of the actual production process. Drawing material flow on the current state map should always start with the process that is most linked to the customers, which in most cases is the shipping department, and then working one's way up to the upstream processes. The material flow is drawn at the lower portion of the map. For each process all the critical information including lead-time, cycle time, changeover time, inventory levels, and so on, are documented. The inventory levels on the map should correspond to levels at the time of the actual mapping and not the average because it is important to use actual figures rather than historical averages provided by the company.

The second aspect of the current state map is the information flow that indicates how each process will know what to make. The information flow is drawn on the upper portion of the map. The information flow is drawn from right to left on the map and is connected to the material flow previously drawn. After of the map a timeline is drawn below the process boxes to indicate the production lead-time, which is the time that a particular product spends on the shop floor from its arrival until its completion. A second time called the value added time is then added. This time represents the sum of the processing times for each process.

The third step in VSM is to develop the future state map. The purpose of the main courses of action of VSM is to emphasize the source of waste and help make target areas progress.

V. DOE

The purpose of the DOE is to classify the future VSM. These factors will be derived from the VSM for operational waste and are expected to include: process and design factors such as Just-In-Time, standardization of work, production smoothing, and Other Waste Reduction Techniques. A fractional factorial experimental design will be used to screen for the most significant factors affecting the system operational performance. A fractional factorial design will allow assessment of the greatest number of potential factors with the fewest experimental runs by analyzing the aliasing effects in the data. Also we are going to use the DOE for our final outcome of this research which is optimize system throughput. Using the results of the DOE, initial feasibility of the prototype system is established and process constraints may be identified. At this point, further improvement to the inspection system may be warranted. Chakravorty and Atwater [7] compared a line balancing approach with Just-In-Time and theory of constraints methods of operating production lines and found the line balancing approach did not perform best under any of the conditions in the study. However, [8] did find that line balancing could outperform JIT under conditions of high system variability, especially at low levels of inventory. The main stages in the production process are shown in Fig. 2. Each stage is staffed by a locally managed team and all material passes through the knit, preparation, dye, finish and dispatch processes. Greasley [9] analyzed the knit process, also termed ring spinning, which takes yarn from the warehouse and knits it into 25kg rolls of cloth. A product mix is created by allocating a number of knit machines to a product type in proportion to the mix percentage. Table II gives a product mix of seven main product types of different material and weight for the plant configuration to be modelled.

VI. Using VSM by DOE

DOE techniques enable designers to determine simultaneously the individual and interactive effects of many factors that could affect the output results in any design. DOE will be used for both states, the current state and the future state which lean tools use to eliminate waste and non-value-added activities at every production or service process in order to bring the most satisfaction to the customer and determine the best design variables from among all possibilities without explicitly evaluating each possibility.

Objective

- Reducing lead-time

Aims

Model can help VSM by:

- Calculating the control of the future map
- Investigating, evaluating, and tracking progress for different situations of proposed state map
- Documenting areas of improvement.

Steps

The levels or factors are:

- The production system (X1)
- TPM (X2)
- Setup reduction (X3)

By using a full factorial design 2^k all possible combinations of these levels are investigated and replicated. Where:

- 2 is the number of levels for each factor
- ^{k} is the number of factors, ^{k} = 3 and factor will be examined at two levels.

We decided to use 2 primary performance measures:

- Lead-time
- WIP work-in-process

Machine and operation due date System will be the two levels used for the production system factor, Tables I, II.

- The Machine system represents the current state map
- The operation due date system represents the future state map

DOE provides a full insight of interaction between design elements, therefore helping to turn any standard design into a robust one. Simply put, DOE helps to pin point the sensitive parts and sensitive areas in your designs that cause problems in Yield. Designers then are able to fix the problems and produce robust and higher yield designs prior going into production.

TABLE I
THE NUMBER IN EACH LEVEL-FACTOR COMBINATION REPRESENT THE AVERAGE LEAD-TIME IN DAYS FOR THE FACTORIAL DESIGNS

Total Productive Maintenance (TPM)				
	Without Setup Reduction		With Setup Reduction	
Production System	Without	With	Without	With
Machine	34.36	34.22	27.28	27.01
	34.35	34.03	27.39	27.30
	34.36	33.87	27.13	27.77
	34.19	34.23	27.33	27.36
	34.12	34.49	27.39	27.56
Operation due date	19.17	12.13	12.13	12.12
	19.28	12.11	12.11	12.11
	19.03	12.14	12.14	12.13
	19.18	12.11	12.11	12.10
	19.23	12.13	12.13	12.12

TABLE II
PROPOSED SETUP REDUCTION TIME

Process	Setup time for main stages (min)	Setup time for stage process flow (min)
Kinit	20	10
Preparation	-	5
Dye	20	5
Finish	20	5
Despatch	(4,8,5,6)	-

VII. SUMMARY

This research is expected to help in understanding how to solve real problems in textile industries, as well as how to improve existing manufacturing practices in the factory. Implementing lean techniques to evaluate the existing manufacturing system of the company and/or industry is valuable tool. By using these methods, development of the current and future state value stream map will be completed. At the end of the process, the company will be able to propose an implementation process for the lean manufacturing system for further future improvements.

ABBREVIATIONS

JTC Janzour Textile Company
WCM World Class Manufacturing
5S's Refers to the Five Japanese Words Seiri, Seiton, Seison, Seiketsu, Shitsuke.
VSM Value Stream Mapping
CRN Common Random Number
CT Cycle Time
JIT Just-In-Time
JPH Jobs Per Hour
LCC Life Cycle Cost
MCBF Mean Cycles Between Failure
MLT Mean Lead Time
MTBF Mean Time between Failures
WIP Work In Process
FIFO First In First Out
GA Genetic Algorithm
GDP Gross Domestic Product
IBE Intelligent Back Ends
LSS Lean Six Sigma
TRD Temperature Rainer Dye. Type of dye machine
MTTR Mean Time to Repair
TPM Total Productive Maintenance

REFERENCES

[1] Hokoma, R. A., "The Current Awareness of Just-In-Time Techniques within the Libyan Textile Private Industry", World Academy of Science, Engineering and Technology, 2010.
[2] Rudrajeet, P., Håkan, T., and Heikki, M., "Antecedents of organizational resilience in economic crises -an empirical", Study of Swedish textile and clothing SMEs, 2013.
[3] Womack, J.P., Jones, D.T., and Ross, D., "The Machine That Changed the World". Macmillan Publishing Company, Canada, 1990.
[4] Fawaz, A., "Lean Manufacturing Tools and Techniques in the Process Industry with a Focus on Steel", PhD Dissertation, University of Pittsburgh, 2003.
[5] Senem, K. B., Koncar, K. V., and Kalaoglu, F., "Wearable obstacle detection system fully integrated to textile structures for visually impaired people", 2012.
[6] Ngai, Peng, Alexander, and Moon, "Decision support and intelligent systems in the textile and apparel supply chain", an academic review of research articles, 2013.
[7] Chakravorty, S.S., and Atwater, J.B., "A comparative study of line design approaches for serial production systems", International Journal of Operations and Production Management 16 (6), 91–108, 1996.
[8] Chakravorty, S.S, and Atwater, J.B., "Do JIT lines perform better than traditionally balanced lines", International Journal of Operations and Production Management 15, 77–88, 1995.
[9] Greasley, A., "Using simulation for facility design: A case study", Aston Research Explorer, 2008.