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Evaluation of maintenance performance of toothpaste manufacturing industry using CMMS

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Abstract:

A maintenance package, such as a computerized maintenance management system (CMMS), significantly aids manufacturing enterprises in conserving production time and costs while generating money by addressing complicated maintenance issues. In this paper, the maintenance performance of CMMS is evaluated based on profit, income, and sales performance, which are the results of the industry's focus on computerized material management and inventory control (CMMIC), resource and asset management (RAM), and computerized maintenance planning and scheduling (CMPS) as essential input factors. When implemented, CMMS offers a comprehensive maintenance solution for various industries. It enhances productivity by minimizing downtime and improving both availability and maintainability. Additionally, it leads to cost savings through increased production time, reduced inventory levels, and improved safety and environmental conditions, thereby promoting the overall health and well-being of employees.

Keywords: Computerized Maintenance Management System (CMMS), Maintenance Management, Asset Management, Manufacturing Industries, Productivity, Workorders, Inventory management .

1. Introduction to Computerized Maintenance Management Systems (CMMS)

Computerization in an organization plays a great role in implementing CMMS and computerized report management (CRM). With the adaptation of Industry 4.0. in the industries, a platform is created for easily implementation of CMMS in the companies. All the necessary maintenance data is collected, updated and retrieved from the computers to support all the maintenance activities automatically and quickly. In this competitive world, complex maintenance activities cannot be well managed without the support of CMMS. Execution of CMMS is fully supported by computers in the industry and at par with the 'Industry 4.0'.

CMMS is well-adopted as a maintenance solution package in many manufacturing industries in India. CMMS also known as Enterprise Asset Management (EAM) software, is designed to help schedule, plan, manage, and track maintenance activities associated with equipment, machines, vehicles, facilities, and services. CMMS provides a central storage location for the majority of maintenance data and information for assets, manages and controls work and materials management/parts usage processes, and tracks maintenance activity over the lifecycle of an asset. All maintenance activities can be monitored and analyzed through robust CMMS reporting and dashboard tools. Most modern CMMS solutions are accessible via mobile devices and tablets. CMMS systems automate most of the logistical functions performed by maintenance staff and management. CMMS systems come with many options and have many advantages over manual maintenance tracking systems. Depending on the complexity of the system chosen, typical CMMS functions may include the following:

a) Work order generation, prioritization, and tracking by equipment/component.
b) elimination of paperwork and manual tracking activities
c) Tracking of scheduled and unscheduled maintenance activities.
d) Storing of maintenance procedures as well as all warranty information by component and all technical documentation or procedures.
e) Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
f) Outside service call/dispatch capabilities.
g) Real-time reports of ongoing work activity.
h) Allow workers to report faults faster
i) Improve communications between operations and maintenance personnel (https://www.emaint.com/cmms-features-benefits) (Amadi and Wit, 2015)

2. Objectives of the study

To validate the maintenance performance of CMMS in the manufacturing industry. CMMS is evaluated by analyzing profit, income, and sales output as outcomes of the industry and computerized material management and inventory control (CMMIC), resource and asset management (RAM), and computerized maintenance planning and scheduling (CMPS) as input factors.

3. Literature Review

The amazing advantages of CMMS include all record keeping and automatic report generation, scheduling and tracking the work orders, and automatically managing the inventory level to the minimum required quantities to manage emergency breakdowns and regular maintenance activities. It is observed from the literature that maintenance is an iterative process and decision-makers with conflicting interests are involved to fetch the best results. A decision-making grid (dmg) was developed for monitoring the maintenance performance of machines. The model reduced the total downtime from 800 hours per month to less than 100 hours per month (Labib, A.W., 1998, 2004). The manufacturing industries that do not have well-planned maintenance strategies are required to ask for support from external resource experts. Future work for investigating the impact of maintenance strategies on production and financial performance is suggested (Muyengwa and Yvonie, 2015). Information technology (IT) plays a vital role in achieving effectiveness and efficiency of equipment with relevant IT tools. A model was developed to find the requirements in maintenance management that ultimately fulfill the demand for maintenance (Kans, 2008). Digitization is considered as the future of manufacturing industries. Decision tree analysis (DTA) and variation mode effect analysis (VMEA) to be used for the selection of maintenance policies (Bokrantz *et al.*, 2016).

How the adoption of Internet technology impacts the industries for information management and purchasing spare parts were beneficial explored for ease of maintenance in the industries. European Maintenance Federation was interviewed to analyze the results (White, 2004). The development of sensors smart tags, data acquisition, signal analysis and wireless technology in the equipment played a great role in achieving efficiency in manufacturing operations. When e-maintenance integrated with new business ideas yield higher overall efficiency of the organization (Adgar *et al.*, 2008).

CMMS is used to collect, store, and retrieve all maintenance-related information promptly. It is also suggested that information and communication technology (ICT) is effective in sharing information across the organization which is taken over by CMMS in maintenance (Amadi and Wit, 2015). The features of CMMS investigated to highlight the need for them in the industry. A model is proposed for decision analysis capability that was frequently missing in existing CMMS earlier. The model employed a hybrid intelligence approach which was analogous to the Holonic concept (Labib, A.W., 2004). The application of CMMS and its affordability is explored in small and medium enterprises (SMEs) because of the high presence and lack of economic resources in Italy (Fumagalli *et al.*, 2009).

A case study was carried out in a medium-sized Irish textile manufacturing industry to explore the basis of maintenance strategy. CMMS was implemented successfully and return on investment analysis revealed 0.46 years as the payback period (O'Donoghue and Prendergast, 2004). Low success rate observed in large-scale industries for implementing CMMS. overall business improvement occurred with CMMS which further improved the reliability and performance of maintenance. World-class maintenance cannot be achieved without the implementation of CMMS (Wienker *et al.*, 2016).

A detailed literature of 142 papers was prepared on maintenance which is further classified into areas and subareas which are maintenance optimization models, maintenance techniques, maintenance scheduling, maintenance performance measurement, maintenance information systems and maintenance policies. The importance of maintenance management is highlighted to researchers and maintenance professionals (Garg and Deshmukh, 2006). Computerized Maintenance Management Information System is presented through a critical literature review. It gives timely information for tough decision-making. Factors like machine availability for production improved by maintenance planning, scheduling, and controlling (Verma and Tewari, 2016). CMMS planning tools and benefits are explored in the manufacturing industries and found support for preventive maintenance instead of conducting corrective maintenance. The work order cycle and the advanced downtime analysis program is presented and found reduction in downtime (Aniki and Akinlabi, 2013). World-class maintenance can be achieved only by computer-integrated maintenance management systems to provide productivity improvement, zero accidents, safe environment and decreased maintenance cost (Mishra *et al.*, 2015). An extended version of fuzzy-TOPSIS was used to develop a specific hierarchic structure considering 17 criteria under five different headings. Also, a case study was carried out in an electricity company to select maintenance software from three alternatives effectively (Uysal and Tosun, 2012).

A case study in the Iranian gas industry was carried out with an integrated CMMS and reliability-centered maintenance (RCM). A functional model was developed to save time by using reliability analysis, failure mode analysis, and maintenance benefit-cost analysis (Beni, 2014). A model for maintenance was developed to investigate the profitability and competitiveness of the industries. CBM approach is recognized as the great potential for the maintenance practice to enhance cost-effectiveness and overall equipment effectiveness (Maletic *et al.*, 2014). For maintenance activities, the industry's computerized system is developed and executed through a case study. For decision making different methodologies are optimized in the interest of the company. A project is suggested to develop a CMMS system for the manufacturing industry (Lopes *et al.*, 2016). Industries have to select CMMS as per the suitability with a multi-criteria decision method (MCDM) known as Analytical hierarchy process (AHP)**.** It fetches cost optimization, utilization of assets, and productivity improvement. AHP promoted the estimation of attributes and selection of real alternatives (Duran, 2011). A computer-based evaluation system is a necessity for maintenance problems. A maintenance evaluation system is proposed with eight factors that enhance the effectiveness of maintenance tasks. Flexibility and adaptability are the necessities of CMMS because every firm is unique and customized as per convenience (Mukattash *et al.*, 2011).

Maintenance problems stops production, delay in lead time, reduce the uptime of the machines, and increase downtime which leads increase the production time, and ultimately reduces productivity and increases the cost of the product. This may further lose competitiveness in the market. Without proper management and automation systems in maintenance leads to waste of resources in the industry. Therefore, a package of maintenance like CMMS is the requirement of the company so that the industry can sustain and grow in today's competitive global market (Shaheen, B. W., & Németh, I. 2022)(Shankar *et al*. 2020, 2021).

4. CASE STUDY

A case study has been conducted for the validation of CMMS results/outcomes in one of the toothpaste manufacturing industries say 'X industry'. 'X industry' manufactures toothpaste for the oral health of people. The factors that enhanced the output of the industry after implementation of CMMS are used as major input factors for the investigation. The input factors used for the validation of the present study are Computerized Maintenance Material and Inventory Control, Computerized Maintenance Planning and Scheduling and Resource and Asset Management as main input factors. These factors selected from the literature review from 27 to 35. Their ranking is also proposed by 26 through literature from 36 to 46. Moreover, Income, Sales Output and Profit are measured as output factors. After the implementation of CMMS in the 'X industry' it has been observed that output factors improved phase wise.

4.1 CMMIC: Computerized Material Management & Inventory Control

It has been observed obviously from the figure 1 that the improvements (that is overall decrease in the inventories concerned with the maintenance) in computerized material management and inventory control is taking place annually in different phases from 2018-2023 after adopting CMMS in the 'X' manufacturing industry. This turned out to be significant reduction in the inventory levels from 68% to 18% which leads to cost savings in the industry.

4.2 RAM: Resource & Asset Management

It has been observed noticeably from the figure 2 that the improvements (that is overall decrease in the average failure rate of the assets) in computerized asset management and resource management is taking place phase-wise from 2018-2023 after adopting CMMS in the 'X' manufacturing industry. This also turned out to be an increase in availability and substantial cost savings in the industry.

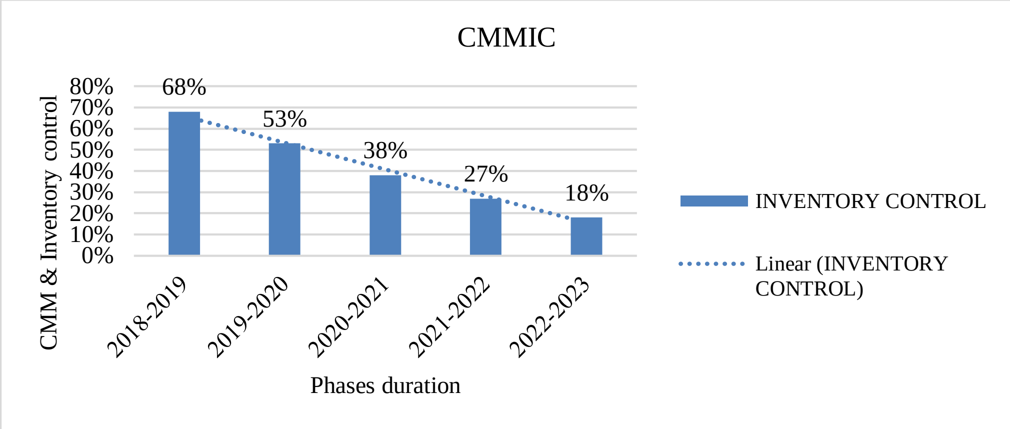

Figure 1: CMMIC versus phases

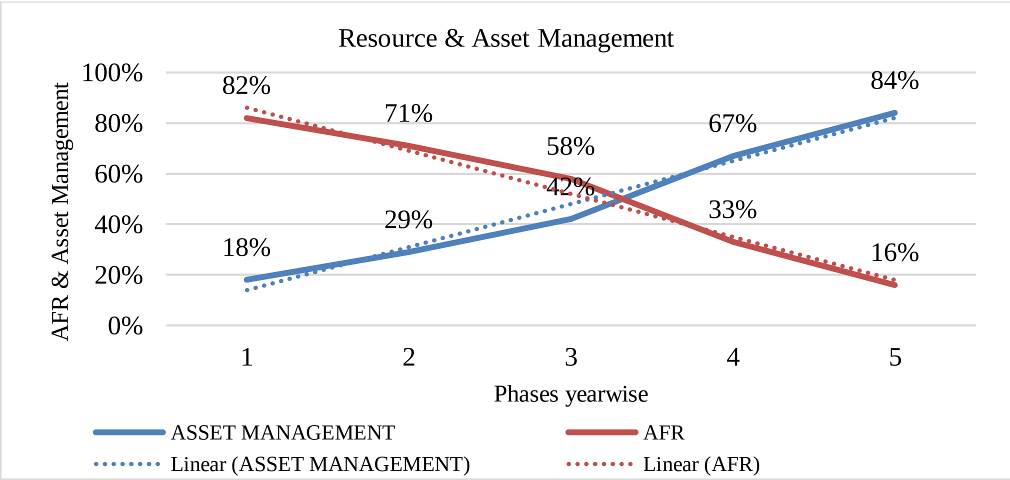

Figure 2: RAM versus phases

4.3 CMPS: COMPUTERIZED MAINTENANCE PLANNING AND SCHEDULING

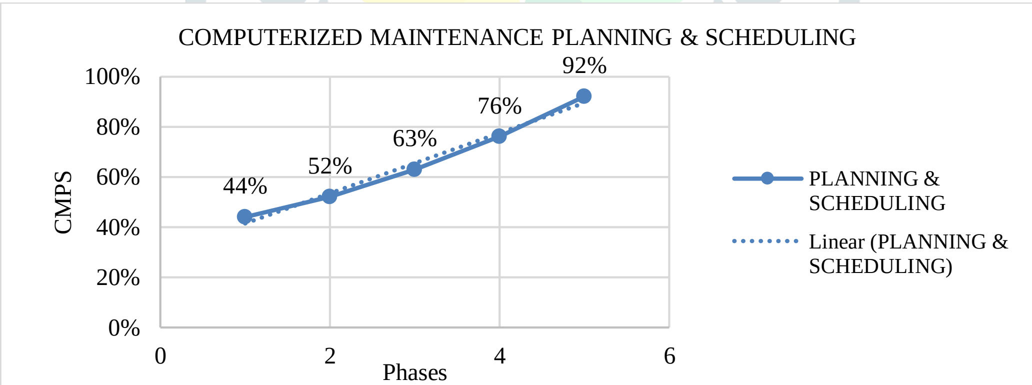

Figure 3: CMPS versus phases

The figure 3 illustrates the progression of executed and planned work orders over five phases from 2018-2023 year-wise with the implementation of computerized planning and scheduling. The initial two phases had success rates of 44% and 52%. The work order completion rates improved further rising to 63%, 76%, and 92% achieved in the third, fourth and fifth successive years in the subsequent phases. The adoption of CMMS further enhanced planning and scheduling performance, leading to reduced asset downtime and increased worker productivity in the industry.

4.4 INCOME

The income collected from the annual reports of the company is shown in the figure 4. Figure 4 is plotted between income and phases year that is during 2018-2019, 2019-2020, 2020-2021, 2021-2022 and 2022-2023 and it was found Rs 77567 lakhs, Rs 80094 lakhs, Rs 103863 lakhs, Rs108299 lakhs and Rs104266 lakhs respectively. It shows the consistent growth in the last 5 years.

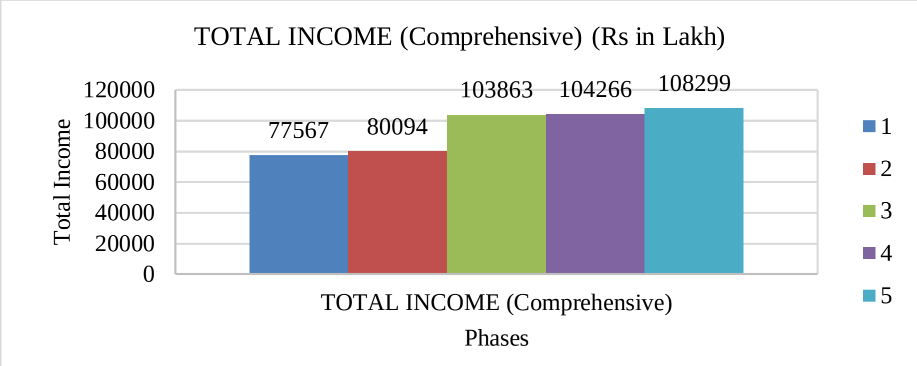

Figure 4: Income versus phases

4.5 Sales Output

It has been observed visibly from the figure 5 that the progress in sales output is taking place in different phases from 2018-2023 after adopting CMMS in the 'X' manufacturing industry. This data collected for the sales output for the last five years. It is also showing growth in sales.

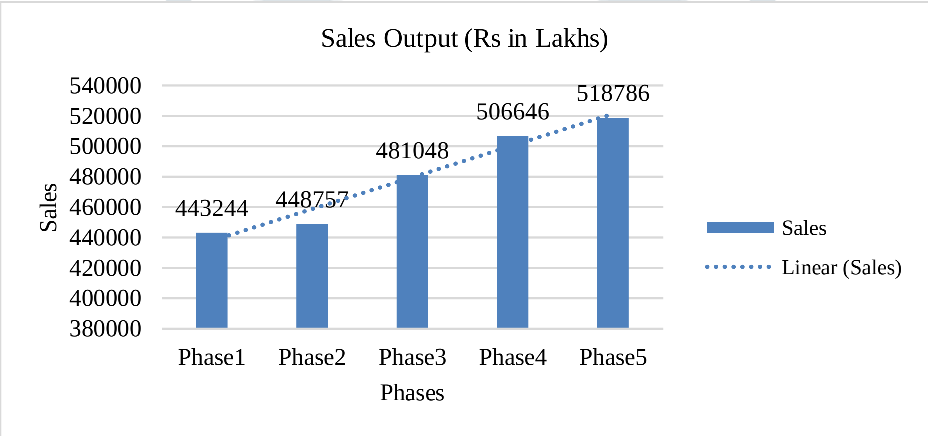

Figure 5: Sales Output verses phases

4.6 Net Profit:

It has been observed evidently from the figure 6 that the profit growth is taking place annually in different phases from 2018-2023 after adopting CMMS in the 'X' manufacturing industry. The profit raised from Rs 77557 to Rs 107832 during the last five years duration.

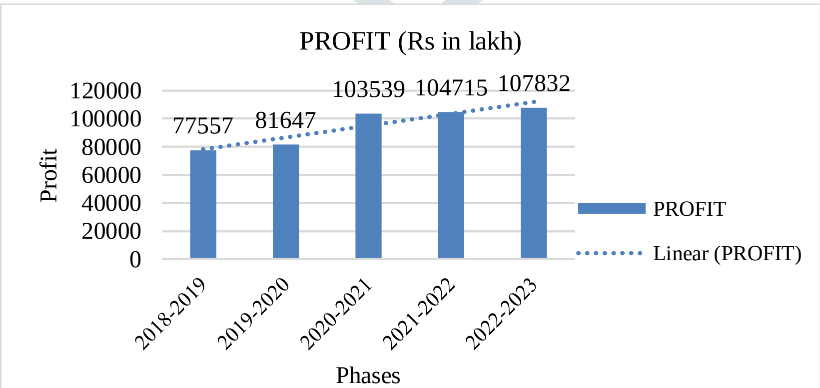

Figure 6: Profit versus phases

5. Limitations and Future Scope

1. Many CMMS programs can now interface with existing Energy Management and Control Systems (EMCS).
2. This can also be coupled with property management systems.
3. The study is limited to North India only.

4. The study can be extended in the other regions of the country for better generalizations of the results obtained with the implementation of CMMS.

6. CONCLUSION

The input factors like computerized material management & inventory control, resource, and asset management, and computerized planning and scheduling improved the outcome of the application of CMMS in the toothpaste manufacturing industry. With the above observations, it is found that output factors like income, sales output, and profit of the industry have grown significantly with the implementation of CMMS. Furthermore, CMMS enhances the efficiency of the machines, equipment, vehicles, assets, and other facilities of the industries by stopping frequent breakdowns, reducing downtime, increasing the uptime, and saving the cost of production which ultimately increases the income, sales, and profit of the company. Therefore, CMMS can be recommended as a maintenance solution for manufacturing and other industries to enhance productivity, profitability, overall organizational achievements, and sustainability.

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Appendix

Table 1: Definitions and Abbreviations used for different factors of CMMS

S.No.	Definition	Abbreviation
1.	Computerized Maintenance Management System	CMMS
2.	Computerized Maintenance Planning & Scheduling	CMPS
3.	Computerized Material Management & Inventory Control	CMMIC
4.	Computerized Report Management	CRM
5.	Enterprise Asset Management	EAM
6.	Resource & Asset Management	RAM
7.	Productivity Improvement	PI
8.	Advanced Downtime Analysis Programme	ADAP
9.	Safety, Health & Environment Improvement	SHEI
10.	Cost Optimization	CO
11.	Information Technology	IT
12.	Information and Communication Technology	ICT
13.	Analytical Hierarchy Process	AHP
14.	Internet of Things	IOT
15.	Industrial Internet of Things	IIOT
16.	Interpretive Structural Modelling	ISM
17.	Multi-criteria Decision Making	MCDM
18.	Technique for order performance by similarity to ideal solution	TOPSIS
19.	Total Productive Maintenance	TPM
20.	Cyber Physical System	CPS

Source: Author's own work.