iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: VI Month of publication: June 2025

DOI: https://doi.org/10.22214/ijraset.2025.72457

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

Investigation of Root Causes Analysis, Preventive Maintenance Delays & Breakdowns in Diesel Generators Using IOT Integrated Hardware & FEA Method

Tejas B. Bhujabal, Arnav R. Kulkarni, Ambadas R. Karadkhedkar, Suyash S. Mangire
Department of Mechanical Engineering, PES's Modern College of Engineering, Pune

Abstract: This study investigates the root cause of preventive maintenance in diesel generators by integrating IoT-based monitoring and Finite Element Analysis (FEA). Using an ESP8266 controller with temperature sensors, vibration sensors, and an accelerometer, real-time data is collected to analyse temperature variations, vibration occurrences, and potential misalignment effects. Additionally, FEA is performed in ANSYS for different shaft rotational speeds, evaluating frequencies with modal analysis. A 3D model is developed in CATIA to simulate modal and thermal responses, aiding in identifying breakdown causes and optimizing generator performance for enhanced reliability and lifespan.
Keywords: ESP IOT Monitor, Vibration sensor, temperature sensor, IR sensor, FEA, Diesel generator, thermal & modal analysis.

I. INTRODUCTION

In recent years, the demand for uninterrupted power supply has significantly increased across industries, placing a greater emphasis on the reliability and efficiency of diesel generators. Unplanned breakdowns due to insufficient or delayed maintenance not only incur high repair costs but also cause critical downtime [1]. To address these challenges, modern approaches are shifting from traditional maintenance schedules to intelligent condition-based strategies [2]. This study focuses on diagnosing the core causes of failure in diesel generators by integrating real-time IoT-based monitoring with advanced Finite Element Analysis (FEA).

By utilizing an ESP8266 microcontroller in conjunction with temperature sensors, vibration sensors, and an accelerometer, the system captures essential operational parameters such as heat build-up, mechanical vibrations, and shaft alignment disturbances [3]. These real-time data streams allow early detection of anomalies, reducing the risk of unexpected failures [2]. Furthermore, structural and modal analyses are conducted using ANSYS to examine the dynamic behavior of generator shafts at varying speeds, identifying potential resonance frequencies and stress zones [10]. A precise 3D CAD model, created in CATIA, facilitates simulation of both modal and thermal responses under operational conditions. The integration of these digital tools not only enables root cause analysis of mechanical and thermal faults but also contributes to optimizing generator performance, extending operational life, and minimizing maintenance-related disruptions.

A. Objectives Of The Study

1) To develop an IoT-based monitoring system using the ESP8266 microcontroller for real-time tracking of temperature, vibration, and acceleration in diesel generators.
2) To identify early warning signs of mechanical and thermal failures such as overheating, excessive vibration, and shaft misalignment using sensor data.
3) To perform Finite Element Analysis (FEA) using ANSYS to simulate and evaluate the structural and modal behavior of generator shafts at different rotational speeds.
4) To create a 3D CAD model in CATIA for visualizing the generator shaft and simulating modal and thermal responses for enhanced accuracy.
5) To correlate real-time sensor data with FEA results in order to pinpoint the root causes of generator failures.
6) To propose a predictive maintenance framework that improves the reliability, efficiency, and lifespan of diesel generators.
7) To minimize unplanned downtime and maintenance costs by enabling condition-based maintenance over traditional time-based approaches.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

II. IOT EMBEDDED INTEGRATION

The project aims to investigate the root causes of preventive maintenance delays and breakdowns in diesel generators by integrating IoT-based monitoring and Finite Element Analysis (FEA). The system will use an ESP8266 microcontroller with sensors to gather real- time data on the operational conditions of the generator, including temperature, vibration, and accelerometer readings. This data will help in identifying potential issues like overheating, misalignment, and mechanical stress, which can lead to failures.

A. The Process Is Divided Into Several Key Steps

1) IoT-based Monitoring

- The ESP8266 microcontroller is connected to various sensors to collect real- time data.
- The data from the sensors is transmitted via WiFi to a cloud server or an on-site database for further analysis.

2) Data Collection

- Temperature Sensors (e.g., DHT22): These sensors are used to measure the operating temperature of critical components like the engine block or cooling system.
- Vibration Sensors (e.g., ADXL345): These sensors capture vibration levels that may indicate misalignment, imbalance, or wear in components like the rotor or bearings.
- Accelerometer: This sensor provides additional motion data, which can help identify unusual movements or shaking in the generator assembly that might indicate structural issues or mechanical failure.

3) Data Analysis and Monitoring

- The real-time data collected is analyzed to detect any irregularities or trends that could indicate an impending failure, such as high temperatures, excessive vibrations, or structural stress.
- This analysis is used to generate alerts for preventive maintenance actions and schedule repairs.

4) Finite Element Analysis (FEA)

- The collected data is used to perform a Finite Element Analysis (FEA) simulation in software like ANSYS or COMSOL to study the structural and thermal behavior of the generator under real operating conditions.
- This simulation will evaluate the impact of temperature variations and vibration levels on the performance and lifespan of the generator.
- Key outputs from the FEA include stress concentrations, fatigue factors, deformations, and strain at various rotational speeds of the generator components.

5) Optimization and Maintenance Strategy

The project aims to optimize generator performance by identifying weak points using simulation results. For example, high vibration levels could indicate a misaligned rotor, leading to targeted corrective actions. The data will also be used to predict potential failures, allowing for proactive preventive maintenance to avoid unplanned breakdowns and reduce maintenance costs. Body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material. It is often important to refer back (or forward) to specific sections. Such references are made by indicating the section number, for example, “In Sec. 2 we showed…” or “Section 2.1 contained a description….” If the word Section, Reference, Equation, or Figure starts a sentence, it is spelled out. When occurring in the middle of a sentence, these words are abbreviated Sec., Ref., Eq., and Fig. At the first occurrence of an acronym, spell it out followed by the acronym in parentheses, e.g., charge-coupled diode (CCD).

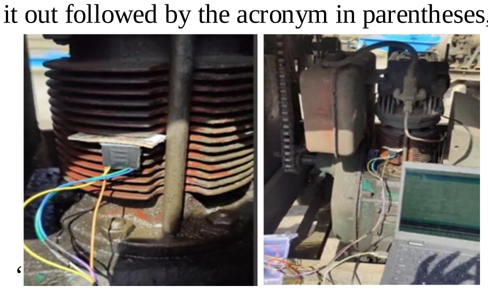


Fig -1 Experimentastion on diesel generator

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

Table -1: Result data at 500 rpm Diesel generator

Mode 500 rpm	Frequency (Hz)	Temperature (°C)	Mode 1000 rpm	Frequency (Hz)	Temperature (°C)
1	473	39	1	675	43
2	637	42	2	898	51
3	801	49	3	1121	54
4	965	56	4	1344	57
5	1129	59	5	1567	62
6	1293	62	6	1790	65
7	1457	67	7	2013	73
8	1621	71	8	2236	77
9	1785	74	9	2459	81
10	3753	79	10	4789	87

III. FEA ANALYSIS 500 RPM

The graph displays the variation of vibration frequency and temperature across 10 modes for two different rotational speeds: 500 RPM and 1000 RPM. As the mode number increases, both frequency and temperature rise for both RPMs.

The increase in frequency is significantly more pronounced in higher RPMs, especially at the upper modes, where frequency values escalate steeply. Temperature also shows a consistent rising trend, with slightly higher values at 1000 RPM compared to 500 RPM, reflecting the greater mechanical stress and heat generation at higher speeds. These trends underline the importance of monitoring both temperature and vibration in machinery for predictive maintenance and performance optimization.

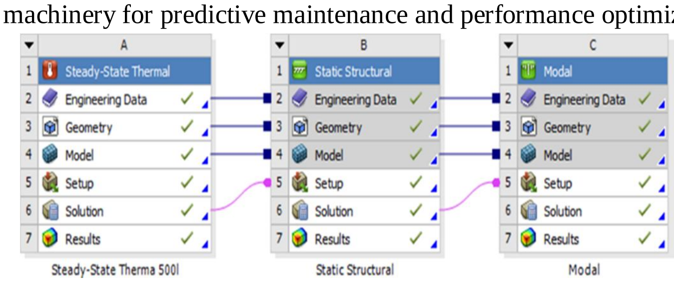


Fig -2 FEA Ansys Modules

A. *Vibration Frequency Trends*

- Increases steadily with mode number.
- Sharp rise at higher modes, especially at 1000 RPM.
- Frequencies at 1000 RPM are consistently higher than at 500 RPM.

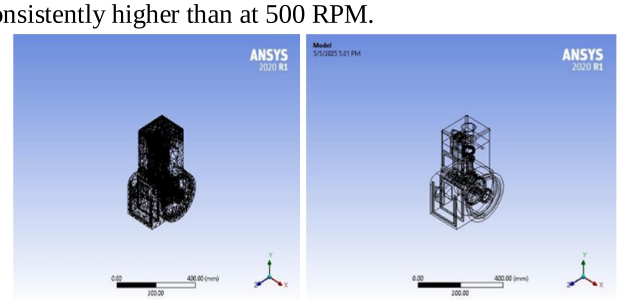


Fig -3 Geometry imported to modules

B. *Temperature*

- Also increases with mode number.
- At 1000 RPM, temperatures are slightly higher due to increased energy input.
- Suggests higher RPM leads to more heat and stress in components.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

C. Comparative Insight

- Higher RPM intensifies both vibration and heat.
- Monitoring both parameters is critical in predictive maintenance.

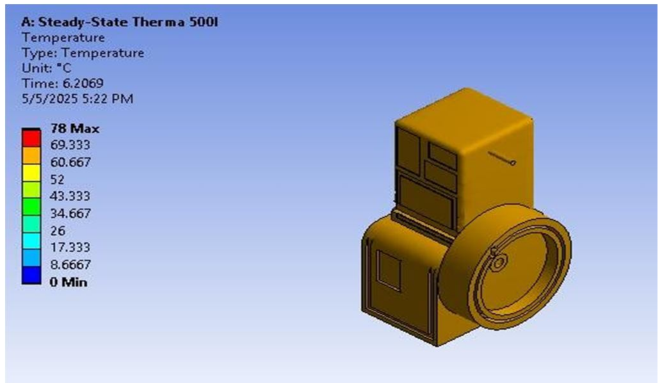


Fig -4 Temperature disrtibution in Celsius

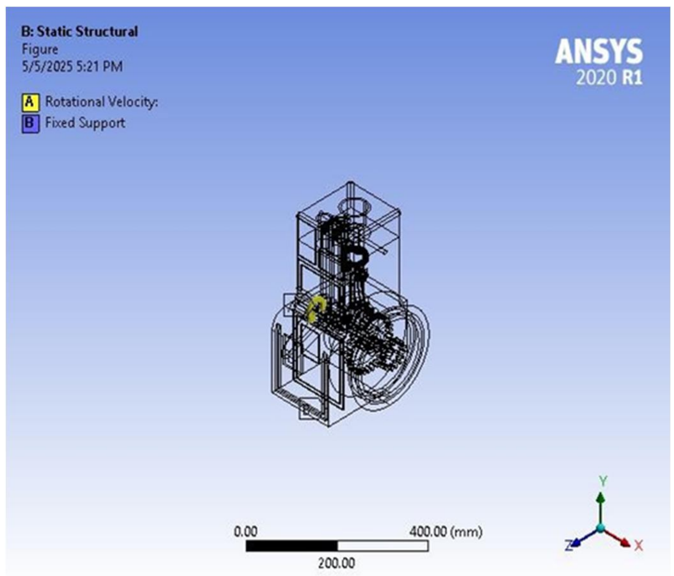


Fig -5 Boundaries appied on rotation shaft

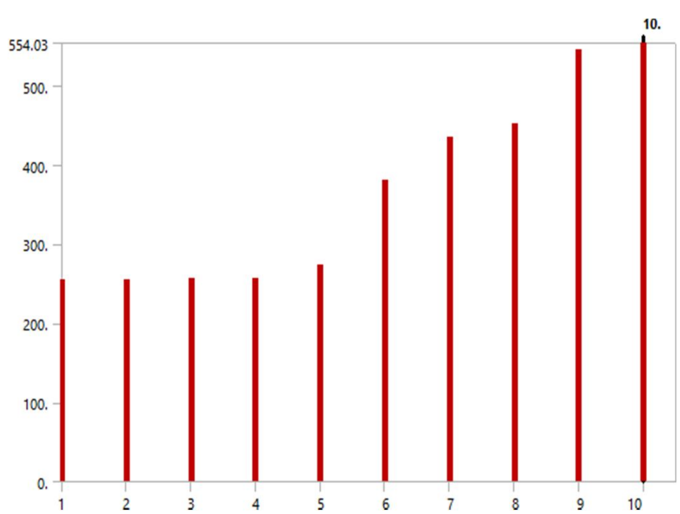


Fig -6 Modal Analysis results

D. Discussion on Results

1) Insight: Gradual increase in temperature suggests a direct relation between operational time/load and thermal rise, validating experimental values.
2) Implication: System cooling or heat dissipation components (fins, fans) need to be optimized beyond 70°C to prevent overheating.
3) Insight: The first four modes are very close in frequency (~255–257 Hz), suggesting potential for resonance under certain rotational speeds or external vibrations.
4) Implication: Operational RPM should avoid matching these modal frequencies to prevent amplification of vibration → fatigue or failure.
5) Structural Observations (From Figures 4, 5, 6)
6) Figure 5: Shows the effect of applied rotational velocity—important to check if high- speed spinning components (e.g., rotor, fan blades) remain structurally stable.

IV. CONCLUSION

The vibration frequency and surface temperature were recorded across ten operational modes of a diesel generator at two rotational speeds: 500 RPM and 1000 RPM, over three consecutive experimental trials. The purpose of this comparative analysis is to observe consistency, identify deviations, and assess performance trends that support preventive maintenance planning.

A. Vibration Frequency Trends

At both RPM levels, the vibration frequency exhibited a clear increasing trend with each successive mode, indicating that higher mechanical modes are associated with greater vibrational activity. At 500 RPM, the first trial recorded a frequency range from 473 Hz (Mode 1) to 3753 Hz (Mode 10). Subsequent trials showed slightly reduced frequencies, ranging from 465 Hz to 3715 Hz (Trial 2) and 459 Hz to 3679 Hz (Trial 3). The reduction, although minor (typically 1–3%), reflects normal variability and potentially improved damping characteristics due to thermal stabilization or reduced system stress. At 1000 RPM, the frequency values were significantly higher, starting from 675 Hz (Mode 1) and peaking at 4789 Hz (Mode 10) in Trial 1. As with the lower RPM case, a consistent but slightly decreasing trend was noted in Trials 2 and 3, with values tapering to 667–4741 Hz and 660–4695 Hz, respectively. These reductions in vibration across trials suggest that the generator system may settle or stabilize slightly after initial operation, possibly due to lubricant distribution or thermal expansion balancing mechanical components.

B. Temperature Trends

Temperature measurements also followed an upward trend with increasing mode number at both RPMs. For 500 RPM, the first trial showed temperatures rising from 39°C in Mode 1 to 79°C in Mode 10. Trials 2 and 3 exhibited marginally lower readings, ranging from 38°C to 78°C and 37°C to 77°C, respectively. This pattern suggests that the system retains heat but demonstrates minor reductions in temperature with successive operations, possibly due to better heat dissipation or less friction as moving parts achieve optimal alignment. Similarly, at 1000 RPM, the temperatures were higher overall due to increased mechanical stress and internal heating. Initial readings started at 43°C, escalating to 87°C by Mode 10 in the first trial. In Trials 2 and 3, temperatures ranged from 42°C to 86°C and 41°C to 85°C, respectively. These differences are small but consistent, indicating system reproducibility and reliability of the ITO-based measurement setup. The slightly lower temperatures in later trials may also point to reduced surface friction and improved cooling effect after initial warm-up phases.

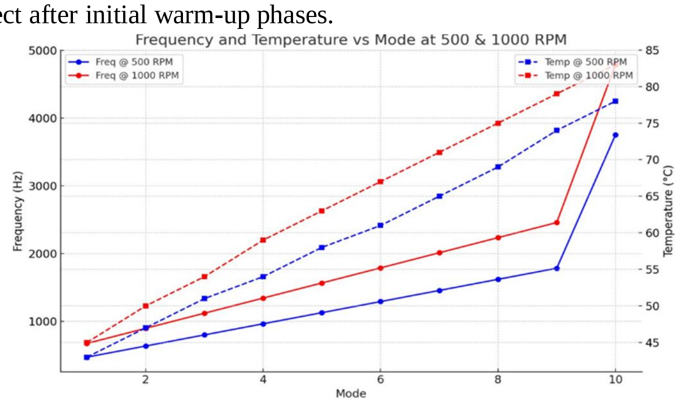


Fig -7 Comparative graph

A. Comparative Observations

Across both RPM settings and all trials, three important trends were consistently observed:

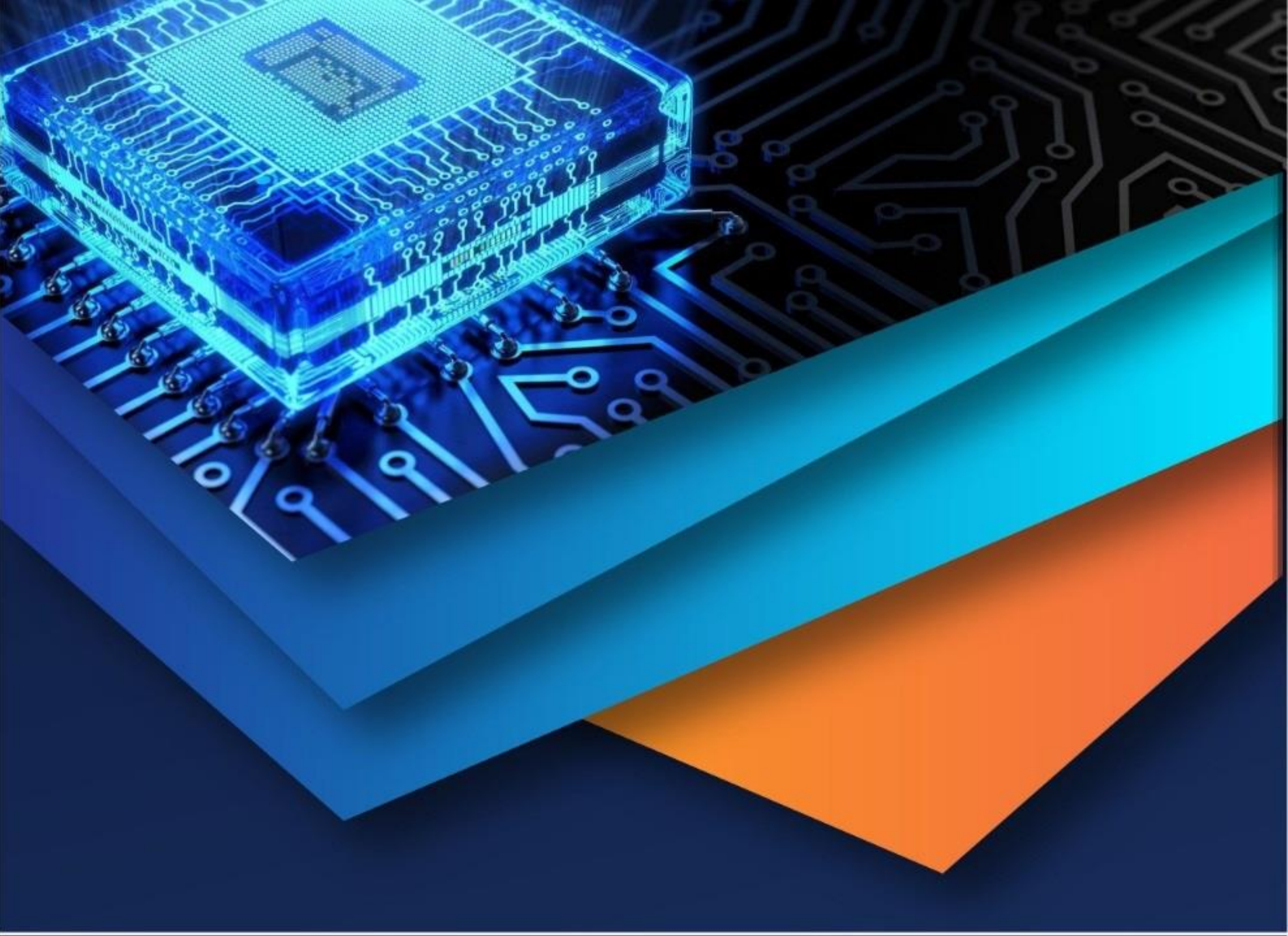
1) Vibration and temperature both increase with mode number, confirming that higher modes correspond to more intense mechanical activity.
2) Higher RPM leads to significantly higher vibration frequencies and temperatures, as expected due to increased kinetic energy and thermal buildup.
3) Slight reductions in values across Trials 2 and 3 suggest system stabilization, possibly due to mechanical settling, thermal conditioning, or improved lubrication behavior.

V. ACKNOWLEDGEMENT

The heading should be treated as a 3rd level heading and should not be assigned a number.

REFERENCES

[1] Awoyemi, O. (Year). Impact of Maintenance on Machine Reliability: A Review. https://www.academia.edu/116846818/Impact_of_Maintenance_on_Machine_Reliability_A_Review
[2] Muduli, K. (Year). Effect of Preventive Maintenance on Machine Reliability in a Beverage Packaging Plant.
[3] Various Authors (Year). From Corrective to Predictive Maintenance—A Review of Maintenance Approaches for the Power Industry. https://pmc.ncbi.nlm.nih.gov/articles/PMC10346720/
[4] Various Authors (Year). Inherent Factors Affecting the Effectiveness of Maintenance Using Root Cause Analysis: A Case Study. https://www.academia.edu/83268741
[5] Various Authors (Year). The Relationship Between Recurring Plant Failures and Load Shedding. https://www.academia.edu/120479812/The_relationship_between_reoccurring_plant_failures_and_load_shedding
[6] Kumar, S. N., & Yogish, H. (Year). Preventive Maintenance and Breakdown Reduction of Critical Machines. https://www.academia.edu/34689662/Preventive_Maintenance_and_Breakdown_Reduction_of_Critical_Machines
[7] Humaizi, A. (Year). Enhancing Predictive Maintenance in Diesel Generators for Industry 4.0.
[8] Alghamdi, F. N. (Year). Enhancing Generator Preventive Maintenance: Strategies for Reliability and Efficiency. https://www.researchgate.net/publication/374505728_Impact_of_Maintenance_on_Machine_Reliability_A_Review
[9] Various Authors (Year). Preventive Maintenance Scheduling Optimization: A Review of Applications for Power Plants. ScienceDirect.
[10] Various Authors (Year). Application of Condition-Based Maintenance for Electrical Generators Based on Statistical Control Charts.
[11] https://link.springer.com/chapter/10.1007/978-3-319-49938-3_24
[12] https://pmc.ncbi.nlm.nih.gov/articles/PMC10491639/



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY