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Research Article

Use of lean manufacturing system in palm oil mill for generating maximum yield

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ABSTRACT
Lean Manufacturing is an approach to system efficiency by reducing waste. Companies need to identify value added activities on products, non-value added activities (waste) must be eliminated to decrease the production lead time. Palm Oil Industry produces 2 main products namely Crude Palm Oil and Kernel Palm Oil. This paper describes the waste analysis occur in the palm oil production process. The deployment of lean manufacturing in PRESCO Palm Oil Mill Company Ltd, Benin, aimed at maximizing yield, was thoroughly investigated. The company had been experiencing a decline in palm oil production, adversely affecting productivity and customer satisfaction. To gather a holistic understanding of the company's current situation, data was meticulously collected through questionnaires, examination of company records, and other relevant sources.. The results derived from the application of lean manufacturing tools and the supply chain quantitative model exhibited a remarkable improvement between (2012-2016) and (2018-2022).The average oil palm extraction increased substantially from 8.67% (2012-2016) to an impressive 30.52% (2018-2022).

Keywords: Lean Manufacturing, Supply Chain, Takt-Time, Eight Deadly Waste, Productivity, Sustainability.

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INTRODUCTION

The palm oil industry is a significant player in the global economy, providing a versatile vegetable oil with applications spanning food, cosmetics, and bio-fuels [1]. Originating in West Africa, palm oil cultivation has expanded to tropical regions worldwide, primarily Indonesia and Malaysia, which are now the leading producers [2].While palm oil offers economic benefits, its production has raised environmental and ethical concerns due to deforestation, habitat destruction, and labour practices. Sustainable initiatives and certifications aim to address these issues [3-4].

The oil palm industry relies on machines like sterilizers, cranes, strippers, digesters, centrifuges, oil dryers, conveyors and mechanical presses for efficient palm oil extraction [5]. According to Ahmadi and Rahim [6], these machines can face issues such as wear and tear, electrical or mechanical problems, steam supply, or hydraulic faults, causing costly production disruptions. To address these challenges, proactive maintenance and root cause analysis (RCA) techniques are crucial for enhancing machine reliability and performance, ensuring the industry's efficient and sustainable operation [7-8].

Lean Manufacturing, often referred to simply as "Lean," is a systematic and proven approach to optimizing production processes and reducing waste in manufacturing industries. Originating from the Toyota Production System (TPS) developed by Toyota in Japan, Lean Manufacturing has become a widely adopted methodology for improving operational efficiency and enhancing quality across various sectors [9-

10].At its core, lean manufacturing is centred on the relentless pursuit of waste reduction. It seeks to streamline operations, enhance productivity, and ultimately deliver greater value to customers. According to Rother and Shook [11], the key principles and concepts associated with lean manufacturing include: eight deadly wastes, Heijunka, takt time, 5S approach, quality tool management, value stream mapping, Kaizen, Kanban, Gemba, and top and bottom-level involvement.

THE LEAN APPROACH

Various research has been carried out using lean manufacturing techniques to optimize production in the industries, such as Monrat*et al.*,[12], developed model using lean to optimize a Thai Mill Palm Oil Mill Industry, thereby the study presents a detailed application of lean principles in the palm oil industry. It offers insights into the implementation of lean techniques and their impact on improving overall performance. The integration of lean manufacturing and industry 4.0 principles in Malaysian Palm Oil Mills was conducted by Zairul*et al.*,[13], This paper explores the integration of lean manufacturing and Industry 4.0 principles in palm oil mills in Malaysia. It provides a comprehensive analysis of how these strategies can be effectively combined to optimize processes. Prakriti *et al.*,[14], used Lean Six Sigma

DMAIC Approach [15-16], [17] to improve the sterilizer technology in Palm Oil Mills which also offers a structured methodology for optimizing specific machinery.

METHODOLOGY

A case study was carried out at PRESCO Nigeria PLC, Benin City, Edo State southern part Nigeria, established in 1991 and it is a group of company. The company main production is palm oil, then other palm materials which they supply to marketers in Nigeria. Beyond its operational functions, PRESCO significantly contributes to the economic and social fabric of its local community. The company provides employment opportunities, skills development, and infrastructural development, fostering a symbiotic relationship with the region.

Data Collection and Analysis Procedure

The method used in collection of the necessary data for the study include: structured questionnaires, company quarterly/annual bulletins and oral literatures. The data collected from these materials were used to develop equations for different process points and analyzing the production processes. PRESCO currently has 398 employees, 100 questionnaires were sent to be filled by these employees. 81 questionnaires were filled and returned, 19 were not returned. Sources of these materials are listed as follows:

i. Records department: Information on the harvest of FFB (Fresh Fruit Bunches), sale of FFB, Quantity of FFB utilized in Oil production, and Quantity of Oil produced were sourced.
ii. Maintenance department: Information on the maintenance schedule applied in the mill section of PRESCO Nig. Ltd.
iii. Interview with production, process engineers involved in the production of palm oil in PRESCO Nig. Ltd
iv. Questionnaires with production and managerial staff on their knowledge about lean manufacturing technique and how frequently they apply them.

RESULTS AND DISCUSSION

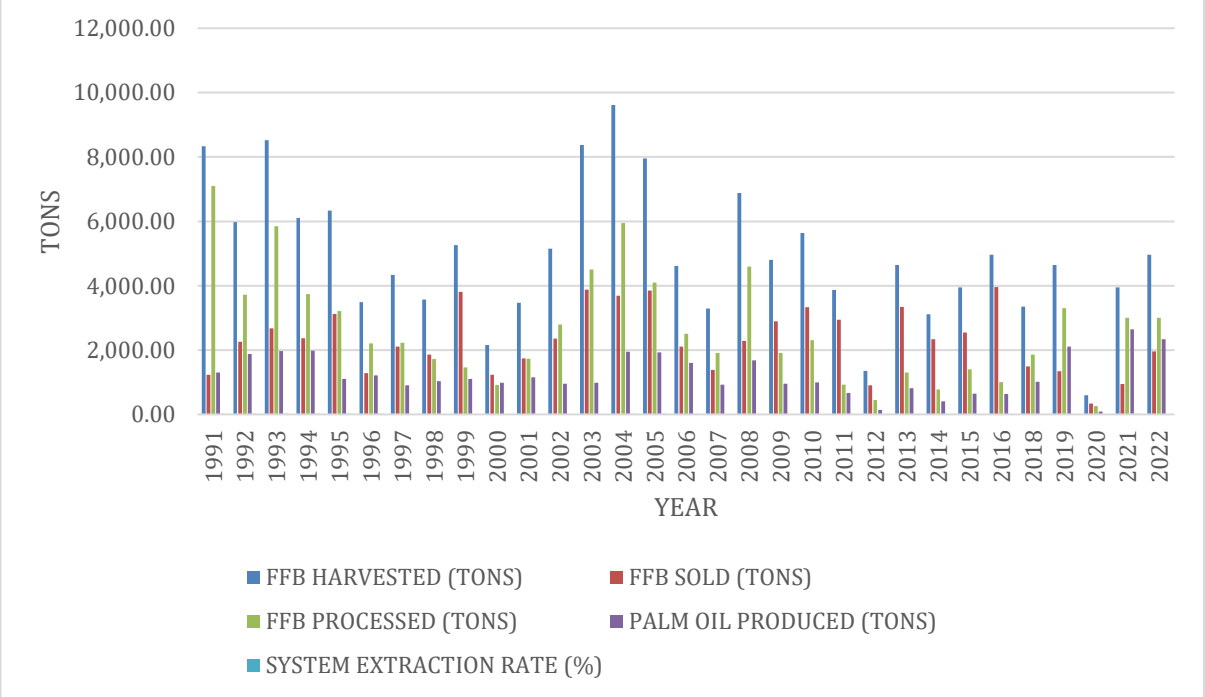

Figure 1. PRESCO Yearly Production and Sales Record (1991- 2022)

This figure provides a comprehensive overview of the company production and processing metrics from 1991 to 2022. The figure include data on fresh fruit bunches (FFB) harvested, FFB sold, FFB processed, palm oil produced, target extraction rate and system extraction rate. The data serves as a valuable resource for understanding the company's historical performance and its adherence to extraction rate targets.

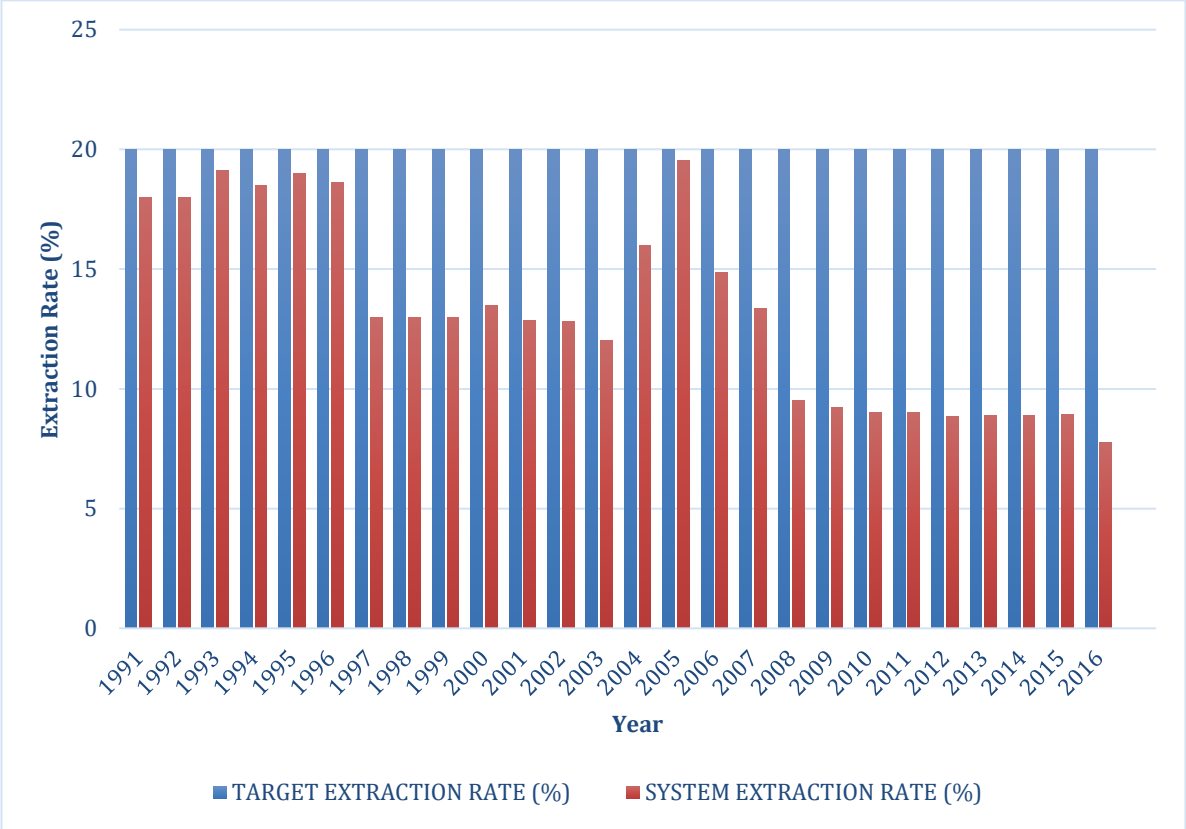

Figure 2: PRESCO Product Target and Archived Rate (1991 – 2016)

This figure presents the company's production target extraction rate and system extraction rate from 1991 to 2016.

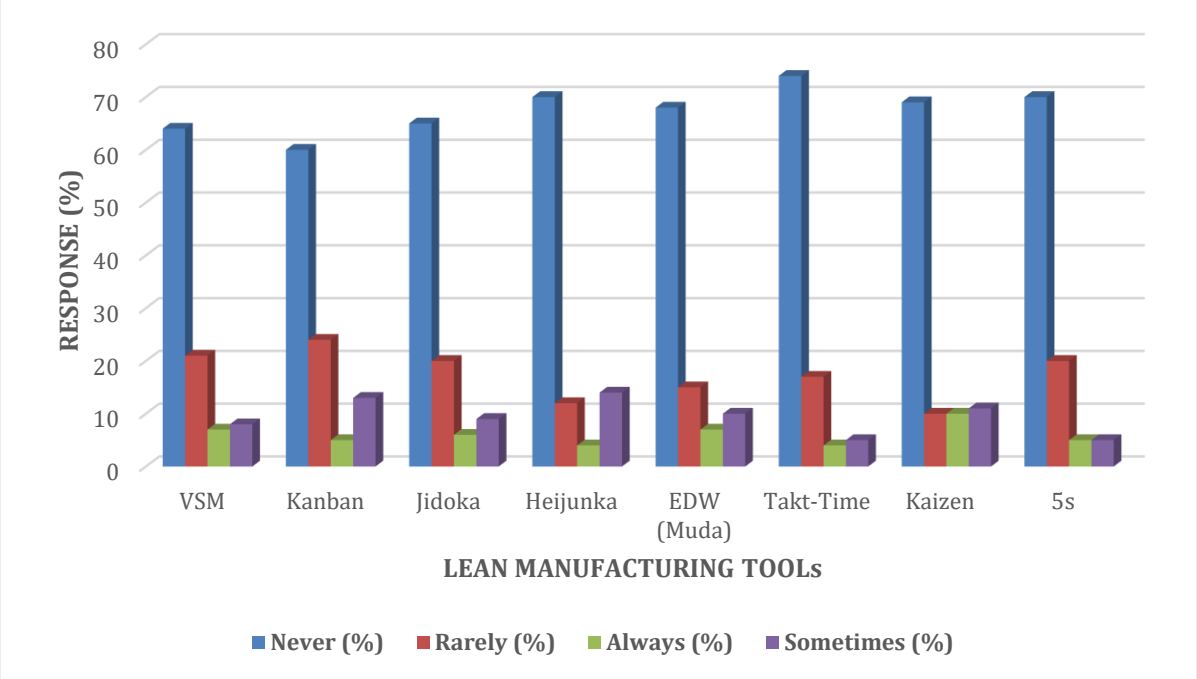

Figure 3: Lean Manufacturing Tools Knowledge Response from the Staff (Questionnaires and File Survey)

Figure 3 presents the frequency of using various Lean management tools within the organization. Notably, Heijunka and Takt-Time shows the highest consistency in application, with 70% and 74% "Always" responses, respectively. However, it's concerning that a significant portion of respondents indicated "Never" or "Rarely" using essential tools like VSM, Kanban, and Jidoka, suggesting potential gaps in implementing these methodologies. The variation in responses underscores the need for a more comprehensive and consistent adoption of Lean practices across the organization for optimal efficiency and continuous improvement.

Takt time represents the maximum time allowed for producing one unit to meet customer demand. The calculated Takt time for the current production process (Table 4) is determined as 3168 seconds, considering time per shift, breaks, and customer demand. The improved production process (Table 5) reflects a reduced Takt time of 2304 seconds, achieved by optimizing the time available, incorporating additional value-adding activities, and maintaining the same customer requirement per shift. This analysis showcases a significant enhancement in efficiency, highlighting the potential for streamlining operations and meeting customer demand more effectively in the improved production scenario.

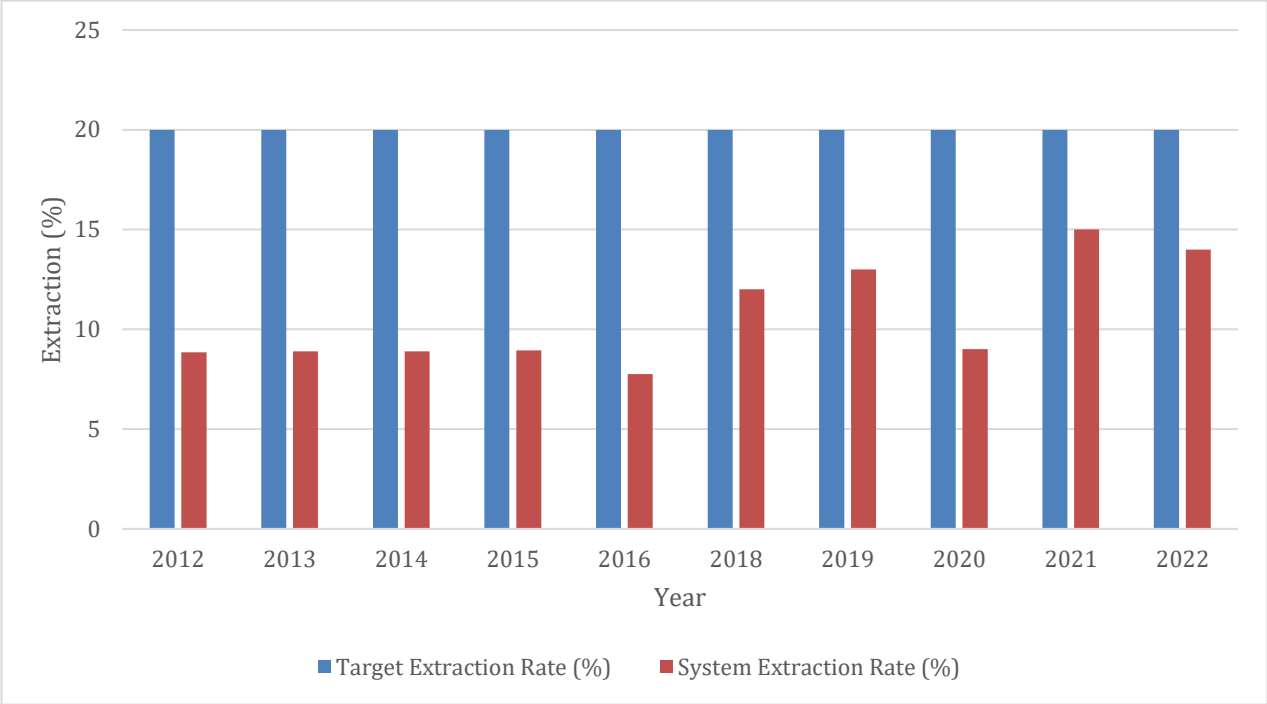

Figure 4: Comparison of Performance Metrics and Extraction Rates in Oil Palm Processing between (2012-2016) and (2018-2022)

Figure 4 depict a comparison of key performance indicators related to the oil palm processing industry over the years. In the initial period (2012-2016), there was a fluctuating trend in FFB harvested, FFB sold, and palm oil produced. However, the target extraction rate remained relatively consistent at 20%, and the system extraction rate varied. In the subsequent years (2018-2022), there is a noticeable shift in performance metrics. FFB harvested and processed increased significantly, leading to higher palm oil production. The target extraction rate is consistent at 20%, but the system extraction rate shows variations, indicating potential operational adjustments. The data suggests a positive trend in achieving extraction goals, with notable improvements in FFB utilization and palm oil output from 2018 onwards.

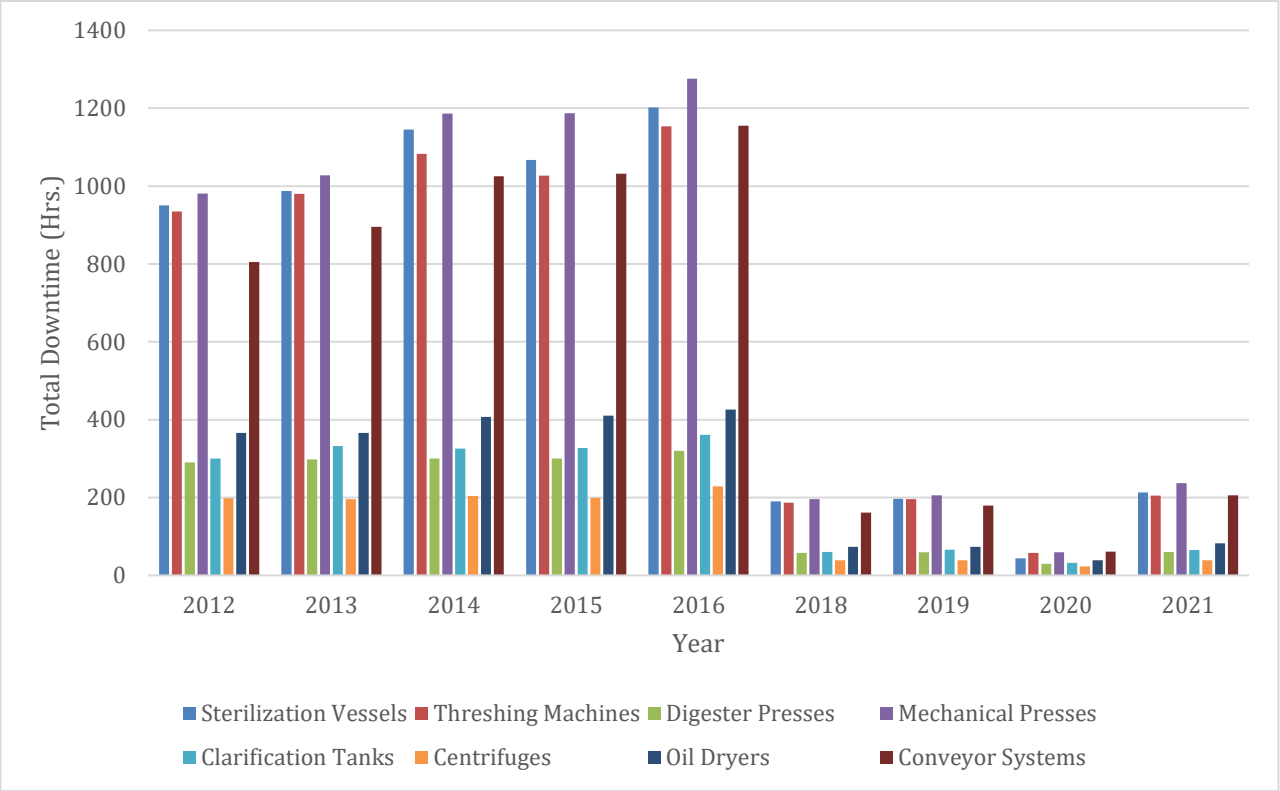

Figure 5: Comparison of the PRESCO Annual Machine Downtime Summary (2012-2022).

Figure 5 presents the comparison of the PRESCO annual machine downtime summary (2012-2022). The trend indicated that the machine downtime reduced drastically from 2018 to 2022 compare to 2012 to 2016 maybe due to the application of lean manufacturing technique especially on the area of employing corrective, preventive, and time schedules against the regular problem involved in the production machine. The lowest downtime was observed in 2020, due to COVID-19 pandemic period were production declined.

CONCLUSION

The analysis of PRESCO's production machine downtime records from 2012 to 2016 revealed varying levels of operational challenges across different machines. The total downtime for each machine demonstrated fluctuations, with the Sterilization Vessels and Threshing Machines consistently showing higher downtime. The years 2018 to 2022 showcased a commendable improvement in the production machine downtime, with a reduction in total downtime for each machine. This positive trend aligns with the implementation of management tools and strategies, as evidenced by the staff's reported inadequate knowledge of the lean manufacturing management tools like VSM, Kanban, Jidoka, Heijunka, EDW (Muda), Takt-Time, Kaizen, and 5S, which were then introduced into the system. In summary, the years 2012-2016 highlighted challenges in machine downtime and associated costs, while 2018-2022 reflected improvements attributed to the adoption of management tools and cost optimization strategies.

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