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Lean Practices in Tractor Manufacturing Industries in India

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Abstract- Lean is one of the most popular concepts of an Industry and being utilized to improve efficiency by reducing or eliminating waste. This study investigates the impact of implementing lean practices in Indian Tractor Industry, specifically the 5S System, Kanban Framework, Worth Stream Planning (VSM), and Kaizen (Nonstop Improvement), based on hierarchical execution in conditions of conveyance and adaptability improvement, business result upgrade, and efficiency improvement. The examination philosophy includes relapse investigation of information gathered from businesses that have embraced lean practices. This research paper will focus on the existing research gap on impact of Lean Practices in the manufacturing operations in Tractor Manufacturing Industry in India.

Keywords: Lean Manufacturing, Shop Floor Management, Qualitative Research, Tractor Industry

I. INTRODUCTION

India has emerged as a key global manufacturing powerhouse. The manufacturing industry in India is now well-known around the world and is expected to rank among the top industrial nations soon. India is regarded as an attractive site for multinational industrial projects. Many other companies are striving to establish themselves in the country, where prominent automakers have already established manufacturing sites. The administration is committed to guaranteeing the nation's overall progress, with an emphasis on smart cities and industrial development. As part of industrial expansion, integrated efforts are. being made to promote modern manufacturing processes. This study deals with Tractor manufacturing industries in India. According to Mordor Intelligence, Indian Tractor Market size is estimated at USD 7.42 billion in 2024, and is expected to reach USD 10.28 billion by 2029, growing at a CAGR of 6.70%.

Lean Manufacturing is a systematic approach for identifying and eliminating waste in manufacturing processes through continuous improvement. With its ability to enhance efficiency, improve productivity, improve quality, and streamline supply chain management, it is reshaping the manufacturing landscape. The primary goal of lean manufacturing is to increase value-added work by eliminating seven fundamental wastes: inventory (raw materials), waiting (of operators, materials, or machines), transportation, overproduction,

motion (of operators, materials, or machines), corrections (rework and scrap), and processing itself. Lean Manufacturing practices has been increasingly adopted in manufacturing industries, however, its effectiveness in tractor manufacturing industry remains unexplored. This paper aims to provide qualitative analysis on impact of lean practices in tractor manufacturing industries in India.

In this paper, the implementation of lean practices and their effects on shop floor efficiency, quality, and productivity has been studied for various tractor manufacturing industries in India. It presents a comparatively study in different tractor manufacturing industries.

This paper is divided into 5 sections as follows: Introduction, Literature Review, Research Methodology, Data Analysis & Discussion and Conclusion. The next section begins with analysis of existing research in this area and research gap as no thesis was previously done in this area.

II. LITERATURE REVIEW

The literature review has been done from various journals and other textbooks to know lean manufacturing techniques, such as 5S approach, Kaizen (Continuous Improvement), Total Productive Maintenance (TPM) and its impact on various industries. This provided authentic preview for selecting the dimensions of study and minimize the existing research gap.

The literature findings are classified into following research streams: Industry 4.0 supports lean manufacturing and vice - versa, performance implications of an Industry 4.0 with lean manufacturing integration, and the effect of environmental factors on an Industry 4.0 and lean manufacturing integration. It is clear from the findings that this area is still immature, with seemingly no common platform of knowledge to build the research on.

According to Womack Jones, and Roos, lean manufacturing uses less of everything compared to mass production, half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. In addition, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products.

Many firms are worried about the environment, and LEAN manufacturing is a means of decreasing waste while maintaining high productivity. This strategy relies mostly on predictive analytics, which encourages data-driven decision-making. This industrial approach helps in ensuring that all defects are detected and remedied in the most effective way.

Russel and Taylor, explained that the major purposes of the use of lean manufacturing are to increase productivity, improve product quality and manufacturing cycle time, reduce inventory, reduce lead time and eliminate manufacturing waste. To achieve these, the lean manufacturing philosophy uses several concepts such as one-piece flow, kaizen, cellular manufacturing, synchronous manufacturing, inventory management, poka-yoke, standardized work, workplace organization, and scrap reduction to reduce manufacturing waste.

Scholars and practitioners identified a strong link between Industry 4.O paradigm and the well- known Lean Production (LP) paradigm. Most studies consider LP as a prerequisite of I4.O and I4.O as a tool to overcome LP limits and boost its practices. However, so far, these effects have been studied only at a high level, without an in-depth and comprehensive pairwise analysis at a practice-technology level. Moreover, few empirical studies have been carried out on this topic. Our paper attempts to fill these gaps by conducting a multiple case studies research to explain the impact of Lean Production in tractor manufacturing industries.

There are five Lean Manufacturing principles: Specify Value, Identify the Value Stream, Make the Steps Flow, eliminate departments that execute a single task process on large batches, let customer pull the product from you and Pursue Perfection.

III. RESEARCH METHODOLOGY

This study employs a qualitative research design to explore the impact of lean manufacturing in the Tractor Industry in India. The qualitative approach is chosen due to its effectiveness in capturing detailed and nuanced insights from industry professionals. By focusing on their experiences and perceptions, the study aims to provide a comprehensive understanding of lean manufacturing practices and their outcomes.

Data was collected through interviews conducted via telephone and in–person meetings with industry professionals. This method allows for flexibility in probing deeper into specific areas of interest while maintaining a consistent structure across interviews. Each interview was conducted between 45 to 60 minutes. All interviews were audio-recorded with the participants' consent and transcribed verbatim for analysis. The subjective questionnaire was developed based on a comprehensive review of the literature on lean manufacturing and its application in the tractor industry. Key themes and questions were identified to ensure all relevant aspects were covered. The questionnaire included open-ended questions designed to elicit detailed responses about the implementation, challenges, benefits, and overall impact of lean manufacturing.

The research was conducted in various industries, selected using purposive sampling to ensure a diverse representation of the tractor industry. The criteria for selection included company size, geographical location, and the extent of lean manufacturing implementation. The Tractor Manufacturing Industries in India are Mahindra & Mahindra, TAFE - Tractors and Farm Equipment Limited, Sonalika - International Tractors Limited, Escorts Agri Machinery, John Deere, New Holland, Kubota Agricultural Machinery, Preet Tractors, Kartar, Ace Tractors etc.

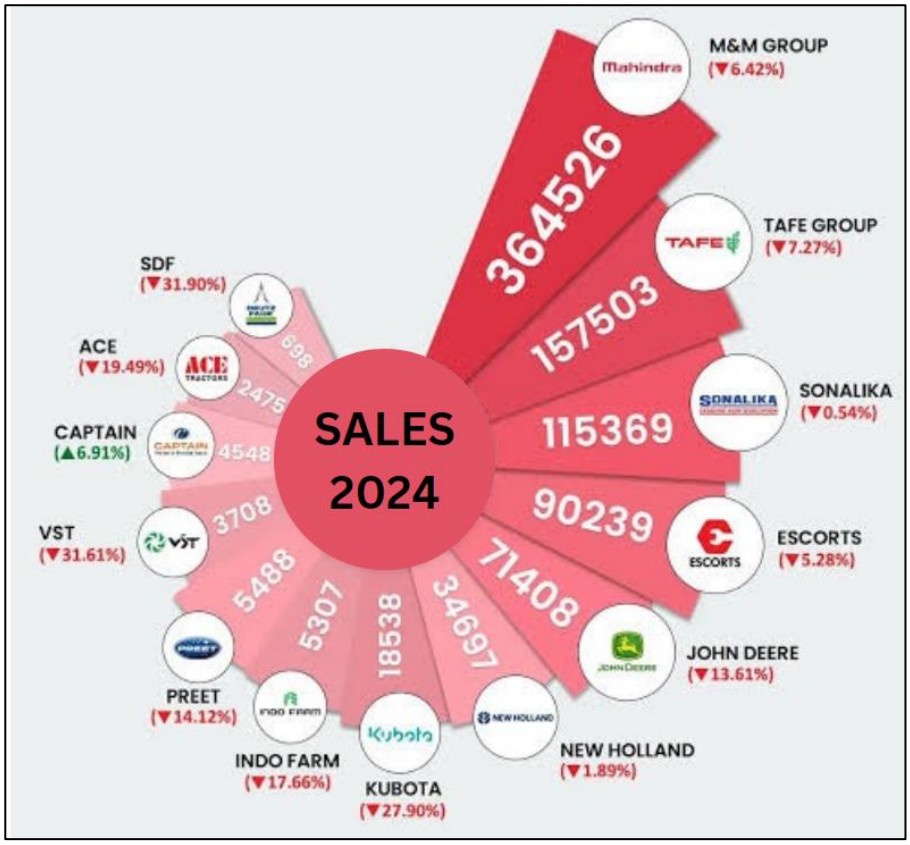
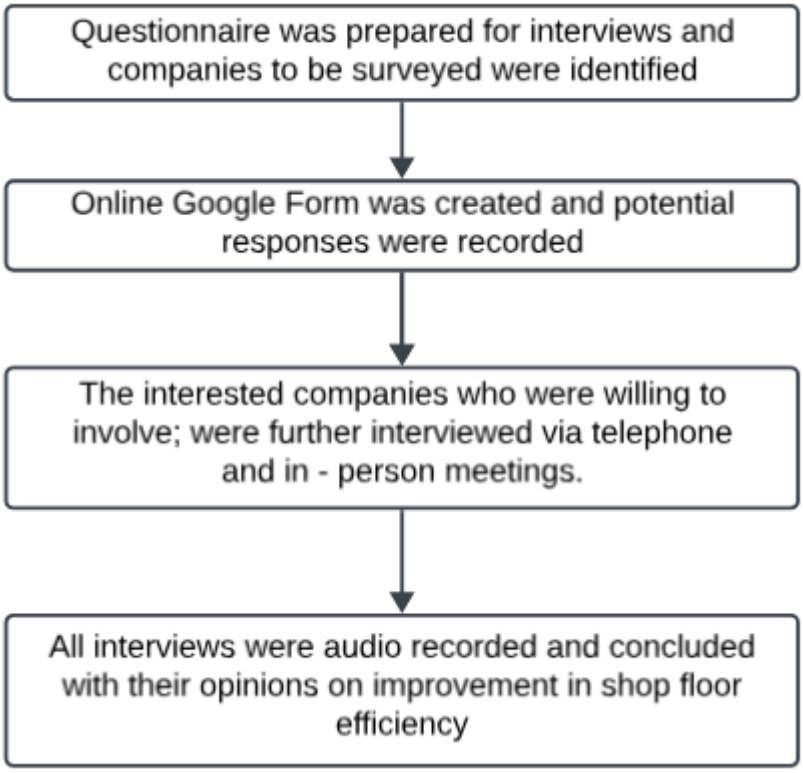


Fig. – Tractor Sales in India FY'24

The study was conducted with senior managers, production managers, quality control managers, lean manufacturing coordinators and other relevant personnel.

The structure of interviews was designed as follows:

- *Introduction:* Briefing the participant on the purpose of the study and ensuring confidentiality.
- *Background Information:* Collecting demographic data and information about the participant's role and experience.
- *Lean Manufacturing Implementation:* Exploring how lean practices were introduced and integrated.
- *Impact Assessment:* Investigating the perceived benefits, challenges, and overall impact of lean manufacturing on various aspects of production and company performance.
- *Conclusion:* Allowing participants to provide any additional insights or suggestions.



Flow Chart for Data Collection Process

The questionnaire started with whether lean practices are being followed or not in their industry, followed methods for monitoring downtime losses, machine life, usage of software like MOST, AVIX, etc for time study & line balancing, plant maintenance system, extent of digitalization, impact of digitalized lean practices, and much more. Other important questions included their direct pass ratio, production schedule adherence rate, mode of check sheet, level of improvement after implementing lean practices and impact of digitalization on the same.

The interview concluded with their opinions on improvement in shop floor efficiency, quality, productivity, and reduction in human errors after implementing these practices. Their future plans for developing existing methods were also discussed. The recorded interviews are further used for analysing and drawing a comparative study between various industries, which is discussed in next section of this paper.

IV. DATA ANALYSIS & DISCUSSSIONS

Company Name	Lean Practices	Turnover
Company 1		INR (100 – 500) Cr
Company 2		More Than 500 Cr
Company 3		More Than 1500 Cr
Company 4		More Than 1500 Cr

Table – Overview of Companies Surveyed

 Not Followed

 Follows lean practices but digitalization in progress

 Follows lean practices with digitalization

Company 1 was established in 2001 and manufactures a range of agricultural tractors, starting from 35 HP and going up to 90 HP. The company's manufacturing plant spans 50,000 square meters, housing advanced machinery for engine assembly, painting, and driveline assembly. The monthly production is less than 500 units. The Company 1 does not practice lean manufacturing and misses out on opportunities to optimize efficiency, reduce waste, and improve overall production quality. There is a lack of an online monitoring system impedes real-time tracking and analysis of production processes, which is essential for identifying bottlenecks and inefficiencies promptly. Even after 25 years of commencing, company 1 is lacking in terms of technology and innovation to reduce human errors and increase productivity.

Company 2 was established in 1969 and offers a comprehensive range of tractors and implements catering to both domestic and international markets, spanning over 130 countries. Its product line includes tractors with power outputs ranging from 20 to 120 HP, designed to meet diverse agricultural needs. This company has implemented several lean manufacturing principles, such as automation and zero-defect production, etc. Despite these lean practices, Company 2 has not fully embraced digitalization in its manufacturing processes. The absence of digital tools and systems limits the company's ability to leverage real-time data for monitoring and optimizing production activities. It still uses physical check sheets for monitoring data which increases human efforts and time required.

Company 3 was established in 1837, offering diverse range of tractors, compact tractors (22.4 - 65.9 HP), utility tractors (50 - 250 HP), specialty tractors (75 - 155 HP), row crop tractors (110 - 410 HP) and 4WD tractors (390 - 830 HP). The tractor per man ratio of this company is 4. The Company 3 uses lean manufacturing practices across its global operations and follows its online production system, a comprehensive framework that incorporates various lean principles to drive continuous improvement, efficiency, and quality. The company uses software for various studies and monitoring of downtime losses, breakdown losses, line balancing, etc. The online software used is Ignition, JDAT for monitoring losses and non – availability status of equipment. Both TBM and CBM are monitored for plant maintenance. The company has improved its production by 40% in last several years with implementation of digitalised lean practices.

Company 4 was established in 1963, marking a significant change in tractor industry. This company has wide range of horsepower (HP) ratings to suit different agricultural needs starting from 15HP to 120 HP or more. Company 4 has been actively implementing lean practices to enhance efficiency and reduce waste in their manufacturing processes. It utilizes SAP (Systems, Applications, and Products) software to manage various aspects of their

operations. The adoption of automation and advanced technologies, such as MES (Managing Executive System) and IoT (Internet of Things), supports lean practices by improving precision, reducing manual errors, and enhancing overall efficiency. MOST (Maynard Operation Sequence Technique) is used for time study and line balancing in this industry. The monthly production has increased up to 3000 tractors by implementing these practices and digitalization. After implementing these practices, shop floor efficiency has improved by 60% in this industry. The Company 4 has integrated its online monitoring system with advanced AI tools to monitor real time data, thus preventing unnecessary breakdowns and increasing productivity.

V. CONCLUSION

The study of sample Tractors industry in India reveals direct proportion of business the companies which adopted Lean religiously are reaping the significant benefits. These benefits are in the form of reduced losses and improved efficiency. The bottom industries, which have adopted minimal or negligible Lean practices, are lagging.

This study also reveals the opportunity misses by the lagging industries to leverage the Lean practices in achieving significant reduction of losses in their operations through various improvements.

Our findings suggest these industries must establish Industrial Engineering departments and hire capable industrial engineers and must adopt the Lean methodology to remain competitive in highly cost competitive Tractor business in India. Lean would help them to reduce cost, improve quality and overall improvement in efficiency enabling them to remain sustainable in such high paced business environment.

Our research also reveals that the top industry could maintain a reasonable product cost due to lesser losses and high scale which enabled them to grow their business. Furthermore, there is a need for awareness of Lean practices through guidance and support to support in implementation of Lean practices by addressing the specific challenges adoption of lean can be enhances. Therefore, these studies indicate an action by the lagging organisations to revisit their approach towards lean, which can help them to achieve excellence in their business and can match the ranks of top Tractor industries in India and can attain a sustainable, competitive, and high profitable business.

ETHICAL STATEMENT

This research study, titled "Lean Practices in the Tractor Industry in India," adheres to the ethical guidelines prescribed by Springer. The study involved a qualitative analysis of top tractor industries in India, employing both surveys and expert interviews to gather data.

1. **Informed Consent:** All participants were well informed about the nature of survey and expert interview purpose of the study, and their voluntary consent was obtained.
2. **Confidentiality and Anonymity:** To ensure privacy, the identities of participants and companies have been anonymized. No identifiable information is disclosed in the publication. Nowhere name of the organisation is used disclosing their internal information.
3. **Data Protection:** Collected data was securely stored and accessed only by the researchers involved, following data protection regulations.
4. **Ethical Approval:** The study received approval from the institutional ethics review board, ensuring compliance with ethical standards for research involving human subjects.
5. **Conflict of Interest:** The authors declare no conflict of interest in this study.
6. **Financial Funding:** There is no financial funding obtained to conduct this study.

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