Adoption of Maintenance Key Performance Indicators in the Namibian Mining Industry

Michael Mutingi, *IAENG*, Veiko Nangolo, and Harmony Musiyarira, Charles Mbohwa

***Abstract*—The adoption of maintenance key performance indicators (KPIs) is crucial to every machine-intensive mining industry. It is important, however, to obtain an in-depth understanding of the nature and rate of adoption of these KPIs. This paper presents an assessment of the adoption of KPIs in the Namibian mining industry. It seeks to investigate the relationship between business strategy and the KPIs adopted, the approach used to derive them, the focus of the measurement system, whether emphasis is on the past or future events, and the usage of performance measurement in managing the maintenance operations. A questionnaire was designed based on concepts from the literature, and distributed to the 17 mining enterprises. A total of 7 (out of 17) responses were obtained. Results of the study indicate that the mines use KPIs fairly effectively and efficiently with some room for improvement. However, the maintenance operations were lacking in the following aspects; low of performance improvement drive, heavy reliance on lagging rather than leading indicators and the wide use of equipment related reactive indicators.**

***Index Terms*—Maintenance, key performance indicators, adoption, mining industry, Namibia**

I. Introduction

THE adoption of maintenance key performance indicators (KPIs) is essential for performance measurement and control, especially for machine-intensive industry. Performance measurement identifies gaps between the desired and the realized performance and then seeks to provide ways of closing the gaps [1]. As such, cautious selection of KPIs is crucial for accurate identification of areas of improvement.

As in every industry sector, performance measurement is vital for the mining industry, specifically for the maintenance operations which are characterized with heavy machinery which is expected to operate continuously. The mining sector often faces a myriad of maintenance issues throughout the world [2]. Thus, in a competitive global marketplace, every mining company should benchmark its maintenance performance against local and global mining enterprises, as well as other machine-intensive industries.

The mining is asset and capital intensive, and is expected to be productive 24 hours a day and seven days a week. Consequently, reliability and productivity of the plant is a highly sensitive issue [3] [2]. In addition, input costs are generally high and need to be kept in check for companies to stay competitive. Maintenance costs in mining are 20-50% of the overall operational costs [4] [5]. Thus, suitable performance measures need to be kept in check and reported regularly for effective management. Related aspects such as safety, work efficiency are also essential [6].

In the Namibian economy, the mining industry is a very important sector, contributing a significant portion of the country's GDP Recently, high input costs, including maintenance costs, have impacted the productivity of the sector [7]. The major commodities in mines are diamonds, uranium, gold, copper and zinc. Namibia produces one of the best diamonds in the world and is one of the top uranium producers [7]. In view of these issues, performance measures need to be derived, tracked, and controlled. Questions motivating this research are as follows:

1. How are maintenance KPIs derived in the Namibian Mining Industry?
2. What is the focus of the KPI; leading or lagging indicators?
3. How are maintenance KPIs across the maintenance operations?

Therefore, the purpose of this research was to make an assessment of the adoption of KPIs in the Namibian mining industry. This involved investigation of the relationship between business strategy and the KPIs adopted, the approach used to derive these indicators, the focus of the measurement system, whether emphasis is on the past or future events, and the usage of performance measurement in managing maintenance operations.

The rest of the paper is structured thus: The next section provides a brief literature review on the exploration of the literature into KPIs related to maintenance opeations. Section III presents the research methodology followed. Results and discussions are presented in Section IV. Section V briefly outlines some managerial implications, deriving from the study. Finally, Section VI concludes the paper.

II. Maintenance KPIs

KPIs are used to identify ways to reduce downtime, costs, waste and to operate more efficiently, with a focus on key result areas [8]. The indicators should also relate to the long

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term business objectives.

Performance indicators fall into two categories; leading indicators which measure inputs to a process, predicting future events, and lagging indicators measure the output of a process, indicating what happened in the past [8] [9]. Lagging indicators tend to obstruct performance improvement. Leading indicators can be viewed as operational indicators while lagging indicators are financial indicators that provide data for monitoring past performance and data for planning future performance [10]. An integrated, balanced, holistic multi-criteria hierarchical framework, consisting of three hierarchical levels of the organization (that is, strategic, tactical and functional) is presented in [11]. Seven categories of KPIs were identified: (1) equipment-related, (2) cost/finance related, (3) maintenance task related, (4) customer related, (5) learning and growth related indicators, (6) health, safety, and the environment (HSE), and (7) employee satisfaction related.

Due to the continuous nature of mining operations, availability, reliability and utilization are key metrics. KPIs should comprise leading (process-centered) and lagging (results-centered), addressing all performance issues of the in maintenance. This research investigated the application of the seven categories in the Namibian mining industry.

III. Research Methodology

Fig. 1 shows our research methodology, adapted from the literature [12] [13]. First, the framework establishes whether a structured process is followed when identifying KPIs. KPIs should also be developed for the different levels of the organization. Maintenance KPIs need to include both leading measures and lagging measures [1]. A balance between the different maintenance categories is crucial [8] [12] [14] [15] [16] [17] [18] [19 [20].

The framework then investigates the effectiveness of the application of performance management. Performance measures should be well communicated and understood in the organization. The purpose of having measures and the importance of continuous improvement in the organization will also be investigated. The questionnaire was derived from the framework to answer the main research questions and sub questions.

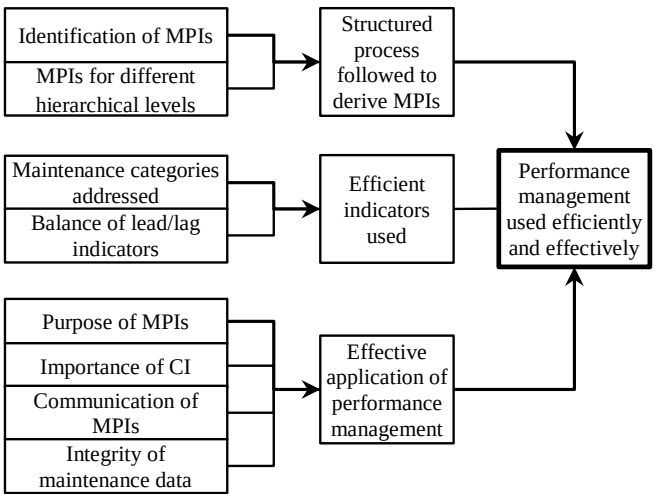

Fig. 1. Research Methodology

The first part of the questionnaire gathered the demographics. Variables used were discrete, nominal and ordinal none-interval Likert scales. Statistical calculations of the results obtained using the research questionnaire tool were performed.

The survey targeted 17 operating mines however, the final sample was 14 mines with several of them having dual roles (mining/plant manager and section engineers) and or satellite sites. The final population represents 59% (17/29), of the total (mines) population including those in exploration as presented in the literature [7]. The final tool was send to 21 potential respondents. The target respondents at the different mines were the managers in charge of managing and directing the maintenance operations at the mines.

IV. Results and Discussions

A. Descriptive Statistics

The demographic characteristics of the respondents include, commodity mined, the type of mining operation, years of experience in maintenance management and experience of the respondent in current role. The results of the survey questions as derived from the research framework will also be presented addressing the following aspects.

1. How are maintenance KPIs identified/developed for the maintenance department in your organization?
2. Out of the suggested list of 28 indicators, which ones are widely used?
3. Which categories of indicators are most important?
4. Which performance indicators are used in the organization?
5. How are maintenance KPIs communicated?

The distribution of the minerals produced in the different mines is shown in Table I.

TABLE I
DISTRIBUTION OF MINERALS

Answer Choices	Responses
Uranium	3 (37.50%)
Diamonds	3 (37.50%)
Gold	1 (12.5%)
Zinc	1 (12.5%)
Copper	0 (0.0%)
Total	8

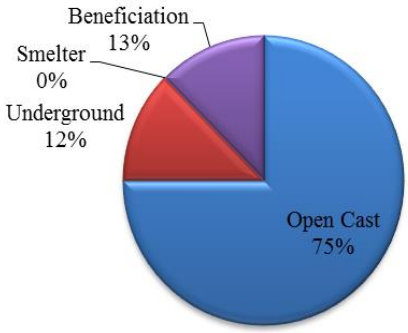

Fig. 2. Distribution of types of mines

Out of the 8 respondents, 3 respondents each indicated that they are mining uranium and diamonds. Further analysis of reveals that the majority of the respondents are into

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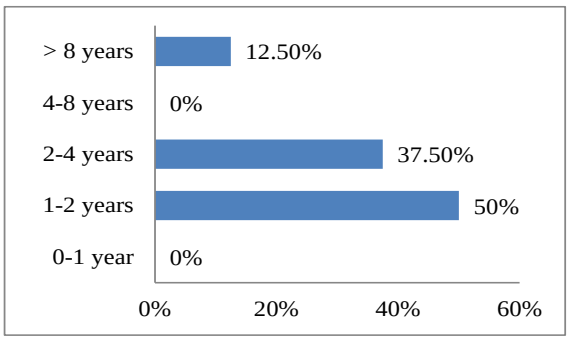
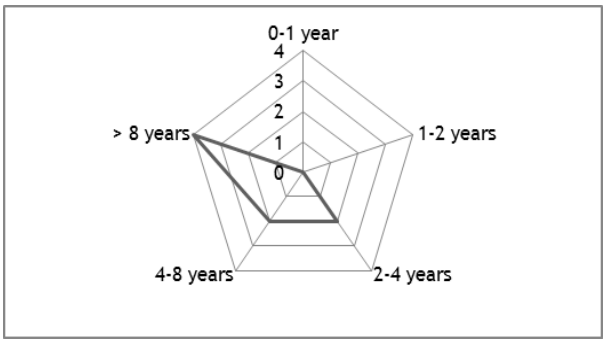


(a) Experience in the current role



(b) Experience in maintenance management of respondents

Fig. 3. Distribution of experience in maintenance management

uranium production as two of those that indicated diamonds are from the same mine

A question was posed for the respondent to indicate in what type of mining operation they are involved in; the results are displayed in the bar graph in Fig. 2, which indicates that 75% or 6 out of the 8 respondents are mining in open cast mines and one respondent indicated they are in beneficiation.

Respondents indicated their experience in maintenance management and also indicate the experience in number of years they have in their current role. The results are depicted on the radar in Fig. 3 (a) and Fig. 3 (b).

Part (a) shows that 50% (4 out of 8) of the respondents have more than 8 years' experience in maintenance management and no one with less than two (2) years' experience. On the contrary, part (b) shows 50% (4 out of 8) of the respondents have been in their current roles for about 1-2 years with only one manager having been in their current role for more than 8 years.

B. *Derivation of Maintenance Performance Indicators*

Respondents were presented with nine methods relating to the development, selection and identification of MPIs and were asked to indicate how MPIs are identified for the maintenance operations of their organisation. The options given to the respondents were according to a four point nominal Likert scale of;

- Not applicable (0)
- Was used, small influence on selection (1)
- Played an important role in selection (2)
- Primary approach used for selection (3)

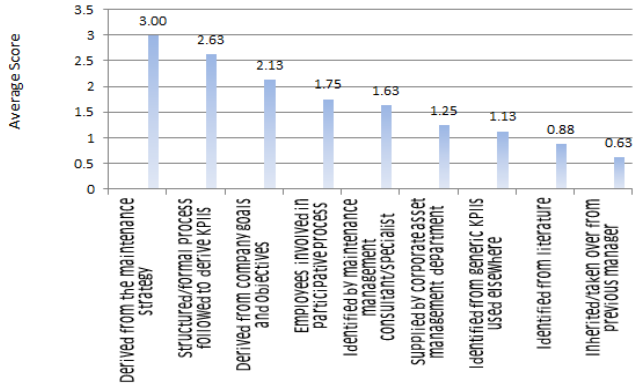


Fig. 4. Method used to identify maintenance performance indicators

The results indicate that the majority of the respondents derived their indicators from the maintenance strategy followed by using a structured/formal approach. The least used method is inherited from the previous manager.

C. *Leading and Lagging Indicators*

The respondents were given a list of 28 commonly used indicators and asked to indicate to what extent the indicators were used in their maintenance operations. A four (4) point Likert scale was used to score the choices with the scale running from (0) not applicable to (3) extensively used.

The scores for the different indicators were analyzed and aggregated. The top ten most used indicators are presented in Fig. 5.

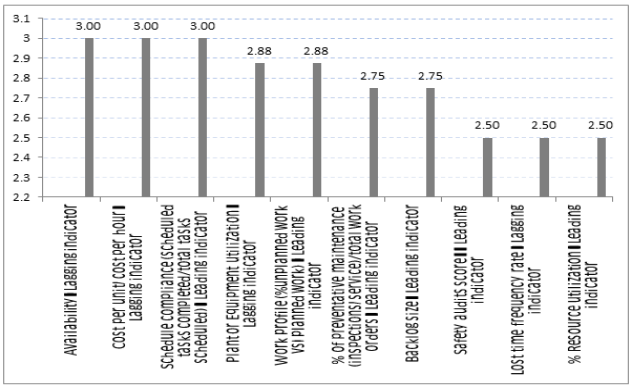


Fig. 5. Extensively used indicators for maintenance

There are six leading indicators in the top ten extensively used indicators and only four lagging indicators. It can also be seen that the lowest ranked indicators also involve many leading indicators with the top indicator being a lagging indicator. Three of the 28 KPIs, safety audits, lost time frequency rate and inspection of safety devices are strongly linked to the expectations as set out in the Labour Act 6 of 1992. The tracing of outstanding defective tasks on safety devices scored outside the top ten widely used KPIs with only 3 or 38% of the respondents indicating they use it extensively.

D. *Categories of Maintenance Indicators*

Some indicators in the previous section were allocated to the different categories and those indicators that were selected, highly (3) by the responded were also marked to

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give a score to the allocated category, as shown in Fig. 6.

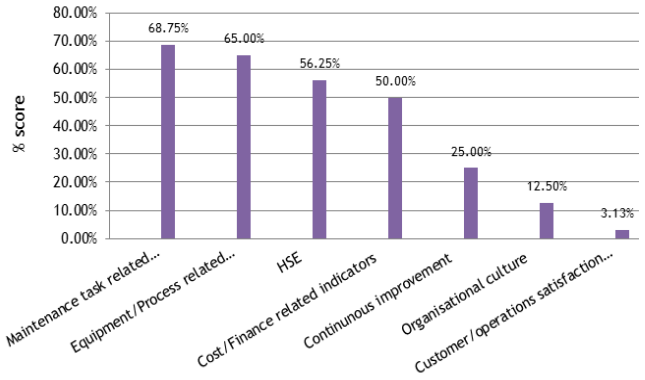

Fig. 6. Categories of maintenance indicators

The results reveal that most operations put a lot of emphasis on maintenance related indicators at 70% and only 3% customer satisfaction related indicators are seen as important which means that maintenance operations do not strive to please their customer which is the production function. HSE and cost related indicators got the same treatment at 50%.

E. Purpose for Maintenance Indicators

To the question what purpose maintenance indicators are used for in the organisations, most respondents indicated that they are used for identifying focus areas and monitoring organisational efficiency. These results are summarized in Fig. 7.

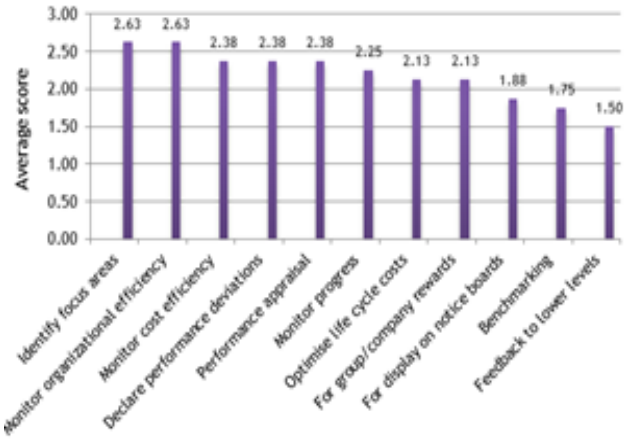

Fig. 7. Purpose for maintenance performance indicators

F. Communication of Maintenance Indicators

Regarding the communication of maintenance indicators in the maintenance operations, 4 out of 8 respondents (50%) reported that structured and formal training on KPIs was utilized, while 3 (37.5%) indicated informal communication by supervisors. Only one respondent indicated that employees were often left to find and interpret the results without assistance or training from the top management. A summary of the modes of communication of indicators is presented in Fig. 8.

The next section discusses the managerial implications of the study.

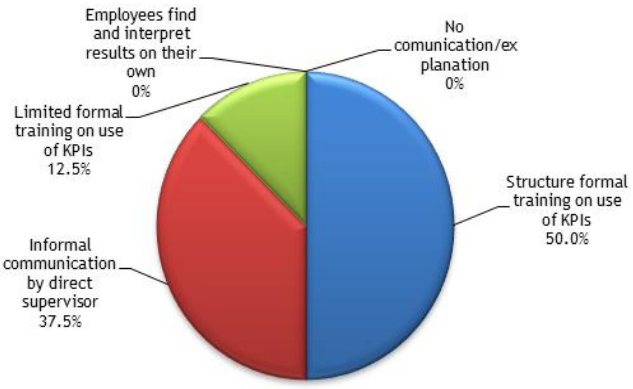

Fig. 8 Communication of maintenance indicators

V. Managerial Implications

From this study, several recommendations can be derived for the managers and policy makers. Some of these are outlined as follows:

- Maintenance operations of the involved mines may need to diversify their focus and concentrate on satisfying their customers (operations).
- Maintenance operations of the involved mines may need to spend more time and resources to drive continuous improve initiatives and interventions like conducting RCA's to get out of the cycle of despair.
- Maintenance operations of the involved mines need to focus on process measures (leading measures) so that they can alter their performance if it's deviating from the intended targets, lagging indicators give a view of the past.

In sum, this research is an important addition to the body of knowledge into maintenance performance management in Namibia and in particular the mining industry. It offers a good platform for further targeted research into the performance management of the maintenance processes in the mining industry

VI. Conclusion

The results and discussions of the results from the preceding sections were used to determine whether the research aim was achieved. The results are based on the eight responses received from managers involved in the management of the maintenance operations in the Namibian Mining Industry. The main conclusions that can be drawn from the results are;

- Based on the responses received it seems the maintenance operations of the surveyed Namibian mines use a structured process to develop and identify maintenance key performance indicators up to the third level of management.
- The surveyed maintenance operations do not use efficient indicators in that they are heavily focused on maintenance and equipment related indicators and neglecting continuous improvement and organizational culture. There seems to be a heavy reliance on lagging indicators rather than leading indicators which measure the process rather than the outcome.
- The results suggest that there is an effective application of performance management across the surveyed

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maintenance operations in Namibia with room for improvement. The application is found to be effective as three of the four operations (75%) are satisfied with only CI found to be lacking.

- There seem to be a general lack of focus on driving continuous improvement and this could be evidenced by the wide use of lagging indicators and reactive maintenance categories.

In conclusion, maintenance operations in Namibia should adopt and use maintenance performance measurement efficiently and effectively. There is room for continuous improvement, basing on a set of carefully selected maintenance KPIs. Future studies should consider carrying out comparative analyses between selected mines to compare them on different aspects and outcomes in the context of adoption of maintenance performance indicators and the associated impact on productivity.

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