PANEVĖŽIO KOLEGIJA ISSN 2029-1280, eISSN 2669-0071. Taikomieji tyrimai studijose ir praktikoje – Applied Research in Studies and Practice, 2024, 20.

MAINTENANCE IN INDUSTRY 4.0

Donatas BALČIŪNAS

Panevėžio kolegija/ State Higher Education Institution, Lithuania

Abstract. The Industry 4.0 industrial revolution is moving at high speed and covers more and more segments. Technologies are constantly improving and help to do work faster, safer, cheaper and simpler. Advanced technologies require more intensive and better maintenance, with requirements to minimize service costs, reduce downtime, and protect the environment by reducing unnecessary waste of materials. Therefore, Maintenance 4.0 is being developed - "Predictive maintenance" and "Prescriptive maintenance" are being applied and developed, where unnecessary maintenance is not performed, but data is analyzed and diagnostic and prognostic models are created based on it. This paper reviews the interaction of the Industrial Revolution with Maintenance models, identifies their main advantages and disadvantages, and delve into their creation methods.

Keywords: predictive maintenance, prescriptive maintenance optimization, Industry 4.0, Maintenance 4.0

INTRODUCTION

The use of computers and other digital devices in manufacturing began in the second half of the 20th century, thus signalling the emergence and development of Industry 3.0. In contrast to Industry 3.0, today's industry has reached a level where all nearby equipment is connected, data is transmitted from one mechanism to another, from one controller to another, systematized and often analyzed by artificial intelligence, which makes decisions without intervention.

Sensor technologies, data analytics, cloud technologies, mobile end devices, and real-time location systems are being deployed to improve the production process (Firoz Khan Fasuludeen at al., 2021). All of this brings us to the Industry 4.0 revolution, it focuses on connecting data, operations and resources through digital connectivity. This requires continuous improvement and implementation of new technologies that would increase production productivity. To implement all advanced manufacturing technologies, it is necessary to combine all the latest achievements: Internet of Things (IoT), big data, artificial intelligence, machine learning and cyber-physical systems (Achouch et al., 2022).

All companies aim to maximize equipment performance and minimize downtime as much as possible. At the peak of the Industry 4.0 revolution, simple maintenance methods such as "Reactive maintenance" or "Proactive maintenance" are not so effective, therefore "Predictive maintenance" and "Prescriptive maintenance" are being applied and developed, where unnecessary maintenance is not performed, but data is analyzed and diagnostic and prognostic models are created based on it.

The objective of the research is to review the current situation and assess and assess the data needed to implement Industry 4.0 maintenance in factories, to conduct an analysis of various maintenance methods and strategies, and to present conclusions.

Research methods: analysis of scientific literature and data analysis.

REVIEW OF MAINTENANCE STRATEGIES

Industry 4.0 is a major breakthrough in the industrial field, which requires simultaneous processing of huge amounts of data, management of different systems, provision of analyses and support of predictive actions. The main components are connected by the Internet: computing, Automation, IoT, Cybersecurity, Smart factory, Big data, digitalization and manufacturing. Considering all the advantages of this industrial leap, it is necessary not to forget about the emerging problems that require active solutions. Various sources indicate that the maintenance strategies can be divided into five branches:

- **Reactive maintenance** – the strategy where maintenance is only performed when a device or mechanical machine breaks down.
- **Preventive maintenance** – proactive actions are taken to prevent problems, and maintenance is performed according to the established schedule and identified faults.
- **Condition-based maintenance** - the condition of the equipment is monitored by sensors and maintenance is performed only when a fault is registered.
- **Predictive maintenance** – is based on long-term equipment monitoring to optimize equipment performance and service life, data is constantly updated and condition status is known in real time.
- **Prescriptive maintenance** – analyses data in real time and provides data on how to delay or completely eliminate equipment failure.

A graphical interpretation of maintenance strategies has been created based on the works of M. Jasiulewicz-Kaczmarek (2020) (see Figure 1).

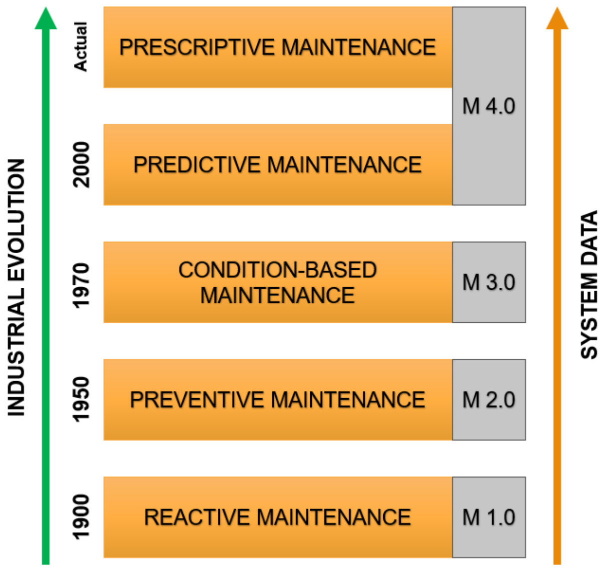

Figure 1 Development of industrial maintenance

According M. Jasiulewicz-Kaczmarek (2020) smart and sustainable maintenance must ensure benefits for this three dimensions:

Social dimension: implements new educational model, improves working safety, improves working condition and improves workers satisfaction.

Environmental dimension: decreases spare parts and lubricant utilization, improves environmental safety, minimizes end of life waste and optimize energy consumption.

Economic dimension: improves economic efficiency, reduces maintenance time, improves machine performance and decreases spare parts inventories.).

USAGE AND PERSPECTIVE OF MAINTENANCE 4.0

All benefits can be achieved by applying Maintenance 4.0, which is the interaction of artificial intelligence (AI) and machine learning (ML), which ensures smooth failure prediction and effectively reduces factory downtime. This technology has gained great importance and the global market is growing every year (see Figure 2). These technologies are expensive, but given the benefits they provide, more and more companies are implementing them. This is well reflected in the exponential growing market.

More and more companies are moving to Industry 4.0 solutions, which require a changing maintenance need that must keep up with the capabilities of the installed equipment. According B. W. Shaheen (2022) Maintenance 4.0 uses advanced analysis methods not only to predict failures, but also to prevent such failures and optimize maintenance schedules and resources. Currently, it can be found in many modern industries, such as the automotive, aerospace, chemical and machining industries.

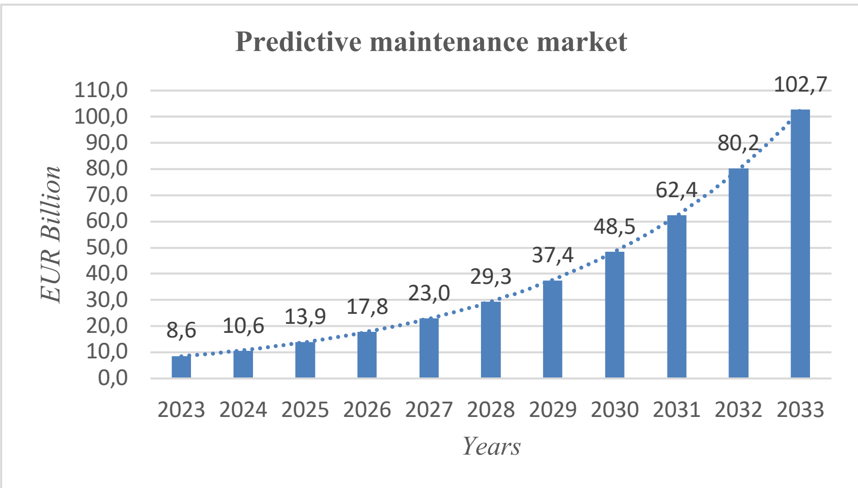

Figure 2 Global market for predictive maintenance components 2023-2033

The failure prediction curve (see Figure 3) is well depicted in the work of M. Achouch (2022). This graph clearly reflects the point at which the installation is working perfectly (Point P) and the point at which a failure sequence of part or all of the installation begins (Point P to Point F). If the development of the failure is detected before a complete functional stop (Point F), then it is possible to eliminate the failure in time, avoid downtime and save repair costs for company.

In the Maintenance 4.0 predictive process the most important work is done by the Big Data sources. It is defined as a large collection of diverse data that is used for machine learning, predictive modelling, and other advanced analytical functions. Industrial Big Data is accumulates from the following sources (Y. Yan et al., 2017):

- Design data
- Machine operation data
- Staff behaviour data
- Cost information
- Logistics information
- Environmental conditions
- Fault detection and system status monitoring data
- Product quality data
- Product usage data
- Customer information

By correctly managing, structuring and processing this collected data, it is possible to accurately predict the onset of failures and inform the operator or other responsible element in the factory about this. Data processing can detect and determine: equipment manufacturing defects, the current condition of the equipment, personnel work habits, product defects, manufacturing defects, and other information important to the company (Y. Yan et al., 2017). And this way, equipment is protected, costs are saved, and the sustainability is preserved.

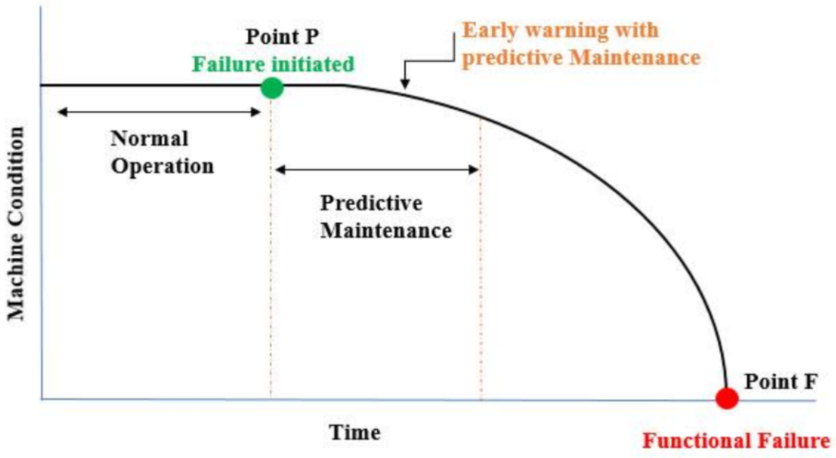

Figure 3 Potential failure diagram (Achouch et al., 2022)

Looking to the future a new industrial revolution, new human-centric era of Industry 5.0, is currently taking shape, in which employees will work with advanced technologies and robots and mechanisms controlled by artificial intelligence, aiming to improve workplace processes and further optimize production. It will create higher-value jobs, giving customers more freedom to meet their needs, and employers more freedom to empower their ideas. But it will also be an industrial revolution that will eliminate the need for unskilled labour, and companies will face human challenges. Along with Industry 5.0 comes Maintenance 5.0, which will be a type of advanced predictive maintenance. It is the interaction of software, robots, and humans.

CONCLUSIONS

Summarizing all the collected and analyzed information, it can be seen that maintenance solutions are constantly evolving and advancing in parallel with the industrial revolution, his requires more and more data and investment for it.

These include:

1. The financial results of a manufacturing company directly depend on the maintenance method used, because service affects downtime, product quality, and sustainability.
2. Properly collected and analyzed data can predict failures and help prevent them. This type of prediction is called “Prescriptive maintenance”.
3. The most important role in “Prescriptive maintenance” is played by data collection and analysis, which is what Big Data describes.

4. The Maintenance 4.0 market is growing exponentially. However, regardless of this, the Maintenance 5.0 system, which will be even more advanced, is being implemented in parallel.

REFERENCES

Jasiulewicz-Kaczmarek, M., Kluk, P., Legutko, S. (2020). Maintenance 4.0 technologies – new opportunities for sustainability driven maintenance. Management and Production Engineering Review, 12:2, 74-87.

Yan, Y., Meng, Y., Lu, L., Li, L. (2017). Industrial big data in an Industry 4.0 environment: challenges, schemes, and applications for predictive maintenance. IEEE Access, vol. 5, pp. 23484-23491.

Psarommatis, F., May, G., Azamfirei, V. (2023). Envisioning maintenance 5.0: Insights from a systematic literature review of Industry 4.0 and proposed framework, Journal of Manufacturing Systems, 68, 376-399.

Cortes-Leaf, A., Cardenas, C., Del-Walle-Soto, C. (2022). Maintenance 5.0: Towards a worker-in-the-loop Framework for resilient smart manufacturing. Appl. Sci., 12, 11330.

Jasiulewicz-Kaczmarek, M., Gols, A. (2019). Maintenance 4.0 technologies for sustainable manufacturing – an overview. SienceDirect, IFAC PapersOnLine, 52-10, 91-96.

Shaheen, B., W., Nemeth, I. (2022). Integration of maintenance management system functions with industry 4.0 technologies and features – a review. Proccesses 2022, 10, 2173.

Firoz Khan Fasuludeen, K., Nida, N., Naveed, A., Mir Irfan, U., H. (2021). Production and maintenance in industries: Impact of Industry 4.0. Impact of Industry 4.0, Industrial Robot, 49 (3), 461-475.

Pinciroli, L., Baraldi, P., Zio, E. (2023).Maintenance optimization in Industry 4.0. Reliability engineering and system safety, 234, 109204.

Achouch, M., Dimitrova, M., Ziane, K., Sattarpanah Karganroudi, S., Dhouib, R., Ibrahim, H., Adda, M. (2022). On predictive maintenance in Industry 4.0: overview, models, and challenges. Appl. Sci., 12, 8081.

Stodola, P., Stodola, J. (2019). Model of predictive maintenance of machines and equipment. Management and Production Engineering Review, Appl. Sci., 10, 213.

Global Predictive Maintenance Market By Component. Internet access: https://market.us/report/predictive-maintenance-market/