

Evaluation Of Maintenance Techniques Of Manufacturing Equipment On Companies Profitability

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Abstract—The subject of maintenance is very important in industries nowadays. Many industries are now changing from one maintenance techniques to another in order to be more effective and efficient in operation. This research evaluates different techniques used by a large pure water-producing factory. Operation data of critical equipment and machine was obtained from the company between 2015 to 2022. Also, economic data was also obtained and a questionnaire was used to obtain some information. The results of the analysis performed (maintenance cost-profit index) based on the data obtained show that the profitability of the company increases when preventive and reactive techniques was used in the company. Also, the results show that maintenance cost is a function of profitability. This research suggests that companies should invest more in maintenance as it will enhance productivity and profitability.

Keywords—Maintenance, Cost, Techniques and Profitability.

1. INTRODUCTION

Manufacturing industries deal with heavy and light electrical and mechanical machines used for production. There are many factors that contribute to the effectiveness of manufacturing industries from machinery to personnel which contribute to the successful operation of any manufacturing industry. Many approaches have been considered to increase the output performance of manufacturing industries. The study of [1] concluded that proper management of staff enhance great output in manufacturing industries while [2] concluded in the study that effective maintenance of equipment and machine increases the productivity of the manufacturing industry. Many industries in developing countries depend majorly on human manpower for effective production which makes them set high policies that will put the staff orderly. However, many of the organizations did not take into consideration the effective maintenance of equipment. Even some of the organization's CEO see the engineer as incompetent whenever demands is be made for the maintenance of equipment. This research will study how effective maintenance techniques used by the manufacturing industry affect productivity and profitability.

Maintenance Techniques/Approach

Many maintenance techniques such as strategies and concepts have been proposed and implemented by researchers and practitioners. Identification, investigation, and execution of numerous repair, replacement and inspection choices are all part of a maintenance strategy. In coordination with production and other relevant tasks, it is concerned with creating the best life plan for each equipment/unit of the plant and the best maintenance schedule for the production equipment. A maintenance strategy outlines what conditions (such as failure, the passage of time and condition) lead to the type of maintenance activity (inspection, repair, or replacement). A maintenance plan is made up of a variety of approaches and/or rules that differ from facility to facility. It depends on various factors such as the objectives of maintenance, the nature of the facility or the equipment to be maintained, workflow patterns (process focus, product focus), and the work environment [3].

The set of diverse maintenance interventions (corrective, preventative, condition-based, etc.) and the overall framework in which these interventions are anticipated are referred to as a maintenance concept [4]. The maintenance idea represents how a corporation views the function of maintenance as an operational function and provides the foundations from which maintenance strategies are built. Many small and large-scale companies have a schedule plan for preventive maintenance of their equipment which supposes to help them to avoid downtime of equipment due to fault. However, many organizations have not built a good preventive schedule plan in order to avoid break down. In this research large scale industries equipment was considered and the maintenance data, schedule plan data and productivity data was obtained to in order to determine how effective the maintenance techniques used is to the output production of the company. Also this research will developed a proposed equipment management flow chart that will help small-scale industries to run effectively.

Revolution of Maintenance Techniques

Maintenance has seen a number of significant advancements. Fig. 1 depicts how maintenance methods have evolved. Industry was not particularly heavily mechanized prior to World War II. The majority of the equipment was overly simplistic in design. Failure

repercussions weren't important and didn't have a noticeable impact. In order to "fix it when it breaks," industrial equipment was therefore used until it broke down. At that time, it was either fixed or replaced [3].

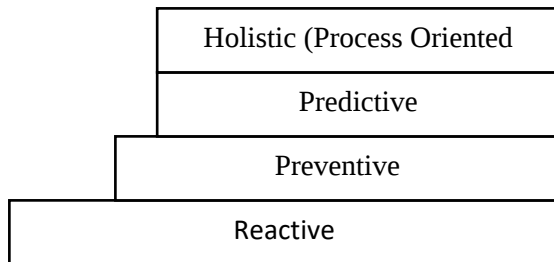


Figure 1: Revolution of Maintenance Techniques

Maintenance was viewed as a necessary evil and a production responsibility. The first maintenance strategy is referred to as reactive maintenance since no steps are done to stop breakdowns or identify their early stages. Although the expenditures associated with upkeep are frequently significant, in some circumstances this strategy could be deemed cost-effective [5].

Increased mechanization resulted from a number of factors after World War II, including a lack of skilled labor in the industrial sector and a rise in consumer demand for a variety of goods. The manufacturing facilities grew in complexity. Cost, lifespan, and availability were seen to be crucial elements in attaining corporate goals. The maintenance department was given the responsibility of doing maintenance, which was seen as a technical issue. Thus this give rise to the second maintenance approach called preventive maintenance. Preventive maintenance is described as "the maintenance carried out at specified intervals or conforming to established criteria and designed to lessen the chance of failure or performance deterioration of an item." Both time-based (calendar time) and use-based (total operating time, number of operations, miles) predefined intervals may be used. These intervals are established by the use of statistical models and optimization [6].

Manufacturing facilities become even more mechanized and sophisticated during the 1970s. Safety, quality, the environment, multi-skilling, and reliability, availability, and maintainability were all seen to be of utmost importance. The industry started using maintenance management information systems (MMIS), condition monitoring (CM), and condition-based maintenance (CBM), which were developed primarily for the aerospace and defense sectors. Maintenance performed in accordance with necessity as determined by condition monitoring is referred to as CBM. These procedures may be categorized as a predictive strategy, which focuses mostly on uncovering prospective and concealed problems and forecasting the state of the equipment.

More work has been done recently to establish internal and external partnerships between maintenance and other

supply chain components as a result of globalization (crossing of boundaries). For instance, assisting with the manufacturing process' improvement, assisting the buying department in choosing the OEM, assisting with the production process design, utilizing company-wide information systems, etc. Monitoring variations in both machine conditions and product quality is also given increased importance. As a result, these methods might be referred to as process-oriented "holistic" approaches [7].

Impact of Equipment Maintenance on Profitability.

According to the American Productivity Quality and Centre (APQC) profitability is referred to be the result of productivity and price recovery. It also described the real output in relation to the actual inputs, and productivity. Productivity depends on how efficient and effective the production process worked.

Furthermore, it is possible to analyses the causes of the changes in profitability, and know how the changes in productivity affect the profit, separately from the changes in the uncontrollable factors, i.e. price recovery. Thus the following model is suggested, by [3] as presented in Figure. 2.

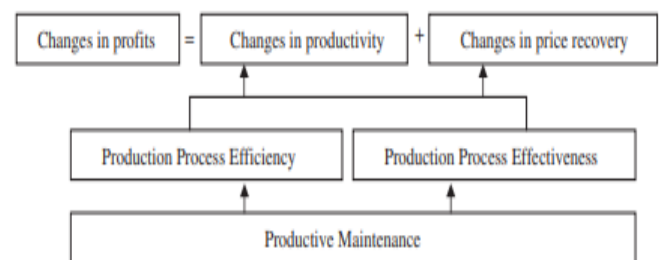


Figure 2: Conceptual model illustrating maintenance impact on firms' profits (adapted From Alsyouf, 2006).

The model shows how a productive maintenance approach that is, one that is effective and efficient could influence the efficacy and efficiency of the manufacturing process.

Productivity and price recovery are two components of the profitability equation that are influenced by the efficacy and efficiency of the manufacturing process. Since it is difficult to track changes in the price recovery index, we will solely analyze the influence of maintenance on the productivity index. This is owing to the fact that the price recovery is influenced by the varying external and uncontrolled elements that have an impact on the costs of the products or the inputs, and that proper maintenance may extend the life of the machine and shorten the production time. It is possible to demonstrate how maintenance affects a business' profitability using this model by raising overall productivity.

Generally, improvement in productivity can be carried out using one of the following ways according to [8]

1. Output increases with a reduced level of input (the ideal).
2. Output increases with the same level of input (working smarter).

3. Output increases faster than that of the inputs (managed growth).
4. Output remains constant while reducing the input (greater efficiency).
5. Output decreases, but decreases the level of input more (managed decline).

Productivity and Profitability

The major aim of maintenance in any organization is to reduce operating costs and improve product or service quality. Therefore, the cost effectiveness of each improvement action could be examined by assessing the relevant cost parameters before and after improvements.

[3], illustrate how could improvements in maintenance effectiveness increase the manufacturing company productivity, hence its profitability. Figure 3, illustrates the relationship of quantity of good quality items produced with both of total cost per unit (TC/unit) curve and product price. However, the following assumption was made:

the product has a constant price and unchanged input costs.

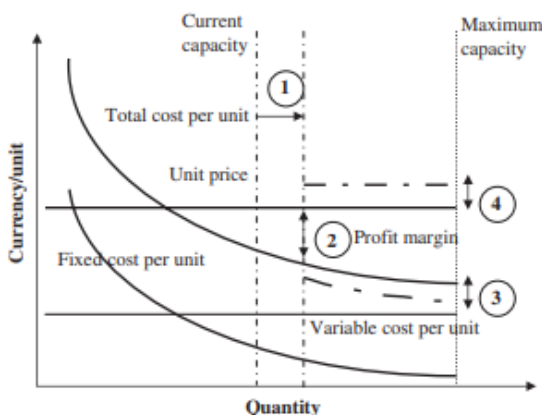
the market is in a boom condition, i.e. high demand in the market.

the total costs consist of variable costs and fixed costs.

the variable cost per unit quality item is assumed to be constant on the short run, while the fixed cost per unit quality item decreases with quantity produced.

The role of maintenance in a company's productivity and profitability improvement.

The relationship between a manufacturing system's capacity and the total manufacturing costs per unit quality item was used to describe and illustrate how maintenance could affect the manufacturing system's productivity and profitability, as conceptually illustrated in Fig. 3.



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Figure 3: Quantity of quality product produce and total cost per unit (adapted from [3])

It was suggested that the variable cost per unit quality item, such as the cost of raw materials per item, may be

regarded as constant in the short term regardless of how many things were created, for a specific period of time. . Also, the fixed cost per unit quality item will decrease based on how many items were produced in that period. This will result in a decreasing total cost per unit item.

2. Data Collection

In order to achieve the aim of this research data was obtained from a pure water-producing company in Akure, Nigeria. The primary data was obtained through the use of questionnaires to the manager and the secondary data was obtained from the company's long book. The name of companies that was contacted for this research was not mentioned in order to avoid infringement of the right. The yearly amount spent on the Maintenance of equipment was obtained and the profit made by the company was also given. Based on the data gathered from the company. The equipment of interest (Critical Equipment) in the water factory the equipment of interest is the MVA Generator, the sealing machine and the purifier machine (RO). The stoppage period both planned and unplanned of this equipment that leads to downtime in production was obtained. Also, the type of maintenance techniques used for the equipment was also obtained and the equipment which is the heartbeat of the industry was stated by the manager. The economic data obtained includes fixed and variable operating costs, profit margin, net profit, working capital, maintenance costs, investments in maintenance and spare parts inventory were collected. However, the economic data were confidential and in order to avoid infringement on right the data used in the analysis were transformed using several suitable factors which still allowed accurate results.

3. RESULTS AND ANALYSIS

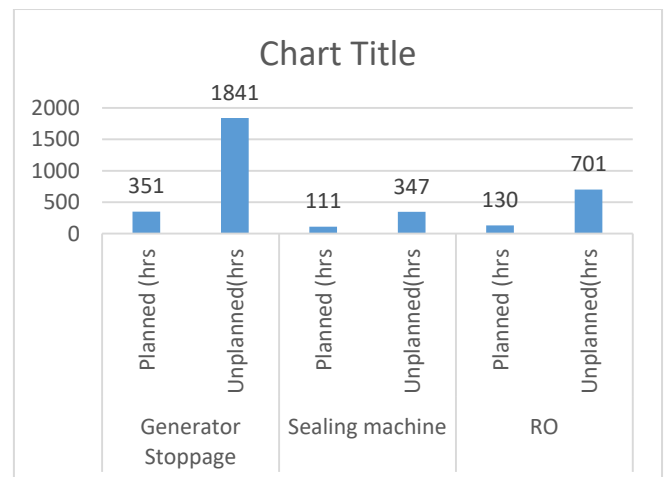


Figure 4: Planned and unplanned Stoppage of Equipment

Figure 4, shows that the planned stoppage hours of the generator, sealing machine and the RO is lower compared to the unplanned stoppage hours which is majorly associated with a fault on the equipment.

Table 1: Yearly Preventive planned used by Company

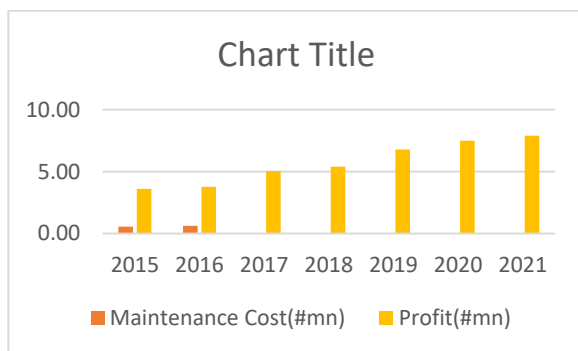
Company	2015	2016	2017	2018	2019	2020	2021	2022
Water Factory	R	R	R	R	R&P	R & d P	R& P	R & P

Legend: P- Preventive Maintenance

R- Reactive Maintenance

Table 1, shows the type of predictive maintenance practice by the water factory and cocoa processing factory in which the water factory made use of reactive maintenance techniques on equipment between the year 2015-2018 and both reactive and preventive techniques were used between 2019-2021. This implies that the maintenance schedule was planned for each across the year 2019-2021, however, if there is an equipment breakdown the management will fix it.

The yearly maintenance cost and profit of the water factory company are presented in figure 5, the results indicate that more money was spent on maintenance when reactive techniques were practised compared to the amount spent when both preventive and reactive maintenance techniques were practised. Also, the profit of the organization showed an increase when both reactive and preventive maintenance was practised and the maintenance cost to profitability ratio index presented in Table 2, indicated that the reactive and preventive techniques used are better than when reactive techniques only are used. This implies that maintenance cost can be a function of profitability.

**Figure 5:** Yearly maintenance cost and Profitability cost for the company water factory**Table 2:** Maintenance cost -Profitability Index

Years	Index
2015	0.16
2016	0.16
2017	0.10
2018	0.13
2019	0.07
2020	0.08
2021	0.09

4. CONCLUSION

This research concludes that the maintenance techniques used on production equipment are a function of profitability in any organization. This research suggests that a preventive approach should be used on equipment in production industries rather than reactive maintenance, also maintenance cost in the industry should be seen as a parameter for efficiency and effectiveness in production.

REFERENCE

- [1] Mfundo N., Kapil G. and Madindwa, M. (2020) Causes and Impact of Human Error in Maintenance of Mechanical Systems. MATEC Web of Conferences 312, 05001, pp. 1-9. <https://doi.org/10.1051/mateconf/202031205001>
- [2] John A. K. and Sadira, M. (2020). Impact Of Improper Installation, Maintenance And Servicing Of Electrical Equipment In Forest Products Industries. Accepted for publication in IEEE Transactions on Industry Applications DOI 10.1109/TIA.2020.2987276,
- [3] Alsyouf, M. (2007). The role of maintenance in improving companies' productivity and profitability. Int. J. Production Economics Vol. 105 70–78.
- [4] Khathutshelo, M. and Brian T. S. (2018). The impact of plant maintenance on quality productivity in Gauteng breweries. Proceedings of the International Conference on Industrial Engineering and Operations Management Washington DC, USA, September 27-29, pp. 1744-1753.
- [5] Sherwin, D.J., 2000. A review of overall models for maintenance management. Journal of Quality in Maintenance Engineering 6 (3), 138–164.
- [6] British Standard, 1984. British Standard Glossary of Maintenance Management Terms in Terotechnology. British Standard Institution, London.
- [7] Al-Najjar, B., 1997. Condition-based maintenance: Selection and improvement of a cost effective vibration-based policy for rolling element bearings. Doctoral Thesis, Lund University, Sweden.
- [8] Neely, A., Gregory, M., Platts, K., 1995. Performance measurement system design. International Journal of Operations and Production Management 15 (4), 80–116.