INDIAN JOURNAL OF
ENGINEERING

19(51), 2022

# Examination of the Maintenance Management Effectiveness in an Industrial Plant

**Sangotayo Emmanuel Olayimika[1*], Benjamin Aina Peter[2], Kibogo Ibrahim[3]**

**To Cite:**
Olayimika SE, Peter BA, Ibrahim K. Examination of the Maintenance Management Effectiveness in an Industrial Plant. *Indian Journal of Engineering*, 2022, 19(51), 116-124

**Author Affiliation:**
[1,3]Department of Mechanical Engineering, Kampala International University, Uganda
[2]Department of Physical Sciences, Kampala International University, Uganda

[*]**Corresponding Author:**
Email: sangotayo.emmanuel@kiu.ac.ug

**Peer-Review History**
Received: 06 February 2022
Reviewed & Revised: 09/February/2022 to 24/March/2022
Accepted: 26 March 2022
Published: 29 March 2022

**Peer-Review Model**
External peer-review was done through double-blind method.



## ABSTRACT

Maintenance is the practice of keeping machines and equipment in excellent working order in order to maximize their efficiency and service life and maintenance management is considered a restorative element of production management. The purpose of this study is to assess the maintenance management in an air conditioning plant. Questionnaires and structured interviews were utilized to accomplish this goal. Descriptive statistics were used to analyse the data collected. The findings indicated that there is an exceptional maintenance management culture the plant considered, as evidenced by an excellent physical condition and security policy. The breakdown of equipment occurs as a consequence of component failure and high workload, and most machine malfunctioning parts are repairable. Corrective and periodic maintenance are emphasized, and a sizable portion of spare components is imported. Corrective and periodic maintenance are emphasized, and a large proportion of spare parts are imported in Uganda. The government should promote local manufacturers to produce spare parts in-house, as the majority of failures occur due to faulty spare components.

**Keywords**: Assessment, Maintenance, Management, Industrial Plant

## 1. INTRODUCTION

The effective maintenance is key to achieve the desired performance. Effectiveness focuses on how good departments and its operations meet their goals. Inventory management, planning and scheduling, and preventive maintenance are widely identified key performance indicators for the effectiveness of maintenance management. However, there are still more to find when it comes to performance measures (Wang et al., 2020, Bokrantz et al. 2020 and Afolalu et al., 2021[a]). Maintaining any piece of equipment or plant is critical to extending its design life. Belt adjustment, correct lubrication of components, and component replacement are all examples of basic maintenance procedures that extend the life of equipment. Machines that are maintained properly can hold tolerances better, generate less scrap, and manufacture parts with greater uniformity and quality (Jiménez et al. 2017).

DISCOVERY SCIENTIFIC SOCIETY

The term maintenance refers to the process of keeping machines and equipment in excellent working order in order to maximize its efficiency and lifespan. It refers to the various steps done by an organization to replace, repair, and maintain the plant's components and equipment in order to ensure that the plant operates continuously within acceptable limitations (Singh et al. 2020; Emovon, 2018). Thus, maintenance management can be viewed as a restorative function of production management, tasked with the responsibility of ensuring that equipment/machines and plant services are always available and in good working order (Marquez et al. 2020). Figure 1 shows how various maintenance management strategies for ensuring that equipment's maximum design life is reached and/or surpassed have evolved through time. Predictive maintenance, reactive maintenance, preventive maintenance, and reliability-centered maintenance are examples of these (Marquez et al. 2020).

Preventive maintenance is a term frequently used to refer to scheduled or meter-based service activities that are designed to prolong the life of equipment and identify possible problems through inspection and early detection. This involves duties performed on specific equipment as part of service contracts, such as cleaning, inspections, lubrication, and testing. Inspection is critical for preventive maintenance since it enables the detection and rectification of issues early (Afolalu et al., 2019). It is the most often used technique for manufacturing operations' maintenance management (Mohajan, 2017).

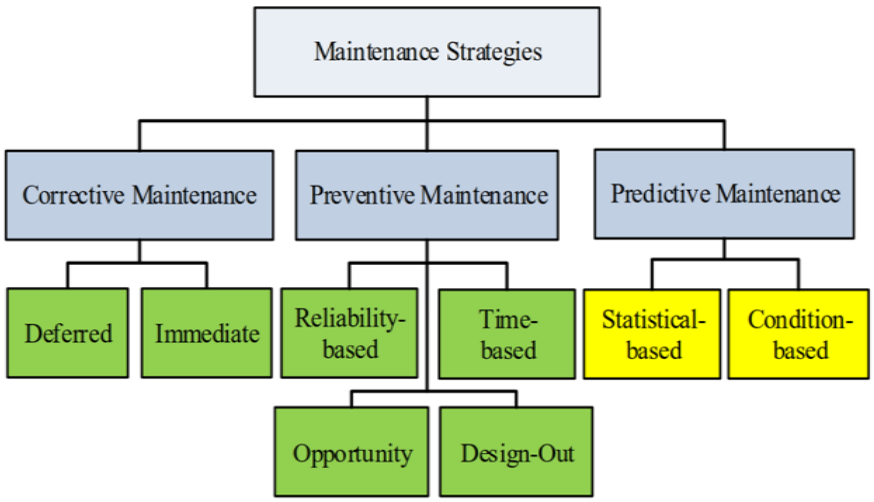


**Fig. 1.** Categories of maintenance strategy (Marquez et al. 2020)

Predictive Maintenance is distinct from preventive repair in that it determines the need for maintenance based on the machine's actual condition rather than on a predetermined timetable (Wang et al. 2015). It entails the use of computer and digital technology to monitor the state of equipment in order to provide early fault identification and intervention with greater precision. It typically comprises surge comparisons, ultrasonic and vibration analysis, oil and coolant analysis, thermographic analysis, and wear particle analysis, among other approaches. (Afolalu et al., 2021[b]) This strategy is easily combined with preventive maintenance since it gives extra data necessary for the development of an efficient predictive maintenance plan. It is frequently used in large, dynamic enterprises (Mohajan, 2017).

Dismantlement maintenance entails a "run until broken" approach. There is no attempt made to maintain the equipment in the manner in which it was originally designed to ensure it reaches the end of its design life. Due to its simplicity and direct approach, it remains the primary technique for maintenance management (Wang et al. 2015). It is also known as "Run-to-failure" management and is typically used for non-critical components such as light bulbs and batteries, or other redundant components that have no effect on the manufacturing process (Mohajan. 2017). .Pintelon and Puyvelde (1997) provided an overview of different PMSs, including indicators, reference numbers, and surveys. Extensive models such as Hibi, Luck, and the Maintenance Management Tool (MMT) have been published, as well as case examples illustrating the use of MMT. This strategy is viewed as more proactive than previous scientific ways to reporting on maintenance performance. Tsang et al. (1999) examined the dangers associated with the indiscriminate application of commonly used maintenance performance measures. Numerous methods for evaluating maintenance performance have been examined. A value-based performance metric seeks to quantify the impact of maintenance efforts on the future value of the underlying assets. The Balance Score Card (BSC) is a new and holistic approach to measuring based on the premise that no one metric is sufficient to reflect a system's overall performance. The other two methodologies are addressed in



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS

detail: systems auditing and Data Envelopment Analysis (DEA). Applying BSC to maintenance performance management is a prospective field of research that may be investigated.

Liyanage and Kumar (2003) recently applied BSC to the development of operations and maintenance performance (O&M) management processes in the oil and gas industry. The article focused on the value of operations and maintenance, rather than on the cost, in the new business environment, and underlines the importance of transitioning from a plant-based policy to a more or less long-term business-oriented strategy. Tsang (1998) explored the concept of BSC as an SMM tool for assessing industrial performance. Al-Najjar and Alsyouf (2004) established a model to assess the economic impact of vibration-based maintenance (VBM (a subset of condition-based maintenance)) and then used it to develop relevant maintenance performance measures. The model used life cycle costs (LCC) as monitoring parameters to offer the necessary information for decision-making, to ensure cost-effective measures, and to promote continuous improvement efforts cost-effectively. Kutucuoglu et al. (2001) examined the importance of PMS in maintenance, focusing specifically on the development of a new PMS utilizing the QFD technique. QFD presented facts and information using a three-stage matrix design and is also referred to as "a home of quality." The reason for this is that the matrix in QFD forms a house-shaped diagram.

According to Arts et al. (1998), MMIS is essential to measure performance. A number of performance indices have been listed for the purpose of assessing maintenance performance. Similarly, an extensive list of indices for maintenance managers with associated benchmarks has been published in a National Petroleum Refiners Association article noted in the preceding study. Raouf and Ben-Daya (1995) suggested a systematic approach to TMM and examined numerous TMM-related challenges, as well as presenting a technique for evaluating the effectiveness of current maintenance management practices. Groote (1995) proposed a system audit approach to maintenance evaluation that is based on a quality audit and quantitative maintenance performance indicators. Additionally, the findings of a study of performance ratios across three industries are provided. Dwight (1999) argued in another work on systems approaches that an absolute definition of maintenance performance in terms of value changes creates tough practical challenges. Additionally, the article indicated that using a systems audit approach to performance monitoring may be able to address some of these issues.

A partial maintenance productivity goal is for the company to optimize its maintenance productivity in economic terms, aiming to produce any level of output at the lowest possible maintenance cost relative to the state of the production system (Lofsten, 2000). The mentioned partial productivity model demonstrates how the output prices of manufactured products and input prices (maintenance costs) vary over time. The model incorporates expected changes in the pricing of outputs and existing inputs. This study examines the maintenance management effectiveness in an industrial plant.

## 2. MATERIALS AND METHOD

This is a framework for resolving a research challenge. The following issues were brought to light during the investigation of the industrial plant's maintenance management assessment: The population of be studied; the percentage of the population of be studied and how this percentage were determined (Sampling technique) were discussed. Data collection and organization were related to the investigation's subject matter and subjected to proper statistical tests.

### Population Size

This is a collection of items or individuals from whom pertinent data was gathered for the study. Three hundred (300) industrial plants' participants were surveyed for this study.

### Sample Frame

This is the subset of the population from which data for this study were gathered. The sample frame is comprised of the total number of Air Conditioning users per area, which is thirty (30) users in elected locations of the industrial plant.

### Sample Size

The study area consists of Communications House, which is separated into five sections, each of which is located in a central and densely populated location. A stratified random sampling technique is used to select the sample size for convenient, because the area is associated with the number of people who use air conditioning, and accurate analysis of the study work, which is ten (10) percent of the people who use air conditioning in each area.



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS

**Sampling Technique**

The sample size was determined by the use of a random sampling process. It was chosen because it assumes that each user within the population has an equal chance of getting selected and that the population's distribution pattern is random.

**Instrument and Data Collection**

The research study relied heavily on primary sources of data, including questionnaires, visual observation, and direct interviews with respondents in the study area. The questionnaire was disseminated within the study region in accordance with the research design in order to collect relevant data, and personal interviews were conducted to corroborate the questionnaire's findings on certain subjects that could not be addressed via questionnaire.

**Method of Data Analysis**

Data analysis is the process of categorizing, summarizing, and examining the acquired data for patterns and linkages. It can be descriptive or inferential, however in this study, both descriptive and statistical tests were utilized to examine the data,

**Descriptive Statistics**

The data received from respondents for the research maintenance management assessment of the air conditioner system was summarized and presented using tables, bar charts, and pie charts.

**Inferential statistics**

This is in addition to the descriptive statistics associated with method analysis. The researchers could draw conclusions that extend beyond the subjects investigated and encompass other subjects that were not studied but are members of the same population as the subjects studied.

## 3. RESULTS AND DISSCUSSION

This section offers a summary of the findings and a discussion of the data collected in the field in accordance with the study's objectives for maintenance management. Tables, frequency distribution summaries, and percentages are used to present the data.

**Demographic Information - Respondent's profile**

Fig. 2.0 illustrates the percentage of responses. The study's data clearly reveal that males engaged in the study at a higher rate (63.3 percent) than females (36.6 percent), implying that few females participated in the research study. The age distribution of respondents in the plant is depicted in Figure 3.

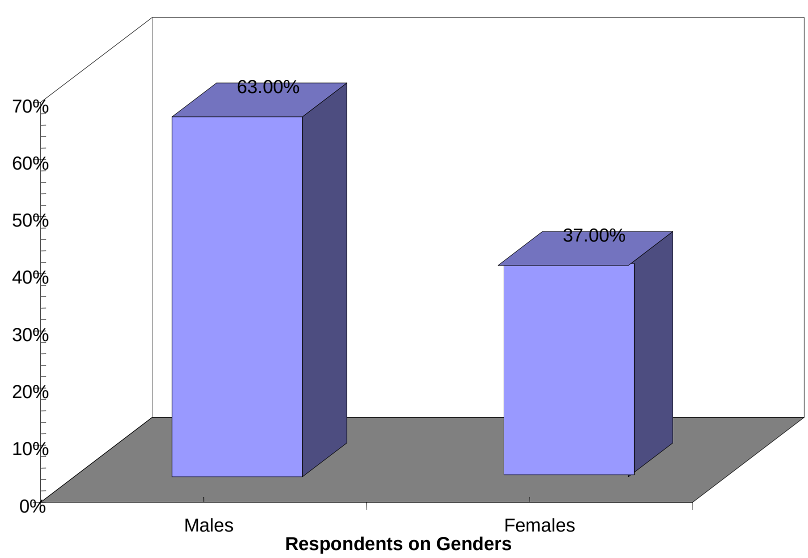


**Fig 2.** Percentage of respondents



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS

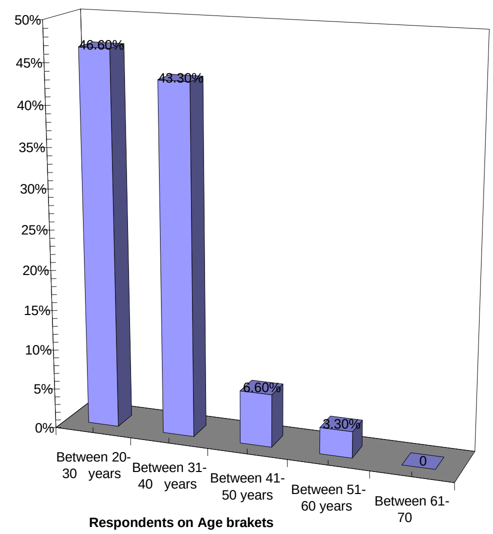


**Fig. 3** Percentage of Age bracket of respondents

Results in fig. 3 shows that there were more respondents between the age bracket of 20-30 and this was represented by 46.6%, respondents in the age bracket 31-40 were represented by 43.3% while those between 41-50 had 6.6%, the respondents between 51-60 were represented by 3.3% and no respondents were between 61-70 years of age bracket, this is true because at this time many people had already resigned doing different income generating activities.

Findings on the level of education attained by the respondents are presented in Fig. 4.0, From the Figure 4.0, it was discovered that 30% of the respondents had attained a masters degree 66.7% of the respondents attained a bachelors degree 3.3% of the respondents have diplomas. An interpretation that those respondents with masters degree were in top positions while the middle positions were filled with those holding Bachelors degree.

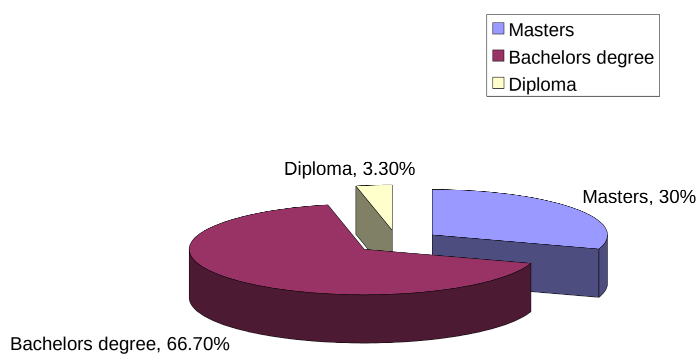


**Fig 4.** Percentage of Respondents on Academic degrees requirements

Fig 5.0 illustrates the findings on the shifts worked by respondents. According to Fig. 5.0, many respondents work two shifts, day and night, simply because the machines require continuous monitoring. This was represented by 66.6 percent of respondents, followed by 33.3 percent who worked a single shift. In Figure 6.0, the frequency with which equipment fails is depicted. According to Fig. 6.0, many respondents agree that equipment breaks down every month, with 50% stating that this is due to the equipment working continuously or certain equipment not being greased; 43.3 percent stated that equipment breaks down annually, stating that the majority of machines are purchased new and thus can perform for a period of time; and 6.6 percent stated that equipment breaks down weekly.



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS

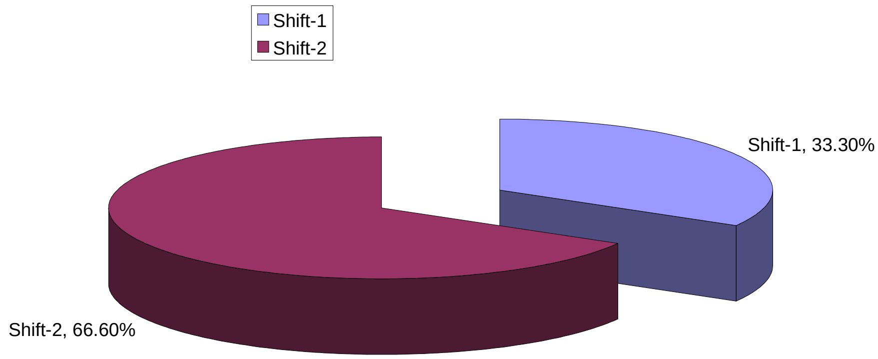


**Fig 5.** Percentage of Respondents on basis of Shifts run

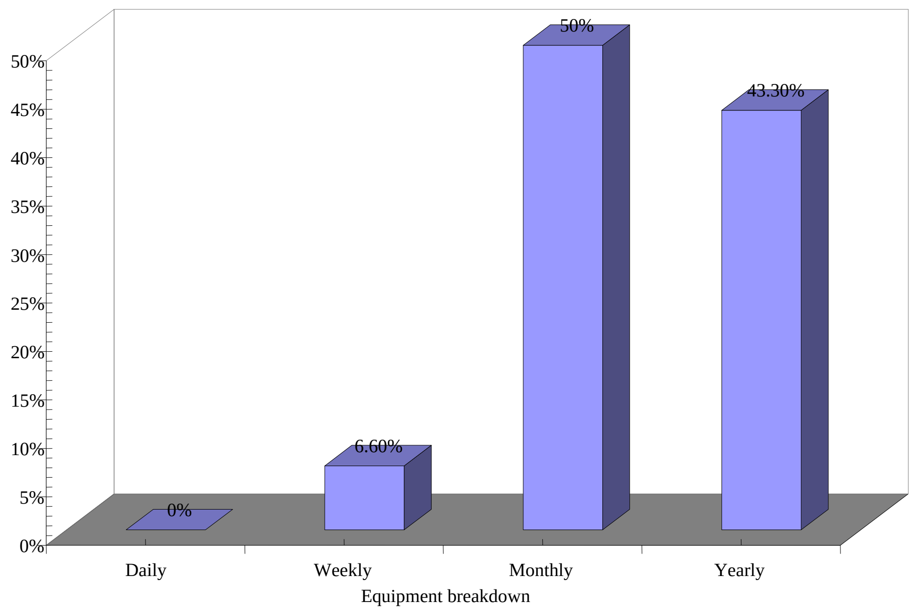


**Fig 6.** Percentage of Equipment breakdown

Fig. 7.0 summarizes the findings about the most likely causes of equipment breakdown. According to the findings in Fig. 7.0, 56.6 percent of respondents strongly agreed that equipment breakdown occurs as a result of component failure, particularly when the equipment is overworked. 23.3 percent agreed that excessive workload damages equipment, and the equipment itself fails as a result of continued operation. 13% stated that the breakdown occurred due of insufficient machinery. Whereas 7% of respondents stated that the incident occurred as a result of an inexperienced operator.

Fig. 8.0 illustrates the findings about the type of maintenance practiced in the surveyed plant.. According to Fig. 8.0, 37% of respondents stated that periodic maintenance is practiced because the equipment is made by the users, it consists of a series of elementary tasks (data collection, visual inspections, cleaning, lubrication, and screw retightening) for which no extensive training is required, and many people despise continuous visits to their offices, so they continue with this type of maintenance as long as the central air conditioning unit is operational; and 30% chose co-maintenance. 13.3 percent stated that they perform running maintenance since the majority of time, air conditioner unit failures, particularly linkages, are discovered when the unit is running. 13.3 percent stated that breakdown maintenance is performed because the majority of units that need to be replaced first fail; scheduled maintenance received no responses.



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS

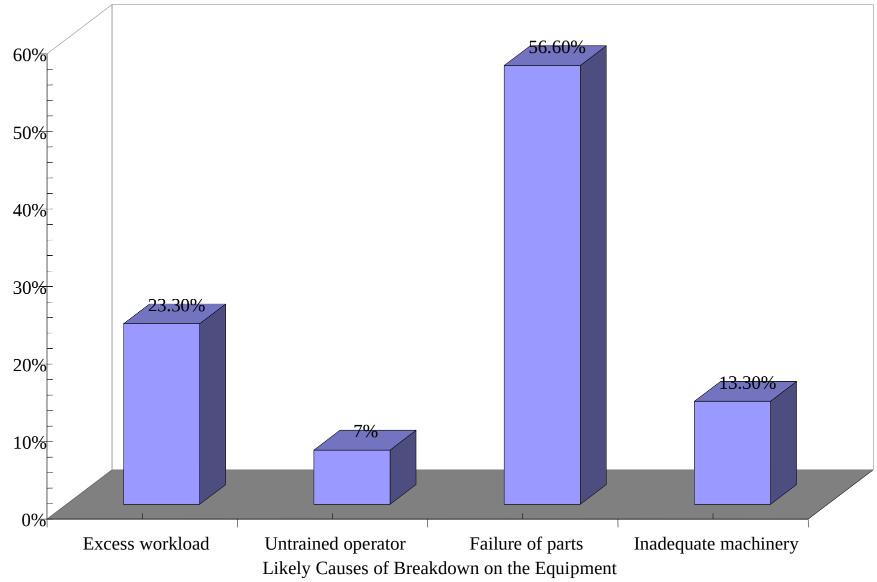


**Fig. 7.** Percentage of likely causes of breakdown on the equipment

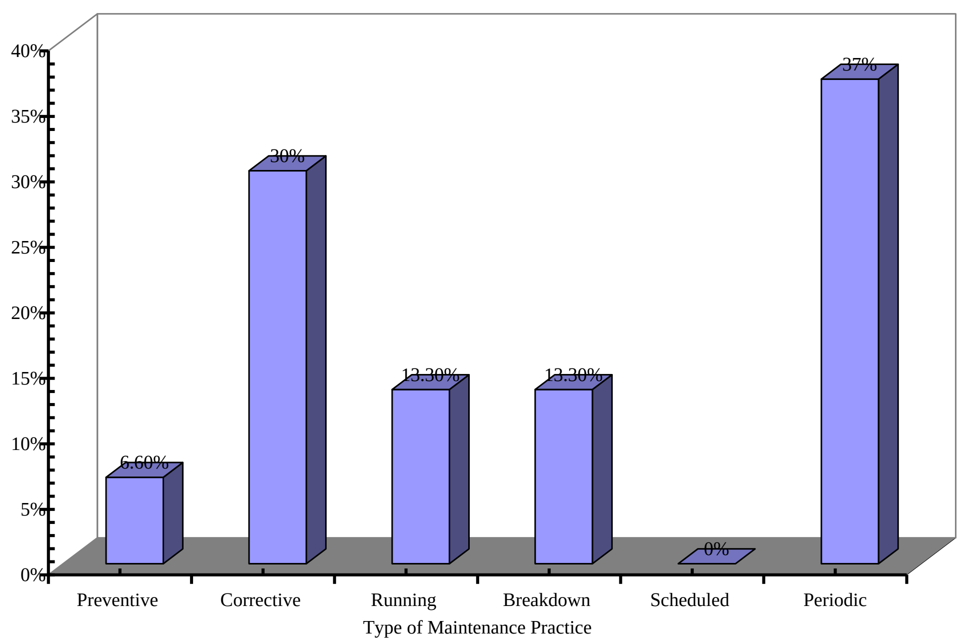


**Fig. 8** Type of maintenance practice

Fig. 9.0 shows the procedure that is followed when machine components fail. According to Fig. 9.0, around 56% of respondents strongly believe that machine malfunctioning parts are fixed; this could be owing to the high cost of original spare parts. 44 percent stated that they replace broken machine parts. This could be due to repaired equipment failing to function properly, in which case the best option is to replace.

Fig. 10.0 illustrates the findings on the procurement of spare parts. According to the findings of the pie chart in Fig. 10.0, 60% of respondents strongly agree that spare parts are acquired locally. This may be due to high taxes, but in most cases, only a few equipment spare parts are required. 40% responded that spare parts are imported. This may be due to a lack of access to spare parts locally or because the spare parts are too expensive while also failing to meet the required equipment requirements.

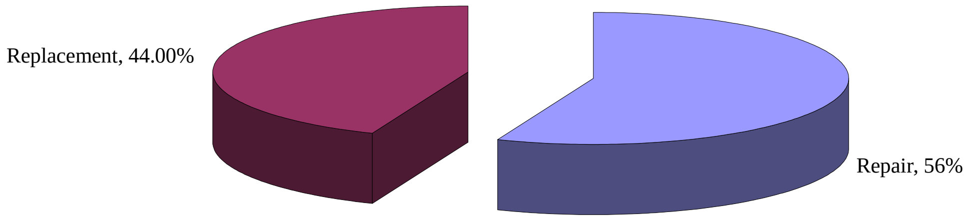


**Fig. 9** Percentage of what is carried out when machine parts are faulty

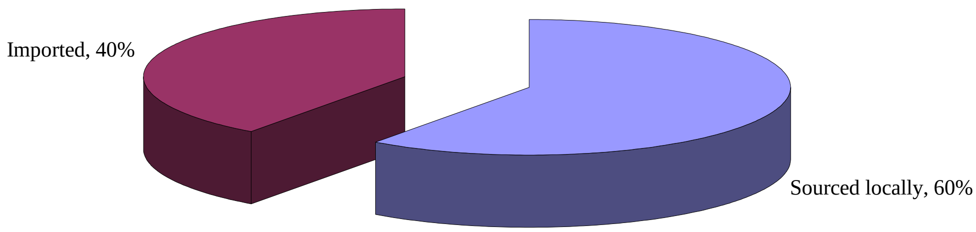


**Fig. 10** Percentage of procurement of spare parts

## 4. CONCLUSION

The following conclusions were obtained from this study: The industrial plant in Uganda has a great maintenance management culture, as evidenced by an excellent health and safety policy, an acceptable provision of wellbeing signage. The breakdown of equipment occurs as a consequence of component failure and high workload, and most machine malfunctioning parts are repairable. Corrective and periodic maintenance are emphasized, and a sizable portion of spare components is imported. The government should promote local manufacturers to produce spare parts in-house, as the majority of failures occur due to faulty spare components. The government should grant funding to build local manufacturers that make spare parts; this would assist lessen the country's reliance on foreign spare parts and will boost economic activity of the country.

**Funding**

This study has not received any external funding.

**Conflict of Interest**

The author declares that there are no conflicts of interests.

**Data and materials availability**

All data associated with this study are present in the paper.

## REFERENCES AND NOTES

1. Afolalu SA, Ikumapayi OM, Abdulkareem A, Soetan SB, Emetere ME, Ongbali SO. (2021)[a]. Enviable roles of manufacturing processes in sustainable fourth industrial revolution–A case study of mechatronics Material today: Proceedings., 44, 2895
2. Afolalu, A., Adelakun, O. J., Ongbali, S. O., Abioye, A. A., & Ajayi, O. O. (2019). A short review on queuing theory as a deterministic tool in sustainable telecommunication system Proc. World Congr. Eng
3. Afolalu, S. A., Oladipupo, S., Ongbali, S. O., Abioye, A. A., Abdulkareem, A., Udo, M. O., & Ajayi, O. O. (2021)[b]. Trends in Manufacturing and Engineering Management, 853
4. Al-Najjar, B. and Alsyouf, I. (2004), "Enhancing a company's profitability and competitiveness using integrated vibration-

based maintenance: a case study", *European Journal of Operational Research*, Vol. 157 No. 3, pp. 643-57.

5. Arts, R.H.P.M., Knapp, G.M.J. and Lawrence, M. (1998), "Some aspects of measuring maintenance performance in the process industry", *Journal of Quality in Maintenance Engineering*, Vol. 4 No. 1, pp. 6-11.
6. Bokrantz, J., Skoogh, A., Berlin, C., Wuest, T., & Stahre, (2020). Smart Maintenance: a research agenda for industrial maintenance management J. International Journal of Production Economics, 224, 107547
7. Dwight, R. (1999), "Searching for real maintenance performance measures", *Journal of Quality in Maintenance Engineering*, Vol. 5 No. 3, pp. 258-75.
8. Emovon I. (2018), "Risk assessment of a tyre manufacturing industry plant: A comparative study of grey relational analysis and PROMETHEE approaches", *Indian Journal of Engineering*, 15, 9-18
9. Groote, P.D. (1995), "Maintenance performance analysis: a practical approach", *Journal of Quality in Maintenance Engineering*, Vol. 1 No. 2, pp. 4-24.
10. Jiménez, A. A., Muñoz, C. Q. G., & Márquez, F. P. G. (2017). Machine learning and neural network for maintenance management. (In International Conference on Management Science and Engineering Management, 1377
11. Kutucuoglu, K.Y., Hamali, J., Irani, Z. and Sharp, J.M. (2001), "A framework for managing maintenance using performance measurement systems", *International Journal of Operations & Production Management*, Vol. 21 No. 1, pp. 173-94.
12. Liyanage, P.J. and Kumar, U. (2003), "Towards a value based view on operations and maintenance performance management", *Journal of Quality in Maintenance Engineering*, Vol. 9 No. 4, pp. 333-50.
13. Lo¨fsten, H. (2000), "Measuring maintenance performance – in search for a maintenance productivity index", *International Journal of Production Economics*, Vol. 63 No. 1, pp. 47-58.
14. Marquez, A.C.., Gomez Fernandez, J. F., Martínez-Galán Fernández, P., & Guillen Lopez, (2020). Maintenance Management through Intelligent Asset Management Platforms (IAMP). Emerging Factors, Key Impact Areas and Data Models A. Energies, 13, 3762
15. Mohajan, H. K. (2017). Two criteria for good measurements in research: Validity and reliability Annals of Spiru Haret University. Economic Series, 17, 59
16. Nikolaidis, C. and Probert, D., Energy method analysis of a two stage vapor compression refrigeration plants performance, Applied Energy, Vol. 60, (1998), pp. 241-256
17. Pintelon, L. and Puyvelde, F.V. (1997), "Maintenance performance reporting systems: some experiences", *Journal of Quality in Maintenance Engineering*, Vol. 3 No. 1, pp. 4-15.
18. Raouf, A. and Ben-Daya, M. (1995), "Total maintenance management: a systematic approach", *Journal of Quality in Maintenance Engineering*, Vol. 1 No. 1, pp. 6-14.
19. Singh, P., Singh, S., Vardhan, S., & Patnaik, A. (2020)., Sustainability of maintenance management practices in hydropower plant: a conceptual framework Materials Today: Proceedings, 28, 1569
20. Tsang, A.H.C. (1998), "A strategic approach to managing maintenance performance", *Journal of Quality in Maintenance Engineering*, Vol. 4 No. 2, pp. 87-94.
21. Tsang, A.H.C., Jardine, A.K.S. and Kolodny, H. (1999), "Measuring maintenance performance: a holistic approach", *International Journal of Operations & Production Management*, Vol. 19 No. 7, pp. 691-715.
22. Wang, K. S., Li, Z., Braaten, J., & Yu, Q. (2015). Interpretation and compensation of backlash error data in machine centers for intelligent predictive maintenance using ANNs *Advances in Manufacturing*, 3, 97
23. Wang, X., Zhao, X., Wang, S., & Sun, L. (2020). Reliability Engineering & System Safety, 195, 106705



ISSN 2319–7757 EISSN 2319–7765 I OPEN ACCESS