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Recent Trend in Application Of Value Stream Mapping: A Literature Review

Vikash Sharma[1], Dr. M. M. Goud[2]

[1]*Production and industrial engineering& PEC (Deemed to be University), ptvikashsharma@gmail.com*
[2]*Production and industrial engineering& PEC (Deemed to be university), mudigoud@gmail.com*

Abstract— Lean manufacturing (LM), a well-known manufacturing strategy, focuses on customer value creation through minimization of waste. The academic research in lean research is limited to Make-to-Stock or Mass Production. However, research lacks specific insights on the implementation of lean in Job-shop or Engineered to order (ETO) environment. Lean implementation initiates with value stream mapping (VSM), depicting flow of material, and information towards customer value creation. VSM are often criticized for their static nature. Thus, this paper investigates Research papers available from 2008 to 2017 to analyse the literature based on the area of application (a type of industry), tools used with VSM, author's profile and country, factor analysis and suggestion or new method proposed to identify the reasons of not implementing Lean in Job-shop (E-T-O).

Key words: Lean Manufacturing, Job-shop production, Value stream Mapping, Simulation-modelling.

I. INTRODUCTION

The term Lean was first coined by (Womack, Jones, & Roos, 1990) in his book "The Machine That can change the world'' to describe the working philosophy of the Toyota Production System during international motor vehicle program (IMVP). This philosophy is based on the concept of customer value creation through waste elimination. In the last two decades, this philosophy was considered as the most important manufacturing strategy to acquire world-class manufacturing outputs (Cottyn, Landeghem, Stockman, & Derammelaere, 2011; Kodali, 2011).

Traditionally, academic research in Lean implementation focused on Make-to-Stock or Mass Production system and lacks the specific insights on implementation of lean in Job-shop (Engineer-to-order) production systems (D Matt, (2013); Jasti & Kodali, 2014; Gurumurthy & kodali, *2014).* But the present era is highly volatile, complex and uncertain in nature where importance of highly flexible systems which deals in highly customized products increased. These Manufacturing firms are trying to remain competitive by adopting advanced tools, techniques, and strategies. Lean manufacturing strategy may be one of the best strategies to remain competitive and acquiring world class manufacturing out-puts. It comprises number of tools like *Pull Production, Kanban, Kaizen, Small Lots, Poka-yoke, Heijunka*, and *Value Stream Mapping* (VSM) (Womack et al., 1990, Pavnaskar et al., (2003), Shah and Ward (2003), Detty and Yingling (2000), and Bhasin and Burcher (2006).

Generally, lean implementation in any production systems initiates with identification of value and value-streams to explore the wastes. It is the popular lean tool, Mike Rother and John Shook introduced it in his book "Learning to See" in 1998 which was Earlier known as material and information flow mapping in Toyota production system. it depicts the end-to-end flow of material, information across the value chain, and highlight the process inefficiencies, communication mismatches, guidelines for the improvement (Abdulmalek & Rajgopal, 2007; Rother & Shook, 2003; Seth & Gupta, 2005). But, generally criticized due to its static nature, known as a pen and pencil technique and a time-consuming process (Braglia, Carmignani, & Zammori, 2006; Kodali, 2011; Lian & Van Landeghem, 2007, Hines et al 1998). Thus, this paper investigates Research papers available from 2008 to 2017 to analyse the literature based on the area of application (a type of industry), tools used with VSM, author's profile and country, factor analysis and suggestion or new method proposed to identify the reasons of not implementing Lean in Job-shop (E-T-O).

II. REVIEW METHODOLOGY

In the present era of internet, the best way to start research is by using internet and database available. Therefore, google scholar is used to reviewing the available literature on the application of value stream mapping. Initially, keywords were used "lean manufacturing", "application of lean manufacturing" and "literature review on lean manufacturing" but after reading some papers it was realized that lean manufacturing is a vast field which comprises of several tools, techniques and value stream mapping is one of them. then after keywords were used "value stream mapping", "application of value stream mapping", "value stream mapping a literature review" and "value stream mapping: a case study".

During this, there were two papers reviewed the literature in which (B. Singh, Garg, & Sharma, 2011) reviewed literature from 1990 to 2008 and differentiate the literature in four categories based on work (conceptual, empirical, case study and survey). He reviled that 38% papers based on the case study, 32% as conceptual work, 24% as empirical work, and 6%as survey articles. (Kodali, 2011) also reviewed the literature available on the application of lean manufacturing and value stream mapping from 1997 to 2008 and developed a taxonomy based on manufacturing systems.

However, after that, there is no such paper available in the literature on value stream mapping technique which highlights the literature based on the area of application (a type of industry), tools used with VSM, author's profile and country, factor analysis and suggestion or new method proposed. In this paper, we try to analyse the recent trend of the application of value stream mapping technique and apply value stream mapping technique with simulation software in M-T-O based organization.

The above-mentioned method for initiating research is best suitable but it also has many limitations like the credibility of the available papers and the research is limited to only the keywords used so many good papers on the topic left behind.

III. LITERATURE REVIEW

S.NO.	AUTHOR/ YEAR	COUNTRY	TYPE OF INDUSTRY	TOOLS/ TECHNIQUE/ APPROACHES	FACTORS ANALYSIS/ SUGGESTIONS
1.	(Behnam, Ayough, & Mirghaderi, 2018)	Iran	Natural fiber clothing industry	VSM+ Analytical Network Approach	Identify mudas (waste) in the production line.
2.	(Dadashnejad & Valmohammadi, 2017)	Iran		VSM+descriptive inferential methods.	Effect of VSM on overall equipment efficiency.
3.	(Seth, Seth, & Dhariwal, 2017)	India+ Qatar	Heavy duty electrical transformer maker based on ETO concept	VSM+ Taguchi Method	Cycle time reduction.
4.	(Ali, Petersen, & Schneider, 2016)	Sweden+ Germany	Software	Flow Assisted VSM	Highlight that how VSM is helpful in identifying challenges and improvement in information flow.
5.	(Alvandi, Li, Schonemann, Kara, & Herrmann, 2016)	Germany+ Australia	Multi-product manufacturing system	VSM+ Simulation modeling	Develop a methodology for modeling multi-product manufacturing systems with the dynamic material, energy and information flow with the aim to generate economic and environmental value stream maps.
6.	(De Steur, Wesana, Dora, Pearce, & Gellynck, 2016)	Belgium+ Uganda+ UK	Agriculture (supply chain)	VSM+ Simulation modeling	Through literature review highlight the importance of value stream mapping technique with simulation in agricultural industry.

7.	(Vinodh, Ben Ruben, & Asokan, 2016)	India		VSM+ life cycle assessment tool(LCA)	Developed a new framework for VSM integrated with LCA to ensure sustainable performance.
8.	(Sunk, Kuhlang, Edtmayr, & Sihn, 2017)	Germany		VSM+ Process Management+ MTM	Highlight how these tools helpful in improving the process, value streams, and individual system.
9.	(Tortorella et al., 2016)	Brazil	Public Healthcare	VSM	Demonstrate the benefits of analyzing healthcare processes using VSM.
10.	(Sunk et al., 2017)	Austria	Automobile industry	IMPROVED VSM	Suggested that new data lines are required to represent parameters and indicators of sustainability.
11.	(Henrique, Rentes, Godinho Filho, & Esposto, 2016)	Brazil	Healthcare	New VSM	Present a new VSM technique for the healthcare industry.
12.	(Kasava, Yusof, Khademi, & Saman, 2015)	Malaysia	Aircraft industry	sustainable domain VSM	Proposed a sustainable domain VSM also highlighted the issues and challenges associated with sustainable domain VSM.
13.	(Suarez-Barraza, Miguel-Davila, & Vasquez-García, 2016)	Mexico+ Spain	Operation management	Supply chain VSM	Describe supply chain VSM to understand the competitive priorities of volume and delivery.
14.	(Dogan & Unutulmaz, 2016)	Turkey	Healthcare	VSM+ Simulation	Describe how VSM with simulation is proven to be an effective tool in healthcare.
15.	(Sabaghi, Rostamzadeh, & Mascle, 2015)	Canada + Iran+ Malaysia	Plastic fabrication company	Total productive maintenance + ANOVA+ JIT+ VSM + simulation	Highlight the importance of various lean tools when compliment to each other.
16.	(Toivonen & Siitonen, 2016)	Finland	Complex systems	VSM+TRIZ Analysis+ ideation tools	Proposed a new VSM Technique to overcome the weakness associated with traditional VSM and enable systematic idea generation based on the holistic understanding of the system.
17.	(Faulkner & Badurdeen, 2014)	USA		Sustainable VSM	Presents a comprehensive methodology to develop Sustainable Value Stream Mapping to identify environmental performance, the societal sustainability assessment as well as visualization methods to present the information in Value Stream Mapping.
18.	(Taylor, Schmidtke, Heiser, & Hinrichsen, 2014)	Germany	Complex production systems	VSM+ Simulation	Developed a simulation-enhanced value stream mapping approach for optimization of complex production environments.

19.	(Venkataraman, Ramnath, Kumar, & Elanchezhian, 2014)	India	Crankshaft manufacturing system	VSM	A case study based on cycle time reduction in the machining process
20.	(Matt, 2014)	Italy	Engineer-to-order (E-T-O) production system	VSM	Develop a set of guidelines to use VSM technique in an E-T-O production system
21.	(Pereira Librelato, Pacheco Lacerda, Henrique Rodrigues, & Rafael Veit, 2014)	Brazil	AUTOMOTIVE INDUSTRY	Theory of constraint (TOC) + VSM	indicate the complementary aspects between TOC and VSM and their benefits to the organization.
22.	(Vamsi Krishna Jasti & Sharma, 2014)	India	Auto components industry	VSM	Highlight the VSM positive impact on process ratio, TAKT time, process inventory level, line speed, total lead and process time and reduced manpower.
23.	(H. S. and A. Singh, 2013)	India	Automotive industry	VSM	Highlight how VSM helps in reducing cycle time, lead time, work- in-process (WIP) inventory.
24.	(S. Vinodh, 2013)	India+ USA	Camshaft industry	VSM+ simulation modelling	explored the practical feasibility of value stream mapping (VSM) for acquiring leanness.
25.	(Schulze et al., 2013)	Japan	Car manufacturing company	4I Framework+ VSM	investigate how value stream mapping (VSM) and its implementation in new product development (NPD) affect organizational learning (OL) in development processes.
26.	(Teichgraber & De Bucourt, 2012)	Germany	Healthcare equipment manufacturing	VSM	Identify the non-value-added activities endovascular stents supplier to the patient.
27.	(Kodali, 2011)	India	Job-shop production system	VSM+ simulation	presents an application of VSM with simulation during the design of lean manufacturing systems.
28.	(B. Singh & Sharma, 2009)	India		VSM	Highlight the importance of VSM in lean implementation in the manufacturing industry.
29.	(Serrano Lasa, Ochoa Laburu, & de Castro Vila, 2008)	Spain		VSM + Simulation modeling	Highlight the importance of VSM in manufacturing system designing.
30.	(Seth, Seth, & Goel, 2008)	India	Oil Industry	VSM	Apply VSM for waste minimization in the process side of the supply chain of cottonseed oil industry.

IV. KEY FINDING FROM LITERATURE REVIEW

In last decade, the implementation of value stream mapping technique outside automotive or mass production increases but not at a faster rate as it could be. the reason associated with are highlighted by some other researchers are as follow:

1) The redundancy of program and unawareness in employees to implement the concept and principles of the lean philosophy are the two major reasons (Bamber and dale, 2000).
2) A number of researchers and practitioners had developed several tools and techniques to investigate individual manufacturing system, most of them fall short in linking and visualizing the nature of entire value stream because of the high variability in products and demand (B. Singh, Garg, Sharma, & Grewal, 2010).
3) Forno, Pereira, Forcellini, & Kipper, (2014) highlighted the possible reasons associated with value stream mapping technique. This paper categories these reasons in 11 different sections which are as lack of integration between processes, lack of clarity of processes, lack of product modularity, low skilled workforce, lack of process stability, difficulties in measuring data in processes, Obsolescence of the current state map, small batches with high mixed production, too flexible production, too intuitive process, lack of support from management and some other problem based on the actual situation of organization.
4) Jaiprakash Bhamu & Sangwan, (2012) highlight use of wrong tools, use of one tool to solve all problems, lack of understanding and poor decision making are the major reasons for lean implementation failure.
5) Value stream mapping technique can be applied any industry irrespective of its type. In literature, many researchers used VSM technique in different -2 field like clothing industry, healthcare, complex production system (job-shop and ETO) and in software development industry. Literature also indicates that we must use some contemporary complimentary tools with VSM to make it more effective in the present scenario of the high variability of products.
6) The key finding that lean or VSM does not give satisfactory results in highly complex environments as it gives in the stable environment over a long period of time, most of the organization while applying lean or VSM focused on MUDA (7wastes). But in highly flexible environment, Muda and Muri depends on MURA i.e. Unevenness or irregularity that governs the systems in highly complex environments.

V. CONCLUSION

This paper studied the literature from 2008 to 2017 analyse the literature based on the area of application (a type of industry), tools used with VSM, author's profile and country, factor analysis and suggestion or new method proposed to identify the reasons of not implementing Lean in Job-shop (E-T-O). This paper will help the future researcher to concentrate on the factors identified through literature survey while applying lean philosophy in job-shop production systems.

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