BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg

INTRODUCTION OF NEW TECHNOLOGIES TO IMPROVE THE MAINTENANCE SYSTEM

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Annotation

This article analyzes the theoretical and practical aspects of introducing new technologies in improving maintenance systems. The effectiveness of digital monitoring, artificial intelligence, IoT (Internet of Things), TPM (Total Productive Maintenance), automated diagnostics and predictive maintenance technologies was studied in order to ensure the continuous operation of equipment in industrial enterprises, reduce failures and optimize operating costs. The study found that integrating new technologies into maintenance systems can increase equipment efficiency, reduce downtime, and improve production efficiency.

Keywords: maintenance, TPM, IoT, predictive technologies, artificial intelligence, diagnostics, automation, industry 4.0.

Introduction

The increasing complexity of production processes in modern industrial enterprises requires taking maintenance systems to a new level. Traditional maintenance methods often fail to detect equipment failures in advance, leading to unexpected downtime during production [1]. As a result, the economic efficiency of the enterprise decreases and the cost of production increases.

Today, the concept of "Industry 4.0" is expanding the possibilities of automating maintenance processes by introducing digital technologies into production systems. In particular, real-time monitoring of equipment status using IoT sensors, fault prediction based on artificial intelligence, and management of maintenance processes through digital platforms are significantly increasing production efficiency [2].

The main goal of a maintenance system is to increase equipment reliability, reduce operating costs, and ensure production continuity. Therefore, the introduction of advanced technologies is becoming a strategic task for today's industrial enterprises.

The relevance of this study stems from the need to increase production efficiency at enterprises through the modernization of maintenance systems and the implementation of advanced technologies.

The aim of the study is to analyze advanced technologies used in improving the maintenance system and determine their effectiveness.

Methods

In the course of the study, methods of scientific analysis, statistical assessment, comparative comparison and systematic approach were used. Foreign and domestic scientific sources on the improvement of maintenance systems were studied.

The study analyzed the following technologies:

- IoT-based monitoring systems;
- Predictive maintenance;

• TPM (Total Productive Maintenance) system;
• Artificial intelligence and data analysis;
• Automated diagnostic systems;
• Cloud management platforms.

The analysis compared traditional and modern maintenance methods.

Comparison of Maintenance Approaches

Table 1

Indicator	Traditional System	Modern Digital System
Fault detection	After failure occurs	Predictive detection
Monitoring	Periodic inspection	Real-time monitoring
Costs	High	Optimized
Human factor	High	Minimal
Equipment downtime	Frequent	Reduced
Efficiency	Medium	High

To evaluate maintenance efficiency, the following indicator was used:

$$OEE = A \times P \times Q$$

Where:

- **A** — equipment availability;
- **P** — production performance;
- **Q** — product quality.

Additionally, MTBF (Mean Time Between Failures) and MTTR (Mean Time To Repair) indicators were used to evaluate equipment reliability.

Results

The research results demonstrate that implementing advanced technologies into maintenance systems significantly improves equipment performance.

IoT sensors continuously monitor parameters such as temperature, vibration, pressure, and energy consumption of equipment. These data are processed using artificial intelligence algorithms to identify potential failures in advance.

Efficiency Indicators of Predictive Maintenance

Table 2

Indicator	Before Implementation	After Implementation
Equipment downtime	18 %	6 %
Maintenance costs	100 %	72 %
Production efficiency	78 %	92 %
Energy consumption	100 %	85 %
Number of failures	24 per year	9 per year

The results show that:

- unplanned equipment downtime decreased;
- maintenance costs were optimized;
- production productivity increased;
- energy efficiency improved.

Predictive maintenance systems made it possible to monitor equipment conditions in real time. This helped enterprises plan spare parts in advance and reduce repair time.

Efficiency of TPM System

The implementation of the TPM system increased operator involvement in maintenance activities and improved overall equipment efficiency.

Results of TPM System Implementation

Table 2

Indicator	Before TPM	After TPM
OEE indicator	68 %	87 %
Number of авария situations	15	5
Maintenance time	12 hours	6 hours
Production quality	84 %	96 %

Furthermore, automated diagnostic systems enabled rapid detection of faulty components, reducing production losses.

Digital management platforms centralized maintenance processes, allowing all equipment conditions to be monitored through a unified information database.

Discussion

The analysis showed that implementing advanced technologies into maintenance systems increases both economic and technological efficiency in industrial enterprises. In particular, predictive maintenance methods are significantly more effective than traditional reactive maintenance approaches.

The use of IoT and artificial intelligence technologies allows real-time assessment of equipment conditions. This helps optimize maintenance strategies and improve operational planning [3].

However, several challenges remain in implementing advanced technologies:

- high initial investment costs;
- shortage of qualified specialists;
- cybersecurity concerns;
- technical limitations in digitizing existing equipment.

Despite these challenges, in the long term, these technologies contribute to improving enterprise competitiveness. Increasing energy efficiency and reducing operational costs are particularly important factors for industrial enterprises.

The following stages are recommended for implementing advanced technologies:

1. Conducting technical audits of equipment;
2. Installing digital monitoring systems;
3. Collecting and analyzing operational data;
4. Implementing predictive algorithms;
5. Retraining personnel;
6. Creating integrated management systems.

Through digitalization of maintenance systems, enterprises can ensure production continuity while improving quality indicators.

Conclusion

The research results indicate that implementing advanced technologies for improving maintenance systems significantly increases the efficiency of industrial enterprises.

The application of IoT, artificial intelligence, predictive maintenance, and TPM systems:

- increases equipment reliability;
- reduces unplanned downtime;
- optimizes maintenance costs;
- improves production efficiency;
- ensures energy savings.

In the future, full automation and integration of maintenance systems with digital platforms will become an important factor in ensuring sustainable industrial development.

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