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LEAN SIX SIGMA (LSS) TO REDUCE COUPLER MOVEMENT TIME: A REVIEW

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ABSTRACT

REVIEW ARTICLE

Our topic of concern is to reduce the coupler movement time that leads to further decrease the overall cycle time of Wagon maintenance. Lean thinking tools focus on a process's speed and efficiency, whereas Six Sigma (LSS) tools focus on its precision and accuracy. Lean Six Sigma is one of the most powerful tools to find out root cause of the problem. In this review paper different research paper on Lean & Six Sigma in different field of engineering, how lean thinking and six sigma integrated to identify complex to complex problem and find out the root cause of the problem. DMAIC is one the fastest technique of LSS, which will be applied in the problem to reduce the coupler movement time in span of three to four month after implementation of LSS.

1. INTRODUCTION

In Wagon Workshop, there are a lot of activities involved during POH (periodic overhauling) of wagons like body repair work, stripping and gas cutting of CBC and its repair, under frame repair, bogie overhauling & dismantling, CTRB repair & mounting, Air brake overhauling & testing, wheel Turing & gauging, lowering of bogie on wheelset, lowering of wagon body on Bogie and last painting & stenciling of wagons.

Coupling facilitates interconnection of rolling stock to form a train. In wagon AAR E type coupler is used. Centre Buffer Coupler (CBC):-

1. Transmits both draft & buffing load between vehicles and to/from under-frame.
2. Absorb high frequency forces during impact.
3. Dissipates low-frequency forces to protect the vehicle from damage.

During POH, in Body repair shop stripping/cutting of CBC taken place and dropped on the floor then sent to CBC shop with help of Crane/FLT for complete overhauling or replacement according to requirement. Overhauled/New CBC sent to respective workstation with help of FLT/Crane and then the same fitted on wagon body with help of EOT crane. In this cycle we have total 3 times, they are:-

1) Before repair movement time, this include
   i) Waiting for FLT/Crane
   ii) Movement Time of FLT/Crane
2) Coupler repair time
3) After repair movement time, this include

i) Waiting for FLT/Crane
ii) Movement Time of FLT/Crane

It is observed for the last 1 year the time taken for coupler (CBC) movement is 120 minutes which is effecting the outturn and customer (internal) dissatisfaction. This is leads to delay in another subsequent process of wagons POH; therefore it is necessary to take step to minimize coupler movement time. According to MUDA in Japan, there are several categories of waste in the industry, namely: rework, over processing, over production, Overproduction consists of making either excessive quantity, waste of time on hand (waiting time) and excessive inventory [1]. In this our focus of concentration is coupler movement. In this research work we are finding the various parameters associated with coupler movement time and finding interrelation among them. For this, we use a method that can be used to minimize waste is by lean concept. Lean is an approach that seeks to improve flow in the value stream and eliminate waste. Lean concept has various tools to reduce or eliminate waste; one of them is six sigma [2]. The Lean Management tools focus on speed and efficiency of a process, while those of Six Sigma on its precision and accuracy [3].

2. REVIEW OF RELATED STUDIES

Neha et. al. [1] tested on the large industry (steel manufacturing industry) and focusing the lean principles, tools and benefits of lean concepts in industries. Lean concept is focus on cost reduction by identifying and eliminating non-value-added activities. The concept how globalized in competitive markets of 21st century for increasing high variety of products at reducing cost, reduced lead time and best quality. This paper addresses lean manufacturing's application.

Ahmed Mousa [2] studied on how Lean approach able to improve flow in the stream/process and simultaneously eliminate waste/non value added activity. In Six Sigma a powerful framework (DMAIC) and statistical tools find the root causes of problem and reduces variation. An integration of both gives a tremendous improved approach that incorporates powerful data-driven method to solve problems and create rapid improved solution at lower cost. In other word it is about doing correct thing with quick and correct speed which helps to overcome problem of reduced activity.

Laureani et. al. [3] did a case study on call centre (service Industry Corporation) to demonstrate the use & application of lean six sigma. In this study the data and process information taken from actual project then after results shows various types of improvements like increase in first-call ratio, reduction in operator numbers and streamlining of activities. This proves that lean six sigma has been successful in the last two decades in the manufacturing sector as well as service sectors too.

Sharma Udit [4] observed in Battery Company that Lean Manufacturing can generate good output but implementation of it very tedious and costly and the output is not a worth. But the integration of Lean and Six Sigma gives reduction in capital cost, streamlining of process as well as improved customer satisfaction.

Shah et al. [5] conducted study on how Combination of Lean practices with Six Sigma has gained immense popularity in ten years ago. A combined Lean and Six Sigma approach is the latest management tools which leads to significant performance benefits that exceed isolated implementation is not yet apparent. This research study attempts to uncover associative and predictive pattern of implementation between 15 Lean practices and the Six Sigma practices. The results of research indicate two major findings. First, implementation of any practice from a broader set of Lean practices improves implementation of Six Sigma. Second, the regression results depict a significant difference in the performance levels of the Six Sigma implementers group compared with the non-implementer group.

Snee et. al. [6] studied that all Fortune 500 business had been utilizing Six Sigma to improve product quality for several years and

had seen strong bottom-line improvements. The company recently implemented lean principles to reduce waste and cycle time, and has seen significant gains. However, the organization is currently experiencing some cycle time and waste issues for which lean approaches are failing. Another business started a lean Six Sigma programme, which was initially effective. Later, it was discovered that some issues had slipped through the cracks and were not amenable to either Six Sigma or lean approaches. Despite the fact that both companies had overcome the once widespread idea that lean and Six Sigma were mutually exclusive approaches to improvement, they failed to get the most out of lean and Six Sigma.

Timans et al. [7], explored and analyzed Lean Six Sigma (LSS) deployment in Dutch manufacturing/engineering small and medium-sized businesses in this research (SMEs). Impeding variables and critical success factors (CSFs) are identified and analyzed. A survey study of Dutch SMEs was used to gather exploratory empirical evidence about LSS deployment. The ranking of the CSFs was validated using statistical testing. Additional in-depth qualitative information was acquired from six case studies to have a better understanding of how firms translate CSFs into practice and deal with hindering obstacles. This case study shows the usefulness of the CSFs and identified three new ones: top management's personal LSS experience, project leader soft skill development, and supply chain focus. In the Netherlands, SMEs do not distinguish between lean manufacturing and Six Sigma, but rather combine the two methodologies.

Shahin et. al. [8] gives suggestion is to explore the most common themes within Lean Six Sigma(LSS) in the manufacturing sector, and to identify any gaps in those themes that may be preventing users from getting the most benefit from their LSS strategy. The analysis of 19 manufacturing case studies yielded significant benefits, which are detailed in this paper. However, because there has been little written about LSS as a holistic strategy for company improvement, there are many gaps and limits that need to be investigated in future research.

Furterer S and Elshennawy [9] studied that TQM is an approach intended at increasing the quality of products and services across a company and is primarily focused on continuous improvement, whereas Lean Six Sigma is an approach targeted at improving quality, reducing variance, and eliminating waste. Over the last few years, the idea of merging the principles and techniques of Lean Enterprise and Six Sigma in a more synergistic manner has surfaced in the literature. There are no examples of Lean Six Sigma program in municipal government in the literature. This paper describes various initiatives in local government to deploy TQM tools, as well as a case study of using Lean and Six Sigma technologies.

Apreutesei M et. al. [10] done case study on many small and medium-sized enterprises, particularly those structured and managed under conventional push methods, can benefit from lean manufacturing. In terms of quality, cycle times, and customer responsiveness, the benefits may be considerable. Many industrial businesses have adopted lean manufacturing as more than a collection of tools and procedures. All personnel in a lean manufacturing environment are always looking for ways to enhance procedures. The tools of Lean Manufacturing, such as kaizen, and Kanban etc. are discussed in this article, which a corporation may employ to eliminate waste (MUDA) during the manufacturing process. The document also includes the seven most prevalent categories of manufacturing waste, as well as some instances from our daily lives.

Manisha Balaji [11] recommended in his case study of a business process engineering implementation at an educational institute. According to the report, the reasons for BPR adoption were improved customer relationships, competitive advantage, better improved change, financial risks, global business trends, and cost savings. The result for the organization after implementation was strong customer

satisfaction, standardization of enrolment and enquiry procedures, cost reduction in operation, reduced lead time, and ability to overcome and retain profitability during industry outages in 2003. The project's success was due to prior preparation and understanding of the processes, which led to integration with the project goals.

Niall piercy et. al. [12] suggested the lean manufacturing be used as an application of improvement techniques in the service sector, and assessed the impact of lean on service improvement. The study looked at the British financial sector, followed the process of lean improvement, and found that using a lean service tool, service call centers may meet both the previously contradictory goals of lower operational costs and better customer service. The study of the basic business of British financial industries such as Policy Co, Bank Co, and Claim Co has been described. The average number of calls a day, average number of letters per day, average employee productivity, percentage of failure, and longest time to execute a client request has been used to determine the results. The number of steps in the overall cycle, the number of departments involved in the total cycle, and the average number of policy holders as work-in-process was all tallied and a percentage reduction has been shown.

Tamer h. haddad [13] has proposed a solution for healthcare facilities based on total production maintenance implementation. Since Total Production Maintenance is an implementation methodology aimed at increasing medical device utilization while lowering failure rates. In-depth interviews, observations, and document collecting have been used to conduct the case study in a Jordanian hospital. The hospital maintenance activities are divided into numerous areas, including medical devices, civil buildings, mechanical devices, and electrical devices, thus the research is focused on the medical device branch of the health care business. The research method was intensively conducted in interviews such that a total of 13 interviews were conducted at the study site, 11 were frontline maintenance staff and two senior managers. of the maintenance department. The author concludes that the TPM principles have a significant advantage over the traditional retention principles found in most healthcare industries**.**

Vlachos et. al. [14] examines how lean methods are applied in the service industry. Because lean is widely used in manufacturing and there is evidence for its applicability in the service business, particularly in hospitals, the research was conducted in a European hotel industry to examine how lean techniques are implemented and the industry's performance. The survey was conducted by generating a questionnaire and sending it to 19 members of the European state union's small and medium hotels, as well as conducting a value stream analysis to identify value contributed and non-value added activities. Process activity mapping, Supply chain response matrix, Production variety funnel, Quality filter mapping, Demand amplification mapping, Decision point analysis, and other value stream methodologies were employed by the author. Significant conclusions emerged from the evaluation of the seven value stream mapping tools. The Process Activity Mapping tool, in particular, demonstrated that both "value streams" have a high percentage of operational time, indicating that waste is highly dependent on external sources. As a result, the research found that lean approaches, which have been successfully implemented in manufacturing industries, could provide benefits and solutions to the hotel business.

Bozena Poksinska [15] discussed lean manufacturing in the healthcare field. The paper discusses the current state of lean production implementation, as well as healthcare, the implementation process, barriers, challenges, enablers, and outcomes of using lean production methods in healthcare. The strategy was developed after a thorough review of the literature on health-care lean thinking, quality management, and operational management. According to the findings, the process

improvement strategy is applied in the lean manufacturing field and focuses on three primary areas: identify value, value stream techniques, and waste elimination. Value stream mapping is a lean tool that is commonly used in the health-care business to implement lean. The results have been analyzed, and the outcomes have been divided into two categories: healthcare system performance and employee development and work environment. The research concludes. All steps in the patient journeys are studied as a whole from start to finish using Value Stream Mapping: from diagnosis to treatment to discharge. This enables for the reduction of waiting times and duplication labour, as well as ensuring that the interconnected steps are connected, as well as overcoming some of the problems that lean in health care faces.

Robert R cima et. al. [16] developed an approach for enhancing the productivity of operating rooms in medical centers. To improve OR efficiency, the case employs lean and six sigma methodologies. The operating room, as well as the pricey units within the Medicare center, determines a hospital's financial performance. Normally, lean and six sigmas are used to improve manufacturing efficiency by removing waste, but in this case, it is being utilized to improve surgery suite efficiency. The case study was carried out by assembling a multidisciplinary team of surgeons, anesthesiologists, nurses, administrators, and IT programmers, and doing a value stream analysis on persons, information processed, and time throughout the full surgical procedure from choice to discharge. Using the lean six sigma methodologies, five work streams were created. The findings were based on work streams and reveal that there has been a significant increase in OR efficiency. It was found that process mapping, leadership support, staff involvement, and sharing performance metrics are crucial to improving OR efficiency.

Eckes et al. [17] conducted a case study of General Electric and provided information on issues and solutions for Six Sigma implementation. GE created a client-focused Six Sigma approach that begins with determining customer needs and concludes with fulfilling or exceeding customer expectations. This strategy is also applicable to the manufacturing and customer-focused service sectors.

A bibliographic study on lean implementation in service sectors has been suggested by Higor Dosreis Leite et. al. [18]. The research focuses on the origins, principles, evolution, and applications of the lean mindset in the service sector. This research is also about lean service, which faces opposition, and there are various restrictions when analyzing lean techniques, some of which are attributable to scare articles in the literature. The author also covered the tool used in lean service, the application areas where lean service is used, and the best practices used. Value stream mapping is a useful method for identifying both value-added and non-value-added activities.

Henk de koning et. al. [19] have proposed a research on lean and six sigmas in the financial sector. Lean six sigma has a considerable impact on cost reduction, efficiency, innovation, quality management, and service operations, according to this study. The study focuses on two Dutch banking institutions. The essay demonstrates how lean thinking and six sigmas can be combined to achieve breakthrough results in the banking sector. The methodology is carried out using the DMAIC method. The two case studies are about reducing information requests, reducing the number of flaws in the process of issuing new insurances, transferring pension rights, and reworking external communication. The percentage of errors in the internal check reduced to 8% after the implementation in Case, resulting in expected savings of €180,000 per year. Similarly, the percentage of errors in the external check dropped to 12%. The overall annual savings of these efforts were expected to be over €175,000 in case B of the implementation processes. The combined Lean Six Sigma approach discussed in this article provides a useful framework for systematically

developing and managing innovations, which is especially useful in the financial services industry. Indeed, Lean Six Sigma combines Six Sigma's organizational infrastructure and diagnosis and analysis capabilities with Lean's tools and best-practice solutions for problems involving waste, rework, defects, and unnecessary time consumption, all of which we have found to be abundant in the financial services industry. The approach used by two Dutch insurance companies exemplifies the significant benefits that this combined approach can achieve.

Sang m. lee et. al. [20] established a study theory on entrepreneurial applications in the service sector using a lean strategy. This study looks at how lean manufacturing can assist the service sector cope with the fast-changing global economic environment. Today, information systems play a significant role in many sectors, including primary, secondary, and university education. This study compares and contrasts the information system that enables the tertiary sector's benefits with supply chains. The study focuses on the supply chain in South Korea to describe entrepreneurial applications in the tertiary sector. Traditional, efficient consumer response, vendor managed inventory, continuous replenishment, collaborative planning, forecasting, and replenishment were among the supply chain systems that were coordinated (CPFR). A variety of efficient concepts have helped modern supply chain management.

Bradley R. Staats et. al. [21] investigated the application of lean principles, knowledge, and learning to software service providers. In this case study, work is compared in between lean software project and a non-lean software project. The case study is conducted in one of India's software service industries. The methodology was developed using the four Toyota production system concepts proposed by Spear and Bowen (1999). The rules are as follows:

Rule 1: All work must be very specific in terms of content, order, scheduling, and outcome.

Rule 2: Every customer–supplier connection must be direct, with a clear yes/no mechanism to transmit requests and receive responses.

Rule 3: Every product and service must have a simple and direct path to market.

Rule 4: Any change must be made using the scientific approach and under the supervision of a teacher at the lowest feasible level in the organization. The technique on task formulation, streamlined communication, simple process architecture, and hypothesis driven problem was discussed based on the following rules. Interviews, meeting observation, inspection of internal documents, and study of archive project data were all used to acquire data. According to the findings of the case study, the lean manufacturing system has had a major impact, and the fundamental processes have been adjusted, resulting in increased operational efficiency. The study further expands on the lean production paradigm by emphasizing the need of identifying problems early in the process.

Osama M. Erfan [22] has proposed a study on the use of lean technologies in the healthcare industry. This study tries to apply lean concepts to the healthcare industry in order to reduce waste. The goal is to boost capacity and efficiency in the trash removal process. The research is being conducted in a Libyan healthcare industry, and the emergency department (ED) is being considered based on data collected from patients who visit on a regular basis. The value stream mapping method was used in this study to identify value added and non-value added activities. The investigation begins with a takt time analysis. From patient registration to results evaluation, a current state value stream mapping is performed. According to the results of the current state mapping, the therapy has a long cycle time, making it a bottleneck process. To shorten the therapy process' cycle duration, a future state mapping is created. So, after implementation, the results demonstrate that lean tools have a very good effect on lowering the effect, and the construction of future state mapping helps to achieve the improvement of the overall

performance of the emergency department of the Libyan healthcare sector to varying degrees.

Hsiang-Chin Hung and Ming-Hsien Sung [23] employed The DMAIC (define, measure, analyze, and improve control) approach in the Taiwanese food industry. Using this strategy, he solved the fundamental problem of process variation reduction. As a result, he was able to lower the high defect rate connected with it. The results obtained were a lower failure rate of tiny custard. He's also provided a theory about the variables that are to blame for Six Sigma project success in the food industry.

Dr. Vidosav Majstorovi, et al. [24] employed DMAIC methodology at a Serbian metal processing manufacturing company in their study. His effort resulted in a reduction in process variability, which reduced the quantity of nonconformities produced. As an outcome, the Sigma Level for the observed production framework increased, as did customer satisfaction.

Through a thorough literature research, Rajeshkumar U. Sambhe [25] explored the Journey of Six Sigma in Indian SMEs. Six Sigma, he explained, is a process improvement and defect reduction methodology used to improve a company's output and actualize organizational excellence through the proper application of statistical tools. Because Six Sigma is a customer-driven methodology, it is critical to priorities projects that deliver the highest level of customer satisfaction by meeting their needs while also increasing profits for the company. According to him, Six Sigma deployment in small and medium-sized businesses is hampered by financial constraints. According to earlier studies, management comm itment is the most important success factor in im plementing Six Sigma technique. Customer satis faction and financial rewards are more important than selecting the proper project.

Six Sigma deployments in medium scale Indian automotive firms was examined by Rajeshkumar U. Sambhe and Dr. Rajendra S. Dalu (2011) [26]. They examined crucial success elements for effective Six Sigma deployment in India's medium-sized automotive manufacturers in their research. The questionnaire approach was used to conduct the survey. Their closing remarks are that there is relatively little research done in the automotive business, and that only 25.64 percent of the medium-scale automobile sector has been studied.

Nilesh V et al. [27] addressed the merits and drawbacks of Six Sigma technique. According to them, the organization's own management and employees, active supplier participation, and active customer participation are the biggest impediments to Six Sigma implementation. Six Sigma, they claimed, is a long-term corporate commitment. It won't work until high management is totally committed. Six Sigma transforms a company's mindset by instilling fact-based decision-making at all levels. The programme alters a company's DNA by altering the way leaders think and strengthening the management pipeline through developing people's management and communication skills.

Rakesh Kumar Tekade and Narendra Kumar Jain [28] highlighted Six Sigma as a Growing Quality Management Strategy with the goal of raising general awareness and supporting the need for Six Sigma adoption. The paper also discusses the advantages of Six Sigma over other quality management methods and tackles questions about its implementation. The authors have covered topics such as Six Sigma's underlying theory and definitions, its historical prospects, and fundamental components such as process, flaws, variation calculation of sigma level, and Six Sigma staff. Through a literature review, they provide a brief summary of DMAIC technique in this work.

The influence of Six Sigma on developing economies like India was studied by Darshak A. Desai and Mulchand B. Patel [29]. The research shows what kind of benefits Indian firms are getting from Six Sigma in general. The report also demonstrates the similarities and contrasts in the benefits received through Six Sigma by different scales and sectors of Indian

industries. This in-depth examination of the benefits reaped by Indian firms as a result of Six Sigma can help other Indian industries, as well as those in other developing nations, to become more focused on their expectations from this improvement initiative. Overall, this research provided a comprehensive picture of the benefits reaped by Indian firms as a result of their Six Sigma development efforts to date. According to the findings of this study, different industries might expect different benefits from Six Sigma adoption depending on their size and kind of operations.

S. Arun Vijay's [30] research aim is to use the Six Sigma DMAIC Model to reduce the cycle time of the patient discharge process in a multidisciplinary hospital setting in India. He has used various quality tools and techniques to study the five phases of the Six Sigma DMAIC Model. This study suggested numerous improvement strategies to reduce the cycle time of the Patient's discharge process, and after their implementation, the cycle time of the Patients discharge process was reduced by 61 percent. A control plan check sheet has also been created in order to maintain the gains made. This study will show health care managers how to use the Six Sigma DMAIC Model to minimize and optimize the cycle time of the patient discharge process in hospitals. The use of Six Sigma DMAIC approaches to decrease and optimize the patient discharge process was verified in this study, which focused on a Medical and Surgical Department. Even though the average discharge time was reduced from 234 minutes to 143 minutes demonstrating 61 percent decrease.

K.G. Durga Prasad et. al. [31] examined a case study in which the Six Sigma Methodology was used in an Engineering Educational Institution. They claim that this technique has aided in the development of an innovative strategy to improve quality in an engineering training institution. Students admitted to engineering educational institutions are treated as raw materials in this study, with the goal of converting them into finished goods termed engineering graduates that match customer (industry) requirements. The first and most important necessity for implementing Six Sigma technique in engineering education is aquality-consciouss mind in the management of the institutions, as well as unconditional dedication and constant effort from every participant in the education system.

In an Indian small-scale firm, Darshak A. Desai [32] employed the Six Sigma DMAIC technique to improve customer delivery obligations. It was discovered that by pleasing existing clients and attracting new business, the firm recorded a 25% increase in turnover as a result of improved service. U. D. Gulhane et. al. [33] recommended that the Six Sigma methodology be used to the medium-scale tool business. For this, he has hired a file manufacturing company. He began his DMAIC project with the goal of lowering the present rejection rate of 35000 flaws per million opportunities for the 6 Regular Taper File to the lowest achievable rejection rate of fewer than 10000 defects per million.

3. CONCLUSION

As per discussed in the introduction part, our main point of the study is coupler movement time. It is observed for the last 1 year the time taken for coupler (CBC) movement is 120 minutes (from Body Shop to CBC Shop), which is affecting the outturn and internal customer dissatisfaction. This leads to delay in another subsequent process of wagons POH; therefore, it is necessary to take step to minimize coupler movement time. As discussed in several kinds of literature review How Lean thinking and Six Sigma approach combined to solve the problems, similarly We are using DMAIC technique to find out cause of the problem and possible solutions to for the same. In the next step DMAIC technique will be followed and data will be analysed on Minitab software.

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