

Lean manufacturing through theory of constraints: An overview in literature arena

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Abstract— Lean Manufacturing is the paradigm that stipulates the performance improvement through the elimination of wastes in organizations. Theory of Constraints (TOC) is the principle that facilitates the performance improvement through the removal of constraints in organizations. As the primary objective of both of these approaches is 'performance improvement', there is a need to integrate both. In order to theoretically examine this aspect, the literature survey conducted in this direction is being reported in this paper. The literature survey was conducted by reviewing the researches conducted for examining the implementation of lean manufacturing paradigm and TOC principles. The information gathered by conducting this literature survey are presented in this paper.

Index Terms— Lean manufacturing, Theory of constraints, Literature review, Drum-Buffer-Rope, Toyota manufacturing systems, Value stream mapping, 5s, Kaizen, Total productive maintenance.

1 INTRODUCTION

During the past three decades, companies have been facing tough competition. As a result, the demand of the customers has been dynamic. Due to this kind of dynamic demand, customers have been demanding varieties of models of products. The volume of customers demanding each model has been volatile. In order to face this situation, modern companies are required to produce varieties of the models of the same product in differing volumes. Customers also demand the products at low price. Hence, the modern manufactures are in need of producing the products by inputting minimum resources and drawing maximum outcomes. While carrying out this task, wastages are to be avoided as modern customers are not willing to pay the price for making wastages. Today, the companies are adopting lean manufacturing paradigm to face this situation. These companies adopt several tools and techniques while implementing lean manufacturing paradigm.

In the field of operations Management the technique TOC is made available to reduce the constraints. Although, as mentioned earlier, many tools and techniques have been used intensively, TOC technique is rarely used while implementing lean manufacturing paradigm in organizations. While realizing this research gap, the literature survey being reported in this paper was carried out.

During the conduct of the research being reported in this paper theory and practice of carrying out designing and manufacturing of submersible pumps were studied. At the

end of conducting this implementation study, the manufacturing of one sub-assembly namely motor was considered as the constraints. In order to overcome the constraints, TOC techniques needs to be integrated with the lean manufacturing paradigm. After this introduction section, the literature surveyed to examine the research applications of TOC in lean manufacturing researches is described. This literature survey was carried out under two domains. In the first domain, the tools and techniques of lean manufacturing were studied. In the second domain, researchers on TOC were studied. The details gathered by reviewing these papers under two domains are highlighted in the subsequent two sections.

2 LEAN MANUFACTURING

Lean manufacturing has its foundation on Toyota Production System. The features of lean manufacturing were developed from Toyota from production system and brought to the world by James Womack and two of this co-author by contributing a book title "The Machine That Changed the World" [7]. Lean Manufacturing enunciates to eliminate waste while producing economically products in varied volumes. Academics and practitioners have reported adoption and application of several tools and techniques like 5S, Kaizen, Single Minute Exchange of Dies (SMED) and Total Productive Maintenance (TPM) while implementing lean Manufacturing paradigm in organizations [8]. Till about the year 2000, both academics and practitioners were not clear about the beginning and ending faces of implementing lean manufacturing program in organizations. However from the year 2000, academics and researchers drew an inference from the researches that, the Value Stream Mapping (VSM) shall be the first tool to be applied while implementing lean manufacturing paradigm in organizations [9]. While implementing VSM, the Current State Map (CSM) is drawn to picturize the activities carried out in the area of study from the perspective of implementing lean manufacturing paradigm. A major measure employed while implementing lean manufacturing paradigm is the fulfillment of the takt time. Takt time refers to the rate at which the product under study is to be produced to meet the customer's requirements. The CSM would reveal the constraints

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that would prevent the meeting of takt time.

3 TOOLS AND TECHNIQUES EMPLOYED IN LEAN MANUFACTURING IMPLEMENTATION

As mentioned in previous section, lean manufacturing has been finding wide applications in organizations of all types. Besides practitioners, researchers have been intensively exploring the ways of implementing lean manufacturing paradigm in organizations. The numbers of papers and the journals publishing them have been so numerous that, during the recent years, two papers reporting the review of papers on Lean Manufacturing have appeared in literature arena. The contributions of these papers are briefly described in this section.

Stone (2012) has mentioned that, from 1970s onwards, scholars have been addressing the lean manufacturing issues in literature arena. However, till 1990s, the word lean was not used to mention lean manufacturing principles. From 1991, when Womack et al (1990) published the book titled "The Machine That Changed the World", the title lean manufacturing was used. While the core principles of lean manufacturing rest on the Toyota Production System, waste elimination and value addition are the basic principles of the lean manufacturing paradigm. This author has traced the publication of papers on lean manufacturing over the past 40 years. Then this author has discussed the progression of researches on lean manufacturing. According to this author, this progression has taken place through five phases. The first phase is called as Discovery phase which took place from 1970 to 1990. The beginning of this phase was marked by Drucker's contribution on lean six sigma under the name of "Toyota Way". The end of this phase was marked by the book titled "The Machine That Changed the World" which was authored by Womack et al (1990).

The second phase of progression is titled as dissemination phase which took place from 1991 to 1996. As the title implies, during the dissemination phase, the tools of lean manufacturing were exposed in few industries. Automobile industry is prominent among them to absorb lean manufacturing principles. During this phase of progression, researchers including Dr. James Womack strove to determine the ways of converting mass production companies into lean manufacturing enterprises. The third phase of progression on lean manufacturing principles is titled as implementation phase. This phase occurred from 1997 to 2000. As the title implies, during this phase, implementation of lean manufacturing involving empirical studies in literature arena was largely carried out. Yet the depth of implementing lean manufacturing paradigm in organizations during this period was not very intensive.

The fourth Phase of the progression on lean manufacturing principles is titled as Enterprise phase. During this phase, the scope of implementing lean manufacturing expanded from manufacturing to other areas like marketing, sales and accounting. This phase occurred during 2001-2005. The number of research article published during this phase

was so high that a review paper by Hines et al (2004) appeared in literature arena exclusively to review the researches on lean manufacturing. An important development during this phase is the appearance of value stream mapping technique which can be used to identify the value streams of using products. The fifth phase as titled as Performance Phase.

According to this author, this phase occurred during 2006-2009. This author has mentioned that, the increasing adoption of lean manufacturing principles in organizations is attributed to the growth of Toyota Motor Company. This author has mentioned that, the publication of papers on lean manufacturing practices has been widespread. Infact as many as 82 journals have published papers.

Arlbjorn and Freytag (2013) have reviewed 154 articles that have appeared in 105 reputed peer-reviewed journals. These authors have mentioned that, the routes of lean manufacturing rest on F.W.Taylor's works on scientific management which appeared in 1912. However it became formal only when Womack et al (1990) brought out the book "The Machine That Changed the World". Thereafter, researches and implementation on lean manufacturing occurred. According to the concepts mentioned in this paper, lean manufacturing implementation is required to take place in three levels. In the first level, the lean philosophy is defined. In the second level, the principles of lean manufacturing are drawn. In the third level, tools and techniques of implementing are chosen. In a framework presented in this paper, as many as 15 tools and techniques of lean manufacturing are listed. An important observation made in this paper is the suggestion made to employ 'Theory of Constraints'.

In both of the above papers, it is mentioned that, some criticisms on lean manufacturing have appeared in literature arena. On the other hand, enormous amount of waste elimination and value addition have been reported to have been reaped in organizations on implementing lean manufacturing principles in organizations. This contradictory observation reveal that, further researches are required to be carried out to determine the effective ways of achieving value addition and waste elimination. In context of drawing this information, it was observed that value stream mapping has been recognized in the recent years by the researchers [6] as the beginning technique of implementing lean manufacturing in organizations.

An unique feature of VSM is the identification of constraints that will result in the creation of waste and retardation of value generation. TOC technique is the most proven technique for overcoming the constraints. Quite interestingly, Arlbjorn and Freytag (2013) have mentioned the need of applying TOC technique in lean manufacturing programs. These inferences coincide with those reported in Taj and Berro (2006). In the context of this observation, the literature survey being reported here was further focused to identify the principles of TOC and its application in lean manufacturing program. The information and knowledge gathered by conducting this literature survey in this direction are presented in the next section.

4 TOC AND ITS APPLICATIONS

Because of its wide popularity, enormous number of papers on TOC has appeared in literature arena. As surveying all these papers is a cumbersome exercise, the contents of two literature review papers on TOC were reviewed during the conduct of the literature survey being reported here. The information and knowledge gathered by reviewing these two papers are presented in this section.

Rahman (1998) has stated that from 1970s, three approaches questioning the basic principles emerged in literature arena. These principles are 'materials requirement planning', Just in Time (JIT) manufacturing and TOC. TOC has got routes on optimized production time tables which were developed in middle 1980s. Thereafter many books dealing implicitly or explicitly the TOC approach appeared. TOC is encompassed with four facets. The first facet defines the philosophy of TOC through six steps. These steps begin with the identification of the constraints and ends with elevation of the same. The second facet of TOC is Drum-Buffer-Rope and Buffer Management. This facet consists of nine rules. One of these rules stipulates that, the size of the batch shall be flexible. Another rule is that, an hour lost in bottleneck is equivalent to the thinking process. The fourth facet focuses on making money. The important parameters that should be measured are net profit, return on investment and cash flow. This author has mentioned that several books on TOC like 'The Goal and The Race' have delineated the TOC concept. Besides an exclusively journal titled 'Theory of Constraint Journal' is published. This author has listed, as many as 42 journals from which he could gather 139 papers. After reviewing these papers, this author has mentioned that, TOC has the capability to reduce the inventory level of the companies. While concluding this paper, this author has stated that, while TOC has found wide application in the area of Production and Management Accounting, it has not found much application in business and service areas.

Many observations of Watson et al (2007) coincide with that of Rahman (1998). Watson et al (2007) have also mentioned that, TOC was developed in the year 1979 from Optimized Production Time Tables. These authors have also mentioned that, enormous number of researchers on TOC has been reported in literature arena. These authors have also mentioned that the growth of TOC was marked by the appearance of many books like 'The Goal and The Race'. TOC has also found applications in fortune 500 companies. These authors have traced the history of TOC from the year 1997 to 2005. These authors have mentioned that TOC is yet to find the full-fledged top management supported implementation in many companies. These authors have mentioned that the benefits of implementing TOC exceed that of lean manufacturing and Total Quality Management. These authors have enumerated the benefits of implementing TOC in organizations. These improvements include reduction in manufacturing cycle time and decrease in the inventory. The findings of both Rahman (1998) and Watson et al (2007) have indicated that the application of TOC in lean manufacturing program will facilitate to achieve significant performance improvement in the

organizations.

5 CONCLUSION

During the past two decades, the implementation of lean manufacturing paradigm has been enabling the organizations to enhance the competitive strength through waste elimination and value addition endeavors. Of late researches have affirmed that VSM has to be a beginning technique for implementing lean manufacturing paradigm in organizations. The CSM of VSM facilitates to identify the constraints that would retard the implementation of waste elimination and value addition endeavours. The overcoming of constraints can be carried out by applying TOC technique [10]. In the context of drawing this observation, interest evoked to examine the views of researchers about this observation. In order to examine this aspect the literature survey presented in this paper was carried out. Enormous number of papers on applying lean manufacturing and TOC techniques in practice has appeared under these two domains. As reviewing all these papers would be a cumbersome task, the literature review papers that appeared under these domains were identified under reviewed. The information and knowledge gathered by reviewing these papers have been briefly presented in this paper. Quite interestingly these information and knowledge have favored the adoption of TOC while implementing lean manufacturing paradigm in organizations. However few authors of the paper have mentioned that TOC is yet to find wide applications in lean manufacturing programs of organizations. In the next context of noticing this observation, this paper concluded by suggesting to carry out researchers on applying study of the impact of TOC in lean manufacturing programmes being pursued in several areas and organizations.

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