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OCCUPATIONAL HEALTH AND SAFETY (OHS) CHALLENGES IN THE MAINTENANCE FOR INDUSTRY 5.0

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Abstract: *The paper presents part of the research related to how maintenance activities performed to maintain or restore in working condition after a failure the specific equipment of Industry 5.0 influence occupational health and safety activities. The focus is on identifying the main maintenance activities in Industry 5.0 and on the subsequent identification of the OHS challenges specific to these actions.*
Keywords: *Industry 5.0, maintenance, occupational health and safety.*

1. INTRODUCTION

The progress of human society has been influenced by a multitude of interconnected factors, factors that have changed and are constantly changing their weight throughout evolution. Among these, however, technology and innovation, in direct connection with scientific research, education and knowledge, have always been at the forefront due to the increase in productivity and the quality of life they generate, respectively for the acceleration of economic and social progress.

The progress of technology and innovation over time has recorded leaps that have revolutionized industrial production systems at the respective times. The main moments and most important characteristics for these leaps, called industrial revolutions, are illustrated in figure 1. As a remark, there is a decrease in the time intervals between industrial revolutions, a decrease generated by the increase in scientific and technical progress.

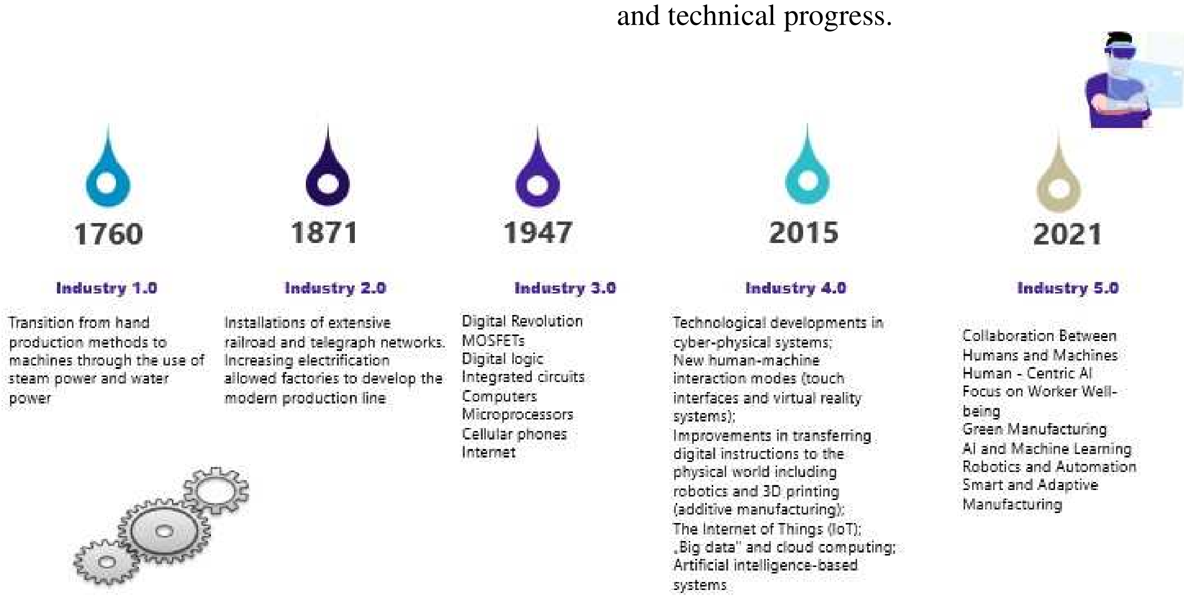

Fig. 1. Timeline for industry revolutions

An important aspect of the evolution of industrial production was the reliability of machines and equipment, respectively of products. Known as the ability of a machine to fulfill its specified function, under specified operating conditions, in a well-defined time, the notion of reliability was complemented by that of maintainability. Maintainability is the ability of a machine to be maintained in working condition or to be restored to working condition after a failure.

This aspect initially generated an increase in the quality of materials and production, followed by the creation of maintenance systems that were capable of maintaining and increasing the availability of production systems. Basically, there was a need for maintenance systems that could keep up with production systems or even surpass them. An evolution over time of maintenance systems is presented in figure 2.

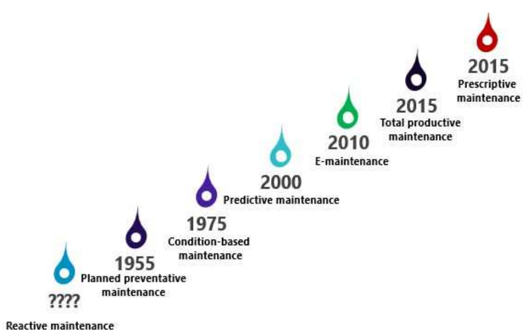

Fig. 2. Timeline for maintenance systems

Among other common points, industrial production systems and their related maintenance systems face occupational health and safety issues, with a higher level of risk being mentioned in maintenance activities.

The higher level of risk in maintenance is generated by exposure to multiple hazards, additional to those usually encountered in industrial systems:

- interventions on used, defective machines, in a work environment with excessive noise, extreme temperatures or with toxic or explosive potential
- working in unpredictable conditions, created by failures
- working under time pressure that leads to making insufficiently substantiated decisions or overloading staff with overtime.

The statistics confirm those presented, for example the European Agency for Safety and Health at Work presents [1] the comparative situation of exposure to hazard among maintenance workers in Spain (2007), figure 3, respectively number of fatal accidents related to maintenance operations (EUROSTAT, 2006), figure 4.

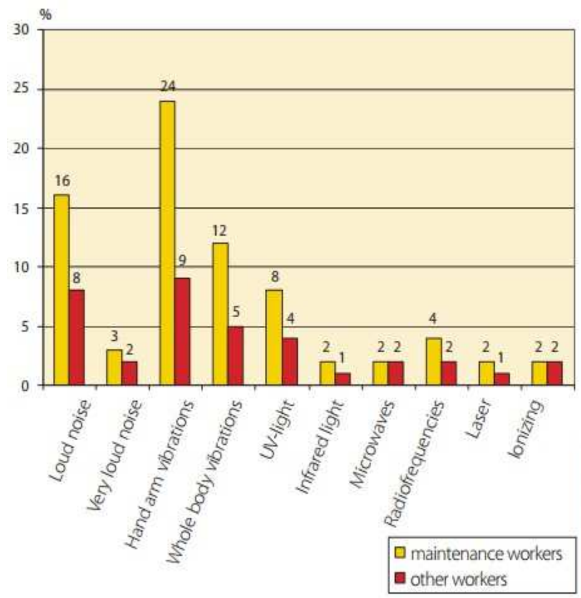

Fig. 3. Exposure to hazards among maintenance workers (Spain, 2007) [1]

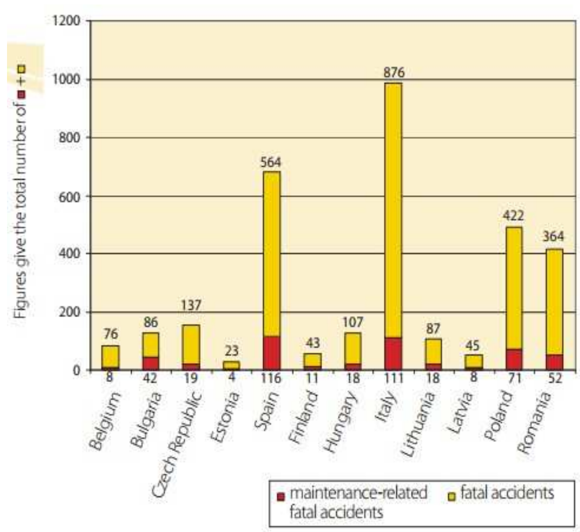

Fig. 4. Number of fatal accidents related to maintenance operations (EUROSTAT, 2006) [1]

Also, the Bureau of Labor Statistics, U.S. Department of Labor, presented a statistic, for 2023, in which the fatal accident rate in maintenance was almost 10 per 100,000 workers, higher than in manufacturing. [2]

2. MAINTENANCE IN INDUSTRY 5.0

Considering the accumulated experience, which shows that a correlation of the maintenance system and the level of complexity of a production system is essential for operational efficiency, safety and cost reduction, we propose a structuring of the main maintenance actions in Industry 5.0 that also presents maximum adaptability to the characteristics of Industry 5.0. [3 - 5]

A diagram (figure 5) was developed to try to identify how maintenance systems will operate and what new directions maintenance will need to adapt to. The diagram will then serve as the basis for identifying the main challenges in terms of health and safety in maintenance work in Industry 5.0

Thus, classic maintenance systems based on preventive actions (planned inspections, time-based maintenance and cleaning and lubrication actions) will continue to be developed, as will predictive maintenance systems (condition monitoring). [6] Prescriptive maintenance systems will increasingly develop, in which artificial intelligence and machine learning capabilities will become increasingly important.

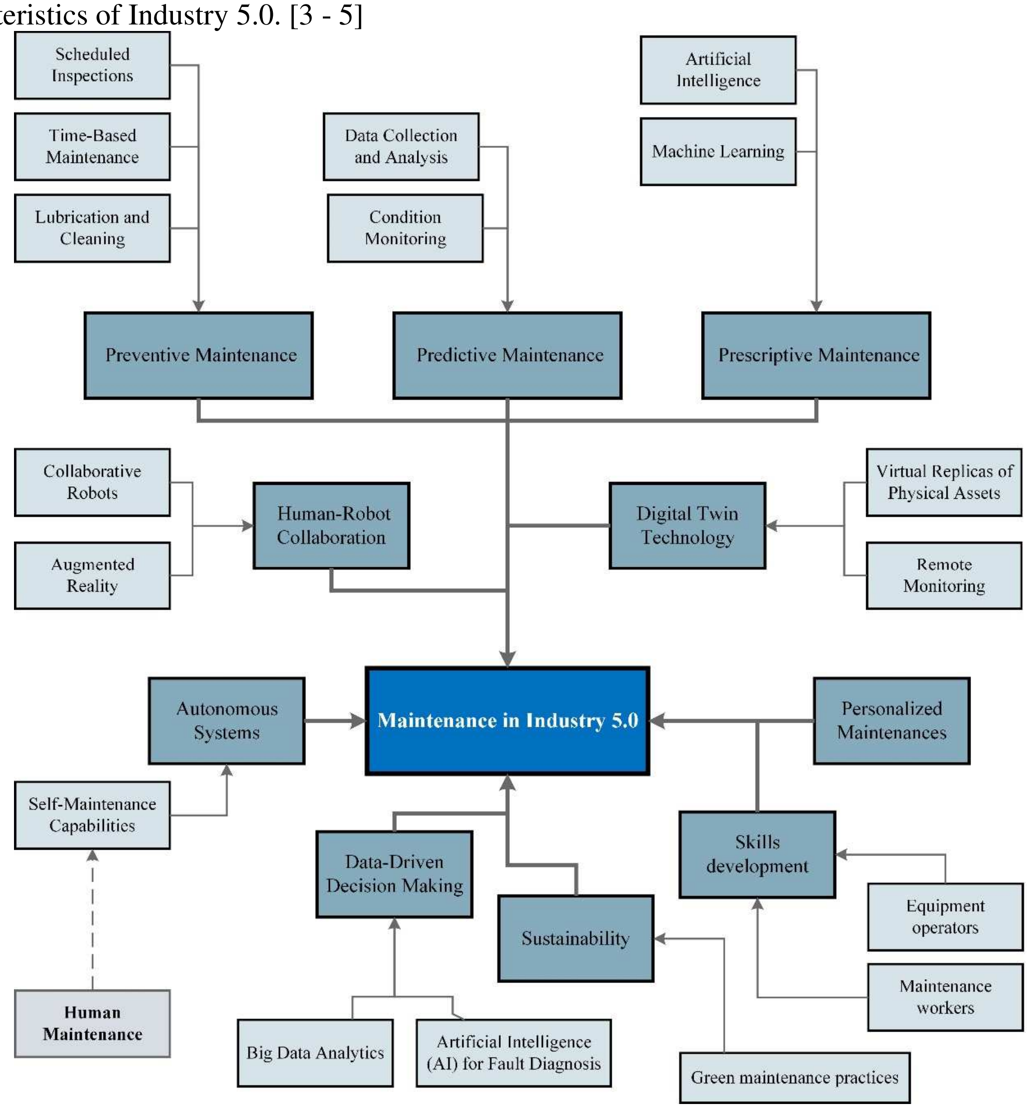

Fig. 5. Maintenance activities in Industry 5.0

It should be emphasized that there is no dividing line between these maintenance systems and that there is no single solution for maintaining production systems. [7]

An analysis of the production system and the customization of the maintenance system are needed, by choosing the most efficient maintenance actions. [8] At the same time, several directions of maintenance activity are identified that must be at the same technological level as production activities. These can be mentioned:

- *Human-Robot Collaboration (HRC),* the interaction and teamwork between humans and robots in a shared workspace side by side without physical barriers. HRC can take many forms: coexistence (humans and robots work in the same environment but on separate tasks) sequential collaboration (humans and robots perform tasks in sequence), cooperative collaboration (humans and robots work together on the same task simultaneously) and responsive collaboration (the robot dynamically adjusts to human input in real time).
- *Augmented reality* created for maintenance guided assembly mode, repair instructions superimposed on machines.
- *Digital Twin Technology* which collects data from sensors on physical assets collect real-time data (temperature, pressure, movement, etc.), processes the data using AI and machine learning analyze the data to detect patterns and predict outcomes and can perform virtual simulations and optimizations. Product twin or process twin are usually used in maintenance.
- *Autonomous systems* which is based on self-maintenance capabilities (automatically activated redundant circuits, self-cleaning activities, automatic filling of lubrication circuits, etc.). Here, however, human intervention for the maintenance of self-maintenance systems must be mentioned.
- *Personalized maintenance* which involves generating a specific maintenance program for a asset of production in accordance with its load or importance for the entire production.
- *Data-driven decision making* is the process of making maintenance decisions based on data analysis, facts, and insights. It involves collecting, processing, and interpreting data to improve accuracy, efficiency, and results.[9]
- *Skills development* for operating personnel with knowledge related to the maintenance of the equipment they operate, going as far as performing routine maintenance actions, but also for maintenance personnel with advanced operating knowledge of the equipment they repair, to better understand the conditions that generate wear and even failure.
- *Sustainability* by implementing green maintenance practices: reduces energy waste by ensuring machines operate efficiently, prevents leaks, emissions, and unnecessary breakdowns, use biodegradable oils and greases minimize environmental contamination, use non-toxic cleaning agents and reduce harmful chemical exposure, recycling used parts, oils, and industrial materials, implementing remanufacturing strategies to extend equipment lifespan, purchasing durable, energy-efficient, and low-emission spare parts.

3. IDENTIFYING CHALLENGES OHS

To identify the Occupational Health and Safety (OHS) challenges in the maintenance activity in Industry 5.0, the approach was to find first the technical and technological innovations that had not been encountered before, with the next stage being to identify the risks specific to each.[10]

Figure 6 presents some of the technical and technological innovations applied in the maintenance systems used by Industry 5.0. and an attempt to detail these innovations. Some of them are obvious and are a natural result of technological evolution, such as the use of exoskeletons to reduce physical effort and correct working positions or the use of wearables for safety and health monitoring of the working environment. But in other situations, efforts are needed to understand, design, implement, use and maintain them. For example,

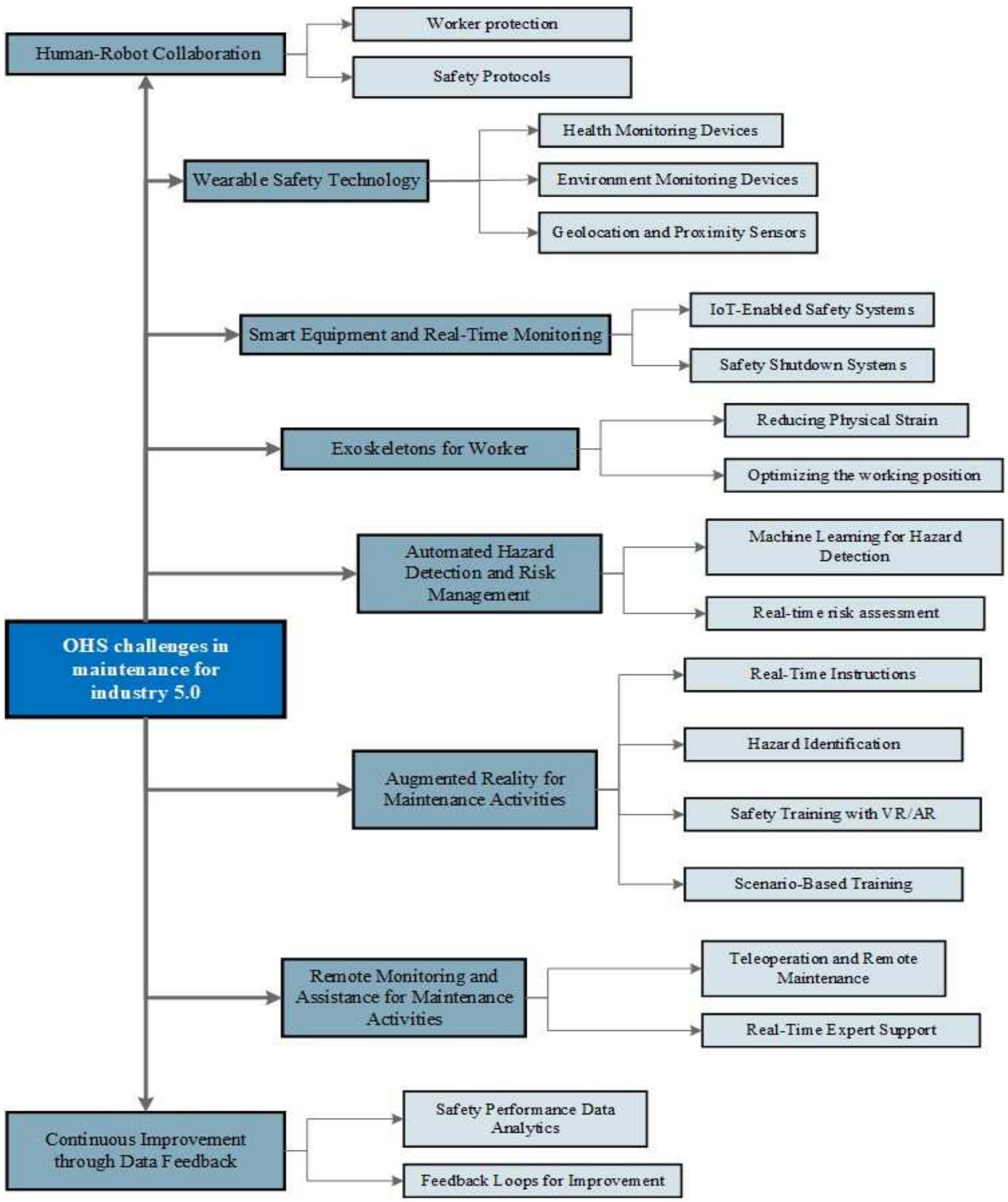

Fig. 6. OHS Challenges in maintenance activities for Industry 5.0

Machine Learning for Hazard Detection requires the implementation of machine-learning software but also time for the machine to "learn" enough.

Another example: IoT Enable Safety System can be an advantage through knowledge obtained from other sources but also a disadvantage if the sources are unverified or even a high safety risk if they are flawed.**4.**

4. CONCLUSION

Currently, maintenance activity is an indispensable component of Industry 5.0 specific activities. Perhaps in the future, humanity will be able to create equipment that does not require maintenance or that repairs itself, but today these aspirations are just a dream. As has been shown, the health and safety of maintenance workers is endangered to a greater extent than in the manufacturing field, so we have identified first of all how maintenance activities must synchronize with production activities in Industry 5.0 and sequentially how these new maintenance activities influence OHS for maintenance workers. In the future, we propose analyses to identify risks for each of these and assess risks from the point of view of the probability of occurrence and the severity of the effects.

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Provocările pentru sănătate și securitate în muncă în întreținerea pentru industria 5.0

Lucrarea prezintă o parte din cercetările legate de modul în care activitățile de întreținere efectuate pentru menținerea sau repunerea în stare de funcționare după o defecțiune a echipamentelor specifice Industriei 5.0 influențează activitățile de sănătate și securitate în muncă. Accentul se pune pe identificarea principalelor activități de întreținere din Industria 5.0 și pe identificarea ulterioară a provocărilor SSM specifice acestor acțiuni.

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