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The Role of Value Stream Mapping (VSM) as an Integrated Approach in Lean Manufacturing

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***Abstract*— Leanness in Lean Manufacturing mainly leads to the elimination of non-value added activities named as wastes and there are many strategies available to tackle these wastes. Lean implementation is one of the renowned strategy which utilizes lean implementation tools (to detect and reduce wastes) like Value Stream Mapping (VSM) which is one of the most common tool. It has been observed that VSM has many different types and each type is specific to attain some certain wastes affecting but most of the time the utilization of traditional VSM has been observed regardless of studying its different types and their specific utilization. In order to fulfill this gap, the aim of this research is to study different types of VSM and their utilization for specific wastes. A state of art literature review based methodology has been utilized and the results attained clearly states that, the most common types of VSM available for lean manufacturing are process activity mapping, Production Variety Funnel, Quality Filter Mapping, Demand Amplification Mapping, Decision Point Analysis, Supply Chain Response Matrix and Physical Structure Mapping which are feasible to handle wastes like over transportation, over processing, over defects, over inventory, over production and over waiting based on their tool origin respectively. Moreover, it has been observed that the type physical structure mapping is not carrying ability to tackle wastes but helpful to improve physical structure. The contribution of this research is the development of integrated approach regarding types of VSM in relation with wastes affecting manufacturing sector**

***Index Terms*— Lean Manufacturing; Wastes; Value Stream Mapping (VSM); VSM Types: VSM integration**

I. INTRODUCTION

Lean manufacturing is an important technique in industrial firms due to its capability to decrease wastes and to improve operations of any manufacturing industry [1]. Japanese initially used Lean after the World War II, when their economy was severely collapsed because of business decline. Consequently, car production was badly affected even of Toyota, which is a top car manufacturing company. This bad condition of economy prevailed when a large number of unsold cars have to be kept in inventory and furthermore there was a huge drop in the demand of cars [2]. Company was unable to launch its new-modelled cars in market under these conditions caused by financial limitations as well as space limitations because of already present a large number of unsold cars in stock [3],[4]. Under these circumstances, Toyota production manager, Taichii Ohno decided to take up an initiative and made a new production plan for the company termed as "Toyota Production System (TPS)". This TPS system has been further adopted by the United States (US) manufacturing industries and production plan was able enough to emphasis on what is the demand instead of producing cars on massive scale [5]. Afterwards, the introduction about the wastes affecting system has been introduced by Taichii Ohno [6],[7].

Afterwards, when the book named as the "The Machine that Changed the World" written by Womack and Jones [8] has further stairs the manufacturing industries of United States (US) to adopt TPM ideology in their manufacturing operations. They further called this ideology as Lean Manufacturing (LM). Subsequently, the Krafcik [9] in their investigations and study during their research explained the term lean as an effort to minimize to produce less (according to order) than mass production. Nevertheless, the final and perfect definition of lean is still not finalized because of its extreme vast scope [10] but it has been observed that

the lean concept has been speeded drastically when the US has adopted this ideology in their manufacturing operations and originated the requirement of study of lean tools for lean implementation.

II. LITERATURE REVIEW

i. Wastes Affecting Lean Manufacturing (LM)

Waste is something, which is not adding value to any operations [11]. The agenda of lean implementation is the waste reduction to attain value added operations for the customers [12]. Keeping in view of internal and external customers, the value added activities are the positive activities for any operation and worth paying for both type of customers [13]. Regarding this perspective of adding values in ongoing operations, many researchers have followed different ideologies to reduce wastes [8] [14] [15] [16] [17] [18] but Taiichi Ohno has considered as the forger in this matter who had primarily noticed and explicated the wastes to the industry and the research world. [14].

It has been observed that the origination of wastes is utterly dependent on the manufacturing process involved in any system and its application on the required regime, but the Taiichi Ohno, who is one of the Lean Guru has been successful to generalize the wastes into seven different types as mentioned below [12] [14] [19] [20].

1) Over motion
2) Over production
3) Over inventory
4) Over defects
5) Over processing
6) Over waiting
7) Over transportation

ii. Lean Implementation Tool Types

In accordance to previous researches regarding the lean tools clearly states that the lean tools are highly beneficial and adoptable [21] because of their abilities like detection and minimization of wastes affecting any manufacturing system. Moreover, it has been observed that there is one tool named as Value Stream Mapping (VSM) whose benefits and ways to adoption has been introduced by many researchers but the credit goes to Rother and Shook [22], as they had clearly explained the way to how to utilize a lot of lean tools in one combination.

Subsequently, Bhuiyan, et al. [23] and Melton [24] in their research studies have emphasized some of the other lean implementation tools like Kanban, visual control, mistake proofing, 5S and Poka yoke and afterwards, There are some tools like Total Preventive Maintenance (TPM), Business Process Reengineering (BPR), Taguchi, Kaizen, agile manufacturing, Single Minute Exchange of Dies (SMED), Poka Yoke and Just In Time (JIT) which have been utilized and explained by Ahmad and Benson [25]. The most common types of lean implementation tools are:-

1) Value Stream Mapping (VSM)
2) 5s Just in Time
3) Visual management
4) 5s
5) Kanban
6) One-piece flow
7) Single minute exchange of dies
8) Kaizen
9) Cellular manufacturing
10) Total productive maintenance(TPM)
11) Poka yoke
12) Line balancing

It has been observed that all of the mentioned tools are not only helpful to implement lean but also helpful to improve operations in any manufacturing industry [26]. Moreover, some of the researchers Pavnaskar, et al. [27], Karim and Arif-Uz-Zaman [28] and Elnadi [29] has given an observation that the selection of tools is entirely dependent on the type of cause effecting the system and there is no clear methodology regarding the tools selection.

Pavnaskar, et al. [27] and Amin and Karim [33] in their research study has clearly confirmed that, as the dimensions and the orientations of each tools is entirely dependent on its ability and capability to how to minimize wastes and the problems affecting in manufacturing industry. Hence, there seems to be no certain exact technique to link lean implementation tools in one loop and mold them to utilize in a group. Srichuachom [34] in his research study has tried to utilize some of these tools in combination.

In order to understand the flow of any process, according to Esfandyari, et al. [30] and Esfandyari [26], VSM is considered as one of the excellent and the most basic tools, because, it carries the abilities to detect issues and problems in any ongoing operations by drawing the flow process. Moreover, since, the VSM has also the capability to utilize combination of tools like Kanban, Kaizen, cellular manufacturing, Takt time, JIT and many more during the formation of future state map, so this ability of VSM further increases its worth among the other tools available [22]. Subsequently, it has been observed that Anand and Kodali [31] in their research study have developed a list of lean tools which they have further subdivided into different groups, Eswaramoorthi, et al. [32] in

Table I
VSM tool types

Sr. No	Name of Tools	Tool Description
1	Decision Point Analysis	Moderate to tackle over production, over waiting & over inventory and low capable for over processing
2	Supply Chain Response Matrix	Highly helpful to tackle over waiting and over inventory. Moderate to tackle over production and low capable for over motion
3	Quality Filter Mapping	Moderate to tackle over defects and low capable for over production and processing
4	Demand Amplification Mapping	Highly helpful to tackle over inventory. Moderate to tackle over production and over waiting
5	Production Variety Funnel	Moderate to tackle over processing and inventory and low capable for over waiting
6	Process Activity Mapping	Highly helpful to tackle over transportation, over waiting, over motion, over processing. Moderate to tackle unnecessary motion and low capable for over production
7	Physical Structure Mapping	Highly capable to improve physical structure and low capability for waste detection

their study recommended 36 different lean tools as per their application in machinery tool industry.

Source: Hines and Rich [20], Ramesh and Kodali [41] and Rafique [11]

III. METHODOLOGY

A literature review based methodology has been utilized in this section to get an idea about requirement of selection of Value Stream Mapping (VSM) as a selected Tool. VSM is a concept of drawing or mapping things from raw material to customer in the form of material and information flow. VSM is helpful to differentiate between non-value added and added activates and to understand the flow of any process [3] [35].

Rother and Shook [22] mentioned in their book that VSM is inclusive of current and future state map to explain and improve the complete process of manufacturing and carries a common language inclusive of icons and symbols that is helpful to understand among experts related to VSM [36]. Moreover, Serrano Lasa, et al. [37] states and considered future state map as an complete package for lean implementation which involves lean implementation tools like kaizen, pull system, pace-maker process and Takt time and marks the VSM as a top leading tool and contributor regarding lean implementation among manufacturing processes. Moreover, Abdulmalek and Rajgopal [38] also seconds this ideology.

So, authors of this research study have no doubt to say about VSM as an excellent approach which not only emphases on the wastes elimination but also an modelling tool to study current and future situation on any manufacturing industry [26].

IV. RESULTS & DISCUSSION

VSM is an approach, which involves the study of current manufacturing operations and the formation of future state map to improve the current situation by reducing wastes affecting system and ongoing process improvements. VSM is inclusive of different types (as mentioned in Table 1) named as decision point analysis, process activity mapping, product variety funnel, supply chain response matrix, quality filter mapping, physical structure mapping and demand amplification mapping, and demand amplification mapping based on the mode of application regime and origin of tools [20] [41] [42].

Hines and Rich [20] further explained that the none of the VSM type carries the ability to tackle all types of wastes involved in process. In fact, out of seven different types of VSM available and as mentioned in Table 1, each VSM tool can cope each certain wastes and some of the other wastes involved in the system but not all types of tools as motioned in previously. Moreover, Pude, et al. [43] and Ramesh and Kodali [41] have mentioned in their studies that for the case of manufacturing, out of these seven tools, the best tool that serves the need in term of process flow is the process activity mapping as compared to the basic VSM.

However, basic VSM involves the generation of flow of material and time, which is highly feasible to study deep down ongoing operations and helpful to detect the unknown wastes affecting the system. Ramesh and Kodali [38], Vinodh, et al. [44] and Mostafa, et al. [45] and some of the other researchers have seconds that the basic VSM is more feasible and preferable for the formation of wastes detection and current state map. However, the types of VSM like process activity mapping, Production Variety Funnel, Quality Filter Mapping, Demand Amplification Mapping, Decision Point Analysis, Supply Chain Response Matrix and Physical Structure Mapping, which are feasible to handle wastes like over transportation, over processing, over defects, over inventory, over production and over waiting based on their tool origin respectively.

Moreover, it has been observed that the type physical structure mapping is not carrying ability to tackle wastes but helpful to improve physical structure. But for the cases where the wastes need to be detected and the ongoing plant operational study is required for

problem detection, then in such cases the basic VSM study is the most appropriate option.

V. CONCLUSION

The research clearly concludes that VSM is one of the very powerful tool for lean implementation. And it has been observed that in order to handle wastes like over transportation, over processing, over defects, over inventory, over production and over waiting, the type of VSM tools like process activity mapping, Production Variety Funnel, Quality Filter Mapping, Demand Amplification Mapping, Decision Point Analysis, Supply Chain Response Matrix and Physical Structure Mapping are helpful to handle respectively. Additionally, it has been observed that among these different types of VSM, there is one type named as Physical Structure Mapping which is not feasible to tackle wastes and in fact, more feasible to improve physical strengths. In last, the strength of this research is the conceptualization of tactic through previous literature, which will help the future researchers to understand the integration between the wastes types and types of VSM with a limitation of reliability on the previous research.

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