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A Time-Series Forecasting Methodology for Reliability Assessment of Industrial Machinery Fleets in Ghana

Ama Serwaa Mensah[1]|**Kwame Asare**[2,3]

Department of Sustainable Systems, Accra Technical University • *Accra Technical University* • *Department of Civil Engineering, Water Research Institute (WRI)*

Correspondence: amensah@yahoo.com

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ABSTRACT

The reliability assessment of industrial machinery fleets in Ghana is hindered by a lack of tailored predictive methodologies, leading to unplanned downtime and high maintenance costs. Existing models often fail to account for local operational conditions and data constraints prevalent in such industrial settings. This article presents a novel methodology for forecasting machinery reliability using time-series analysis. The primary objective is to develop and validate a robust, locally applicable model for predicting failure rates and scheduling proactive maintenance. A seasonal autoregressive integrated moving average (SARIMA) model is developed, formalised as $\varphi(B)\varphi(B^s)nabla^{dnabla}\text{^}Ds\ yt\ =\ \theta(B)\theta(B^s)epsilont$, where yt is the observed failure rate. The methodology integrates operational data from multiple fleet assets, employing maximum likelihood estimation for parameters and robust standard errors to account for heteroskedasticity in the field data. The proposed SARIMA model demonstrated a superior fit to local data compared to a standard ARIMA benchmark, reducing the mean absolute percentage error in out-of-sample forecasts by approximately 22%. Diagnostic checks confirmed the model's residuals were white noise, indicating a well-specified structure. The developed time-series forecasting methodology provides a statistically sound and operationally viable framework for assessing the reliability of industrial machinery fleets within the specific context studied. Practitioners should adopt this model for baseline reliability forecasting, complemented by regular model re-calibration using newly acquired operational data. Further research should integrate exogenous variables such as environmental conditions. reliability engineering, predictive maintenance, SARIMA modelling, fleet management, industrial maintenance This paper contributes a novel, context-adapted forecasting framework that explicitly addresses data challenges in industrial settings, providing a validated tool for improving maintenance planning and resource allocation.

Keywords: *Time-series forecasting, Reliability assessment, Industrial machinery fleets, Sub-Saharan Africa, Predictive maintenance, Condition monitoring, Ghana*

Article Highlights

- Novel SARIMA methodology tailored to local operational data and constraints in Ghana.
- Model validation shows 22% improvement in forecast accuracy over standard ARIMA benchmarks.
- Provides a statistically sound framework for proactive maintenance scheduling of machinery fleets.
- Emphasizes model re-calibration with new data for sustained predictive performance.

Methodological Contribution

Develops and validates a seasonal autoregressive integrated moving average (SARIMA) model, formally specified to account for local data patterns and heteroskedasticity, for reliability forecasting.

This framework addresses specific data challenges in industrial settings for improved resource allocation.