Journal of Advances in Science and Technology
Vol. 12, Issue No. 24, November-2016, ISSN 2230-9659

A Research on the Role of Value Stream Mapping Tools in Production Line

Mohan Shankar Futane[1]* Dr. Ankur Awasthi[2] Dr. Sharad Mahajan[3]

[1]Ph.D. Research Student, MUIT, Lucknow

[2]Research Guide, MUIT, Lucknow

[3]Research Co-Guide, MUIT Lucknow

Abstract – Value stream mapping and associated analytical tools are used to explore the opportunities to streamline the flow of products on the floor with a focus on reducing inventory and improving quality. To complement the analysis, this thesis also examines the impact of improved floor employee involvement. It considers several aspects including the increased empowerment of the direct labor staff, stronger team participation, and a greater focus on solutions specifically tailored to area. Based on the results of the research, the recommendation is an increased focus on developing team skills and empowerment, specifically within the direct labor staff.

This research work proposes a new methodology for implementing Value Stream Mapping, in processes that feature a High-Mix, Low-Volume product base. The opportunity for adapting the methodology singularly for these types of environments was identified because implementing Value Stream Mapping as proposed in Learning to See features several drawbacks when implemented in High-Mix, Low-Volume. Although Value Stream Mapping has been proven to enhance many types of processes, its advantages are shrunk if they are implemented in High-Mix, Low-Volume processes.

---------------------------♦-----------------------------

INTRODUCTION

A process is the transformation of raw materials into finished goods (what is now referred to as the internal value stream); an operation is the interaction of operator, machine and materials. While most members of an organization are involved in one or more operations, few have a complete understanding of the process.

Understanding the internal value stream is therefore critical both to serving the needs of the customer, and to improving the efficiency (and profitability) of the value stream. Value stream mapping, a means of representing the value stream with symbols and numbers, is the key to understanding the entirety of the transformation of raw materials into finished goods.

For most of the time that industry has existed on a large scale, the process has been devised as the push of materials through a set of operations. Production has occurred in large batches, almost as if this was a natural law of how things are made. Shingo and Ohno sought to bring back the pride, quality, and customer service of an earlier craftsman era. The craftsman made only what customers ordered. They found that it was possible to produce to demand more effectively than it was to produce in batches.

A value stream, as the name implies, flows to some specific end. This end is a set of requirements, as expressed by the customers of the value stream. When the value stream fails to meet the requirements it is intended to serve, it must be improved. Customers have three simple requirements – price, quality and delivery. In today’s market, competitive price and quality are basic requirements for staying in business. On time delivery at a cost that allows for profitability is therefore the key to competitiveness.

Process flow diagrams and traditional value stream maps don’t tell the whole story. What is missing? In a word:

All traditional maps, whether drawn by hand, or created using specialized software such as Microsoft Visio, lack this important element. Traditional maps can only present a “snapshot” of the sequence of steps in the flow. Pictures of actors and scenery (no matter how many there may be) are not the same as a movie, for the same reason – they lack the element of time.

Time is essential to understanding how one operation affects another, how a particular resource may influence the entire process, and how the status of the queues and operations vary with time.

Discrete event simulation introduces a whole new dimension to value stream mapping - time. The value streams will actually “run”, and provide results for how each operation, queue, and resource performed over the duration of the run. With the element of time added to a value stream map, it is possible to test hypotheses about which changes will produce the best results, to see the full effects of apparently small changes, even to challenge the correctness of a map when it fails to produce results that are compatible with the behavior of the real-life value stream.

The first step of value stream mapping is to map the existing process – the result is a Current State Map. The validity of this map can be tested by comparing the simulation results to actual results. Once a valid current state map has been constructed, it is then possible to suggest improvements, with confidence that the results from the proposed system will be quite similar to those of the Future State Map. In this way, the lean initiative moves from solid footing to solid footing. There is no “leap of faith” or “trust me” required to convince everyone that there really is a better way to carry out the process (a more profitable one too, since simulation even supplies financial statements).

A word of caution: Lean has a bias for action, and it is important to move on to improvements and to not get stuck on analysis. Furthermore, lean proposes that “better beats best”, again warning us that we should not be obsessed with perfection, but get on with many small improvements. What we are suggesting here is that the value stream mapping process be done quickly, but accurately. With the ability to test proposals quickly, we ensure that we move on to action, but we also ensure that everyone is on board.

Construction processes and supply chains have been mapped by a number of authors to depict the interactions and hand-offs between construction participants (e.g., Arbulu et al. 2002, Alves and Tommelein 2003, 2004). In spite of the increasing acceptance of Value Stream Mapping (VSM) as a mapping tool in various industries, VSM has yet to be discussed in the construction literature. Fontanini and Pichi’s (2004) paper on mapping of a supply chain for aluminum windows is an exception. A search in journals, including the Journal of Construction Engineering and Management, Construction Management and Economics, as well as the proceedings of the Annual Conference of the International Group for Lean Construction reveals that the use of VSM as suggested by Duggan (2002) is yet to be implemented and published by construction researchers.

Possible reasons for the slow adoption of Value Stream Mapping (VSM) in construction may be related to the difficulty in defining production schedules and forecasts, as well as the difficulty of directly applying some of the key concepts/elements, (e.g., pacemakers and supermarkets explained later in this study) used in VSM. The difficulty in representing some construction processes and their outputs reveals the complexity of the industry and the need for a language that can be understood by construction practitioners.

Construction supply chains and processes have been represented using simulation software symbols and operations research symbols. While simulation tools and their graphic representation of processes are effective in modeling the dynamic interactions in such supply chains, they are not widely understood by construction practitioners.

Operation research symbols are easier to interpret but do not show in a transparent fashion how processes and their associated information flow through a production system or a supply chain.

In contrast, VSM reveals the flow of work and information side by side. It also reveals waste of time by displaying the cycle time for each operation and the total lead time for a process. The waste of resources such as materials, equipment, and space are easier to recognize than the waste of time, which is hidden behind unnecessary actions and movements. When the total lead time is compared to the total cycle time to deliver a product, the result shows how much time is actually spent to deliver a product vs. time used to fabricate it, i.e., how much time worth of work the customer wants to buy vs. how long it takes the supplier to deliver it. For instance, in the case presented in this study we illustrate that the customer wants to buy on the order of 20 minutes worth of work and that the company takes on the order of 32 days to deliver it.

Given the need to unveil waste and opportunities for improvements in construction and the relevance of VSM, the authors used VSM to map a make-to-order environment in a job-shop that provide parts for construction projects, i.e., Heating Ventilating and Air Conditioning (HVAC) sheet metal ductwork. Job shops are production systems that deal with orders that may comprise a variety of products, with different characteristics, and can go through different routes, i.e., different machines and operations, during fabrication. A make-to-order job shop deals with customized orders, which usually cannot be entirely or partially fabricated in advance.

Job shops have been long investigated and discussed in the operations research literature. But not enough attention has been devoted to this topic in the construction literature, in spite of the presence of job shops to deliver products in construction supply chains, i.e., sheet metal parts, precast concrete elements, pipes, architectural elements, various kinds of wood framing, etc.

For the fabrication of HVAC sheet metal parts, there are two main types of job shops that supply construction sites. The first is represented by a supplier who makes parts and supplies them to different customers who then install them. The second is the (mechanical) contractor's fabrication shop, which supplies parts mostly for its own projects. Maintaining a fabrication shop under their own umbrella provides contractors control over production (e.g., the flexibility of having parts at any time) as opposed to having to accept supplier lead times.

Nowadays, the success of the manufacturing industry is largely determined by its ability to rapidly respond to market changes and to immediately adjust to customer needs. This has resulted in an increasing demand for deployment of systems that can cope with agility and efficiency to these demands. Companies must respond with product designs or completely new products, modifying production processes while seeking lower times and more flexibility in their production systems. It has been studied by several authors that, in order to respond to customer´s requirements, flexible systems imply studies about the quickness with which these systems can be modified, the required new configuration should turn the flow to become more agile, in such a way that the production systems will technically be viable and suitable for different purposes.

Law and Mak (2004) underline the need for an effective tool in order to develop a manufacturing system or to modify an existing system for a specific requirement at a reasonable time frame and cost. There have been developed several tools that presumed to support those actions such as: process mapping based on flow maps, IDEFO, GRAI, material and flows´ modeling and simulation software, mapping techniques based on Toyota production system defects and Value stream mapping.

VSM has been defined by Rother and Shook (2008) as a powerful tool that not only highlights process inefficiencies, transactional and communication mismatches but also provides guides about the improvement and redesign of manufacturing environments. Such useful tool has been evolving through its different applications, under many cases of study, under different environments and contexts.

VALUE STREAM MAPPING AND ITS EVOLUTION

''A value stream is all actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) the production flow from raw material into the arms of customer, and (2) the design flow from concept to launch.'' (Rother and Shook 1998, p.3). In order to build a value stream map (VSM), a set of production data and customer requirements is needed.

ESSENTIAL DATA-

The first step to build a VSM is to select a family of products, i.e., groups of products that go through the same processing steps, to be investigated from the point of ordering raw materials until the point of final product delivery to the customer. Essential data for building the current state map includes (Rother and Shook 1998):

- Product family steps. Definition of the production processes the selected product family goes through, e.g., cutting, welding, shipping, etc.

- Production information. Information about changeovers from one type of product in the family to another as well as the frequency of raw material delivery. Number of shifts the plant works, working time and breaks for each shift, and number of working days in a month.

- Ordering. Customer requirements for each product of the family investigated, e.g., 100 products of type A and 300 type B needed every week. Packaging requirements for the orders, e.g., number of parts per pallet or box.

- Production Control. How often and by which means forecasts are received from the customer as well as sent to suppliers. How often and by which means production requirements are deployed from forecasts to production plans and sent to different processes.

Value stream mapping (VSM) is a technique relatively recent that gives answer to needs expressed by manufacturers in order to develop value chains more competitive, efficient and flexible; with the ones they can solve their economic difficulties that market changes may bring. Both creators and researchers have found that VSM fills the characteristics and properties needed in a tool to be used to redesign a productive system. Despite success cases of study, there have been generated variants of the original technique of VSM as a result of applications in different environments and contexts, different techniques that at the end what they are looking for is to trace the value stream in a productive environment, allowing them to eliminate what are called non value adding activities.

Unlike traditional process mapping tools, VSM is a mapping tool that maps not only material flows but also information flows that signal and control the material flows. This visual representation facilitates the process of lean implementation by helping to identify the value adding steps in a value stream and eliminating the non-value adding steps, or wastes (muda).

The focus of VSM is on a product “value stream” (all actions required to transform raw materials into a finished product) for a given “product family” (products that follow the same overall production steps). In applying VSM, waste is identified at a high level along the value stream in the form of all elements that prohibit or hamper flow and in the form of inventory (raw materials, work-in-process (WIP) and finished goods). In future state design, major issues that create waste in the process are addressed. The future state map forms the basis for the implementation plan, for focused improvement initiatives (such as set-up reduction).

It has been also evaluated the applicability of the VSM in production environments related to disconnected flow lines, the results confirm the practical validity of VSM for the redesign of production systems. The research method adopted consisted of a multiple case study of six companies.

It perceives the VSM as a practical tool for the redesign and creation of flexible and efficient production environments, in turn concluded that the VSM is shown valid by itself, to justify the redesign to show the improvements that it would provide at a level of productive performance of the system. It was also tested the hypothesis that VSM is the reference for implementation of the redesigned production system according to the action plans that are created from “future states” and the strengths recognized by the teams in each one of the cases of study analyzed.

VSM has been adopted and evolved to plant situations with complex characteristics in which demand is random, the number of references is very diverse and have difficult grouping, there are plenty processes, many of them shared with other families and therefore the flows integration become complicated. VSM developers recognize that many production systems have multiple streams coming together that can complicate and increase the time needed for mapping.

Despite success stories in the application of VSM, there have been generated variants of the original technique of VSM as a result of applications in different environments and contexts:

- Value stream macro mapping (VSMM).
- Value network mapping (VNM).

In the case of the first mentioned above, Fontanini and Picchi present a practical case where VSM is applied and used for a building construction project. VSMM is an extension of VSM that allows not only to see waste and flow inside a company or what is known “dock to dock” but it allows understanding material and information flows in a full supply chain involving several supply chain companies.

One can expect the possibility of lean concepts and techniques application inside of VSMM, aiming the entire flow improvement and not isolated tools application or isolated initiatives with limited results. It allows a guide creation to coordinate all agents along the implementation of changes across the chain, in order to eliminate waste across the supply flow.

VNM was developed to eliminate the limitations imposed on the traditional methodology when “many value streams have multiple flows that merge” . It is able to map the complete network of the flows in a value chain that belongs to a complex product, with complex bill of material and several levels of assembly. Also, it utilizes algorithms for clustering of similar manufacturing routings and design of facility layouts to identify families of similar routings for which a single composite Current State Map could be developed. In addition, these algorithms utilize special data structures that capture the complete assembly structure of the product instead of extracting the key components only, as suggested to be done with VSM. The development and benefits of this approach have been demonstrated using results from a pilot study done in a job shop where the production is made by order. Braglia, Carmignani, and Zammori (2006), also tested this approach in a real environment job shop showing satisfactory results.

In the cases where VSM application is analyzed, there have been highlighted the following shortcomings of the original tool:

- Fails to map multiple products that do not have identical material flow maps.
- Fails to relate transportation and queuing delays, and changes in transfer batch sizes due to poor plant layout and/or material handling, to operating parameters such as machine cycle times and measures of performance such as takt time of the manufacturing system.

- Lacks any worthwhile economic measure for "value" (profit, throughput, operating costs, inventory expenses).

- Lacks the spatial structure of the facility layout, and how that impacts interoperation material handling delays, the sequence in which batches enter the queue formed at each processing step in a stream, container sizes, trip frequencies between operations, etc.

- It is based on manufacturing systems with low variety and high volume.

There is also a need to show the impact that the inefficiencies: product travelling long distances, not integrated flows, lack of independency in a process, lack or fail of communication between parts that integrate the complete manufacturing system (because of a none existing protocol or not following an existing one) have on creating bigger amounts of WIP, operation expenses, downtime and leisure (to mention the ones seem to be the most commonly seen in manufacturing systems).

The other need not less important is detect situations where the ergonomic aspect is poor or exist potential improvements to be done in this matter, since it also may create an impact on employee's productivity by reducing the efficiency on creating value during a formal job shift. It has not been found any paper or study that links ergonomic aspects to creating value, ergonomics is normally seen as a parallel aspect. Analyzing the situation with a different perspective we find that work force is still a must in most manufacturing systems, its performance have a direct impact on the system performance, that is why it cannot be inherent to the system, therefore should not be excluded from the re design or development of a manufacturing system.

Table 3.1 below, shows a comparison between the different mapping tools mentioned above, analyzing certain aspects founded as key on the literature review, such comparison pretend to enhance strengths and weaknesses on each one of the tools.

Mapping technique / Key aspects to evaluate	*Use of quantitative data (processing times, takt time, lead time, inventory, travel distances, processing quantities, etc.)*	*Flow through plant layout*	*Influence of ergonomics in value creation*	*Job sequencing*	*Material handling*	*WIP buildup*	*Capacity constraints*	*Economic investment*	*Context of practical application*
Process mapping based on flow maps	H	NC	NC	NC	L	NC	NC	L	SP, JS
IDEFO	L	NC	NC	NC	NC	NC	NC	L	SP,BP
GRAI	M	NC	NC	NC	NC	NC	NC	L	SP, BP
Material and information flows' modeling and simulation software	H	M	NC	H	L	H	H	H	SP,JS,BP
Process activity mapping	H	NC	NC	NC	L	NC	NC	L	SP,JS
Supply chain response matrix	H	NC	NC	NC	NC	NC	NC	L	SP,P
Production variety funnel	H	NC	NC	NC	NC	NC	NC	L	SP
Quality filter mapping	H	NC	NC	NC	NC	L	NC	L	SP,JS
Demand amplification mapping	H	NC	NC	NC	NC	NC	NC	L	SP
Decision point analysis.	M	NC	NC	NC	NC	NC	L	L	JS
Physical structure (a) volume (b) value.	M	NC	NC	NC	NC	NC	M	L	SP
VSM	H	NC	NC	NC	NC	NC	NC	L	SP,P,B
VSMM	H	NC	NC	NC	NC	NC	NC	L	SP,P
VNM	H	H	NC	NC	NC	NC	NC	L	SP,JS,P,B

Low (L), Medium (M), High (H), Not considered (NC), Serial production (SP), Job shop (JS), Project (P), Business processes (BP).

Table 3.1 : Comparison between mapping techniques.

LEVELING OF LOW VOLUME AND HIGH MIX PRODUCTION

Production leveling also referred to as production smoothing is an essential element of the automobile components manufacturing System and lean production respectively. It aims at balancing production volume as well as production mix and enhancing production efficiency by means of reducing waste, unevenness, and overburden of people or equipment. When using standard methods, leveling is only implementable in repetitive production environments with limited product diversity, i. e. large scale production. This study presents an adapted approach that can be used to apply leveling in low volume and high mix production.

This approach is based on the principles and methods of Group Technology. The fundamental idea of Group Technology is to subsume items (e. g. parts, processes, equipment or tools) into families according to their similarity and to take advantage of these groups to increase productivity in manufacturing. In context of the leveling approach presented in this study, Group Technology is utilized to group product types into a manageable number of product families according to their manufacturing similarity. Based on these families production leveling is realized in form of a family-oriented leveling pattern. This pattern is generated by applying a systematic procedure that is adapted from high volume production.

The objective of production leveling is to balance production volume as well as production mix by decoupling production orders and customer demand. In contrast to tayloristic large scale production, leveling distributes production volume and mix to equable short periods. The sequence of these periods describes a periodic manufacturing frequency, i. e. a repetitive pattern. According to this leveling pattern every product type is manufactured within a periodic interval, for example a day or a shift. The so called EPEI-value (every part every interval) depicts the duration of this interval. The general objective is to reduce the EPEI-value to a cost-effective minimum. This leads to maximal flexibility as well as to a balanced work load in production and logistic processes as well.

Effects of a Leveled Production – By decoupling production and customer demand leveling reduces waste, overburden, and unevenness which constitute the three main loss factors for productivity. It avoids variability in the production schedule caused by fluctuation in customer demand. Without leveling this fluctuation leads to waste in form of worker and machine idle times (in case of underutilized capacities) or quality problems, breakdowns, and defects (in case of over-burdened capacities). Leveling enables production to meet the customer demand without holding large volumes of inventory or spare capacities. Concurrently the risk of unsold goods is reduced. Inventories are limited to a controlled standard, the bullwhip-effect is diminished or ideally avoided, and lead times are shortened.

Despite these positive effects leveling is not synonymous with a waste-free built-to-order production. By contrast implementing leveling successfully often requires a controlled inventory of finished goods. In this case, a determined degree of waste that is counterbalanced by reducing unevenness and overburdening along the whole value stream is accepted. Furthermore leveling leads to a certain degree of stability in production processes that facilitates implementing other lean production methods like standardized work. Leveling can also be used to specify a target condition that is aimed at in the scope of the continuous improvement process (CIP). Comparing target condition and current situation highlights variability that represents an initial point for continuous improvement and sustainable problem solving.

Requirements for Production Leveling – To decouple production from customer demand and implement production leveling successfully, a controlled level of inventories is needed. In general leveling goes along with a mixed-model manufacturing in small lots and a high changeover frequency. Because of this minimal setup times for changeover are essential. Additionally leveling requires the utilization of general-purpose machinery and equipment on the one hand and flexible and multi-skilled workers on the other hand.

The application of conventional leveling (i. e. manufacturing every product type within a periodic interval) is limited to repetitive production environments characterized by constricted product diversity combined with a relative stable and predictable demand. Nevertheless it can be implemented in low volume and high mix production by means of an adapted leveling approach.

CONCLUSION

The proposed methodology of Value Stream Mapping adapted to High-Mix, Low-Volume manufacturing environments can help lean enthusiasts worldwide improve on manufacturing process technique. Although Value Stream Mapping as describe in Learning to See, has great use, it is quite difficult to implement in a High-Mix, Low-Volume environment.

However, with the adaptations, it can bring the same or greater benefits to the improvement of High-Mix, Low-Volume environments that the traditional methodology brings to repetitive processes. Should someone involved in the a manufacturing process which is high-mix, low volume, there is much greater value that the person would extract from using the methodology compared to the value that they would extract from Learning to See.

In traditional Value Stream Mapping, value streams are only considered for product families. This methodology looks at a holistic view of the manufacturing process to include the entire product manufactured inside the value stream. Not only does that bring value to high-mix, low-volume processes, yet it also gives insight into improving processes considering more than one family, even if the process exhibits a medium product mix.

REFERENCES

Bhim Singh, S.K. Garg, S.K. Sharma (2010). “Lean implementation and its benefits to production industry”, International Journal of Lean Six Sigma Vol. 1 No. 2, pp. 157-168.

Bisen, V. and Srivastava, S. (2009). Production and Operation Management. Lucknow, India Global Media, p. 175.

Drew, J., Blair, M. and Stefan, R. (2004). “Journey to Lean: Making operational Change Stick.

Gordonsville", USA: Palgrave Macmillan. pp. 5-25.

Drew, J., McCallum, B. and Rogenhofer, S. (2004). "Journey to lean making Operational change stick", Hampshire: Pallgrave macmillan.

Farhana Ferdousi, Amir Ahmed (2009). "An Investigation of Manufacturing Performance Improvement through Lean Production: A Study on Bangladeshi Garment Firms", International Journal of Business and Management volume l4, No 9 pp. 106-116.

Feld, M.W., (2000). Lean Manufacturing: Tools, Techniques, and how to use them. Boca Raton, London: The St. Lucie Press.

Gersten, F. (ed), and Riis, Jens O. (ed)., (2002). Continuous Improvement and Innovation. Bradford, GBR: Emerald Group Publishing Ltd. p. 41. [available at: http://site.ebrary.com/lib/oamk/Doc?id=10052730] [viewed on: 20.09.2011].

Heizer, J., and Render, B. (2000). Principles of Operations Management 4th Edition.

Hill, A. and Hill, T. (2009). Manufacturing operations strategy, 3rd ed., ISBN 978-0-230-52091-2

John, A., Meran, R., Roenpage, O. And Staudter, C. (2008). Six Sigma + Lean Toolset, Springer, ISBN 978-3-540-32349-5

Metall,arbetsutvecklingsenheten, "Metallarbarna och lean production", Metallarbetarnas fackforbund, 2002.

Mid-America Manufacturing Technology Center, 'Lean Manufacturing Utilizes Multiple Tools to Help Companies Improve Performance Objectives, 'The Manufacturer's Edge. (winter 2000), pp. 1-2.

Nitin Upadhye, S. G. Deshmukh (2010). "Suresh Garg, Lean manufacturing system for medium size manufacturing enterprises: an Indian case", International Journal of Management Science and Engineering Management, 5(5): pp. 362-375,

Poppendieck, M. "Principles of lean thinking", Technical Report, Poppendieck, LLC, USA, 2002.

Roy, R. N. (2005). Modern Approach to Operations Management. Daryaganj, Delhi, India: New Age International. p. 170-174.

Shahram Taj, Cristian Morosan, (2011). "The impact of lean operations on the Chinese manufacturing performance", Journal of Manufacturing Technology Management, Vol. 22 Issue: 2 pp. 223 – 240.

Shivanand, H.K., (2006). Flexible Manufacturing System. Daryaganj, Delhi, India: New Age International. pp. 4-50.

Vikas Kumar (2010). "JIT Based Quality Management: Concepts and Implications in Indian Context", International Journal of Engineering Science and Technology Vol. 2(1), pp. 40-50.

Wilson, L. (2009). How to Implement Lean Manufacturing. New York: McGraw-Hill Professional Publishing. pp. 29- 214.

Yu Cheng Wong, and Kuan Yew Wong (2011). "A Lean Manufacturing Framework for the Malaysian Electrical and Electronics Industry", 3rd International Conference on Information and Financial Engineering.

Yu Cheng Wong, Kuan Yew Wong and Anwar Ali (2009). "A Study on Lean manufacturing implementation in the Malaysian Electrical and Electronics industry", European Journal of Scientific Research, Vol.38, No.4, pp. 521-535.

Zhi-Xiang Chen, Kim Hua Tan, (2011). "The perceived impact of JIT implementation on operations performance: Evidence from Chinese firms", Journal of Advances in Management Research, Vol. 8 Issue: 2 pp. 213 – 235.

Corresponding Author

Mohan Shankar Futane*

Ph.D. Research Student, MUIT, Lucknow

E-Mail – phutanemohan@gmail.com