DEVELOPMEMT OF AN OPTIMAL INTERVAL MAINTENANCE PLAN.

A CASE OF NAMEKARA MINING COMPANY

BY

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ABSTRACT

Extraction, haulage and material and processing of ore to get the end products largely depend on the availability, reliability and effective utilization of equipment. Equipment at Namekara mining company takes 45% of the total production costs, so it is important to keep it in normal working conditions and the availability of equipment high. In this study, failure data for the excavator, wheel loader, scrapper, conveyor belt system and haulage trucks were collected and found haulage trucks with the highest failure rate. Haulage equipment was decomposed into individual subsystems and the transmission, hydraulic dumping and the body subsystems were found to be having the highest failure frequencies. Therefore, the reliability study that has been conducted in this research has based mostly on these subsystems of truck N6.

Failure and mining data for the three haulage equipment used at the mine was collected from maintenance and mining records and has been analyzed. The data was collected over a seventeen-month period of the mine's operation. Trend and serial correlation tests to validate the assumption of IID (Independent and Identically Distribution) has been conducted. According to the results, the data collected has been found to be independent and identical meaning the occurrence of the current failures does not depend on the previous failures. Therefore, data can be used to model the sub system's reliability. FMEA for the three critical subsystems was also carried out followed by fault tree diagrams to analyze the equipment from subsystem level to components level in order to ascertain the root causes of failures and come up with improvements have been made. This was done to improve system performance and also gain a thorough understanding of the infant and direct causes of failures to subsystems and components. FMEA indicated that cylinder seal failure, valve failure, hydraulic pump failure, electrical components failure, clutch failure and failure for the transmission to engage are the most critical failure modes according to their RPN values.

The time between failure (TBF) for the three subsystems was analyzed and tested for distribution estimation and the Weibull distribution had a higher correlation coefficient. The reliability study for the subsystems was therefore done using the Weibull distribution. Reliability plots have been obtained for the three subsystems, preventive reliability maintenance intervals for the three subsystems have been obtained. Maintaining reliability and availability of equipment to meet the production requirement is vital for maintenance and production departments of the mine. To achieve these levels, equipment should be maintained at appropriate times to reduce machine/equipment downtimes as well as reducing maintenance costs.

KEYWORDS:

Reliability centered maintenance (RCM), corrective maintenance (CM), mean time between failures (MTBF), haulage truck, downtime, maintainability.

DECLARATION

I declare that this research project is my own original work except where due acknowledgement has been made. I declare that this work has never been submitted to this university or any other institution for partial fulfillment for any award

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Cannot forget the tangible and spiritual effort of my mother and beloved sisters dedicated towards my reaching here. I am thankful to them for never giving up on me.

APPROVAL

This is to certify that this final year project report has been written under the guidance of my supervisors and it is to be handed in to the department of mining engineering at Busitema university.

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ABREVIATIONS AND SYMBOLS USED

MTTR- mean time to repair

MTTF- mean time to failure

MTBF- mean time before failure

RUL- remaining useful life

IID- Identical and independent distribution

CFF cumulative failure frequency

TBF time between failure

TTR cumulative mean time to repair/restoration

MLE maximum likelihood estimation

N5, N4, N6- different haulage truck IDs used at the mine

RCM Reliability centered maintenance

CM Corrective maintenance

MAD Mean Absolute Deviation

MAPE Mean Absolute Percentage Error

MSD Mean Square Error

IQR Inter Quartile Range

AD Absolute Deviation.

cdf- cumulative distribution function

β- Weibull shape parameter

λ- Weibull scale parameter

t- time consideration

pdf-probability distribution function

μ – Weibull location parameter

1 CHAPTER ONE

This chapter entails the background to the study, statement of the problem, justification, objectives of the study, scope of the study (both conceptual, geographic and time scopes), significance of the study and conceptual diagram.

1.1 BACKGROUND

Mining is known to be one of the major causes of civilization due to the use of different minerals in the manufacturing and processing industry as a result of technological change. The increase in production of some minerals such as copper, iron, gold, silver, tin and also some industrial minerals such as graphite, limestone, vermiculite, phosphates and graphite has led to a continuous increase in economic development. The production of minerals mostly depends on the investment capital in the industry, also the rate at which the mining machinery are being utilized or the efficiency and availability of the equipment to perform the work as required which affect the production rates of the mine(Equipment, 2017). Mining machinery break downs contribute to a major cause of downtime in mines since the equipment won't be available for work as required by the mining company(Work and Production, 2014). This greatly reduces the companies' revenues since mining is one of the highly expensive businesses to start and run. The change in performance/decrease in equipment's availability and reliability not only reduces the company's daily production but also reduces the company's revenues(Kahraman, 2018). The direct loss in revenue due to reduced output of the mine and also due to salary wages for example machine operators' wages and increased maintenance costs(Todinov, 2006).

This thesis aims at looking at the various causes of machine break downs as well as both the planned and unplanned downtime stoppages to come up with a proper management and preventive maintenance plan that will look most at optimizing the costs associated with production breakdowns and also analyzing the available maintenance plane to reduce the occurrence of unplanned breakdowns during the work shifts as well as increasing machinery availability. Mining equipment availability is the duration a mine machinery of equipment is available when it matters. The change in this time or a reduction in the equipment's uptime reduces the number of cycles or the required production of the mine(Galatia, 2020). Neglecting the small reductions in machine uptime have a huge impact on the company revenues since the hourly cost of production cannot reduce as long as the mine in under operation. It is there important to look at the both the waiting and operator/mechanics cost to come up with a proper maintenance plan that will look into detail the optimization of the maintenance team for proper utilization and allocation of the maintenance team.

Be it in a manufacturing or mining company, unplanned production downtimes are a growing bane that is affecting the overall productivity and operational efficiency. To counter this, mining companies are beginning to appreciate the benefits that the digital tools and technologies have brought in reducing their production downtime(Geitner, no date)(Antgren and Brännström, 2022). However automated mining machinery are expensive, this makes it difficult for an economy whose mining industry is at its infancy stages. A work force productivity platform can identify

References

Abdel-Aziz, I. and Helal, M. (2012) 'Application of Fmea-Fta in Reliability-Centered Maintenance Planning', *The International Conference on Applied Mechanics and Mechanical Engineering*, 15(15), pp. 1–11. Available at: https://doi.org/10.21608/amme.2012.37083.

Aboura, K., Agbinya, J.I. and Eskandarian, A. (2014) 'Weibull Decision Support Systems in Maintenance', *Organizacija*, 47(2), pp. 81–89. Available at: https://doi.org/10.2478/orga-2014-0008.

Alvi, A. (1997) 'ScholarWorks at WMU'.

Antgren, A. and Brännström, A.L. (2022) 'Classifying Downtime Events for Connected Factories Using Machine Learning'.

Cheng, Y.-L. *et al.* (2016) 'We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %', *Intech*, 11(tourism), p. 13.

Dhillon, B. (2006) 'Corrective and Preventive Maintenance', *Maintainability, Maintenance, and Reliability for Engineers*, pp. 143–160. Available at: https://doi.org/10.1201/9781420006780.ch12.

Engineering, F. (no date) 'Why Take a Preventive Approach?'

Equipment, U.O. (no date) *No Title*.

Fu, Y. (2022) 'Electrical Line Fault Detection and Line Cut-Off Equipment and Control', *Journal of Control Science and Engineering*, 2022. Available at: https://doi.org/10.1155/2022/3857938.

Galatia, D. (2020) 'Exploring Factors that Affect Reliability of Open Pit Heavy Mining Dump Trucks : A Case of Bisha Mining Share Company , Eritrea', 9(6), pp. 206–219. Available at: https://doi.org/10.21275/SR20528131656.

Geitner, F.K. (no date) *Machinery Failure Analysis and Troubleshooting*.

Javadnejad, F. *et al.* (2022) 'Optimization Model for Maintenance Planning of Loading Equipment in Open Pit Mines', *European Journal of Engineering and Technology Research*, 7(5), pp. 94–101. Available at: https://doi.org/10.24018/ejeng.2022.7.5.2907.

Jia Huang, J.-X.Y. (2010) 'No TitleFailure mode and effect analysis improvement', *No TitleFailure mode and effect analysis improvement* [Preprint].

Kahraman, A. (2018) 'ThinkIR : The University of Louisville ' s Institutional Repository'.

Kovalev, V. *et al.* (2014) 'Preventive maintenance of mining equipment based on identification of its actual technical state', *Taishan Academic Forum - Project on Mine Disaster Prevention and Control*, pp. 184–189. Available at: https://doi.org/10.2991/mining-14.2014.29.

Kuzin, E., Bakin, V. and Dubinkin, D. (2018) 'Mining Equipment Technical Condition Monitoring', *E3S Web of Conferences*, 41, pp. 0–5. Available at: https://doi.org/10.1051/e3sconf/20184103020.

Lai, C. (no date) *Generalized Weibull Distributions*.

Management, A. (2017) ‘III. Current State of the Assets’, pp. 1–5.

Milod Zakaria Ahmed and Ali, H.M. (2022) ‘International Conference on ELECOM’, in *Estimation of Weibull Distribution Parameters by Using Excel Solver Tool for Wind Speed Data at Al-Aziziyah, Libya*. Mauritius, p. 44. Available at: https://doi.org/https://doi.org/10.1109/ELECOM54934.2022.9965234.

Palmer, R.D. (2019) *Maintenance Planning and Scheduling Handbook*. 4th Editio. New York: McGraw-Hill Education.

Pandey, R. and Kumari, N. (2018) ‘Bayesian Analysis of Power Generalized Weibull Distribution’, *International Journal of Applied and Computational Mathematics*, 4(6). Available at: https://doi.org/10.1007/s40819-018-0573-z.

Ramachandran, S. and Amirthalingam, V. (2020) ‘Optimisation of pavement maintenance scheduling using transition matrices’, *Infrastructure Asset Management*, 7(1), pp. 2–14. Available at: https://doi.org/10.1680/jinam.18.00003.

Rastegari, A. *et al.* (2017) *Condition Based Maintenance in the Manufacturing Industry : From Strategy to Implementation*.

Razali, M.N. *et al.* (2020) ‘Big data analytics for predictive maintenance in maintenance management’, *Property Management*, pp. 513–529. Available at: https://doi.org/10.1108/PM-12-2019-0070.

Silva, R.O. and Pozo, H. (2017) ‘Weibull Distribution: Reliability Centered Maintenance and the Use of Bayesian networks’, *Asian Journal of Applied Sciences*, 05(05), pp. 2321–0893.

Snee, R. (2016) ‘Failure Modes and Effects Analysis’, *Failure Modes and Effects Analysis*, p. 6.

Soewardi, H. and Wulandari, S.A. (2019) ‘Analysis of Machine Maintenance Processes by using FMEA Method in the Sugar Industry’, *IOP Conference Series: Materials Science and Engineering*, 528(1), pp. 0–7. Available at: https://doi.org/10.1088/1757-899X/528/1/012023.

Systems, S. (no date) ‘Basic Concepts on Probability’.

Todinov, M.T. (2006) ‘Reliability value analysis of complex production systems based on the losses from failures’, *International Journal of Quality and Reliability Management*, 23(6), pp. 696–718. Available at: https://doi.org/10.1108/02656710610672498.

Wang, Z. *et al.* (2022) ‘An Integrated Approach-Based FMECA for Risk Assessment: Application to Offshore Wind Turbine Pitch System’, *Energies*, 15(5), pp. 1–25. Available at: https://doi.org/10.3390/en15051858.

Work, M.T. and Production, I. (no date) ‘Downtime cost and Reduction analysis : Survey results’, pp. 1–78.

Works, H.I. (2022) ‘Fault Detection Base d on Ar tificial Intelligence’, (December), pp. 15–16.

Zhao, B. *et al.* (2018) ‘Determining optimal preventive maintenance interval for component of Well Barrier Element in an Oil & Gas Company Determining optimal preventive maintenance interval for component of Well Barrier Element in an Oil & Gas Company’. Available at: https://doi.org/10.1088/1757-899X/337/1/012066.